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. II.

Thefe are thy glorious Works, Parent of Good,
Almighty! Thine this univerfal Frame,
Thus wond'rous fair! Thyfelf how wond'rous then!

MILTON.

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CHAP. III.

Of FISHES.

[Continued.]

12. *Of the generation of Fiſhes.*
13. *Of ſome particular ſorts of Fiſhes.*
14. *General Reflections.*

12. AS to the Generation of Fiſhes, ſome of them are viviparous, others oviparous. The womb and ovaries of moſt fiſhes, are not unlike thoſe of birds. The female caſts out innumerable eggs, in the ſea, in lakes, in rivers. Great part of theſe are devoured by the males. The reſt are hatched by the warmth of the ſun, and the young ones immediately ſwim away, without any help from the parent.

Sea-Tortoiſes lay their eggs on the ſea-ſhore, and cover them with the ſand. It is not uncommon to ſee a great number of young Tortoiſes riſe out of the ſand, and without any guide or inſtructions, march with a gentle pace toward the water. But the waves uſually throw them back upon the ſhore, and then the birds deſtroy the moſt of them. So that out of two or three hundred of them it is ſeldom that ten eſcape.

It ſeems at firſt view, that nature, in this inſtance, charges herſelf with unneceſſary expence. But a little reflection ſhews the contrary. We do not complain of the fertility of an hen, which frequently lays above two hundred eggs in one year: although it may be, that not one chick is hatched out of all theſe. The deſign of the author of nature is plain: not barely to preſerve the ſpecies, but at the ſame time, to provide man and other animals with an excellent food. So his intention in the fertility of a Tortoiſe, is not barely to continue that ſpecies, but to accommodate a number of other animals with food convenient for them.

But whence could ariſe the common opinion concerning the generation of Soles? namely, that they are produced from a kind of Shrimps or Prawns? A French gentleman being determined to try, put a large quantity of Prawns into a tub about three feet wide, filled with ſea-water. At the end of twelve or thirteen days, he ſaw there eight or ten little Soles, which grew by degrees. He repeated the experiment ſeveral times, and always found little Soles. Afterwards he put ſome Soles and Prawns together, in one tub, and in another Soles alone. In both the Soles ſpawned; but there were no little Soles, only in the tub where the Prawns were.

But how can Prawns be of uſe toward producing Soles? Farther obſervations cleared up this. When Shrimps or Prawns are juſt taken out of the ſea, you may diſcern between their feet many little bladders, which are ſtrongly faſtened to their ſtomach,

mach, by a kind of glue. If you open theſe bladders gently, you ſee a ſort of embrio's, which viewed with a microſcope, have all the appearance of Soles.

Now here lies the myſtery. Theſe are the eggs or ſpawn of Soles, which in order to hatch, are faſtened to the Shrimps or Prawns: like many plants and animals, which do not grow or receive nouriſhment, but upon other plants and animals. The Prawns therefore are the foſter-mothers of Soles, during their firſt infancy. And this has occaſioned many to imagine they were their real mothers.

The coming of certain kinds of fiſh in ſhoals to certain coaſts, at a certain time of the year, is of great advantage to mankind. But the reaſon of it has been little underſtood. Yet obſervation may clear it up. There is a ſmall inſect common in many ſeas, particularly on the coaſt of Normandy, in June, July, and Auguſt. They then cover the whole ſurface of the water as a ſcum. And this is the ſeaſon when the Herrings come alſo in ſuch prodigious quantities. The fiſhermen deſtroy much of theſe vermin; yet to theſe alone their fiſheries are owing. For it is evident the Herrings feed on theſe, by the quantities found in all their ſtomachs. And doubtleſs, the very reaſon of their coming is to feed upon them. Probably the caſe is the ſame in all other places, where the Herrings come in the ſame plenty.

The numberleſs ſwarms of Herrings, Cod and other fiſh, that come forth yearly from their ſhelter, under the ice adjoining to the north pole, divide themſelves into three bodies. One part direct their courſe ſouthward, toward the Britiſh iſlands:

 another

another part weſtward, toward Newfoundland; and other places in North-America: and the third part along the coaſt of Norway, and then through the Sound into the Baltic.

The water, though quite ſtill before, curls up in waves wherever they come. They croud together in ſuch numbers, that they may be taken up by pailfulls.

A large ſhoal of Herrings, reaches (according to the fiſhermen's account) an hundred or two hundred fathom deep. They extend alſo to a conſiderable circumference. Were they all to be caught, the greateſt part would be loſt. For it would be impoſſible to get hands, tubs, ſalt, and other neceſſaries to cure them. Several hundred ſhip-loads are ſent every year from Bergen alone to foreign parts: beſides the quantities that the peaſants at home conſume, who make them their daily proviſion.

The fiſhers on the weſtern iſles of Scotland obſerve, that there is a large Herring, double the ſize of a common one, which leads all that are in a bay, the ſhoal following him wherever he goes. This leader they term the King of Herrings: and when they chance to catch it alive, they drop it carefully into the ſea, judging it petty treaſon to deſtroy a fiſh of that name.

Mackrels come in the ſame numbers at certain times of the year; and for the ſame reaſon. They are particularly fond of a ſea-plant, the narrow-leaved, purple Sea-wick, which abounds on the coaſts of England; and is in its greateſt perfection in the beginning of ſummer: though at ſometimes later than other, according to the ſeverity or mildneſs of the winter.

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The chief occasion of their coming is to feed on this plant. And those who attend to its growing up, would know when to expect the Mackrel, better than those who listen for thunder.

But this is not the sole occasion of their coming. The real truth is this. The sea near the pole is the native country of all Fish of Passage. The ice which continually covers that sea, affords them a safe retreat. Large, voracious fish, want a free air for perspiration, and cannot pursue the smaller sort into their sanctuaries, where they multiply so prodigiously, that at length for want of subsistence, they are forced to quit their retreat. The large fish wait for them at the extremity of the ice. They devour all they can catch, drive them close into the coasts, while the birds of prey pour down upon them from all quarters. In consequence of this persecution their march is always in columns, which are commonly as thick as they are broad. With regard to the Herrings, they quit the ice in the beginning of the year. But the prodigious columns which they form, soon divides into two wings. The right moves westward, so as to be near Iceland, in the month of March. The left bends its course easterly, and comes down the north sea to a certain latitude, where it divides into two other wings, the eastern most of which coast along Norway. Hence it sends off one division, by the strait of the Sound, into the Baltic. another towards the country of Holstein, Bremen. &c. and thence into the Zuderzce. The western wing, which is the largest, falls directly upon the isles of Shetland and the Orkneys. And thither the Dutch go, to wait their coming. All that escape these dexterous fishers, go on toward Scotland, and dividing again into two columns, one

 passes

paſſes to the eaſt of that kingdom, and goes round England, detaching numerous diviſions to the coaſts of Frieſland, Holland, Zealand, Flanders, and France, while the other moves to the weſtward of Scotland and Ireland. The remains of the whole weſtern wing, which have eſcaped the nets of the fiſhers, and the voracity of other fiſh and fowl, having at length rallied in the channel, the column is formed anew; and then iſſues into the ocean: from which (without ſhewing itſelf again on the coaſt) it regains, like the remains of the firſt weſtern wing, which had not travelled ſo far, the polar ice, at the approach of winter. And under the protection of this, the loſs is repaired, which the ſpecies had ſuffered ſince they left it.

Thus does the divine wiſdom ſupply many thouſands of men with food, as well as numberleſs other animals: and yet prevent any decay of that neceſſary proviſion, which is continually conſumed and as conſtantly recruited.

The Tunnies come in equal ſhoals at certain ſeaſons, to the coaſts of Provence and Languedoc, But it is on another occaſion. The fiſh called by the French the Emperor, is the great enemy of theſe fiſh. He is in ſummer ſo plentiful in thoſe ſeas, that they cannot eſcape him but by flying to the ſhallow waters.

The Pilchards catched on the coaſt of Brittany, are ſtill a ſtronger proof, of the natural means that bring fiſh in ſhoals to certain places. The people of Brittany purchaſe from Norway, the offals and entrails of all the large fiſh caught there. Theſe they cut in pieces, and ſtraw in vaſt quantities on the ſea along the coaſts. This always brings thither ſhoals

ſhoals of Pilchards, enough to ſupply all the maritime places in the neighbourhood.

The Salmon (bred both in the ſea, and in rivers) is another fiſh, which comes in ſhoals at certain times. But this is on another occaſion. The female Salmon chiefly ejects her roe at the mouth of rivers, in ſhallow water. The male comes preſently after, keeps other fiſh from devouring it, and caſts his ſperm upon the roe. They are in great plenty from the middle of April till the middle of July; at which time alſo they come in ſhoals into the rivers, partly to refreſh themſelves in freſh water, and partly to rub or waſh off in the ſtrong currents, a greeniſh vermin called Salmon Lice: inſects wiſely deſigned by the Creator, to drive this rich and valuable fiſh into the hands of men.

The Salmon when they are going up the rivers out of the ſea, always ſwim as near the bottom as they can. And on the contrary, when they are going down them into the ſea, they always ſwim near the ſurface. The reaſon is, in going up, they ſwim againſt the current, which always runs ſwifteſt at the ſurface. When they are going down on the ſurface, the current alone is ſufficient to carry them.

At Leixlip, ſeven miles from Dublin, there is a fine water-fall, or Salmon-leap ſo called from the numberleſs Salmon which leap up it, at the ſeaſon of the year for ſpawning. When they come to the foot of the fall, you may obſerve them frequently to leap up juſt above the water, as if to make an obſervation of the diſtance. Soon after they leap up again, with an attempt to gain the top, and perhaps riſe near it;

but the falling water drives them down again. The same fish soon springs up again, and rises above the fall; yet this is equally unsuccessful, for dropping with their broadsides on the rapid curvature of the waters, they are thrown back again headlong. The only method of succeeding in their attempt, is to dart their heads into the water, in its first curvature over the rocks. By this means they first make a lodgment on the top of the rock for a few moments, and then scud up the stream. There seems to be a peculiar instinct in them, to aim at this very point; for the force of the stream on the top of the precipice, is less at the bottom, close to the rock than on the surface. 'Tis almost incredible, the height to which they will leap, they frequently leap near twenty feet. The manner of their doing it is, by bending their tails round, almost to their heads; it is then by the strong re-action of their tails against the water, that they spring so much above it.

13. One particular instance of the divine care, is observable in the Turbot. He is not well able to swim, especially in stormy weather, He must then keep at the bottom, and stick in the sand. And for that reason he is provided, with a skin or membrane which draws over his eyes, to keep the sand out of them.

Whales are as many degrees raised above other fishes in their nature, as they are in their size. They resemble beasts in their internal structure, and in some of their appetites and affections. They have lungs, a midriff, a stomach, intestines, liver, spleen, bladder, and parts of generation like beasts.

beafts. Their heart alfo refembles that of beafts, driving red and warm blood in circulation through the body.

As thefe animals breathe the air, they cannot bear to be long under water. They are conftrained, every two or three minutes, to come up to the furface to take breath, as well as to fpout out through their noftril (for they have but one) the water which they fucked in while gaping for their prey.

The fenfes of thefe animals feem alfo fuperior to thofe of other fifhes. The eyes of other fifhes are covered only with that tranfparent fkin that covers the reft of the head; but in all the cetaceous kinds, they are covered by eye-lids, as in man. This keeps that organ in a more perfect ftate, by giving it intervals of relaxation. The other fifhes, that are ever ftaring, muft fee, if for no other reafon, more feebly, as their organs of fight are always exerted.

As for hearing, they are furnifhed with the internal inftruments of the ear, although the external orifice no where appears. It is probable, this orifice may open by fome canal into the mouth; but this has not as yet been difcovered.

It is likely, that all animals of the kind can hear, as they certainly utter founds to each other. This vocal power would be as needlefs to animals naturally deaf, as glaffes to a man that was blind.

But it is in the circumftances in which they continue their kind, that thefe animals fhew an eminent fuperiority. Other fifh depofit their fpawn, and leave the fuccefs to accident: thefe never produce above one young, or two at the moft; and this the female fuckles entirely in the manner of quadrupedes, her breafts being placed as in the human-kind.

In fishes of the Whale-kind, the tail has a different position from what it has in all other fishes. For whereas in these it is erected perpendicular to the horizon, in them it lies parellel thereto; partly to supply the use of the hinder pair of fins, which these creatures have not, and partly that they may be able to raise or depress their body at pleasure. For it being necessary they should frequently come to the top of the water, to take in, or let out the air, they are provided with an organ to facilitate their ascent and descent as they have occasion. And as for turning their bodies in the water, they perform that as birds do; by strongly moving one of their fins, while the other is quiescent.

The Norway Whale is frequently sixty or seventy foot long. His shape pretty much resembles that of a cod: he has a large head, and small eyes in proportion. On the top of the head are two openings, through which he spouts out the water (which he takes in, as he breathes) like a large fountain, which makes a violent noise.

His skin is smooth and not very thick. The colour of his back is dark and marbled. His belly is white. His throat is very narrow, in proportion to his size. Under his backbone lies a long bladder, which he dilates or contracts as he pleases. He rows himself with his tail. They copulate after the manner of land animals.

The female brings forth but one or two at a birth, at which time they are nine or ten foot long. They suck for some time: when they are tired with swimming, she carries them between her great fins. Under the skin lies the blubber or fat. Its usual thickness is about six inches:

but

but about the under lip it is found two or three ſeet thick. Out of this the oil is extracted. One Whale ordinarily yields forty or fifty, ſometimes eighty or ninety hundred weight.

The uſe of blubber ſeems to be, partly to poiſe the body and make it equiponderant to the water; partly to keep the water at a diſtance from the blood, leſt it ſhould be chilled by its immediate contact; and partly to keep the fiſh warm, by reflecting the hot ſteams of the body, and ſo redoubling the heat.

Under the fat is the fleſh of a reddiſh colour. Their general food, is certain ſmall inſects, which float upon the water, in great heaps, and are no larger than flies. But they likewiſe eat various ſorts of ſmall fiſh, particularly herrings, which they drive together in large ſhoals, and then ſwallow vaſt quantities at a time, The Whale commonly goes under the ſhoal; then opens his mouth and ſucks in all he can. Sometimes he ſwallows ſo many, that he is ready to burſt, and ſets up a hideous roar.

But he is far more troubled by a ſlender fiſh about four feet long, which tears great pieces of fleſh out of him. The Whale then not only makes a frightful noiſe, but often leaps a conſiderable height. In theſe leaps he ſometimes raiſes himſelf perpendicular above the ſurface of the water, and then plunges himſelf down with ſuch violence, that if his head ſtrikes againſt any of the hidden rocks that are in the ſhallows, he fractures his ſkull, and comes inſtantly floating up dead. So there is no creature in the world ſo great or ſtrong as to be exempt from calamities!

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The Whalebone-Whale is about ſeventy feet long, and very bulky, having ſcales, and no fins, but only one on each ſide, from five to eight feet long.

The Spermaceti Whale is much of the ſame dimenſions. The Spermaceti oil lies in a great trunk, four or five feet deep, and ten or twelve feet long, near the whole length, breadth, and depth of the head. It ſeems to be no other than the brain. Not but ſome other parts of the fiſh yield an oil; but not ſo good as that in the trunk. The care of their young is remarkable: while they carry them under water, they often riſe for the benefit of the air. However they are chaſed or wounded, as long as they have ſenſe, and perceive life in their young, they will not leave them, and if in their flying the young one drops off, the dam comes about, and paſſing underneath takes it again.

Whales are gregarious, being ſometimes found an hundred in a ſwarm, and are great travellers. In autumn the Whalebone Whales go weſtward; in ſpring eaſtward again. The ſeveral kinds of Whales do not mix with each other, but each keep by themſelves.

Their wonderful ſtrength lies chiefly in the tail. A boat has been cut down from the top to the bottom by the tail of a Whale, and the clapboards hardly ſplintered, though the gunnel on the top was of tough wood. Another has had the ſtern-poſt, three inches thick, cut off ſmooth without ſo much as ſhattering the boat, or drawing the nails of the boards.

It is commonly ſuppoſed, that all fiſhes are mute, as well as void of hearing. But a late author ſays, There is one kind of Whale, that when

when they are ſtruck roar ſo loud as to be heard two miles. He likewiſe aſſerts, that ſome of them have hearing, as have frogs, ſnakes, and all the lizard kind, though they have not the uſual outward apparatus of hearing. But they have the auditory paſſage, by which ſound is conveyed, and internal organs, to which the meatus auditores reaches. This is obſervable in all the Whale kind, and in all fiſhes that have lungs. And whereas ſome have ſuppoſed, that water cannot tranſmit ſound, the contrary of this is now well known. Many experiments have ſhewn, that even a man under water may hear what is ſpoken in the open air.

The Hippopotamos, or River-Horſe, is above ſeventeen feet long from the ſnout, to the inſertion of the tail; above ſixteen feet in circumference round the body, and above ſeven feet high: the head is near four feet long, and above nine feet in circumference. The jaws open about two feet wide, and the cutting teeth, of which it hath four in each jaw, are above a foot long.

Its feet reſemble thoſe of the elephant, and are divided into four parts. The tail is ſhort, flat, and pointed; the hide is impenetrable to the blow of a ſabre; the body is covered over with a few ſcattered hairs of a whitiſh colour. The figure of the animal is between that of an ox and a hog, and its cry between the bellowing of the one, and the grunting of the other.

It chiefly reſides at the bottom of the great rivers and lakes of Africa; the Nile, the Niger, and the Zara; there it leads an indolent life, ſeldom diſpoſed for action, except when excited by the calls of hunger. Upon ſuch occaſions, three

or

or four of them are often ſeen at the bottom of a river, forming a kind of line, and ſeizing upon ſuch fiſh as are forced down by the violence of the ſtream. In that element they purſue their prey with great ſwiftneſs and perſeverence; they ſwim with much force, and remain at the bottom for thirty or forty minutes without riſing to take breath. They traverſe the bottom of the ſtream, as if walking upon land. But it often happens, that his fiſhy food is not ſupplied in ſufficient abundance; it is then forced to come upon land, where it is an aukward and unweildy ſtranger; it moves but ſlowly, yet it commits dreadful havock among the plantations of the helpleſs natives, who ſee their poſſeſſions deſtroyed, without daring to reſiſt their invader. Their chief method is, by lighting fires, ſtriking drums, and raiſing a cry to frighten it back to its favourite element. But if they happen to wound it, it then becomes formidable to all that oppoſe it: overturning whatever it meets. It poſſeſſes the ſame inoffenſive diſpoſition in its favourite element, that it is found to have upon land; it never attacks the mariners in their boats, as they go up or down the ſtream; but ſhould they inadvertently ſtrike againſt it, there is much danger of its ſending them, at once, to the bottom. "I have ſeen, ſays a mariner, one of theſe animals open its jaws, and ſeizing a boat between his teeth, at once, bite and ſink it to the bottom. I have ſeen it upon another occaſion, place itſelf under one of our boats, and riſing under it, overſet it with ſix men which were in it; who, however, happily received no other injury." Such is the great ſtrength of this animal; and from hence, probably, the imagination has been

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willing to match it in combat againſt others more fierce and equally formidable. The crocodile and ſhark have been ſaid to engage with it, and yield an eaſy victory; but as the ſhark is only found at ſea, and the Hippopotamos never ventures beyond the mouth of freſh water rivers, it is moſt probable that theſe engagements never occurred; it ſometimes happens, indeed, that the princes of Africa amuſe themſelves with combats, on their freſh-water lakes, between this and other formidable animals; but whether the rhinoceros or the crocodile are of this number, we have not been particularly informed. If this animal be attacked at land, and finds itſelf incapable of vengeance from the ſwiftneſs of its enemy, it immediately returns to the river, where it plunges in head foremoſt, and after a ſhort time riſes to the ſurface, loudly bellowing, either to invite or intimidate the enemy; but though the negroes will venture to attack the ſhark, or the crocodile, in their natural element, and there deſtroy them, they are too well apprized of the force of the Hippopotamos to engage it; this animal, therefore, continues the uncontroulled maſter of the river, and all others fly from its approach and become an eaſy prey.

As the Hippopotamos lives upon fiſh and vegetables, ſo it is probable the fleſh of terreſtrial animals may be equally grateful: the natives of Africa aſſert, that it has often been found to devour children and other creatures that it was able to ſurpriſe upon land; yet it moves but ſlowly, almoſt every creature, endued with a common ſhare of ſwiftneſs, is able to eſcape it; and this animal, therefore, ſeldom ventures from the river ſide, but when preſſed by the neceſſities of hunger, or of bringing forth its young.

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The female always comes upon land to bring forth, and it is supposed that she seldom produces above one at a time; upon this occasion, these animals are particularly timorous, and dread the approach of a terrestrial enemy; the instant the parent hears the slightest noise, it dashes into the stream, and the young one is seen to follow it with equal alacrity.

The young ones are said to be excellent eating; but the negroes, to whom nothing that has life, comes amiss, find an equal delicacy in the old. Dr. Pocock has seen their flesh sold in the shambles, like beef; and it is said, that their breast, in particular, is as delicate eating as veal. As for the rest, these animals are found in great number, and as they produce very fast, their flesh might supply the countries where they are found, could those barbarous regions produce more expert huntsmen. But this creature, which once was in such plenty at the mouth of the Nile, is now wholly unknown in Lower Egypt, and is nowhere to be found in that river, except above the cataracts.

One can hardly tell whether to rank him among land or water animals. He sleeps on land, but passes all the rest of his time under water. But in one respect he is different from all other creatures that live partly on land, and partly in the water. All other sorts of amphibious animals have the faculty of swimming; but this has not. He has to feed under water, yet is the most unwieldy of all creatures, and cannot swim at all. He comes out of the water in an evening to sleep: and when he goes in again, he walks very deliberately in overhead, and pursues his

his courſe along the bottom, as eaſy and unconcerned as if it were in the open air. The rivers he moſt frequents are very deep, and where they are clear, this affords an aſtoniſhing ſight.

An animal of this ſize and make, muſt be one of the ſtrongeſt in the world. It therefore required from nature no ſwiftneſs, either to avoid purſuit, or to overtake its prey, as it was deſigned to feed chiefly on vegetables. The manner of its feeding is this. When he walks into a river, he ſeldom looks about till he is near the middle. Here he ſeeks for the larger water-herbs, particularly for the root of a large water-lilly. People from a boat on the ſurface frequently ſee this. He roots up theſe with his noſe, like a hog, and his mouth and throat being very wide, ſwallows them up in vaſt morſels half chewed.

But he has frequently occaſion to breathe: in order to which, when feeding at his eaſe, his cuſtom is, every thirty or forty minutes, to riſe to the ſurface of the water. This he does, by a ſpring from the bottom, made with all his feet at once. Having taken a little freſh air, and looked about him, he drops to the bottom again.

Of all the inhabitants of the deep, thoſe of the Shark Kind are the moſt voracious. The ſmalleſt of this tribe is not leſs dreaded by greater fiſh, than many that ſeem more powerful; nor do any of them ſeem fearful of attacking animals far above their ſize. But the great White Shark joins to the moſt amazing rapidity, the ſtrongeſt appetites for miſchief: as he approaches nearly in ſize to the whale, he far ſurpaſſes him in ſtrength and celerity, in the formidable arrangement of his teeth, and his inſatiable deſire of plunder.

The

The White Shark is found from twenty to thirty feet long. Some aſſert, that they have ſeen them of four thouſand pounds weight. The mouth is enormouſly wide; as is the throat, and capable of ſwallowing a man with great eaſe. But its furniture of teeth is ſtill more terrible: of theſe there are ſix rows, extremely hard, ſharp-pointed, and of a wedge-like figure. It is aſſerted, there are ſeventy-two in each jaw, one hundred and forty-four in the whole. With theſe the jaws both above and below are planted all over, but he has a power of erecting or depreſſing them at pleaſure. When the Shark is at reſt, they lie quite flat in his mouth: but when he prepares to ſeize his prey, he erects all this dreadful apparatus, and the animal he ſeizes, dies pierced with an hundred wounds in a moment.

His ſkin is rough, hard, and prickly, being that ſubſtance which covers inſtrument-caſes, called Shagreen.

No fiſh can ſwim ſo faſt as he; he outſtrips the ſwifteſt ſhips, plays round them, darts out before them, and returns to gaze at the paſſengers. Such amazing powers, with ſuch great appetites for deſtruction, would quickly unpeople even the ocean: but providentially the Shark's upper jaw projects ſo far above the lower, that he is obliged to turn on one ſide (not on his back, as is generally ſuppoſed) to ſeize his prey. As this takes ſome ſmall time to perform, the animal purſued often ſeizes that opportunity to eſcape.

Tortoiſes are commonly known to exceed eighty years old; and there was one kept in the archbiſhop of Canterbury's garden, at Lambeth, that was remembered above an hundred and twenty.

It

It was at laſt killed by the ſeverity of a froſt, in its winter retreat, which was a heap of ſand, at the bottom of the garden.

The young Tortoiſes are generally excluded in about twenty-ſix days. The little animal no ſooner leaves the egg than they ſeek for their proviſion, and their ſhell, with which they are covered from the beginning, expands and grows larger with age. As it is compoſed of a variety of pieces, they are capable of extenſion at their ſutures, and the ſhell admits of increaſe in every direction. It is otherwiſe with thoſe animals, whoſe ſhell is compoſed all of one piece, that admits of no increaſe; which, when the tenant is too big for the habitation, muſt burſt the ſhell, and get another. But the covering of the Tortoiſe grows larger in proportion as the interior parts expand; in ſome meaſure reſembling the growth of the human ſkull, which is compoſed of a number of bones, increaſing in ſize in proportion to the quantity of the brain. All Tortoiſes, therefore, as they never change their ſhell, muſt have it formed in pieces: and though in ſome theſe marks have not been attended to, yet doubtleſs they are general to the whole tribe.

It is of different magnitudes, according to its different kinds; ſome Turtles being not above fifty pounds weight, and ſome above eight hundred.

The great Mediterranean Turtle is the largeſt of the Turtle kind, with which we are acquainted. It is found from five to eight feet long, and from ſix to nine hundred pounds weight.

All Tortoiſes having ſmall and weak feet, are exceeding ſlow in their motions. They have neither tongue nor teeth, nor any offenſive weapon. How then can they take, how can they

they chew, or in any degree comminute their food? This is well provided for: they break not only ſhells, but ſometimes even ſtones with their lips: which by their exceſſive hardneſs effectually ſupply the want of teeth, But how can they defend themſelves? Abundant proviſion is made for this alſo. Their ſhells more than cover the whole body, and are of ſo firm a texture, that a loaded waggon may go over them, without any injury either to the ſhell or the creature within it.

The blood of Tortoiſes is colder than any common ſpring water; yet is the beating of the heart as vigorous as that of any animal, and the arteries as firm as thoſe of any creature.

There is ſomething highly remarkable in the change of tadpoles into frogs; but there is ſtill ſomething more remarkable in the Frog-fiſh. Theſe are found in great numbers in the river Surinam. At firſt they are perfect frogs, they are ſpotted with brown, yellow, and green; but are paler on the belly, their hinder feet are webbed, like thoſe of a gooſe, the fore-feet without webs. The firſt change the animal undergoes, is by the growing of a tail. After this the fore-feet decreaſe, and periſh by degrees. The decreaſe of the hinder legs follows, and at laſt the Frog is changed into a perfect Fiſh.

It may not be unacceptable or unprofitable to thoſe who ſee God even in his loweſt works, to add a ſhort account of a few more inhabitants of the waters.

Flying

Flying-Fiſh are very rarely a foot long. They have a pretty large, though thin and light head. The mouth is generally open; the body ſmall, roundiſh, and tapering towards the tail: beſides the uſual fins, they have under their necks, three broad and pretty long ones, of a more ſubtle ſtructure, nearly as thin as a fly's wing, but ſtrengthened with rows of bones. On the back part of their neck they have alſo a flying fin, about ſix inches long, quite erect. And lower down the back, there is another ſhorter but broader. Theſe wings they uſe to eſcape the purſuit of creatures too powerful for them. They riſe ſeveral feet above the water, and fly the length of two or three muſket-ſhot. Then they drop, becauſe their wings are dry, which ſerve them no longer than they are moiſt.

The Ink-Fiſh, as ſome call it, has a ſtill more extraordinary way of eſcaping its purſuers. "I have lately, ſays the author of the natural hiſtory of Norway, procured a dryed one, which is two foot long. The body is almoſt round, reſembling a ſmall bag, and is blunt at both ends. But the head is the moſt remarkable part. It has two large eyes, and a mouth like a birds beak. Above this ſtands eight horns, like a ſtar. Each horn is octangular, and covered with many ſmall, round, balls, ſomething larger than a pin's head. On each ſide of the body there are two ſkinny membranes, with which he can cover himſelf all over. The fore-part of the body is quite filled with a black fluid. When it is purſued, it diſcharges this which colours the water all around, and renders it inviſible. This is a wonderful gift of of nature, for the preſervation of an animal, otherwiſe utterly helpleſs.

The Arboreſcent Star-Fiſh is another of the curioſities of nature. It is upwards of a foot in diameter, having its mouth in the middle. The figure of the trunk is pentangular, and from the five angles ariſe as many branches, which ſubdivide into ſeveral others, and thoſe again into others, that are leſs, till the laſt are ſcarce thicker than horſe-hairs, and in number above a thouſand. In ſwimming he ſpreads all theſe branches like a net; and when he perceives any prey within them, draws them in again, and ſo takes them with all the dexterity of a fiſherman.

Full as ſurpriſing a creature is the Torpedo, a flat fiſh, much like a thorn-back. It is common on the coaſts of Provence, and is eaten without any ill effect. But upon touching it with the finger, the perſon commonly (though not always) feels an unuſual, painful numbneſs, which ſuddenly ſeizes him up to the elbow, and ſometimes up to the ſhoulder. It reſembles, but far exceeds, the pain felt by ſtriking the elbow violently againſt an hard body. But it laſts only a few moments, and gradually wears away. If a man touch it even with a ſtick, he feels a little of it. If he preſſes his hand ſtrongly againſt it, the numbneſs is the leſs. But it is ſo uneaſy as to oblige him, very ſpeedily to let it go. Many have attempted to account for this; but ſhould we not rather honeſtly own our ignorance?

The Sea-Nettle, ſo called, is another ſtrange production of nature, common, I ſuppoſe, in all the

the northern ſeas. It generally ſwims on the top of the water, and is throughout ſoft, ſmooth, and tranſparent. It appears to be a lump of ſlime or jelly. But it co-heres firmly together, being marked in the middle with a croſs ſomewhat like a flower-de-luce.

Theſe creatures are blue, white, or red, and ſome of them have many branches underneath. Theſe are uſually ſomething larger than the common ſort, and are of a dark red. They all abound with a corroſive poiſon, which if it drop on any part of the body will cauſe a ſmart and an inflammation, muchlike that produced by nettles. Hence it has its name. However it is no vegetable, but evideutly a living creature. For it has ſenſation: it grows, moves to and fro, contracts and extends itſelf. It often picks up and devours ſmall fiſh, and is itſelf devoured by others.

The care of the Creator is obſervable, even in ſo inconſiderable a creature as a Limpet, a ſmall ſhell-fiſh, which ſo faſtens itſelf to the rock, that ſcarce any thing can unlooſe its hold.

The fact has long been known. But the manner of its faſtening itſelf, was not underſtood till very lately. Its ſhell approaches to the figure of a cone; the baſe of which is occupied by a large muſcle, which alone has nearly as much fleſh in it, as the whole body of the fiſh. This is not covered by the ſhell, but ſerves the creature equally to move forward or to fix itſelf to the rock. When it is in a ſtate of reſt, which is the common caſe, it applies this muſcle every way round to the ſurface of ſome ſtone, and thereby holds itſelf fixt to it ſo firmly, that it is impoſſible to take it off with the hands. Thoſe who would remove them are obliged to make uſe of a knife for that purpoſe. And even then it is not eaſy: for on whatſoever ſide the blade of the knife attempts to enter, the fiſh immediately fixes its muſcle with double force to the ſtone,

The true cauſe of his adheſion is a viſcous juice, a kind of glue, thrown out by this muſcle, which though it is not preceptible to the eye, yet it is eaſily perceived by the touch. For if immediately after the removing a Limpet from the ſtone, the finger be applied to the place, it is faſtened very ſtrongly to it, by means of the glue left there. But if any wet have come upon the ſtone, ſince the fiſh has been removed, no viſcoſity can be perceived on it, the whole ſubſtance of the glue being immediately diſſolved. This conſideration may lead us to obſerve the great care of nature over all her works. How eminently is it manifeſted in this little fiſh? It was abſolutely neceſſary for its preſervation, that it ſhould have a power of fixing itſelf to the ſtone, or it would have been waſhed away by every wave. And this power is given it, by means of that glue which fixes it ſo firmly. But when it is fixed, how ſhall it be looſed? This is equally neceſſary. For if there be not ſome power in the animal itſelf, to diſſolve this glue, it muſt needs periſh for want of food, when once fixt to a barren ſpot. Water is the proper diſſolvent of this glue. But it cannot be the external water. This is kept at a diſtance, by the cloſe adheſion of the outer rim of the great circular muſcle. And 'tis needful it ſhould: elſe it would always diſſolve the glue, as ſoon as it was diſcharged. But the under ſurface of the body of the animal is covered all over with ſmall tubercles, moſt of which contain water. When therefore

fore it would move, it has only to difcharge a fmall quantity of this water, and the cement immediately diffolves and fets it at liberty The other tubercles doubtlefs contain the vicfous matter. So that when the animal would fix itfelf, it needs only to fqueeze one fet of its tubercles, and then it would loofe itfelf with the other.

14. Upon the whole, how natural are the reflections, which a late writer makes on the inhabitants of the waters?

What an abundance of fifh do the waters produce? In thefe I feem to difcern nothing but a head and a tail. They have neither feet nor hands. Nor have they any neck: fo that their head cannot be turned at all, any otherwife than by turning the whole body. Were I to confider their figure only, I fhould think they were deftitute of all that was neceffary for the prefervation of their life. But with thefe few outward organs they are more nimble and dexterous, than if they had feveral hands and feet. And by the ufe they make of their tails and fins, they are carried along like arrows.

But as almoft all fifhes prey upon each other, and cannot fuftain their own lives, any otherwife than by continually deftroying thofe of their own fpecies, how can the inhabitants of the water fubfift? How can many fpecies efcape utter deftruction? God has guarded againft this, by multiplying them in fo prodigious a manner. More than three hundred thoufand eggs have been counted in the roe of a fingle Salmon. By this means, let them be deftroyed ever fo faft, ftill their increafe is equal to their confumption.

But who can explain how the inhabitants of the ſea enjoy their perfect health, in the midſt of water ſo loaded with ſalt? And by what art is it, that they preſerve even there, a fleſh that has not the leaſt taſte of it?

Why do thoſe which are fitteſt for the uſe of man, come and offer themſelves on our coaſts? While ſo many that would be uſeleſs, if not pernicious, affect remoteneſs from us.

Why do ſeveral of them, in their ſtated ſeaſons, run up into our rivers, and communicate the advantages of the ſea, to ſuch countries as are far diſtant from it? What hand conducts them with ſo much care and goodneſs, but thine, O thou preſerver of men?

CHAP.

CHAP. IV.

Of R E P T I L E S.

1. Of their motion: 2. Of serpents: 3. Of their Brain, Stomach, Generation: 4. Venom: 5. Of some particular sorts of Reptiles: 6. Water lizards often change their skins: 7. Re-production of parts cut off: 8. Of tape-worms: 9. Of worms that feed on stones.

1. NOT far removed from fishes are Reptiles, so named from their creeping, or advancing on the belly. Many species of them have legs and feet, but very small in proportion to the body. There is a world of contrivance in their motion. The whole body of the earth-worm for instance, is a chain of annular muscles, or rather, one continued spiral muscle, the orbicular fibres whereof being contracted, make each ring narrower and longer, by which means it is enabled, like the worm of an augre, to bore its passage into the earth. Its creeping may be explained by a wire, wound on a cylinder. If this is taken off, and one end extended and held fast, it will bring the other near it. So the worm having shot out its body, which is spiral, takes hold by its small feet,

feet, and so brings on the hinder part. Its feet are placed in a four-fold row, the whole length of the worm With these, as so many hooks, it fastens to the earth, or whatever it creeps over, sometimes this, sometimes that part of the body, and stretches out, or draws after it another.

2. The most eminent species of Reptiles are Serpents, which we may therefore particularly consider. Their bodies are of a very peculiar make, having a compages of bones articulated together. Here part of the body is applied to the ground, and the other part shot forward, which being applied to the ground in its turn, brings the other after it. The spine of their back variously writhed, helps their leaping, (as the joints of the feet in other animals.) They make their leaps by means of the muscles that extend the folds thereof.

The number of joints in the back-bone are numerous beyond what any one would imagine. In the generality of quadrupeds they amount to not above thirty or forty. In the serpent kind they amount to an hundred and forty-five from the head to the vent, and twenty-five more from that to the tail. The number of these joints must give the back-bone a surprising degree of pliancy: but this is still increased by the manner in which each of these joints is locked into the other. In men and beasts the flat surfaces of the bones are laid one upon the other, and bound tight by sinews; but in serpents the bones play one within the other like ball and socket, so that they have a full motion upon each other in every direction. Thus if a man were to form a machine composed of so many joints as are in the back of a serpent, he would find it no easy matter to give it such strength and

and pliancy at the ſame time. The chain of a watch is but a bungling piece of work in compariſon.

Though the number of joints in the back bone, is great, yet that of the ribs is ſtill greater; for, from the head to the vent, there are two ribs to every joint, which makes their number two hundred and ninety in all. Theſe ribs are furniſhed with muſcles, which being inſerted into the head, run along to the end of the tail, and give the animal great ſtrength and agility.

The ſkin alſo contributes to its motions, being compoſed of a number of ſcales united to each other by a tranſparent membrane, which grows harder as it grows older, until the animal changes, which is generally done twice a year. This cover then burſts near the head, and the ſerpent creeps from it, by an undulatery motion, in a new ſkin, much more vivid than the former. If the old ſlough be then viewed, every ſcale will be diſtinctly ſeen like a piece of net-work.

There is much geometrical neatneſs in the diſpoſal of the ſerpents ſcales, for aſſiſting the animal's ſinuous motion. As the edges of the foremoſt ſcales lie over the ends of the following, ſo theſe edges, when the ſcales are erected, which the animal has a power of doing in a ſmall degree, catch in the ground, like the nails in the wheels of a chariot, and ſo promote and facilitate the animal's progreſſive motion. The erecting theſe ſcales are by means of a multitude of diſtinct muſcles, with which each is ſupplied, and one end of which is tacked each to the middle of the foregoing.

Serpents differ very widely as to ſize. The Lyboija of Surinam grows to thirty ſix feet long. The litle ſerpent at the Cape of Good Hope is

 not

not above three inches, and covers whole ſandy deſarts with its multitudes! This tribe of animals, like that of fiſhes, ſeems to have no bounds put to their growth. Their bones are in a great meaſure cartilgenous; and they are conſequently capable of great extention; the older therefore a ſerpent becomes, the larger it grows; and as they live to a great age, they arrive at an enormous ſize. Leguat aſſures us, that he ſaw one at Java, that was fifty feet long.

Vipers are often kept in boxes for ſix or eight months, without any food whatever; and there are little ſerpents ſometimes ſent over to Europe, from Grand Cairo, that live for ſeveral years in glaſſes, and never eat at all, nor even ſtain the glaſs with their excrements. Thus the ſerpent tribe unite in themſelves two very oppoſite qualities; wonderful abſtinence, and yet incredible rapacity.

Serpents will ſwim a long time, but they cannot ſtay long under water, without being ſuffocated. In winter they retire under ſtones, roots of trees, old walls, or any warm, dry ſhelter. Here they ſleep half dead, though with their eyes open, till the returning ſun recalls them to life.

3. Their Brain little differs from that of fiſhes: but their Stomach very much. It is like a looſe gut, which runs along, from the jaws quite to the tail. They have likewiſe ſolid ribs and vertebræ, at ſmall diſtances, from the neck to the end of the tail. Hereby they are enabled, to raiſe themſelves up, to ſupport, to writhe themſelves into rings, to ſpring forward, and to ſuck or ſwallow any thing with ſurpriſing force. And their whole fleſh is of ſo cloſe and firm a texture,

that

that they will live for ſome time, even after they are cut in pieces. There is nothing more harmleſs than the common Snakes: they are as innocent as flies.

There is a great deal of geometrical nicety in the ſinuous motion of Serpents. For the aſſiſting herein, the annular ſcales under their body, are very remarkable, lying croſs the belly, contrary to thoſe in the back and the reſt of the body. Alſo the edges of the foremoſt ſcales, lie over the edges of the following ſcales from head to tail. So that when each ſcale is drawn back, or ſet a little upright by its muſcle, the outer edge of it is raiſed a little from the body, to lay hold on the earth, and ſo promote the ſerpent's motion. But there is another admirable piece of mechaniſm, that every ſcale has a diſtinct muſcle, one end of which is fixed to the middle of its ſcale, the other to the upper edge of the next ſcale. There is nothing peculiar in the generation of Serpents, moſt of which are oviparous.

4. Vipers and many other Serpents have ſmall bags near the root of their teeth, which contain the poiſon. When they bite, this is ſqueezed out, by the compreſſion of thoſe bags. If they are taken out of a viper, the liquid they contain mixed with the blood of an animal, cauſes death. But if taken in by the mouth, it does no harm, loſing its efficacy by mixing with other liquids.

A Viper has the biggeſt and flatteſt head of all the Serpent kind. It is uſually half an ell long and an inch thick, with a ſnout not unlike that of an hog. It has ſixteen ſmall teeth in one row; beſide two large, ſharp, hooked, hollow, tranſparent teeth, placed at each ſide of the lower jaw. Theſe convey the poiſon into the wound, through a long ſlit. They are flexible, and then only raiſed, when the Viper is going to bite. The roots of them are encompaſſed with a little bladder, containing a large drop of a yellow inſipid juice. The ſlit is a little below the point of the teeth, which are not hollow to the top. Hence ariſe all thoſe dreadful ſymptoms, which frequently end in death. But they are all prevented or removed, by rubbing oil upon the wound.

Vipers creep but ſlowly, and never leap or bite, unleſs provoked. They are of a yellowiſh colour, ſpeckled with longiſh brown ſpots. The belly is of the colour of well-poliſhed ſteel. Other Serpents lay eggs; the female Viper only brings forth her young alive, wrapt up in ſkins, which break on the third day, and ſet them at liberty.

The venom of a Viper is not mortal to a ſound and robuſt body, though attended with painful ſwellings, violent vomitings, phrenſies, and convulſions. In eight or ten days, the poiſon having run through divers parts of the body, throws itſelf into the ſcrotum, and ſwelling it extremely, cauſes great heat, and much urine very hot and ſharp, by which it is diſcharged, this being the certain criſis of the diſeaſe.

But a ſickly or fearful perſon, bit by a Viper ſurely dies, if there be not ſpeedy help. Any one bit, in two or three days weighs almoſt as much more as he did before. Who can account for this?

It is remarkable, that the youngeſt Vipers are provided with poiſonous teeth grown to perfection, commenſurate to their bulk; that ſo they

may

may be able to kill their prey and feed themselves, as foon as they are born.

The poifon of a Rattle-Snake is equally fatal and more fwift in its operation. For it frequently kills within an hour. The Snake is from ten to fifteen feet long. But whenever it moves in order to bite, the tail begins to rattle: and that confiderably loud: fo that a man if he has prefence of mind, may eafily get out of his way. When he bites an hare, he is obferved to lick her all over before he takes her into his mouth: probably, that having moiftened and fmoothed her fkin, he may the more eafily fwallow her.

It is very remarkable, that he frequently ftays under a tree, on which a bird or fquirrel is hopping about, with his mouth wide open. And the event conftantly is, the creature in a while drops into it. Sir Hans Sloane thinks, he has wounded it firft: and that he then waits under the tree, till the poifon works and the animal drops down into the mouth of its executioner.

But this is not the cafe, as plainly appears, from what many have been witneffes of. A Swallow, purfuing his prey in the air, if he cafts his eye on a Snake beneath him, waiting with his mouth wide open, alters his courfe, and flutters over him in the utmoft confternation, till finking gradually lower and lower, he at laft drops into his mouth.

To the fame purpofe is the famous experiment of Dr. Sprenger, mentioned in the Hamburgh magazine. He let loofe a moufe on the ground, at a little diftance from a common fnake. It made a few turns, and fqueaked a little, and then ran directly, into the mouth of the fnake, which all the while lay ftill, and without motion.

The Rattle-Snake being leſs nimble than others, would find difficulty in getting its prey, were it not for the ſingular proviſion made, by the rattle in his tail. When he ſees a ſquirrel or bird on a tree, he gets to the bottom, and ſhakes this inſtrument. The creature looking down, ſees the terrible eye of the Snake bent full upon it. It trembles, and never attempts to eſcape, but keeps his eye upon the deſtroyer, till tired with hopping from bough to bough, it falls down, and is devoured. Indeed the ſame power is in the Viper. The field-mice, and other animals, which are its natural food, if they have once ſeen his eyes, never eſcape, but either ſtand ſtill or run into his mouth.

But Vipers in general will not eat, after they are under confinement. The Viper-catchers throw them together into great bins, where they live many months, though they eat nothing. It is only a female Viper, when big with young, that will eat during its confinement. If a mouſe be thrown into the bin, at the bottom of which forty or fifty Vipers are crawling, among which one is with young, ſhe alone will meddle with it, and ſhe not immediately. The reſt paſs it by, without any regard, though it be their natural food. But the female, after ſhe has done this ſeveral times, will at length begin to eye it. Yet ſhe paſſes by it again, but ſoon after ſtops ſhort, and holding her head facing that of the mouſe, ſeems ready to dart at it, which however ſhe never does, but opens her mouth, and brandiſhes her tongue. Her eyes having now met thoſe of the mouſe, ſhe never loſes ſight of it more; but they face one another, and the Viper advances with her open mouth, nearer and nearer, till without making

ing any leap, ſhe takes in the head, and afterward the whole body.

A common Snake will avoid a man; but a Rattle-Snake never turns out of the way. His eye has ſomething ſo terrible in it, that there is no looking ſtedfaſtly at him. But he creeps very ſlow, with his head cloſe to the ground, ſo that one may eaſily get out of his way. His leaping is no more than uncoiling himſelf, ſo that a man is in no danger, if he is not within the length of the Snake. Neither can he do any harm, unleſs he firſt coil, and then uncoil himſelf; but both theſe are done in a moment.

The noiſe they make is not owing (as ſome imagine) to little bones lodged in their tails. But their tail is compoſed of joints that lap over one another, like a lobſter's, and they make that noiſe by ſtriking them one upon another. This is loudeſt in fair weather; in rainy weather they make no noiſe at all. It is remarkable, that whenever a ſingle Snake rattles, all that are within hearing rattle in like manner.

Of how extremely penetrating a nature is their poiſon? A man provoking one of them to bite the edge of his broad-axe, the colour of the ſteeled part preſently changed: and at the firſt ſtroke he made with it in his work, the diſcoloured part broke out, leaving a gap in the axe.

A gentleman in Virginia has lately given a particular account, of what he felt after being bit by one of them.

" Hearing, ſays he, a bell upon the top of a ſteep hill, which I knew to be on one of the cows of the people where I then quartered. I went

went right up the hill; but near the top my foot ſlipped, and brought me down upon my knees. I laid my hand on a broad ſtone to ſtay myſelf; I ſuppoſe the Snake lay on the other ſide, who bit my hand in an inſtant, then ſlid under the ſtone, and ſounded his rattles. But I ſoon found him, cruſhed his head to pieces with a ſtone, took him up in my left hand, and ran home, ſucking the wound on my right hand, and ſpitting out the poiſon. This kept it eaſy; but my tongue and my lips grew ſtiff and numb, as if they were froze. When I came home, one preſently ripped a fowl open, and bound it upon my hand. This eaſed me a little. I kept my elbow bent and my fingers up, which kept the poiſon from my arm. Another bruiſed ſome turmeric, and bound it round my arm, to keep the poiſon in my hand. This kept my arm eaſy for ſome hours; and my hand, though numb, was not much ſwelled, nor even painful: but about midnight it puffed up on a ſudden, and grew furious, till I ſlit my fingers with a razor. I alſo ſlit the back of my hand, and cupped it, and drew out a quart of ſlimy ſtuff, yet my arm ſwelled. Then I got it tied ſo faſt, that it was almoſt void of feeling. Yet would it work, writhe, jump, and twine like a Snake, change colours, and be ſpotted. And the ſpots moved to and fro upon the arm, which grew painful at the bone. All things were applied for two days which could be thought on; but without effect, till the aſhes of white aſh-bark made into a plaiſter with vinegar, drew out the poiſon. We then untied my arm; but within two hours all my right-ſide turned black. Yet it did not ſwell, nor pain me. I bled at the mouth ſoon after, and continued

tinued bleeding and feverifh four days. The pain raged ftill in my arm, and I was by times delirious for an hour or two. After nine days the fever went; but my hand and arm were fpotted like a Snake all the fummer. In autumn my arm fwelled, gathered, and burft, fo away went poifon, fpots and all.

But the moft furprifing circumftance was my dreams. In all fickneffes before, thefe were always pleafant. But now all were horrid. Often I was rolling among old logs; fometimes I was a white oak cut in pieces. Frequently my feet would be growing into two hickary trees: fo that it was a terror to me, to think of going to fleep.

5. It is a wonderful provifion which is made for thofe Snakes, who are inhabitants of the waters. A Water-Snake has no air-bladder like fifhes: but to make amends for this want, it has a large membranous air-bag on its back, which it empties or fills with air at pleafure, by an aperture which it can fhut fo clofe, that the leaft globule of water cannot enter. By this means it can enlarge or leffen the bulk of its body, and inhabit any depth of water.

As for the Serpent of the Waters, of which an account is gravely given, by the writer of the Natural Hiftory of Norway, which he talks of, as being five or fix hundred yards long, and as rearing his head higher than the main-maft of a man of war, I prefume it is very nearly related to the Craken of the fame author: a fea-monfter, to which a whale is but a fhrimp, larger than twenty men of war put together. And this our

our writers of magazines and reviews, ſwallow without any difficulty! Is it from the juſt judgment of God, that men who do not believe the bible, will believe any thing?

The King of all Reptiles which are known with any certainty, is the Crocodile. There are ſixty-two joints in the back-bone, which, though very cloſely united, have ſufficient play to enable the animal to bend like a bow to the right and the left; ſo that what we hear of eſcaping the creature by turning out of the right line, and of the animal's not being able to wheel after its prey, ſeems to be fabulous. It is likely the Crocodile can turn with great eaſe; for the joints of its back are not ſtiffer than thoſe of other animals: and we know by experience, it can wheel about very nimbly for its ſize.

It is probable, that the ſmell of muſk, which all theſe animals exhale, may render them agreeable to the ſavages of that part of Africa. They are often known to take the part of this animal which contains the muſk, and wear it as a perfume about their perſons. Travellers are not agreed in what part of the body their muſk-bags are contained; ſome ſay in the ears; ſome, in the parts of generation; but the moſt probable opinion is, that this muſky ſubſtance is amaſſed in glands under the legs and arms.

The American Crocodile, or Alligator, is only fifteen or ſixteen feet long. But thoſe bred in Afric, or the Eaſt-Indies, are ſaid to be between five and twenty and thirty. It may well be ſaid of him, (which cannot be ſaid of the whale) that *his ſcales are his pride:* for on his back, as well as on his head, they are impenetrable as ſteel.

No.

No creature dares withſtand him. *He is the king of all the children of pride.* And as every female Crocodile lays ſome hundreds of eggs at once, they would utterly diſpeople the waters, were it not that the male devours all he can find of them. And ſo diligent is he in his ſearch, that ſcarce one out of an hundred eſcapes him. It is another inſtance of divine mercy, that he cannot bite under water. By this circumſtance, creatures that are able to dive, generally eſcape his ravenous jaws. It is a vulgar error, that he moves the upper jaw: he moves the lower only.

The Chameleon (as well as the Alligator) is of the Lizard Kind. Some in Egypt are twelve inches long; but the Arabian ſeldom exceeds ſix. He has four feet, and a long flat tail, whereby he hangs on trees, as well as by his feet. His ſnout is long, his back ſharp, and grained like ſhagreen. He has no ears, neither does he make or receive any ſound. The tongue is half the length of the animal, round to the tip, which is flat and hollow, ſomewhat like an elephant's trunk. And this he darts out, and draws back with ſurpriſing ſwiftneſs. The great uſe of this is, to catch flies, (which are its proper food, not the air, as is vulgarly thought) by darting it out upon them. Its colour is not always the ſame. One at Paris, when it was in the ſhade, and at reſt, was of a bluiſh grey. In the ſunſhine this changed to a darker grey, and its leſs illumined parts to various colours. When handled or ſtirred, it appeared ſpeckled with dark ſpots bordering upon green. If it was wrapt up a few minutes in a linen cloth, it was ſometimes taken out whitiſh. But it did not take the colour of any other cloth

or

or ſubſtance that incloſed it. So that its aſſuming all the colours it comes near, is a groundleſs imagination.

The Chameleon at London was of ſeveral colours, like a mottled coat. The moſt diſcernible were, a green, a ſandy yellow, and a liver colour. When ſtirred or warmed it was ſuddenly full of black ſpots, as big as a large pin's head. But when it was quiet, they gradually diſappeared.

There are four ſpecies of Chameleons, 1. The Arabian, about the ſize of the green lizard. This is of a whitiſh colour, variegated with reddiſh and yellowiſh ſpots. 2. The Egyptian, which is of a middle hue, between a whitiſh and a fair green. 3. The Mexican. And 4. A kind which has been frequently ſhewn in Europe, and differs from all the reſt. His head is large; but he alters his body at pleaſure, inflating it more or leſs: and not only his body, but his legs and tail. This is peculiar to him. The body thus puffed up, will remain ſo two hours. But it is inſenſibly ſinking all the time. It can continue a long time in either of theſe ſtates; but is generally uninflated. It then looks miſerably lank and lean: its backbone may be ſeen perfectly; its ribs counted, and even the tendons of the feet diſtinctly ſeen through the ſkin.

Its mouth is furniſhed with continued, denticulated bones: but it does not appear what uſe they are of, ſince it preys on flies, and ſwallows them whole, unleſs for holding a ſtick in its mouth croſs-ways: which according to Ælian, he frequently does, to prevent being ſwallowed by ſerpents.

The ſtructure and motion of his eyes are ſurpriſing. They appear to be large ſpheres, of which

which one half ſtands out of the head, and is covered with a thick ſkin, perforated with a ſmall hole at top. Through this is ſeen a very vivid and bright pupil, ſurrounded with a yellow iris. This hole is a longitudinal ſlit, which he opens more or leſs at pleaſure. The motion of his eyes is not leſs ſingular. It can turn them, ſo as to ſee either forward, backward, or on either ſide, without moving the head at all, which is fixt to the ſhoulders. And he can give one eye all theſe motions, while the other is perfectly ſtill. Each foot has five toes, all of one ſide, two behind and three before. He moves very ſlowly on the ground, but on trees more eaſily. Its tail is then its ſafety, as it twiſts it round the branches, when in any danger of falling.

But how can ſo ſlow a creature catch the moſt nimble ſort of inſects? What nature has denied it in agility, is abundantly ſupplied by other means. Its ſlow, and eaſy motion renders it but little ſuſpected at a diſtance. And when it comes within a proper ſpace of its object, it ſtretches out its tail, poiſes its body, and fixes itſelf, ſo as ſeldom to meet with a diſappointment. When all is ready, it uncoils its long, ſlender tongue, and darts it ſo ſwift as ſcarce ever to miſs its prey.

The common colour of the Chameleons in Smyrna is green, toward the belly inclining to a yellow. But thoſe in the ruins of the caſtle are greyiſh, like the ſtones among which they breed. One of them, having been kept in a napkin, appeared whitiſh; but it never changed to red or blue, though wrapt in cloth of thoſe colours for ſeveral hours together. On being handled or diſturbed, it became ſtained with dark ſpots, bordering on green. Sometimes from a green all

over

over, it became full of black ſpots; ſometimes when it appeared black, green ſpots ſuddenly appeared. So far is it from being true, that it changed its colour, according to every object near it. Nor could we perceive this change to be any fixed law, it rather ſeemed ſpontaneous. This only was conſtant; being placed on green, it bebecame green; being on the earth, it changed to the colour of earth.

Another uncommon creature of the Lizard kind is a Salamander. This is ſuppoſed to live in fire; but without any ground. It is indeed generally found in the chinks of glaſs-houſes, or near furnaces, where the heat is ſo great, that no other animal could endure it, without being deſtroyed in a few minutes. But ſome years ago, the trial was made by ſeveral gentlemen, whether it could really live in fire. Some charcoal was kindled, and the animal laid upon the burning coals. Immediately it emitted a blackiſh liquor, which entirely quenched them. They lighted more coals, and laid it upon them. It quenched them a ſecond time in the ſame manner. But being preſently laid on a freſh fire, it was in a ſhort time burnt to aſhes.

In many parts of Lower Egypt, there is a kind of Lizard termed Oocaral. It reſembles a crocodile, only that is but three or four feet long, and lives wholly on the land. As it is exceeding fond of the milk of ewes and ſhe-goats, it makes uſe of a remarkable expedient. It twiſts its long tail round the leg of the ewe or goat, and ſo ſucks her at his leiſure.

In moſt parts of Italy there are ſwarms of Lizards, eſpecially of the green kind. In the ſpring

ſpring hundreds of them are ſeen, baſking on the roofs, and crawling up and down the walls of houſes. They are very nimble, and have a bright ſleek ſkin, and beautiful eyes, but are entirely harmleſs. The Scorpions are not ſo; they harbour not only in old walls and under ſtones, but in every part of the houſe, eſpecially the beds; and if touched, immediately ſting. The ſting of an Apulian ſcorpion, has the ſame effect with the bite of a tarantula. And it requires the ſame method of cure; only by different inſtruments, the flute and bagpipe in particular, with the briſk beat of a drum. But the common remedy againſt the ſting of a ſcorpion is, to bruiſe the animal, and bind it on the wound.

6. With regard to Water-Lizards, commonly called Newts, which moſt people ſuppoſe to be venomous, they are harmleſs as Land-Lizards, and are found in ſummer, in moſt ſhallow ſtanding waters. One who kept ſeveral of them in glaſs jars for many months obſerves, in reſpect of that odd circumſtance, caſting their ſkins, they do this every fortnight or three weeks. A day or two before the change, the animal appears more ſluggiſh than uſual, and takes no notice of its food, which at other times it devours greedily. The ſkin in ſome parts appears looſe, and not of ſo lively a colour as before. It begins this work, by looſening with its fore-feet, the ſkin about its jaws, puſhing it forward gently and gradually both above and below the head, till it can ſlip out firſt one leg and then the other. Then it thruſts the ſkin backward as far as thoſe legs can reach. Next it rubs itſelf againſt pebbles, gravel, or whatever

whatever elſe it can meet with, till more than half the body is freed from the ſkin: which then appears doubled back, covering the hinder part of the body and tail. Then turning its head round to meet its tail, it takes hold of the ſkin with its mouth, and ſetting his feet thereon, by degrees pulls it off, drawing the hind-legs out, as it did the fore-legs. If you then examine the ſkin, it will be found inſide outward, but without the leaſt hole or breach, the part which covered the hind legs ſeeming likes gloves turned inſide out, though entirely perfect and unbroken. They do not however put off the coverings of their eyes, as moſt kinds of ſnakes do; for the ſkin of the Newt has always two holes, at the places where the eyes have been. When the ſkin is off, if it be not ſoon taken away, the creature ſwallows it whole.

Many creatures of very different kinds, put off their ſkins or ſhells at certain periods, and if we may gueſs at other ſhell-fiſh by the freſh water ſhrimps, their ſhells are put off without any breach but one, lengthways in the middle of the belly part, through which the body, tail, and claws are pulled out, and the ſhell left in a manner whole. In the inſect tribe, the changes of caterpillars are well known. The ſpider throws off its ſkin as frequently, getting out of it by a rupture underneath, and leaving every claw intire, and even the horny covering of his forceps. Even the mite caſts its ſkin at ſeveral ſhort periods, and nearly in the ſame manner.

A particular ſpecies of Water-Lizards, Abbe Spallanzani terms an Aquatic Salamander. Yet he he obſerves, this cannot bear any great degree either of heat or cold. But the moſt remarkable circumſtance relating to it is, that let its tail, legs, or even jaws be cut away, and in a ſhort time they are re-produced. The tail, beſide a complete apparatus of nerves, muſcles, glands, arteries and veins, has vertebræ of real bone. And their legs do not differ from thoſe of the moſt perfect animals, in the number of bones, whereof they are compoſed.

7. Now when the legs and tails of this animal are taken away, new vertebræ, new bones are produced: a phænomenon as wonderful as any hitherto known. This takes place in every known ſpecies of Salamanders, at any period of their life, on the earth or in the water; and let the length of the divided part be greater or leſs. Nor do the conſtituent parts of the new tail differ from thoſe of the part that was cut, either in number, ſtructure, or connexion. But a whole year is ſcarce ſufficient to render the new part equal to that which was cut off. Indeed the regenerating power ceaſes during the winter half year.

When the part re-produced is cut off, it is ſucceeded by another, which proceeds in the ſame manner as the former, and this a ſecond. a third, or fourth time: the Salamander ſtill forming new parts by the ſame unalterable laws.

There are in the legs of a Salamandar ninety and nine bones. In the four regenerated legs there is the ſame number. The form and internal ſtructure of the re-produced, and bones of the natural, are the ſame. But the colour of the new bones is ſomewhat different, and their ſubſtance more tender. And all theſe parts are re-

pro-

produced in the ſame manner and the ſame time, whether the creature is fed, or kept faſting.

When their jaws are cut off, the ſame thing happens. New bones are re-produced, new teeth, new cartilages, veins and arteries. From the wonderful reproduction of ſo many parts in this, may we not extend our enquiry to other animals of equally complicated ſtructure? Let us enquire firſt concerning Tad-poles. If the whole of their tails be cut off, they ſink to the bottom of the water, and periſh. But if part only, they ſoon recover it. In one ſummer's day the reproduction makes a rapid progreſs in young Tad-poles. And in a ſhort time, the new part of the tail and the old together, equal the tail of others born at the ſame time. A ſecond, third, and fourth reproduction conſtantly follows, upon a ſecond, third, or fourth ſection. Nay, ſucceſſive regenerations never fail, as long as the Tad-pole keeps its tail.

If no nouriſhment is given Tad-poles, they do not grow, nor are the membranes of the infant ſtate caſt off. Yet the tails cut off, will be reproduced nearly in the ſame time.

If the head of an Earth-worm be cut off, a new head is reproduced. Nay, if both the head and tail are cut off from the middle part, both of them are reproduced, Nor is this regenerating power ſoon exhauſted. A ſecond reproduction being cut off, is ſucceeded by a third, this by a fourth, that by a fifth, and ſo on.

The ſame thing takes place in another kind of worm, little known, which he calls an Aquatic Boat-worm. It is compoſed of rings like the earth-

earth-worm, which it ſhortens or lengthens at pleaſure, and ſo moves from place to place. Toward the head it is as large as the largeſt gooſe-quill, and its length is about a ſpan. It lives in ſhallow, clear water, either ſtagnating or flowing gently, fixing its fore part in the mud, whence it is nouriſhed. The back part reaches the top of the water, and being ſtretched and hollowed, form a kind of boat on the ſurface. Its ſides riſe above the water, ſo that none gets in. But on the leaſt agitation of the water, the inſect immediately ſhuts up his boat, and retires into the mud. When the motion is over, he again thruſts his tail out of the water, and makes his boat afreſh, which remains entire till he is diſturbed again. And this he does not fail to make, though the mud is removed, and he left with little water. It ſeems the organs of reſpiration are placed in this part, as they are in various ſorts of aquatic animals.

Theſe worms are quicker in their reproduction than earth-worms. They more eaſily recover their heads, as well as tails, and this power exerts itſelf throughout the whole year.

The caſe of the Snail may ſeem ſtill more ſtrange. It can firſt, reproduce its horns. After they have been cut off, the trunk becomes like a ſmall knob, whence ſprings a black point, which is the eye. The trunk then increaſes in length and ſize, till it equals the former horn.

If the head be cut off, a new one ſucceeds; but in a ſingular manner. If a worm's head be cut off, the reproduction is an entire organic body, that is, a part in miniature exactly ſimilar to that which was cut off. But what appears on the trunk of a Snail, is not an entire organic body, containing in miniature all the parts of the head which were cut off: but these parts grow piece by piece at different intervals, and require time to unite and consolidate into one mass, resembling the original pattern. For instance. Sometimes the re-production is like a round, small body, containing the primary parts of the two lips, and of the small horns, which are united to the mouth, and to the new-formed teeth. This round body is placed on the center of the trunk. The large horns and the fore part of the Snail, which in the entire animal are contiguous to the head, are wanting. Another trunk shews the larger horn on the right side, more than a tenth of an inch long, already provided with its eye. Under this, at some distance, the first lineaments of the lip appear. In a a third Snail arise three horns, two of which are of their natural length, while the third is but just above the skin. Some shew nothing but the trunk, without any sign of re-production, although the head was taken off at the same time with that of the others, from which are come forth such a number and variety of organs: on the contrary, in some Snails, there is no difference between the old and the new head: only there is an ash-coloured line, painting out exactly where the head was cut off.

That Earth-worms feed upon earth, will be put beyond dispute, if any one is at the pains to examine the little curled heaps of dung, which are ejected out of their holes. But it is in all probability, not pure earth, but such as is made of leaves, roots, and plants, when gradually rotted and mouldered away. And what makes this the more probable, is, that they are observed to drag the leaves of trees into their holes.

8. Both

8. Both the whole Tape-worm, and every part of it feems to be a compleat animal. In every joint there is a mouth for receiving food, and doubtlefs organs for digefting it. Single joints, as well as larger pieces, are frequently voided alive. All thofe pieces are almoft equally turgid with chyle. Now is it not probable, that a fingle worm, fhould in voiding, be broke in fo many pieces: and had it been done fome time before, they would be emaciated? There feems then to be an analogy, between this jointed worm and knotted grafs; each joint of which is a complete plant, and propagates itfelf. It is indeed a Zoophyton, a plant-animal, bred in animal-bodies: fince fo large and frequent detruncations, do not deftroy the life of it.

9. Not only vegetables and animals have their refpective infects, to which they afford food as well as habitation, but Stones themfelves. Thofe kind of worms, called Lithophagi, are a proof of this. One might think it incredible, that thefe little creatures fhould fubfift by gnawing Stones. And yet nothing is more certain, thefe worm-eaten ftones being found almoft every where. Thefe are generally lime-ftones. Grit and free-ftone is feldom eaten in this manner. Yet there is an antient wall of free-ftone in the Benedictine abbey at Caen in Normandy, fo eaten with worms, that one may put one's hands into many of the cavities. The worms are covered with a greenifh fhell, having flat heads, a wide mouth, and four black jaws. And they lay their eggs in thofe cavities, which they gnaw in the ftone.

One more reptile we may examine a little more minutely, in which the wifdom of God is not a little displayed. It is a common Leech. When this is at rest, its upper lip forms a regular semicircle. When he moves, this semicircle becomes two oblique lines, the junction of which makes an angle, which he applies to whatever he would fix himself to. The two lips then make a sort of hollow. Both these and its mouth are made of so supple fibres, that they take the figure of the part they are applied to, and fix perfectly close to it.

The wounds it makes are not punctures, but three cuts made like three rays, which uniting in a center make equal angles with each other. They appear as if made by a fine lancet. They are indeed made by three rows of fine and sharp teeth, which the microscope shews to be placed along the middle of a strong muscle. When the mouth has seized on any part, the muscle exerts its action, and strikes in all the teeth at once.

Between the mouth and the stomach there is a small space, in which are two different arrangements of fibres. The one set are flat and plain, the others are circular. The former contracting in length, enlarge the capacity of the throat; and the circular ones determine the blood toward the stomach, by contracting it when the blood is received. Hence it passes into a kind of membranous sack, which serves the animal both for stomach and intestines. This takes up the greatest part of its body. On each side of this long canal there is a number of little bags. These being filled with blood, swell out the body of the animal to a size. Here it remains for many months, and serves the creature for nourishment. If any thing is excreted, it can be only by insensible perspiration, since the creature has no anus,

anus, nor any aperture which can ſupply the place of one.

Frogs change their ſkins every eight days. Toads, as well as Frogs, are harmleſs, defenceleſs creatures, and their greateſt crime is their uglineſs.

Newly generated Frogs, which fall to the bottom, remain there the whole day; but having lengthened themſelves a little, (for at firſt they are doubled up) they mount to the mucus which they had quitted, and feed upon it with great vivacity. The next day they acquire their Tadpole form. In three days more they have little fringes, that ſerve as fins beneath the head, and theſe four days after aſſume a more perfect form. It is then they feed greedily upon the pond-weed; and leaving their former food, on this they continue to ſubſiſt, till they arrive at maturity. When they come to be ninety-two days old, two ſmall feet begin to burgein near the tail; and the head appears to be ſeparate from the body. The next day the legs are conſiderably enlarged; four days after they refuſe all vegetable food; their mouth appears furniſhed with teeth; and their hinder legs are completely formed. In two two days more the arms are completely produced, and now the Frog is every way perfect, except that it ſtill continues to carry the tail. In this odd ſituation the animal, reſembling at once both a Frog and a Lizard, is ſeen frequently riſing to the ſurface, not to take food, but to breathe. In this ſtate it continues for ſix or eight hours, and then the tail dropping off, the animal appears in its perfect form.

Thus the Frog, in lefs than a day, having changed its figure, changes its appetites alfo. So extraordinary is this transformation, that the food it fed upon fo greedily but a few days before, is now utterly rejected. It would even ftarve, if fupplied with no other. As foon as the animal acquires its perfect ftate, it becomes carnivorous, and lives entirely upon worms and infects. But as the water cannot fupply thefe, it is obliged to quit its native element, and feek for food upon land, where it lives by hunting worms, and taking infects by furprife.

" Concerning the Toad, fays Mr. Arocott, that lived with us fo many years, and was fo great a favourite, the greateft curiofity was its being fo remarkably tame; it had frequented fome fteps before our hall-door, fome years before my acquaintance commenced with it, and had been admired by my father for its fize (being the largeft I ever met with) who conftantly paid it a vifit every evening. I knew it myfelf above thirty years; and by conftantly feeding it, brought it to be fo tame that it always came to the candle and looked up, as if expecting to be taken up and brought upon the table, where I always fed it with infects of all forts. It would follow them, and when within a proper diftance, would fix its eyes, and remain motionlefs for near a quarter of a minute, as if preparing for the ftroke, which was an inftantaneous throwing its tongue at a great diftance upon the infect, which ftuck to the tip, by a glutinous matter. The motion is quicker than the eye can follow. I cannot fay how long my father had been acquainted with the Toad before I knew it; but when I was firft acquainted with it, he ufed to mention it as the old Toad. I have

have known it for thirty-ſix years. This Toad made its appearance as ſoon as the warm weather came, and retired to ſome dry bank to repoſe till ſpring. When we new layed the ſteps, I had two holes made in the third ſtep, on each ſide, with an hollow of more than a yard long; in which I imagined it ſlept, as it came from thence at its firſt appearance. It was ſeldom provoked. Neither that Toad, nor the multitudes I have ſeen tormented with great cruelty, ever ſhewed the leaſt deſire of revenge. In the heat of the day Toads come to the mouth of their hole; I believe for air. I once from my parlour window obſerved a large Toad I had in the bank of a bowling-green, about twelve at noon, in a very hot day, very buſy and active upon the graſs. So uncommon an appearance made me go out to ſee what it was; when I found an innumerable ſwarm of winged ants had dropped round his hole, which temptation was irreſiſtible. Had it not been for a tame raven, I make no doubt but it would have been now living. This bird one day ſeeing it at the mouth of its hole, pulled it out, and although I reſcued it, pulled out one eye, and hurt it ſo, that notwithſtanding it lived a twelvemonth, it never enjoyed itſelf, and had a difficulty of taking its food, miſſing the mark for want of its eye."

All Toads are torpid and unvenemous, and ſeeking the darkeſt retreats, not from the malignity of their nature, but the multitude of their enemies.

CHAP. V.

Of INSECTS.

THERE remains only the loweſt order of animals, uſually termed Inſects, becauſe they have an inciſion, as it were, which in a manner cuts them in two parts. Of theſe I would ſpeak the more largely, becauſe generally they are little known.

Rather

Rather they are despised, and purposely passed over, as unworthy of our consideration. And yet it is certain, the wisdom of the great Creator does most conspicuously shine in them.

1. As to the Shape of their bodies, though it be somewhat different from that of birds, being for the most part not so sharp before, to cut and make way through the air, yet it is better adapted to their manner of life. For considering they have little need of long flights, and that the strength and activity of their wings, far surpass the resistance they meet with from the air, there was no occasion for their bodies to be so sharpened. But the nature of their food, the manner of gathering it, and the great necessity they had of accurate vision, and large eyes in order thereto, required the largeness of the head, and its amplitude before the rest of the body is all well-made, and nicely poised for their flight and other occasions.

The make of their bodies is no less admirable: not built throughout with bones, covered over with flesh, and then with skin, as in most other animals: but cloathed with a curious mail of a middle nature, serving both as a skin and bone too; as it were on purpose to shew, that the great contriver of nature is not bound up to one way only.

How admirably are the legs and wings fitted for their intended service? Not to overload the body nor to retard it, but give it the most proper and convenient motion. What for example, can be better contrived for this service than the wings? Distended and strengthened by the finest bones, and these covered with the finest and lightest membranes; and many of them provided with the finest articulations, and foldings, in order to be laid up in their cafes, when they do not ufe them; and yet always ready, to be extended for flight.

2. The ftructure of the Eye is in all creatures an admirable piece of mechanifm. But this is peculiarly obfervable in that of an infect. Its hardnefs is an excellent guard againft external injuries; and its outer coat is all over befet with curious, tranfparent inlets, enabling it to fee every way, without any lofs of time, or trouble to move the eyes.

And their feelers, befides their ufe in cleaning the eyes, are a good guard to them in their walk or flight, enabling them by the fenfe of feeling to difcover annoyances, which, by their nearnefs, might efcape the fight.

The eye of a Fly is in truth an affemblage of multitudes, often many thoufands of fmall eyes. Nature has given each Fly two large reticular eyes (that is covered with a kind of net-work.) And as each contains fuch a multitude of fmaller eyes, one would imagine this might fuffice. Yet fome Flies have four reticular eyes; the two fmaller are placed as ufual, the two larger are behind the other, on the upper part of the head.

In different fpecies the reticular eyes are of different colours. Some are brown, fome yellow, green, red, and this in all the different fhades of thofe colours. And fome have the glofs of metals highly polifhed.

But befide thefe, many fpecies of Flies have a ort of eyes, which are not reticular, but of a perfectly fmooth and even furface, and far fmaller than the reticular. Three of thefe are on the back of the head of vaft numbers, which are triangularly placed. Some have more, and fome have

have lefs than three. Gnats have none of them. Their heads are in a manner covered with their reticular eyes, fo as to leave no room or occafion for fmooth ones.

Nor are thefe fmooth eyes peculiar to Flies. Other infects alfo have them: the grafs-hopper in particular has two, which are placed near the nofe.

3. The fpecies of infects are almoft innumerable. All of thefe fome fuppofe to have no Heart, as they have no fenfible heat, none that can be perceived either by the touch, or by any other experiment. But this is a miftake. Many indeed have not fuch an heart as other animals have : but all have fomething analogous to it, fomething that anfwers the fame purpofe.

Some likewife have thought, that infects have no Refpiration. But later experiments fhew, that there is no fpecies of them which has not lungs, and thofe larger in proportion than other animals. In moft of them they lie on, or near the furface of the body. And hence it is, that if Flies are befmeared with oil, or any other unctuous matter, they die in a fhort time, their Refpiration being ftopt, fo that they are properly fuffocated.

4. Some alfo have imagined, That infects were Generated out of mere putrifaction, becaufe they obferved worms come out of putrified flefh, which afterwards turned to flies. But it is certain, if putrifying flefh be fhut up clofe, no worms are ever generated from it. Hence we learn, that Flies lays their eggs in flefh, which hatch when it putrifies: fo that the animal juft comes to life when its food is ready for it. All infects lay their

eggs, where there is heat enough to hatch them, and proper food as soon as they are hatched. Those whose food is in the water, lay their eggs in the water: those to whom flesh is a proper food, in flesh: those to whom the fruits or leaves of vegetables are food, are deposited on the proper fruits or leaves. And constantly the same kind is found on the same fruit or plant. Those that require more warmth, are lodged by the parent, in or near the body of some animal. And as for those to whom none of these methods are proper, the parents make them nests by perforations in the earth, in wood, in combs: carrying in and sealing up provisions, that serve both to produce the young, and to feed them when produced.

The eggs of all insects become worms, commonly called Nymphæ. They are next changed into Aureliæ, so called, inclosed in a case; and these dying, a Fly or Butterfly succeeds.

Some Aureliæ shine like polished gold. From the beautiful and resplendent colour, some authors have called it a Chrysalis, implying a creature made of gold. This brilliant hue, which does not fall short of the best gilding, is formed in the same manner in which we see leather obtain a gold colour; though none of that metal ever enters into the tincture. It is only found by a brown varnish laid upon a white ground; and the light thus gleaming through the transparency of the brown, gives a charming golden yellow. These two colours are found one over the other in the Aureliæ, and the whole appears gilded, without any real gilding.

To

To trace theſe wonderful changes a little, in one kind of inſect. A Silk-Worm, from a ſmall egg, becomes a worm of the caterpillar kind, and feeds on mulberry-leaves, till it comes to maturity. Then it winds itſelf up into a ſilken caſe, about the ſize and ſhape of a pigeon's egg; and is metamorphoſed into an Aurelia, in which ſtate it has no motion or ſign of life: till at length it awakes, breaks through its ſilken ſepulchre, and appears a butterfly.

As ſoon as the Silk-Worm has ſtrength, he makes his web, a ſlight tiſſue, which is the ground of his admirable work. This is his firſt day's employ. On the ſecond, he covers himſelf almoſt over with ſilk. The third he is quite hid. The following days he employs in thickening his ball, always working from one ſingle end ſo fine a thread, that thoſe who have examined it, affirm it would reach ſix miles.

The Silk-Spider makes a thread, every whit as ſtrong, gloſſy, and beautiful as the Silk-Worm. It ſpins from ſeven nipples. Theſe, as ſo many wire-drawing irons, draw out a viſcous liquor, which gradually dries in the air, and becomes ſilk.*

Each of theſe nipples contain many ſmaller nipples, inviſible to the naked eye; through the ſeveral perforations whereof, numberleſs finer threads are drawn. Before the Spiders begin to ſpin, they apply more or fewer of the large nipples to the body whence the web is begun. And

* All boneleſs inſects are hermaphrodites, as are ſnails, leeches, and many ſorts of worms. But ſuch worms as become flies are not, being indeed of no ſex.

And as they apply them more or leſs ſtrongly, more or fewer of the ſmaller nipples come to touch: and accordingly the whole thread will be compounded of more or fewer ſingle threads. One compound thread frequently conſiſts of fifteen or ſixteen ſingle ones.

Their threads are of two kinds: one ſerves only for the web with which they catch flies. The other is much thicker and ſtronger, in which they wrap up their eggs, in order to ſhelter them from the cold, as well as from devouring inſects. Theſe threads they wind looſely round, reſembling the balls of ſilk-worms that have been looſened for the diſtaff.

The balls are grey at firſt, but turn blackiſh when long expoſed to the air. From theſe balls a ſilk is made, nothing inferior to the common ſilk. It takes all kinds of dyes, and may be made into all kinds of ſtuffs. Only there is a difficulty in keeping the ſpiders: for they are ſo extremely quarrelſome, that if an hundred of them be put together, in a few hours ſcarce twenty will be left alive.

5. Amazing wiſdom is diſplayed in the make of the Common Spider. She has ſix teats, each furniſhed with innumerable holes. The tip of each teat is divided into numberleſs little prominences, which ſerve to keep the threads apart at their firſt exit, till they are hardened by the air. In every teat, threads may come out at above a thouſand holes. But they are formed at a conſiderable diſtance, each of them having a little ſheath, in which it is brought to the hole. In the belly are two little ſoft bodies, which are the firſt ſource of the ſilk. In ſhape and tranſparency they reſemble glaſs beads, and the tip of each goes winding toward the

the teat. From the root of each bead proceeds another branch much thicker, which alſo winds towards the ſame part. In theſe beads and their branches is contained the matter of which the ſilk is formed, the body of the bead being a kind of reſervoir; the two branching canals proceeding from it.

It was before obſerved, that the tip of each teat may give paſſage to above a thouſand threads. And yet the ſize of the teat in the largeſt Spider does not exceed a ſmall pin's head. But the ſmalleſt Spiders no ſooner quit their eggs than they begin to ſpin. Indeed their threads can ſcarce be perceived, but the web formed thereof is as thick and cloſe as any. And no wonder, as four or five hundred little Spiders often concur in the ſame work. How minute are their teats! When perhaps the whole Spider is leſs than the teat of its parent. Each parent lays four or five hundred eggs, all wrapt up in a bag. And as ſoon as the young ones have broken through the bag, they begin to ſpin.

And even this is not the utmoſt which nature does. There are ſome kinds of Spiders ſo ſmall, as not to be diſcerned without a microſcope. And yet there are webs found under them! What muſt be the fineneſs of theſe threads? To one of theſe the fineſt hair is as a cart-rope.

There are ſeveral ſpecies of Spiders that fly, and that to a ſurpriſing height. " The laſt October, ſays an eminent writer, I took notice that the air was very full of webs. I forthwith mounted to the top of the higheſt ſteeple on the Minſter [in York] and could thence diſcern them yet exceeding high above me. Some of the Spiders that fell upon the pinnacles I took, and found them to be of a kind, which ſeldom or never enter houſes,

and

and cannot be ſuppoſed to have taken their flight from the ſteeple.

There are divers animals as well as Spiders, that have ſome way of conveyance, utterly unknown to us. Thus the animals on the ſtanding waters, ſo numerous as often to diſcolour them, and tinge them red, yellow, or green. That theſe have ſome way of conveyance is certain, becauſe not only moſt ſtagnating waters are ſtocked with them, yea, not only new pits and ponds, but even holes, and gutters on the top of houſes, churches, and ſteeples. That they have not legs for travelling ſo far, is manifeſt; it is therefore probable, either that they dart out webs, and can make themſelves buoyant, and lighter than the air: or that their bodies are naturally lighter than air, and ſo they can ſwim from place to place. It is highly propable, the eggs of ſuch as are oviparous may be light enough to float therein.

To trace this matter farther: every one muſt have obſerved threads floating in the air: but few conſider what end they ſerve. They are the works of Spiders. Their uſual method is, to let down a thread, and then draw it after them. But in the midſt of this work they ſometimes deſiſt; and turning their tail according to the wind, emit a thread with as great violence, as a jet of water diſcharged from a cock. Thus they continue darting it out, which the wind carries forward, till it is many yards long. Soon after, the Spider throws herſelf off from her web, and truſting herſelf to the air, with this long tail, will aſcend ſwift, and to a great height with it. Theſe lines, which the Spiders attach to them (though unobſerved) make theſe air-threads, that waft them along the air, and enable them to prey on many inſects, which they could not reach by any other means.

All

All Spiders that ſpin, young as well as old, caſt out theſe threads, and ſail thereby in the air, And the threads themſelves ſhew the uſe thereof, being uſually hung with the fragments of devoured animals.

When the threads are newly ſpun, they are always ſingle, and are generally ſeen aſcending higher and higher. But when they are ſeen coming down, they are ſometimes compoſed of three or four, and either without any Spider or with ſeveral. 'Tis plain this happens from the threads meeting and intangling in the air, which of courſe brings them down.

It is common to ſee a Spider mount to the topmoſt branch of a buſh, and from thence dart out ſeveral threads one after another, trying, as it were, how ſhe likes them. When ſhe has darted one ſeveral yards, ſhe will of a ſudden draw it up again, and wind it into a link with her fore-feet, but more frequently break it off, and let it go. A Spider will ſometimes dart out and break off many threads, before it ſpins one that it will truſt to. But at length ſhe ſpins one to her liking, and commits herſelf to the air upon it.

The buſineſs of feeding is not all the uſe of theſe threads; but they evidently ſport and entertain themſelves by means of them, floating to and fro in the air, and changing their height at pleaſure.

Theſe air-threads are not only found in autumn, but even in the depth of winter. The ſerene days at Chriſtmas bring out many: but they are only ſhort and ſlender, being the work of young Spiders, hatched in autumn, and are thrown out as it ſeems only in ſport. The thicker ones of autumn are the only ones intended to ſupport the old Spiders, when there is plenty of ſmall flies in the

the air, which make it worth their while to ſail among them.

6. A Tarantula is a kind of Spider, chiefly found near the city of Tarentum, in Apulia. It is about the ſize of an acorn, and has eight eyes and eight feet. Its ſkin is hairy: from its mouth riſe two trunks, a little crooked and exceeding ſharp. Through theſe it conveys its poiſon: they ſeem likewiſe to be a kind of moveable noſtrils, being in continual motion, eſpecially when it is ſeeking its food. It is found in other parts of Italy, but is dangerous only in Apulia. And there it does little hurt in the mountains (which are cooler) but chiefly on the plains. Indeed it is not venomous, but in the heat of ſummer, particularly in the dog-days. It is then ſo inraged as to fly upon any that comes within its reach.

The bite cauſes a pain, like that by the ſtinging of a bee. In a few hours the patient ſeels a numbneſs, and the part is marked with a ſmall livid circle, which ſoon riſes into a painful tumour. A little after he falls into a deep ſadneſs, breathes with much difficulty, his pulſe grows feeble, and his ſenſes dull. At length he loſes all ſenſe and motion, and dies, unleſs ſpeedily relieved. An averſion to blue and black, and an affection for white, red, and green, are other unaccountable ſymptoms of this diſorder.

There is no remedy but one. While he lies ſenſeleſs and motionleſs, a muſician plays ſeveral tunes. When he hits on the right, the patient immediately begins to make a faint motion. His fingers firſt move in cadence, then his feet: then his legs, and by degrees his whole body. At length he riſes on his feet, and begins to dance, which

which ſome will do for ſix hours without intermiſſion. After this he is put to bed, and when his ſtrength is recruited, is called up by the ſame tune to a ſecond dance.

This is continued for ſix or ſeven days at leaſt, till he is ſo weak that he can dance no longer. This is the ſign of his being cured; for if the poiſon acted ſtill, he would dance till he dropt down dead. When he is thoroughly tired he awakes as out of ſleep, without remembering any thing that is paſt. And ſometimes he is totally cured; but if not, he finds a melancholy gloom, ſhuns men, ſeeks water, and if not carefully watched, often leaps into a river. In ſome the diſorder returns that time twelvemonth, perhaps for twenty or thirty years. And each time it is removed as at firſt. Can even Dr. Mead account for this?

Equally unaccountable are the two relations publiſhed ſome years ſince, by a phyſician of undoubted credit. The firſt is: a gentleman was ſeized with a violent fever, attended with a delirium. On the third day he begged to hear a little concert in his chamber. It was with great difficulty the phyſician conſented. From the firſt tune, his face aſſumed a ſerene air, his eyes were no longer wild, and the convulſions ceaſed. He was free from the fever during the concert; but when that was ended, it returned. The remedy was repeated, and both the delirium and fever always ceaſed during the concerts. In ten days, muſic wrought an entire cure, and he relapſed no more.

The other caſe is that of a dancing-maſter, who through fatigue, fell into a violent fever. On the fourth or fifth day he was ſeized with a lethargy, which after ſome time changed into

a furious

a furious delirium. He threatened all that were present, and obstinately refused all the medicines that were offered him. One of them saying, that perhaps music might a little compose his imagination, a friend of his took up his violin, and began to play on it. The patient started up in his bed, like one agreeably surprised, and shewed by his head (his arms being held) the pleasure he felt. Those who held his arms, finding the effects of the violin, loosened their hold, and let him move them, according to the tunes. In about a quarter of an hour, he fell into a deep sleep. When he awoke he was out of all danger

We have many other odd accounts of the power of music; and it must not be denied, but that on some particular occasions, musical sounds may have a very powerful effect. I have seen all the horses, and cows in a field, where there were above an hundred, gather round a person that was blowing a French horn, and seeming to testify an aukward kind of satisfaction. Dogs are well known to be very sensible of different tones in music; and I have sometimes heard them sustain a very ridiculous part in a concert.

The great old lion which was some years since kept at the infirmary in Edinburgh, while he was roaring with the utmost fierceness, no sooner heard a bag-pipe, than all his fierceness ceased. He laid his ear close to the front of the den, nibbled his nose and his teeth against the end of the pipe, and then rolled upon his back for very glee. I have seen a German flute have the same effect on an old lion, and a young tyger in the Tower of London.

7. There is found in America a kind of Spider more mischievous than even the Tarantula, chiefly

chiefly in the valleys of Neyba, and others within the Jurifdiction of Popayon. It is called a Coya. It is much lefs than a bug, and is of a fiery red colour. It is found in the corners of walls and among the herbage. On fqueezing it, if any moifture from it falls on the fkin of either man or beaft, it immediately penetrates the flefh, and caufes large tumours, which are foon followed by death.

The only remedy is, on the firft appearance of a fwelling, to finge the perfon all over the body with a flame of ftraw, or of the long grafs growing on thofe plains. This the Indians perform with great dexterity, fome holding him by the feet, others by the hands.

Travellers here are warned by their Indian guides, if they feel any thing crawl on their neck or face, not even to lift their hand, the Coya being fo delicate a texture, that it would immediately burft. But let them tell the Indian what they feel, and he comes and blows it away.

The beafts which feed there, are taught by inftinct, before they touch the herbage with their lips, to blow on it with all their force, in order to clear it of thefe pernicious vermin. And when their fmell informs them, that a Coya's neft is near, they immediately leap and run to fome other part. Yet fometimes a mule, after all his care, has taken in a Coya with his pafture. In this cafe after fwelling to a frightful degree, it expires upon the fpot. Thus does even the irrational creation "groan and travel in pain together," untill it fhall be "delivered into the glorious liberty "of the children of God!"

7. Mention

8. Mention was made of the extreme ſmallneſs of ſome Spiders. But how much ſmaller are thoſe Animalcula, diſcerned by the Microſcope? Theſe are in almoſt all water. Even in that wherein the beſt glaſſes can diſcover no particles of animated matter, after a few grains of pepper, or a ſmall fragment of a plant of almoſt any kind has been ſometime in it, animals full of life are produced and ſo numerous as to equal the fluid itſelf in quantity.

A ſmall quantity of water taken from any ditch in ſummer, is found to abound in juſt ſuch creatures, only larger. Nay any water, ſet in open veſſels in the ſummer months, will after a few days, yield multitudes of them.

Theſe we know by their future changes are the fly-worms of gnats, and ſeveral other ſorts of flies. And we eaſily judge, they owe their origin to the eggs of the parent fly there depoſited. No doubt then but the air abounds with other animalcula, as minute as the worms in theſe fluids. And theſe are the flying worms of theſe animalcula which after a proper time ſpent in that ſtate, will become flies like thoſe to which they owe their origin.

The waters in which different liquors are infuſed afford a proper matter for the worms of different ſpecies of flies. And ſome of theſe doubtleſs are viviparous, others oviparous. This may occaſion the different time taken up for producing inſects in different fluids. Thoſe proper for the worms of a viviparous fly, will be ſooneſt full of them: whereas a longer time is required to hatch the eggs of the oviparous.

Now every animalcule being an organized body, how delicate muſt the parts be that are neceſſary

to

to make it ſuch, and to preſerve its vital actions? It is hard to conceive, how in ſo narrow a compaſs, there is an heart, to be the fountain of life, muſcles neceſſary for its motion, glands to ſecrete its fluids, ſtomach and bowels to digeſt its food, and other innumerable parts, without which an animal cannot ſubſiſt. And every one of theſe muſt have fibres, membranes, coats, veins, arteries, nerves, and an infinite number of tubes, whoſe ſmallneſs exceeds all efforts of imagination. And yet there are parts that muſt be infinitely ſmaller than theſe, namely the fluids that move through them, the blood, lymph and animal ſpirits, whoſe ſubtility even in large animals, is incredible.

As to ſome of the animalcules obſerved by Lewenhoeck, he computed, that three or four hundred of them placed cloſe together in a line, would only equal the diameter of a grain of ſand. Twenty-ſeven millions then of theſe animals equal in bulk a grain of ſand!

But Hartſocker carries the matter ſtill farther, If, ſays he, according to our preſent ſyſtem of generation, all animals were formed from the begining of the world, and incloſed one within another, and all of them in the firſt animal of each ſpecies: how minute muſt the animalcula produced now, have been at the beginning?

9. Even the meaneſt and moſt contemptible of inſects, ſhews the wiſdom of its creator. Fleas, for inſtance, depoſit their eggs only on ſuch animals, as afford them a proper food. Theſe hatch into worms of a ſhining pearl colour, which feed on the ſcurff of the cuticle. In a fortnight they are very active, and if diſturbed, ſuddenly roll themſelves into a ball. Soon after they begin to creep,

creep, with a very ſwift motion. When arrived at their full ſize, they ſpin a thread out of their mouth, wherewith they form themſelves a caſe. After a fortnight's reſt here, each of them burſts a perfect Flea, leaving its exuviæ behind. It is milk-white till the ſecond day before its eruption: then it changes colour and gets ſtrength, ſo that upon its firſt delivery, it ſprings nimbly away.

Minute animals are found proportionably much ſtronger and more active than large ones. The ſpring of a Flea in its leap vaſtly exceeds any thing greater animals are capable of. Mr. De Liſle has computed the velocity of a little creature, which ran three inches in half a ſecond. Now ſuppoſing its feet to be the fifteenth part of a line, it muſt then, in order to travel over ſuch a ſpace in ſuch a time, make five hundred ſteps in the ſpace of three inches: that is, it muſt ſhift its feet five hundred times in a ſecond, or in the ordinary pulſation of an artery. What is the motion of any large animal, in compariſon of his? Or what is the ſwiftneſs of a greyhound or a race-horſe, to that of ſuch an animalcule?

The body of a Flea appears, by a microſcope, to be all over curiouſly adorned with a ſuit of poliſhed ſable armour, neatly jointed, and beſet with multitudes of ſharp pins. It has ſix legs, the joints of which are ſo adapted, that it can fold them up one within another; and when it leaps, they all ſpring out at once, whereby its whole ſtrength is exerted, and the body raiſed above two hundred times its own diameter.

10. A Louſe alſo affords to our obſervation, a very delicate ſtructure of parts. It is divided into the

the head, the breaſt, and the tail. In the head appear two fine black eyes, with a horn that has five joints and is ſurrounded with hairs, ſtanding before each eye. From the noſe projects in a ſheath the piercer or ſucker, which it thruſts into the ſkin. This is judged to be ſeven hundred times finer than an hair. It has no other mouth than this.

The ſkin of the breaſt is tranſparent, and from the under part of it proceed ſix legs, each having five joints; each leg is terminated by two claws, which it uſes as we would a thumb and middle finger.

If one of them when hungry be placed on the back of the hand, it will thruſt its ſucker into the ſkin, and the blood it ſucks may be ſeen paſſing in a fine ſtream to the fore-part of the head. Falling into a roundiſh cavity there, it paſſes on to another receptacle in the middle of the head. Thence it runs to the breaſt, and then to a gut which reaches to the hinder part of the body, where in a curve it turns again a little upward. It then ſtands ſtill, and ſeems to undergo a ſeparation: ſome of it becoming clear and watry, while other black particles paſs down to the anus.

Lice are not hermaphrodites; and the males have ſtings, which the females have not. A female lays in twelve days an hundred eggs, which hatch in ſix days. Suppoſe theſe produce fifty males, and as many females: theſe females coming to their full growth in eighteen days, may each in twelve days lay an hundred eggs more. And theſe in ſix days more may produce a young brood of five thouſand. So ſwiftly do theſe creatures multiply!

Moſt animals are ſubject to lice, but each of a different kind, and none of them like the human. Nay, even inſects are not free. Beetles, earwigs and ſnails are particularly ſubject to them. Numberleſs little red lice are often ſeen about the legs of ſpiders. A ſort of whitiſh lice are common on bees. They are alſo found on ants.

Fiſhes, one would think, living in the water, and perpetually moving to and fro, ſhould be free from lice. But they have their ſorts too, which neſt under their ſcales, the ſalmon in particular. Beſide which, there are frequently found great numbers of long worms, in the ſtomach and other parts of fiſh. And theſe work themſelves ſo deeply into their fleſh, that they cannot eaſily be got out.

Many inſects are bred in the noſtrils of ſheep. One may take out twenty or thirty rough maggots at a time. A rough, whitiſh maggot is found alſo within the inteſtinum rectum of horſes. Others are generated in the backs of cows, which at firſt are only a ſmall knot, being an egg laid there by ſome inſect. Afterward it grows bigger, and contains a maggot, lying in a purulent matter.

In Perſia ſlender worms, ſix or ſeven yards long, are bred in the legs and other parts of men's bodies. Yea, there have been divers inſtances of worms taken out of the tongue, gums, noſe, and other parts, by a perſon of Leiceſter, before many witneſſes.

11. A very extraordinary kind of inſect, is that which is called a Death-Watch, becauſe it makes a noiſe like the beating of a watch. They are of two kinds. One is a ſmall beetle. ſomewhat

what more than a quarter of an inch long, of a dark brown, and ſpotted, having a large cap on the head, and two feelers ſpringing from beneath the eyes. Dr. Derham obſerved it to draw back its mouth, and beat with its forehead. He kept two, a male and a female, in a box, for ſome months, and could bring one of them to beat when he pleaſed, by imitating its beating. And he ſoon found this ticking to be the way, whereby they wooed one another.

The other kind is a greyiſh inſect like a Louſe, which beats ſome hours together without intermiſſion, and that ſlowly; whereas the former beats only ſeven or eight ſtrokes at a time, and much quicker. It is very common in ſummer in all parts of our houſes, is nimble in running to ſhelter, and ſhy of beating, if diſturbed; but is free to beat, and to anſwer your beating, if you do not ſhake the place where it lies. This commonly, if not always, beats either in or near paper. It is at firſt a ſmall, white egg, like a nit. It hatches in March, and creeps about with its ſhell on. It is then ſmaller than the egg itſelf, but ſoon grows to the perfect ſize.

That Death-Watches do woo one another, but not always, we may learn from the account of an accurate obſerver. " As I was in my ſtudy, I happened to hear what is called a Death-watch. Inclining my head toward a chair, I found it was beating there. The manner of its beating was this. It lifted up itſelf on its hinder legs, and extending its neck, ſtruck its face upon the ſedge, which was bared upon its outward coat, about the length of half an inch. The impreſſion of its ſtrokes was viſible: the outward court of the ſedge being depreſſed, where it had juſt been beating, for about the compaſs of a ſilver-penny. I am inclined to think it beats for food. There were ſeveral places on the ſedge, where it had been at work, and where it had probably been ſojourning for ſome days.

" Poſſibly the inſect may ſometimes woo its mate by beating thus: but it was not the caſe now. It had not any other of its kind near it. It ſeemed therefore to be preparing its food. It was about a quarter of an inch long, of a dark dirty colour, having a broad helmet over its head, which he can draw up under it, ſo that it is a notable defence againſt the falls, to which he is continually expoſed, creeping over rotten and decayed places.

" The ſecond day after I took it, I opened the box, and ſet it in the ſun. It was ſoon very briſk, and crept nimbly to and fro, till ſuddenly it ſtruck out its wings, and was going to take its leave; but on my ſhading it over, it drew in its wings, and was quiet."

This ſeems to be the ſmalleſt of the beetle kind. A gentleman deſcribes one of a very different ſort, in the Philoſophical Tranſactions. " On the removal of a large leaden ciſtern, I obſerved at the bottom of it black beetles. One of the largeſt I threw into a cup of ſpirits, (it being the way of killing and preparing inſects for my purpoſe.) In a few minutes it appeared to be quite dead. I then ſhut it up in a box about an inch and a half diameter, and throwing it into a drawer, thought no more of it for two months, when opening the box, I found it alive and vigorous, though it had no food all the time, nor any more air than it could find in ſo ſmall a box, whoſe cover ſhut very cloſe. A few days before, a friend had ſent me three or four cock-roaches.

These

These I had put under a large glass; I put my beetle among them, and fed them with green ginger, which they ate greedily; but he would never taste it, for the five weeks they lived there. The cock-roaches would avoid the beetle, and seem frighted at his approach: but he usually stalked along not at all regarding whether they came in his way or not. During the two years and an half that I have kept him, he has neither eat nor drank.

" How then has he been kept alive? Is it by the air? There are particles in this, which supply a growth to some species of plants, as sempervive, orpine and house-leek: may not the same or the like particles supply nourishment to some species of animals? In the amazing plan of nature, the animal, vegitable and mineral kingdoms, are not separated from each other by wide distances, but near their boundaries, differ from each other, by such minute and insensible degrees, that we cannot find out certainly, where the one begins, or the other ends. As the air therefore nourishes some plants, so it may nourish some animals: otherwise a link would seem to be wanting, in the mighty chain of beings. It is certain cameleons and snakes can live many months without any visible sustenance: and probably, not merely by their slow digestion, but rather by means of particles contained in the air, as this beetle did; yet doubtless in its natural state, it used more substantial food. So the plants above-named thrive best with a little earth, although they flourish a long time, and send forth branches and flowers, when they are suspended in the air.

" Even in the exhausted receiver, after it had been there half an hour, it seemed perfectly unconcerned, walking about as briſkly as ever. But on the admiſſion of the air, it ſeemed to be in a ſurpriſe for a minute.

"After I had kept him half a year longer, he got away, through the carleſſneſs of a ſervant who took down the glaſs."

12. A Female-Fly, within four and twenty hours after her congreſs with the male, begins to depoſit her eggs on ſome ſubſtance proper to give nouriſhment to the worm that is to be produced. Theſe eggs in general are white and oblong. But there are ſome of them which are ſingular. To deſcribe one ſpecies of them may ſuffice, the eggs laid on hog's dung.

They are white and oblong, but of a peculiar make. At one end of each of theſe eggs, between that end and the middle, are two little wings, ſtanding out on either ſide. As ſoon as the Fly has laid her eggs, ſhe thruſts them into the dung. This keeps the coat of the egg ſoft; otherwiſe the embryo could never get out. But if the whole egg were thruſt in, the creature would be ſuffocated, as ſoon as it is hatched. Therefore part only is to be emerſed, and part to be left out. And this is admirably provided for by theſe wings. For when the female thruſts in the egg, it eaſily enters at the ſmaller end, which is the part firſt protruded from her body: but it ſtops at the wings, and ſo the upper part remains open to the air.

Some ſpecies of Flies faſten their eggs to the ſides of veſſels of water. All theſe eggs have a thin flake running down the two ſides diametrically oppoſite. So that they look as if they were incloſed in a frame. The uſe of this frame is, to hold

hold the body of the egg more firmly to the ſide of the veſſel. Thoſe eggs which have it not, are depoſited by the Female Fly with a viſcous matter about them.

Some Flies lay their eggs in the bodies of caterpillars. Theſe are at great pains to carry thoſe catterpillars to the places where it is proper their eggs ſhould be hatched. There is one ſpecies whoſe worm can never ſucceed, unleſs it be both bred in the caterpillar, and that caterpillar buried under ground. To this purpoſe the parent, when ready to lay her eggs, forms a hole in the ground, and covers it with a little clod. Then ſhe goes in ſearch of a proper catterpillar, perhaps one much larger than herſelf, which nevertheleſs ſhe drags to her hole. This ſhe uncovers, and goes in to ſee if all is right. Then ſhe goes and draws the caterpillar in, depoſits her eggs in his fleſh, and ſtops up the hole with ſeveral pellets of dirt and duſt, carefully rammed in between. When the worms are hatched, they feed on the fleſh, of the caterpillar till they are full grown. Then they change into Aureliæ, and afterward into the form of the Parent-fly: in which ſtate they eaſily make their way out of the ground.

12. Some of theſe lay their eggs in the bodies of ſmaller Flies. They often fly with one of them in their legs, the head of it being cloſe to their bellies. They carry theſe to little holes in the ground. In the firſt they lay their eggs. Then they bring others, to be food for their young when hatched. One Fly is not enough; therefore their parents carry them more every day, crawling backward into the hole, and dragging in the Flies after them. When the worms change into Aureliæ, their caſes are made of the exuviæ of the Flies they have been feeding on.

The eggs of insects are usually the occasion of what are termed blights. These seldom happen but on the blowing of sharp easterly winds. Many insects attend those winds, and lay their eggs on proper plants. Indeed the large worms or caterpillars which attend some blights, seem to be only hatched by those winds. But they probably bring those swarms of insects, which occasion the curling of the leaves of trees.

Every insect feeds on one plant and no other. On this only it lays its eggs. Hence it is, that one kind of tree only is blighted, and the rest escape. All trees then cannot be blighted at once, unless one wind could bring the eggs of all insects, with as many different degrees of heat and cold, as are required to hatch and preserve each species.

And what though we do not always perceive animals in blights? By microscopes we discover animalcula, a million times less than those that are perceivable by the naked eye. The gentlest air may waft these from place to place: so that it is no wonder if they are brought to us from Great Tartary, even the cold air of which may give them life, and from whence there is not so much sea as to suffocate them in its passage, by the warmth and saltness of its vapours.

Trees are preserved from blights, by sprinkling them with tobacco-dust or pepper-dust, which are death to all insects.

But one kind of blight is caused, merely by long continued, dry, easterly winds. These stop the perspiration in the tender blossoms, so that in short time they wither and decay: soon after, the tender leaves are affected; their perspiring matter becoming thick and glutinous, so as to be a proper nutriment to the insects, which are then always found upon them. In this case the in-

sects

ſects are not the cauſe, but the effect of the blight.

It is a kind of blight that produces Galls, which are the buds of oaks ſwelled out. The cauſe is, into the heart of the tender bud, a fly thruſts one or more eggs. This egg ſoon becomes a worm, and eats itſelf a little cell in the pith of the bud, which would have grown into a branch. The ſap, which was to nouriſh that branch, being diverted into the remaining parts of the bud, theſe grow large and flouriſhing, and become a covering for the cell of the inſect.

Not only the willow and ſome other trees, but plants alſo, nettles, ground-ivy, and others, have ſuch caſes produced upon their leaves. The parent-inſect, with its ſtiff tail, bores the rib of the leaf when tender, and makes way for her egg into the very pith. Probably ſhe lays it there, with ſome proper juice, to prevent the vegetation of it. From this wound ariſes a ſmall excreſcence, which when the egg is hatched grows bigger, and bigger as the worm increaſes, ſwelling on each ſide the leaf, between the two membranes. This worm turns afterwards to an Aurelia, and then to a ſmall green Fly.

The Aleppo-Galls, wherewith we make our ink, are of this number, being only caſes of inſects, which knawed their way out, through the little holes we ſee in them.

For a ſample of the tender balls, ſee the balls as round, and ſometimes as big as ſmall muſket-bullets, growing under oaken leaves, cloſe to the ribs of a greeniſh yellowiſh colour. Their ſkin is ſmooth, with frequent riſings therein. Inwardly they are very ſoft and ſpungy; and in the very center is a caſe, with a white worm therein, which afterwards becomes

becomes a fly. As to this gall, there is one thing peculiar. The fly lies all winter within this ball, and does not come to maturity till the following spring. In the autumn these balls fall to the ground with their leaves. Yet the insect inclosed in them, is fenced against the winter frosts, partly by other leaves lying upon them, and partly by the thick spungy wall, afforded by the galls themselves.

13. There are few insects more prolific than the Gnat. All its changes from the egg to the perfect animal are fulfilled in three weeks or a month: and there are usually seven generations of them in a year, in each of which the parent lays two or three hundred eggs. These she ranges in the form of a boat, and each leg is shaped like a nine-pin. The thicker ends of these are placed downward. They are firmly joined together by their middles, and their narrower parts stand upward.

Viewed with a microscope, the larger end is observed to be terminated by a short neck, the end of which is bordered by a kind of ridge. The neck of each is sunk in the water, on which the boat swims: for it is necessary they should keep on the surface, since otherwise the eggs could never be hatched.

The ranging these in so exact order, requires the utmost care in the parent. Gnats lay their eggs in the morning hours, and that on such waters, as will give support to their young. Here the parent places herself on a small stick, a leaf, or any such matter near the water-edge, in such a manner, that the last ring but one of her body, touches the surface of the water. The last ring of of all, where there is the paſſage for the eggs, is turned upward, and every egg is thruſt out vertically. When it is almoſt diſengaged, ſhe applies it to the ſides of the cluſter already formed: to which it readily adheres by means of a viſcous matter wherewith they are covered.

The great difficulty is, to place the firſt laid eggs in a proper poſition to receive the reſt, and to ſuſtain themſelves and them, in a proper direction. Theſe ſhe with great precaution places exactly, by means of her hinder legs. And when a ſufficient number of them are arranged, all the reſt is eaſy: inaſmuch as theſe are a firm ſupport to all that follow them.

Theſe are circumſtances ſufficiently extraordinary in this little animal; but it offers ſomething ſtill more curious in the method of its propagation. However ſimilar inſects of the Gnat kind are in their appearances, yet they differ widely in the manner in which they are brought forth; for ſome are oviparous, ſome viviparous; ſome are males, ſome are females, ſome are of neither ſex, yet ſtill produce young, without any copulation whatſoever. This is one of the ſtrangeſt diſcoveries in all natural hiſtory! A Gnat ſeparated from the reſt of its kind, and incloſed in a glaſs veſſel, with air ſufficient to keep it alive, ſhall produce young, which alſo, when ſeparated from each other, ſhall be the parents of a numerous progeny. Thus down for five or ſix generations do theſe extraordinary animals propagate in the manner of vegetables, the young burſting from the body of their parents, without any previous impregnation. At the ſixth generation, however, their propagation ſtops; the Gnat no longer produces its like from itſelf, but requires the acceſs of the male.

 14. A Cicadula

14. A Cicadula is a small insect found in May and June, on the stalks of leaves of plants, in a kind of froth, commonly called Cuckoo-Spit. This froth is not from the plant, but the mouth of the animal; and if it be gently wiped away, will be presently seen issuing out of its mouth, till there is as large a quantity of it as before. They are of the shape of a louse, some being whitish, some yellowish, and others green. They often change their skins, while they live in this froth, and only creep a little. But when they leave the plant they hop and fly, having wings which cover the whole body.

The Cochineal is an insect of the same species with the Gall-insect. It is found adhering to several plants; but only one communicates its valuable qualities to it, the Opantia or Prickle Pear. This consists of thick smallish leaves, and its fruit, resembling a fig, is full of a crimson juice, to which the insect owes its colour.

When first hatched, it is scarce bigger than a mite, and runs about very swiftly. But it soon loses its activity, and fixing on the least and most juicy part of the leaf, clings there for life, without moving any more, only for its subsistence, which it sucks wthin its probocis.

The male has no appearance of belonging to the same species. They are smaller than the female, have wings, and like the butterfly, are continually in motion. They are constantly seen among the females, walking over them, as it were carelessly, and impregnating them. But it is the female only which is gathered for use, four times in the year; for so many are the generations of them.

15. The

15. The moſt ſingular part of the life of a Drone-Fly, is that it paſſes in the form of a worm. It is then diſtinguiſhed from all other worms by its long tail: at different times this is indeed of different lengths: but it is always longer than the worm itſelf. It is round, ſmooth, and very ſmall at the extremity; ſometimes no thicker than a horſe-hair. To know the uſe of this tail, we muſt firſt know the nature of the worm itſelf. It is an aquatic, and never leaves the water till it changes into its Fly-ſtate. They lie in multitudes in the mud at the bottom of veſſels of ſtinking water. Put them into veſſels of clean water, and they will ſoon ſhew the uſe of their tails. Though they live under water, they cannot live without breathing freſh air. This is the end to which their long tails ſerve. For even while they lie buried in the mud, their tails are extended to the top of the water, and being open at the extremity, let air into their bodies. And as ſoon as they are in a veſſel of freſh water, they get to the bottom and thruſt up their tail to the ſurface. They can lengthen them at pleaſure: to be aſſured of this, you need only pour in more water. The worms then lengthen their tails proportionably, in order to breathe from the ſurface: by adding more and more water you will find they can extend their tails to the length of five inches: an extremely remarkable length for a creature little more than half an inch long. Beyond five inches however they cannot go. And if you make the water of a greater depth, they leave the bottom, and either travel up the ſides of the veſſel to a proper height; or elſe ſwim in the water, at the depth of five inches.

16. No

16. No ſpecies of Flies is more remarkable, than the larger Fire-Fly of Jamaica. It is above an inch long, and proportionably broad. Moſt of its internal parts are luminous; only the thickneſs of the cover hinders its appearing. But on forcing the rings that cover the body a little aſunder, light iſſues from all the entrails. The head has two ſpots juſt behind the eyes, which emits ſtreams of ſtrong light. But though theſe flow naturally from the inſect, yet it has a power of interrupting them at pleaſure. And then theſe ſpots are as opaque as the ſurface of the body.

A perſon may read the ſmalleſt print by the light of one of theſe inſects, if held between the fingers, and moved along the line, with the luminous ſpots over the letters. They are ſeldom ſeen in the day, but wake with the evening, and move and ſhine moſt part of the night. They readily fly toward each other. Hence the negroes have learned, to hold one between their fingers, and wave it up and down, which others ſeeing fly directly toward it, and pitch upon the hand. They are ſo torpid by day, it is hard to make them diſcover ſigns of life; and if they do, they preſently relapſe into the ſame ſtate of inſenſibility. As long as they remain awake, they emit light: but they are vigorous only in the night.

17. One more inſect of the fly kind, we cannot paſs by unnoticed: the Ephemeron, or Fly that lives but part of a day. It appears uſually about Midſummer. It is produced about ſix in the evening, and dies about eleven. But before it become a fly, it exiſts three years as a worm in a clay

a clay caſe. It never eats from the time of its change to its death, nor has any organs for receiving or digeſting food. The buſineſs of its life is ſummed up in few words. As ſoon as it has dropt its clay coat, the poor, little animal being now light and agile, ſpends the reſt of its ſhort, winged ſtate, in friſking over the waters. During this the female being impregnated, drops her eggs upon the water. Theſe ſink to the bottom, where they are hatched by the heat of the ſun into little worms, which make themſelves caſes in the clay, and feed on the ſame, or on what the waters afford, without any need of parental care. Thus they are inhabitants of the water, till the time comes for ſhaking off their ſhell, and emerging into air.

Of one ſort of Ephemeron, Mr. Collinſon writes thus. May 26, 1744, I was firſt ſhewn this, by the name of May-Fly. It lies all the year, but a few days, at the bottom of the river; then riſes to the ſurface of the water, and ſplitting opens its caſe, up ſprings the new animal, with a ſlender body, four ſhining wings, and three long hairs in its tail. It next flies about to find a proper place, where it may wait for its approaching change. This comes in two or three days. I held one on my finger, while it performed this great work. It was ſurpriſing to ſee, how eaſily its back ſplit, and produced the new birth, which leaves head, body, wings, legs, and even its three-haired tail behind, or the caſes of them. After it has reſted a little, it flies nimbly to ſeek its mate. The males keep under the trees, remote from the river. Hither the females reſorted, and when impregnated, ſoon left the males, ſought the rivers, and kept continually playing

playing up and down on the water. Every time they darted down, they ejected a cluster of eggs. Then they sprang up again. Thus they went up and down, till they had exhausted their stock of eggs and spent their strength, being so weak that they can rise no more, but fall a prey to the fish. This is the end of the females. The males never resort to the river, but having done their office, drop down and die.

In a life of three or four days, they eat nothing. They have no apparatus for that purpose; yet they have strength to shed their skin, and to perform the ends of their life with great vivacity.

But how poor an end, to our apprehension, is answered by the life of this, and innumerable other animals?

18. The eggs of Butterflies do not increase in bulk while in the body of the female. As soon as they are impregnated by the male, they are ready to be laid. But this requires some time, both because of their number, and the nicety with which she arranges them. This indeed is the whole business of her life: for when they are laid, she dies.

The female does not deposit them at random, but searches out a sort of plant which the Caterpillars can feed on as soon as they are hatched. Neither does she scatter them irregularly and without order, but disposes them with perfect symmetry, and fastens them together by a viscous liquor discharged from her own entrails. And those species whose hinder part is covered with long hairs, gradually throw them all off, and therewith

therewith make a neſt, wherein the eggs are kept ſafely, till the time of their hatching.

19. Some Caterpillars are hatched in the ſpring, as ſoon as the leaves they are to be fed on begin to bud. After thirteen days, they change into Aureliæ, and having paſt three weeks in that ſtate, they iſſue forth winged, with all the beauty of their parents.

The wings of Butterflies fully diſtinguiſh them from flies of every other kind. They are four in number; and though two of them be cut off, the animal can fly with the two remaining. They are in their own ſubſtance tranſparent; but owe their opacity to the beautiful duſt with which they are covered, and which has been likened, by ſome, to the feathers of birds; by others, to the ſcales of fiſhes. In fact, if we regard the wing of a Butterfly with a good microſcope, we ſhall perceive it ſtudded over with a variety of little grains of different dimenſions and forms, generally ſupported on a footſtalk, regularly laid upon the whole ſurface. Nothing can exceed the beautiful and regular arrangement of theſe little ſubſtances. Thoſe of one rank are a little covered by thoſe that follow: they are of many figures: here may be ſeen a ſucceſſion of oval ſtuds; there a cluſter of ſtuds, each in the form of an heart: in one place they reſemble a hand open; and in another, they are long or triangular; while all are interſperſed with taller ſtuds that grow between the reſt, like muſhrooms upon a ſtalk.

The eyes of Butterflies have not all the ſame form; for in ſome they are large, in others ſmall. In all of them the outward coat has a luſtre, in which

which may be diſcovered the various colours of the rainbow. When examined cloſely, it will be found to have the appearance of a multiplying-glaſs; having a great number of ſides or facets, in the manner of a brilliant cut diamond. Theſe animals, therefore, ſee not only with great clearneſs, but view every object multiplied in a ſurpriſing manner. Puget adapted the cornea of a fly in ſuch a poſition, as to ſee objects through it by means of a microſcope; and nothing could exceed the ſtrangeneſs of its repreſentations: a ſoldier, who was ſeen through it, appeared like an army of pigmies; for while it multiplied, it alſo diminiſhed the object. It ſtill, however, remains a doubt, whether the inſect ſees objects ſingly, as with one eye; or whether every facet is itſelf a complete eye, exhibiting its own object diſtinct from all the reſt. The trunk, which few Butterflies are without, is placed exactly between the eyes; which, when the animal is not ſeeking its nouriſhment, is rolled up like a curl. A Butterfly, when it is feeding, flies round ſome flower, and ſettles upon it. The trunk is then uncurled, and thruſt out, ſearching the flower to its very bottom. This ſearch being repeated ſeven or eight times, the Butterfly then paſſes to another; and continues to hover over thoſe agreeable to its taſte, like a bird over its prey. This trunk conſiſts of two hollow tubes, nicely joined like the pipes of an organ.

Butterflies as well as moths employ their ſhort lives in a variety of enjoyments. Their whole time is ſpent either in queſt of food, which every flower offers; or in purſuit of the female, whoſe approach they often perceive at above two miles diſtance. Their ſagacity in this particular is aſtoniſhing;

aſtoniſhing; but by what ſenſe they are capable of doing this; is not eaſy to conceive. It cannot be by ſight, ſince ſuch ſmall objects muſt be utterly imperceptible at half the diſtance: it can ſcarcely be by the ſenſe of ſmelling, ſince the animal has no organs for that purpoſe. Whatever be their powers of perception, certain it is, that the male, after having fluttered, as if careleſly, about for ſome time, is ſeen to take wing and go forward, ſometimes for two miles together, in a direct line to where the female is perched on a flower.

Caterpillars are of no ſex, it not being their buſineſs to propagate, till they commence Butterflies. Yet many of them are not ſo harmleſs as they ſeem; for they deſtroy their fellows whenever they can. Put twenty Caterpillars of the Oak together in a box, with a ſufficient quantity of leaves, their natural food. Yet their numbers will decreaſe daily, till only one remains alive. The ſtronger ſeizes the weaker by the throat, and gives him a mortal wound. When he is dead, the murderer begins to eat him up, and leaves only the ſkin with the head and feet. But this is not the caſe of all. Many ſpecies live peaceably and comfortably together.

Yet even theſe are expoſed to dangers of a more terrible kind. The worms of ſeveral ſorts of flies, continually prey upon them. Some are upon, ſome under the ſkin, and both eat up the poor, defenceleſs animal alive.

It is ſurpriſing to ſee with what induſtry theſe little creatures weave the caſes, in which they paſs their Aurelia-ſtate. Some are made of ſilk, mixt with their own hair, with pieces of bark, leaves, wood, or paper.

There

There is one ſort that builds in wood, and gives its caſe an hardneſs greater than that of the wood itſelf. This is the Caterpillar of the Willow, which is one of thoſe that eat their exuviæ. He has ſharp teeth, wherewith he cuts the wood into a number of ſmall fragments. Theſe he unites together into a caſe, by means of a peculiar ſilk, which is a viſcous juice that hardens as it dries. In order to make this ſilk enter into the very ſubſtance of the fragments, he moiſtens every one of them, by holding them ſucceſſively in his mouth for a conſiderable time. In this firm caſe he is afterward to be included till he becomes a Butterfly. But how ſhall a creature of this helpleſs kind, which has neither legs to dig, nor teeth to gnaw, get out of ſo firm and ſtrong a lodgment as that wherein it is hatched? Nature has provided for this alſo. As ſoon as it is hatched, it diſcharges a liquor which diſſolves the viſcous matter that holds the caſe together, ſo that the fragments fall in pieces of themſelves. And accordingly, near its mouth, there is always found a bladder of the ſize of a ſmall pea, full of this liquor.

Some Caterpillars ſpin all the way they walk, a thread of ſilk, which marks their journey. Now what end does this ſerve? A little obſervation will ſhew. Trace one of them till he chances to fall, and you will ſee the uſe of this thread. Being faſtened to the leaves and twigs, it ſtops the creatures fall. Nor is this all. It can alſo by means of this thread, re-aſcend to the place from whence it fell. And when it is ſafe got up again, it continues its motion as before.

Another curious artifice is that by which the ſame ſpecies of Caterpillars make themſelves caſes

of

of leaves before they change into Aureliæ. The niceſt hands could not roll theſe up ſo regularly, as they do without hands or any thing like them. They perform it thus. The Caterpillar places itſelf on the upper ſide of a leaf, ſo far from the edge that he can reach it with his head. Turning himſelf round, he then brings the edge of the leaf to the point juſt oppoſite to it. It next draws lines from the edge of this leaf to that point: and doing this all the way along the leaf, its narrowneſs toward the point makes it form a cloſe caſe there. It ſtrengthens the firſt bending of the leaf, by many parallel threads, and then faſtening other threads to the back part of the leaf, draws them as tight as it can. The caſe is then formed. The ſame method repeated makes the additional caſes, five or ſix over each other. And every one of theſe is ſufficiently ſtrong, ſo as to make the inner ones uſeleſs. He then enters his cell, and undergoes his change. Meantime his covering ſerves him alſo for food. For ſo long as he has need to eat, he may feed upon the walls of his caſtle: all of which may be eaten away, except the outer one of all. Probably every Caterpillar makes his caſe thick enough to ſerve the neceſſary calls of his future hunger.

Many ſpecies of Butterflies lay a great number of eggs in the ſame place. Theſe all hatch very nearly at the ſame time. And one would naturally ſuppoſe, that the young brood of all, would be inclined to continue and live together. But it is not ſo: the different ſpecies have different inclinations. Some keep together from the time they are hatched, till they change into Aureliæ. Others ſeparate as ſoon as able to crawl, and hunt their fortune ſingle. And others live in

community

community till a certain time, and then each ſhifts for itſelf. Thoſe that live wholly together, begin by forming a line with their little bodies upon a leaf; their heads all ſtanding even, and in this manner they move and eat together. And often there are ſeveral ranges of this ſort, which make ſo many phalanxes, and eat into the leaf they ſtand on, with perfect equality.

Many do this while young, who when they grow large, make one common habitation, ſurrounded by a web, which is the joint work of all: within which, each has a neſt of its own ſpinning.

When they have made their common lodging, each takes its courſe over the tree or buſh for food. Thus many hundreds of them form a regular republic. The ſeparate cell of each, is finally the place where it paſſes its change into the Aurelia and perfect ſtate. But many ſpecies do not ſeparate even then; but are found in their Aurelia-ſtate all huddled together; numbers of their caſes making one confuſed maſs.

One thing more is highly obſervable in them. The regularity of their marches. They are exactly obedient to their chief. When they change their quarters, one marches ſingle firſt; two others follow, and keep their bodies very nicely in the ſame poſition with his. After theſe there follows a large party. Theſe regulate their motions by the former: and ſo the order is continued through the whole company. When the leader turns to the right or left, the whole body does the ſame inſtantly. When he ſtops, they all immediately ſtop, and march again the moment he advances.

20. The

20. The outward covering of the body, is in many animals changed ſeveral times: but in few more frequently than the Caterpillar. Moſt of theſe throw it off at leaſt once in ten days. Indeed in the whole inſect claſs, the moſt numerous of all animated beings, there is ſcarce one which does not caſt its ſkin, at leaſt once, before it arrives at its full growth. But the Catterpillar changes more than his ſkin: even the outward covering of every, the minuteſt part of its body. And what they throw off has the appearance of a compleat inſect, preſenting us with all the external parts of a living animal. If the Catterpillar be of the hairy kind, the ſkin it throws off is hairy, containing the covering of every hair. And even the claws and other parts that are not viſible without a microſcope, are as plain in this as in the living animal. But what is more amazing is, that the ſolid parts of the head, the ſkull and teeth are diſtinguiſhable therein. The throwing off an old ſkull and teeth, to make way for new ones, is an act beyond all comprehenſion! A day or two before, the creature refuſes to eat, and walks very ſlowly, or not at all. He turns from ſide to ſide, and often raiſes his beak, and gently depreſſes it again. He frequently raiſes his head, and ſtrikes it down rudely againſt any thing he ſtands upon. Frequently the fore-part of the body is raiſed from the place, and thruſt very briſkly backward and forward, three or four times together. There are likewiſe diſtinct motions within every ring. Theſe are ſeverally inflated and contracted alternately, by which the ſkin is looſened from them; till by this means, and its remaining without food, the body is quite diſengaged from its covering.

When

When this time approaches, all the colours of the ſkin grow faint, and looſe their beauty, receiving no nouriſhment from the body. And as the creature continues ſwelling and ſhrinking, the ſkin, being no longer ſupple, cracks along his back. The crack always begins, at the ſecond or third ring, from the head. As it opens, the new ſkin is ſeen within. This opening he eaſily enlarges, thruſting his body like a wedge, out of the ſlit, till he lengthens it through four rings. Then he has room to draw out the whole body. Firſt, the head is by ſeveral motions looſened, drawn out of the old ſkull, and raiſed through the crack: this is then laid ſoftly on the old ſkin of the part. By the ſame motions the tail end is diſengaged, drawn out, and laid ſmoothly on the old ſkin. It takes the animal ſeveral days, to prepare for the laſt operation. But when the crack is once made, the whole remaining work is done in leſs than a minute.

The hairs found on the caſt ſkins of the Hairy Caterpillars ſeem at firſt, like the other part of the exuviæ, to be only the covering of the hairs incloſed. But that is not the caſe. They are ſolid things themſelves, not barely coverings. In truth, the creature when firſt hatched has all its ſkins perfectly formed, one under another, each furniſhed with its hairs, ſo that the old ones fall off with the old ſkins. And probably the erecting theſe is one great means of forcing off the old ſkins.

Perhaps the ſame ſort of mechaniſm is uſed even by thoſe Caterpillars which do not appear to be hairy. For they really are ſo, as the microſcope ſhews. When the upper ſkin of one juſt ready to change, is ſlit longitudinally in the place

place where the crack would be, the ſkin may be taken off; and it is eaſily ſeen, how the new one lies below. The hairs are diſpoſed in the niceſt manner, for lying ſmooth under the upper ſkin. They grow in ſeparate tufts, which never lie one upon another, but together form one ſurface.

It is remarkable, that immediately after this change, they appear much larger than they did before. And they really are ſo. The very head and ſkull are greatly larger than before the change. The operation of the Cray-fiſh in changing its ſhell, may explain this. This alſo is found conſiderably larger, when out of the ſhell than before. In both caſes, the body had grown ſo much, that it was too big for its covering. However, while it remained in it, the parts were compreſſed, and forced to lie in that narrow room. But as ſoon as that covering is off, every part diſtends itſelf to its proper ſize.

Indeed, ſo large a ſkull, being a hard ſubſtance in the Caterpillar, could not have been compreſſed into a ſmaller. But the fact is, the new ſkull never hardens till the change approaches, and then imperfectly. At the ſame time it neceſſarily takes, from the place it is in, an oblong form. In this ſhape it is found a few hours before the old ſkin is caſt off; not incloſed within it, but extended under the ſkin of the firſt ring of the body. When the old ſkull is thrown off, the new one ſoon hardens, and takes its proper figure.

We call the creature hatched from the egg of a Butterfly, a Caterpillar. But it is a real Butterfly all that time. A Caterpillar changes its ſkin four or five times, and when it throws off one, appears in another of the ſame form. But when it throws off the laſt, as it is now ſo perfect, as to need no farther nouriſhment, ſo there is no farther need of teeth, or any other parts of a Caterpillar.

'Tis plain from hence, that the change of a Caterpillar into an Aurelia, is not the work of a moment, but is carrying on from the very time of its hatching from the egg. But while the Butterfly lies in the body of the Caterpillar, its wings are long and narrow, and wound up into the form of a cord, and the feelers are rolled up on the head. The trunk alſo is twiſted up, and laid on the head, but in a very different manner from what it is in the perfect animal, or indeed in the Aurelia.

A Butterfly then in all its parts, is in the Caterpillar in all its ſtates. But it is more eaſily traced, as it comes nearer the time of being changed into Aurelia. The very eggs hereafter to be laid by the Butterfly, are to be found not only in the Aurelia, but even in the Caterpillar, all arranged in their natural, regular order. In the Caterpillar indeed they are tranſparent: but in the Aurelia, they have their proper colour.

As ſoon as the limbs of the Butterfly are fit to be expoſed to the more open air, they are thrown out from the body of the Caterpillar, ſurrounded only with thin membranes. And as ſoon as they arrive at a proper degree of ſtrength and ſolidity, they break through theſe, and appear in their perfect form.

The animal then creeps a little on, and there reſts; the wings being quite folded up. But by degrees they expand, and in leſs than half an hour appear in all their beauty.

In the beginning of May 1737, the Cornel-trees, near Monaghan in Ireland, appeared covered

vered with ſmall Caterpillars, employed partly in feeding on the leaves, partly in crawling over the bark of the tree. Each as it crawled left a fine thread ſticking to the bark. By the end of May, there was not a leaf on any of the trees, except a few reſerved for a curious purpoſe. But ſnſtead of the green, a white cloathing covered the whole bark, from the ground to the point of the ſmalleſt twigs, and that ſo gloſſy, that it ſhewed, in the ſun, as if it was caſed in burniſhed ſilver. Then they covered with the ſame all the aſh, beech, lime, yea the very weeds which grew near them.

But how did they travel from tree to tree? Many crawled along the ground. But many had a quicker way. They hung by their own threads from the utmoſt branches of the tree, ſo that a ſmall breeze wafted them to the next tree, as ſpiders paſs from one buſh to another.

As they made no uſe of the threads left behind them, probably they wrought for no other purpoſe, than to rid themſelves of that glutinous matter, out of which it was ſpun.

In the beginning of June, they retired to reſt. Their manner of executing this, was very ingenious. Some choſe the under ſide of the branches, juſt where they ſpring from the trunk, that they might be defended from the water, which in a ſhower, running down the bark of the tree, is parted by the branches, and ſent off on each ſide. Here they draw their threads acroſs the angle made by the trunk and branch; and croſſing thoſe with other threads, make a ſtrong covering. Within this they place themſelves lengthways among the threads, and rolling their bodies round, ſpin themſelves into little hammocks, in the mean time ſhrinking into half their length. Theſe hammocks being ſuſpended by the tranſverſe threads, do not preſs each other. That they may take up the leſs room, they lie parallel to each other, in the moſt convenient order poſſible. Others, ſtill more ingenious, faſten their threads to the edge of the leaves which they had ſaved for that purpoſe: and with that ſlender cordage pulling in the extremities of the leaves, draw themſelves into a kind of purſe, within which they form the ſame ſort of work, and lay themſelves up as above. They lay themſelves up in great numbers together, both becauſe many were neceſſary to the work of providing a common covering, and alſo to keep one another warm, while preparing for the great change.

Between the worm thus laid up, and the hammock incloſing it, there is a tough brown ſhell, probably formed of ſome glutinous matter, tranſuding through its pores. In the end of June, they gnaw through the ſhells and hammocks, and come forth a moſt beautiful fly. After its reſurrection, it needs no food. Thoſe that came out in a room, lived as long there as the reſt did abroad. After a while ſeveral of them diſcharged a drop of brown liquor, probably containing the egg. But as it was not lodged in a proper receptacle, it produced no worm the next year.

As the Cornel only ſupplies this worm with food, ſo it is the only nurſe of its egg. There is not an animal or a vegetable, but yields habitation and food to its peculiar inſect. The ſcheme of life begins in vegetation: and whenever nature produces vegetables, ſhe obliges them to pay for their nouriſhment, to certain animals which ſhe billets

billets upon them. Each of these again, is to diet and lodge another set of living creatures. This just community in nature, which suffers nothing to subsist merely for itself, is found not only every where on the earth, but likewise every where in the waters. By microscopes we discover an infinity of little creatures, feeding on the floating vegetables, or on one another. Indeed, as to the sea, we know only what happens near the shores, where we find vegetables of various kinds, which breed and nourish a like variety of insects. These, with a multitude of others bred in the mud, are the prey of the smaller kinds of fish, and they again of a greater. That this scheme of nature, found every where else, dives into the depths of the ocean, we may gather from the wonderful kind of fishes, washed up by the storms now and then from the deep waters.

Now it is on the Cornel alone, that the worms we have spoken of can be propagated and fed. The specific qualities with which its juices are impregnated, are peculiarly suitable to this insect. If these reside in the essential oil of the plant, this, as well as the other insects, subsisting on vegetables, have the skill to extract, nicer than any chymist can do, the essential oil of each plant, nothing else therein, being of a nature sufficiently peculiar, either to assist the propagation, or supply the nourishment of the insect.

21. The Ant lays eggs like flies, from which are hatched small worms without legs. These are sharp at one end, and blunt at the other: after a short time they change into a large, white Aurelia; vulgarly called Ants-Eggs: whereas they are larger than the Ants themselves. They move these

at their pleasure. When an Ant's neſt is diſturbed, and the Aurelia ſcattered abroad, the Ants are at infinite pains to gather them and make them a neſt again. Nay, thoſe of one neſt will often do this for the Aurelia of another.

At the bottom of an Ant's neſt, which is built with ſmall pieces of dry earth, there is always a large quantity of eggs, worms, and Aurelia. The Aureliæ are covered only with a thin ſkin, and if opened ſhew the Ant in its ſeveral ſtages toward perfection.

In every neſt, as in every bee-hive, there are three kinds of the inſect, males, females, and working Ants, or labourers. Theſe laſt are neither male nor female, nor have any buſineſs, but taking care of the young brood. Male Ants have four wings and three lucid points on their head, and their eyes are larger than thoſe of the female or labourers. They are not found in the neſts at all ſeaſons, but only at particular times. It ſeems they are killed (like drone bees) as ſoon as the ſeaſon for impregnating the females is over.

The body of the female is larger and thicker than that of the male, or labourer; and contains a great number of eggs, placed in regular lines. She has alſo the three lucid points on her head, which ſeem to be three eyes.

The Ant examined by the microſcope appears a very beautiful creature. Its head is adorned with two horns, each having twelve points. Its jaws are indented with ſeven little teeth, which exactly tally. They open ſideways exceeding wide, by which means the Ant is often ſeen graſping and carrying away bodies of three times its own bulk. It is naturally divided into the head, the breaſt, and the belly, each joined to the other by a ſlender a ſlender ligament. From the breaſt proceed three legs on each ſide. The whole body is caſed over with a ſort of armour, ſo hard as ſcarce to be penetrated by a lancet, and thick ſet with ſhining, whitiſh briſtles.

They bring out not corn, but their young, every day, and ſpread them near their neſt, in little heaps, on a kind of dry earth, provided for that purpoſe. They carry them back at night. But it is obſerved, they never bring them out, unleſs in a day that promiſes to be fair. In the prognoſtics of this they ſhew great ſagacity. Where it is dangerous to expoſe them in the day times, by reaſon of the birds, they vary their rule, bringing them out in the night, and carrying them back in the morning.

They do not eat at all in winter, but ſleep like moſt other inſects. There is a ſtrait hole in every Ants neſt, about half an inch deep; after which it goes ſloping into their magazine, which is a different place from that where they eat and reſt. Over the hole they lay a flat ſtone or tile, to ſecure them from their great enemy the rain. In a fair day, the hole is open; but when they foreſee it will rain, and every night, the cover is drawn over, with great ingenuity as well as labour. Fifty of the ſtrongeſt of them ſurround the ſtone, and draw and ſhove in concert. The like pains they take every morning, to thruſt it back again.

An Ant never goes into any neſt but her own; if ſhe did, ſhe would be ſeverely puniſhed. And if ſhe returned again after this warning, the others would tear her in pieces. Therefore they never attempt it, but in the laſt extremity: ſometimes they will rather ſuffer themſelves to be taken.

Ants do not bite, as is vulgarly ſuppoſed. But red Ants have a ſting, which expreſſes a corroſive liquor, that raiſes a ſlight inflammation. The black Ants have no ſting.

On opening an Ant-hill, a great quantity of eggs is uſually found. They look like the ſcatterings of fine ſalt, and are too minute to be ſeen diſtinctly by the naked eye. Through a microſcope they appear like the eggs of ſmall birds, and are as clear as the air-bladder of fiſhes. They lie in cluſters under cover of ſome light earth. The Ants ſeem to brood over them, till every granule is hatched into a worm, not much larger than a mite. In a ſhort time theſe turn yellowiſh and hairy, and grow to near as big as their parent. They then get a whitiſh film over them, and are of an oval form. If this cover be opened after ſome days, all the lineaments of an Ant may be traced; though the whole is tranſparent, except the eyes, which are two dark ſpecks.

The care theſe creatures take of their young is amazing. Whenever a hill is diſturbed, all the Ants are found buſy, in conſulting the ſafety, not of themſelves, but of their offspring. They carry them out of ſight as ſoon as poſſible; and will do it over and over, as often as they are diſturbed. They carry the eggs and worms together in their haſte; but as ſoon as the danger is over, they carefully ſeparate them, and place each by themſelves, under ſhelter of different kinds, and at various depths, according to the different degrees of warmth which their different ſtates require.

In the ſummer they every morning bring up the Aureliæ near the ſurface of the earth. And from ten in the morning till about five in the afternoon. they may be found juſt under the ſurface. But if you ſearch at eight in the evening, they

they will be found to have carried them all down And if rainy weather be coming on, they lodge them at least a foot deep.

Though Ants unite in colonies, in such places as are agreeable to their different natures, yet they often vary their residence. But the several species never intermix, though they will be good neighbours one to another.

Their architecture is adjusted with remarkable art. The whole structure is divided into numerous cells, communicating with each other by small subterraneous channels, which are circular and smooth. They carry on all their works by means of their double saws, and the hooks at the extremity of them.

A colony from the latter end of August, to the beginning of June, consists of a female, and various companies of workers: and besides these in the latter end of June, all July and part of August, of a number of winged Ants.

The labouring Ants, being of no sex, are wholly employed in providing for the young, which the Queen deposites in the cells. In whatever apartment she is present, universal joy is shewn. They have a particular way of skipping, leaping, prancing, and standing on their hind legs. Some walk gently over her, others dance round her, all express their loyalty and affection; of all which you may be convinced in a few moments, by placing the queen and her retinue under a glass.

The queen lays three different sorts of eggs, male and female in spring, neutral in July and part of August. The common Ants then brood over them in little clusters, and remove them to and fro, for a just degree of heat. The young disengage themselves from the membranes that enclose the eggs, just as the silk-worms do. The female eggs put on the form of worms, some time in February; the male, by the latter end of March, the neutral by September. The first summer they grow little, and less in winter. In the beginning of April the second year, they visibly increase every day. By the end of May the male and female attain their full growth, and are ready for another change. This long continuance of Ants in the vermicular state, has nothing like it in any other class of insects. The vermicles in a few days infold themselves in a soft silken covering, and so commence Aurelias, which are commonly mistaken for Ants eggs. As soon as they tend to life, the workers give them air, by an aperture in the end of the covering. This they gradually enlarge for a day or two, and then take out their young.

There is a larger and a smaller sort of winged Ants, the latter male, the former female. Those females, which escape being devoured by other creatures, become queens, and give birth to new colonies.

In all other insects the loss of their wings lessens their beauty, and shortens their lives. But Ants gain by that loss: this being the prelude of their ascending the throne.

The young are fed by the juices of most sorts of fruits, which the labourers extract, and receive into their own stomach; where they are prepared, and afterwards transfused into the tender vermicles.

Perhaps in warm climates, Ants do not pass the winter in sleep, as they do with us. If so, they need a store of food, which in our climate is quite needless. Accordingly those who have accurately examined their most numerous settlements, could never find out any reservoir of corn

or

or other aliments. And they that have carefully obferved their excurfions from and return to their colonies, could never obferve that they returned with any wheat corn, or any other vegetable feed: though they would eagerly attack a pot of honey, or a jar of fweet-meats.

But is it not faid, Prov. vi. 8. *She provideth her meat in the fummer, and gathereth her food in the harveft?*" It is: but this does not neceffarily mean any more, than that fhe collects her food in the proper feafon. Nor is any thing more declared, ch. 30. 35, than that Ants carry food into their repofitories. That they do this againft winter, is not faid: neither is it true in fact.

In England, Ant-hills are formed with but little apparent regularity. In the fouthern provinces of Europe, they are conftructed with wonderful continuance. They are generally formed in the neighbourhood of fome large tree and a ftream of water. The one is the proper place for getting food; the other for fupplying the animals with moifture, which they cannot well difpenfe with. The fhape of the Ant-hill is that of a fugar-loaf, about three feet high, compofed of various fubftances; leaves, bits of wood, fand, earth, bits of gum, and grains of corn. Thefe are all united into a compact body, perforated with galleries down to the bottom, and winding ways within the ftructure. From this retreat to the water, as well as to the tree, in different directions, there are many paths worn by conftant affiduity, and along thefe the bufy infect pafs and repafs continually; fo that from May or the beginning of June they work continually till the bad weather comes on.

The chief employment of working Ants is in finding a fufficiency of food. They live upon various provifions, as well of the vegetable as the animal kind. Small infects they kill and devour; fweets of all kinds they are particularly fond of. They feldom, however, think of their community till themfelves are firft fatiated. Having found a juicy fruit, they fwallow what they can, and then tearing it in pieces, carry home their load. If they meet with an infect above their match, feveral of them will fall upon it at once, and having torn it in pieces, each will carry off a part of the fpoil. If they meet with any thing that is too heavy for one to bear, and yet which they are unable to divide, feveral of them endeavour to force it along, fome dragging, others pufhing. If any one of them makes a lucky difcovery, it immediately gives advice to others, and then at once, the whole republic put themfelves in motion. If in thefe ftruggles one of them happens to be killed, fome furvivor carries him off to a great diftance, to prevent the obftructions his body might give to the general fpirit of induftry.

In autumn they prepare for the feverity of the winter, and bury their wheat as deep in the earth as they can. It is now found that the grains of corn, and other fubftances with which they furnifh their hill, are only meant as fences to keep off the rigour of the weather. They pafs four or five months without taking any nourifhment, and feem to be dead all that time. It would be to no purpofe therefore for Ants to lay up corn for the winter, fince they lie that time without motion, heaped upon each other, and are fo far from eating, that they are utterly unable to ftir. Thus what authors have dignified by the name of a magazine, a magazine, appears to be no more than a cavity, which ſerves for a common retreat, when they return to their lethargic ſtate.

But what has been falſely ſaid of the European Ant, is true of thoſe of the tropical climates. They do lay up proviſions, and as they probably live the whole year, ſubmit to regulations unknown among the Ants in Europe. Thoſe of Africa are of three kinds, the red, the green, and the black; the latter are above an inch long, and in every reſpect, a moſt formidable inſect. They build an Ant-hill from ſix to twelve feet high; made of viſcous clay, and in a pyramid form. The cells are ſo numerous and even, that a honey-comb ſcarce exceeds them. The inhabitants of this edifice ſeem to be under a very ſtrict regulation. At the ſlighteſt warning they ſally out upon whatever diſturbs them, and if they arreſt their enemy, he is ſure to find no mercy. Sheep, hens, and even rats are often deſtroyed by theſe mercileſs inſects, and their fleſh devoured to the bone. No anatomiſt can ſtrip a ſkeleton ſo clean as they.

If a frog be put into a box with holes bored therein, and the box laid near a neſt of Ants, they will entirely diſſect him, and make the fineſt ſkeleton poſſible, leaving even the ligaments unhurt.

21. One of the moſt dreadful enemies of the Ants is the Formica-leo or Ant-Eater: it is ſoft as a ſpider, but has in its form ſome reſemblance of a wood-louſe. Its body is compoſed of ſeveral rings: it has ſix legs, four joined to the breaſt; and the other two to a long part, which may be termed the neck. Its head is ſmall and flat, and it

it has two remarkable horns, the ſixth of an inch long, as thick as a hair, hard, hollow and hooked at the end. At the origin of each of theſe horns, it has a clear and bright black eye.

He is not able to hunt after prey, nor to deſtroy large inſects. He can only inſnare ſuch as come by his habitation, and of theſe, few are ſuch as he can manage. All the winged tribe eſcape by flight, and thoſe that have hard ſhells are of no uſe to him. The ſmallneſs of the Ant, and its want of wings, make it his deſtined prey. The manner wherein he proceeds is this. He uſually encamps under an old wall for ſhelter, and always chuſes a place where the ſoil is compoſed of a light, dry ſand. In this he makes a pit in the ſhape of a funnel, which he does in the following manner.

If he intends the pit to be but ſmall, he thruſts his hinder parts into the ſand, and by degrees works himſelf into it. When he is deep enough, he toſſes out with his head the looſe ſand which is run down, artfully throwing it off, beyond the edges of the pit. Then he lies at the bottom of the ſmall hollow, which comes ſloping down to his body.

But if he is to make a larger pit, he firſt traces a larger circle in the ſand. Then he buries himſelf in it, and carefully throws off the ſand, beyond the circle. Thus he continues running down backward in a ſpiral line, and throwing off the ſand above him all the way, till he comes to the point of the hollow cone, which he has formed by his paſſage. The length of his neck, and the flatneſs of his head, enable him to uſe the whole as a ſpade. And his ſtrength is ſo great that he can throw a quantity of ſand, to ſix inches diſtance,

diſtance. He likewiſe throws away the remains of the animals he has devoured, that they may not fright other creatures of the ſame ſpecies.

Where the ſand is unmixed, he makes and repairs his pit with great eaſe. But it is not ſo where other ſubſtances are mixed with it. If when he has half formed his pit, he comes to a ſtone not too large, he goes on, leaving that to the laſt. When the pit is finiſhed, he creeps up backwards to the ſtone, and getting his back ſide under it, takes great pains to get it on a true poiſe, and then creeps backward with it, to the top of the pit.

We may often ſee one thus labouring at a ſtone four times as big as his own body. And as it can only move backward, and the poiſe is hard to keep, eſpecially up a ſlope of crumbly ſand, the ſtone frequently ſlips when near the verge, and rolls down to the bottom. In this caſe he attacks it again, and is not diſcouraged by five or ſix miſcarriages; but attempts it again, till at length he gets it over the verge of his place. Yet he does not leave it there, leſt it ſhould roll in again, but always removes it to a convenient diſtance.

When his pit is finiſhed, he buries himſelf at the bottom of it in the ſand, leaving no part above it, but the tips of his horns, which he extends to the two ſides of the pit. Thus he waits for his prey. If an Ant walk on the edge of his pit, it throws down a little of the ſand. This gives notice, to toſs up the ſand from his head on the Ant; of which he throws more and more, till he brings him down to the bottom, between his horns. Theſe he then plunges into the Ant, and having ſucked all the blood, throws out the ſkin as far as poſſible. This done, he mounts up the

the edges of his pit, and if they have suffered any injury, repairs it carefully. He then immediately buries himself again in the center, to wait for another meal.

This creature has no mouth, but it is through its horns that it receives all its nourishment. And as they are so necessary for its life, nature has provided for the restoring them, in case of accidents: so that if they are cut off, they soon grow again.

When he has lived his stated time, he leaves his pit, and is only seen drawing traces on the sand. After this he buries himself under it, and incloses himself in a case. This is made of a sort of silk with grains of sand cemented together by a glutinous humour which he emits. But this would be too harsh for his body: so it serves only for the outward covering. He spins within it one of pure, fine, pearl coloured silk, which covers his whole body. When he has lain some time in this case, he throws off his outer skin, with the eyes, the horns, and all other exterior parts, and becomes an oblong worm, in which may be traced the form of the future fly. Through its transparent skin may be seen new eyes, new horns, and all other parts of the perfect animal. This worm makes its way about half out of the case, and so remains, without farther life or motion, till the perfect fly makes its way out of a slit in the back. It much resembles the Dragon-fly. The male then couples with the female and dies.

22. The sagacity of Bees, in making their combs, cannot be too much admired. The labour is distributed regularly among them. The same Bees, sometimes carry the wax in their jaws, and moisten it with a liquor which they distil upon

on it, and ſometimes build the walls of their cells. But they that form the cells, never poliſh them. Others make the angles exact, and ſmooth the ſurface. The bits of wax which are ſcraped off in doing this, others pick up, that none may be loſt.

Thoſe that poliſh, work longer than thoſe that build the walls; poliſhing not being ſo laborious a work as building. They begin the comb at the top of the hive, faſtening it to the moſt ſolid part thereof. Hence they continue it from top to bottom, and from ſide to ſide. The cells are always ſix ſided: a figure which, beſide the advantage it has in common with the ſquare, of leaving no vacancies between the cells, has this peculiar to itſelf, that it includes a greater ſpace within the ſame ſurface than any other figure.

It is a grand queſtion, Is there any part of a plant without iron? It is certain honey is not. And if ſo delicate an extract from the fineſt part of flowers, and that farther elaborated in the bowels of the inſect: if this be not without iron, we may deſpair of ſeeing any part ſo.

The trunk of a working Bee, is not formed in the manner of a tube by which the fluid is to be ſucked up; but like a beſom to ſweep, or a tongue to lick it away. The animal is furniſhed alſo with teeth, which ſerve in making wax. This ſubſtance is gathered from flowers like honey: it conſiſts of that duſt or farina which contributes to the foundation of plants. Every Bee when it collects this, enters into the cup of the flower, particularly ſuch as have the greateſt quantities of this yellow farina. As the animal's body is covered over with hair, it rolls itſelf within the flower, and is ſoon covered over with duſt, which

which it brushes off with its two hind legs, and kneads it into two little balls.

The habitation of Bees ought to be very close; and what their hives want, from the negligence or unskilfulness of man they supply by their own industry: so that it is their principal care, when first hived, to stop up all the crannies. For this purpose they make use of a resinous gum, which is more tenacious than wax. When they begin to work with it, it is soft, but it acquires a firmer consistence every day. The Bees carry it on their hinder legs, and plaister the inside of their hives therewith. Their teeth are the instruments by which they model and fashion their various buildings, and give them such symmetry. Several of them work at a time, at the cells which have two faces. If they are stinted in time, they give the new cells but half the depth which they ought to have; leaving them imperfect, till they have sketched out the cells necessary for the present occasion. The construction of their combs, costs them a great deal of labour: they are made by insensible additions, and not cast at once into a mold as some are apt to imagine. There seems no end of their shaping, finishing, and turning them neatly up. The cells for their young are most carefully formed; those designed for drones, are larger than the rest, and that for the queen Bee, the largest of all. Honey is not the only food on which they subsist. The meal of flowers is one of their favourite repasts. This is a diet which they live upon during the summer, and of which they lay up a large winter provision. The wax is no more than this meal digested and wrought into a paste. When the flowers are not fully blown, and this meal is not offered in sufficient

ficient quantities, the Bees pinch the tops of the ſtamina in which it is contained, with their teeth; and thus anticipate the progreſs of vegetation. In April and May the Bees are buſy from morning to evening, in gathering this meal: but when the weather becomes too hot, they work only in the morning. The Bee is furniſhed with a ſtomach for its wax, as well as for its honey. In the former their powder is altered, digeſted, and concocted into wax; and is then ejected by the ſame paſſage by which it was ſwallowed. Beſide, the wax, thus digeſted, there is a large portion of the powder kneaded up for food in every hive, and kept in ſeparate cells for winter proviſion. This is called by the country people Bee-bread; and contributes to the health and ſtrength of the Bee during the winter. We may rob them of their honey, and feed them during the winter with treacle, but no proper ſubſtitute has yet been found for the Bee-bread; without it the animal becomes conſumptive and die.

Honey is extracted from that part of the flowers called the *nectaræum*. From the mouth it paſſes into the firſt ſtomach, or honey-bag, which when filled, appears like an oblong bladder. When a Bee has filled its firſt ſtomach, it returns back to the hive, where it diſgorges the honey into one of the cells. It often happens that the Bee delivers its ſtore to ſome other at the mouth of the hive, and flies off for a freſh ſupply. Some honey-combs are left open for common uſe, many others are ſtopped up, till there is a neceſſity of opening them. Each of theſe are covered carefully with wax; ſo cloſe that the cover ſeems to be made at the very inſtant the fluid is depoſited within them.

It

It was formerly thought that Bees do not collect honey in the form we see it, but lodge it in their stomachs, till its nature is changed. But we now know that they merely collect it. Many flowers afford it; but beside this, there are two kinds of honey dews. The one does not fall, but is a mild sweet juice, which having circulated in the vessels of plants, is separated by proper strainers, and exsudes on the leaves, though sometimes it is deposited on the pith, or in the sugar canes.

So the leaves of the holm oak are frequently covered with thousands of small drops, which point out the several pores from which they proceeded, and are no other than pure honey. But it is found only on the old leaves, which are strong and firm, not on the tender ones, which are newly come forth: although the old are covered by the new ones, and so sheltered from any thing, that could fall from above. Mean time the leaves of the neighbouring trees, have no moisture upon them: whereas, if it falls as a dew, it would necessarily wet all the leaves without distinction.

The other kind of honey-dew, springs from a small insect called a Vine-fretter: the excrement of which is the most delicate honey in nature. They settle on branches of trees that are a year old; the juice of which, however, harsh at first, becomes in the bowels of the insect equal in sweetness to any honey whatever.

There are two species of these flies, the smaller is green; the other, twice as large, is blackish. Hearing many Bees buzzing in a tuft of holm-oak, upon observing, I found the tuft of leaves and branches covered with drops which the Bees collected. Each of the drops was not round, but of

a longish

a longiſh oval. I ſoon perceived from whence they proceeded. The leaves covered with them, were juſt beneath a ſwarm of the larger Vine-fretters; which from time to time raiſed their bellies, and ejected ſmall drops of an amber colour. I catched ſome of them on my hand, and found they had the very ſame flavour with what had before fallen on the leaves. I afterwards ſaw the ſmaller vine-fretters eject their drops in the ſame manner. This is the only honey dew that falls: and this never falls from a greater height than a branch, where a cluſter of theſe inſects can fix themſelves.

Ants are as fond of this honey as Bees. The large black ants follow the inſect which lives on oaks and cheſnut-trees: the leſſer attend there on the elder. But as ants cannot ſuck up fluids like Bees, they wait juſt under the vine-fretters, in order to ſuck the drop juſt as it falls.

The vine-fretters afford moſt honey about midſummer, as the trees are then fulleſt of juice, the trees nevertheleſs, though pierced to the ſap in a thouſand places, do not ſeem to be hurt at all.

The ſting of a Bee or Waſp is a curious piece of workmanſhip. It is an hollow tube, within which, as in a ſheath, are two ſharp bearded ſpears. A waſp's ſting has eight beards on the ſide of each ſpear, ſomewhat like the beards of fiſh-hooks. Theſe ſpears in the ſheath, lie one with its point a little before that of the other. One is firſt darted into the fleſh, which being fixed, by means of its foremoſt beard, the other ſtrikes in too, and ſo they alternately pierce deeper, the beards taking more and more hold in the fleſh: afterward the ſheath follows, to convey the poiſon into the wound. When the beards are lodged deep in the

the flesh, Bees often leave their stings behind them, if they are disturbed before they have time to withdraw their spears into their scabbard.

The Queen-Bee is somewhat larger, considerably longer, and of a brighter red than others. Her office is, to direct and lead the swarm, and to raise a new breed. She brings forth ten, fifteen, or twenty thousand young ones in a year: so that she may literally be said to be the mother of her people. In an hive of eight or ten thousand, there is usually but one Queen-Bee.

Drones, or males have no stings, and are larger and darker-coloured than the working Bees. The eggs for them are placed in a larger sort of cells. They are also nurses to the young brood.

It is certain Bees foresee rain, though we know not how. Hence no Bee is ever caught in a sudden shower: unless it be far distant from the hive, or any way hurt or sickly.

Thus much may be seen on the outside of the hive. But when we look within, how is the wonder increased! to see so many thousands all so busily at work, and with such admirable regularity! Nor is there less wonder in observing the clusters of them, when they take some rest. Their method then is, to get together and hang one to another in vast numbers. When these clusters are large, they are only shapeless heaps; when smaller they are a sort of festoon or garland, each end being fastened to the branch, and the middle dropping from it. The manner in which they hang is this. Each with one or both of his fore-legs lays hold of one or both of the hinder-legs of the Bee that is next above it.

Through

Through a glaſs hive we ſee, that as the combs are carried down from the top to the bottom of the hive, each is placed parallel to the former, but not touching it, there being a ſpace between for the Bees to walk. Theſe are their public ſtreets, and by means of theſe they can make uſe of every cell. There are likewiſe alleys cut from ſtreet to ſtreet, through the ſubſtance of the ſeveral combs.

All the cells are uſed in common. Some of them contain only honey, and are covered with a lid of wax. Theſe are never touched by any Bee. But other cells are open, and a Bee is often ſeen ſo lodged in one of theſe, that only its hinder part appears. The meaning hereof is, each of theſe open cells contains at the bottom a Bee-worm. Certain Bees duly viſit theſe, plunging their heads into the ſeveral cells, one after another.

The fruitfulneſs of the female is the leſs ſtrange, when we conſider the number of the males. In any hive there are, at the ſeaſon, ſeveral hundreds: in ſome two or three thouſand. Theſe are the joint fathers of the numerous offspring, and when they have done their work, are all killed. The wings of the female reach only to the third ring of her body: whereas thoſe of all other Bees cover the whole body. But though ſhe is thus eaſy to be diſtinguiſhed, yet few have ever ſeen a Queen-Bee: as ſhe is always cloſe covered in the hive.

Mr. Reaumur, deſiring to try how far the accounts given of the homage paid by the others to the Queen-Bee was true, cauſed a ſwarm of Bees to be ſwept down into a glaſs-hive. Among theſe there was one female. She was ſoon diſtinguiſhed by her ſhape, and the ſhortneſs of her wings.

For

For a while ſhe walked alone at the bottom of the hive; the reſt ſeeming to regard nothing but their own ſafety. The female after going twice or thrice up the ſides of the hive, to the top of it, where they were hung, at laſt going in among the cluſter, brought down about a dozen with her. Attended with theſe, ſhe walked along ſlowly at the bottom of the hive. But the reſt continuing at the top, ſhe went again and again, till they all came down and formed a circle about her, leaving her a free paſſage wherever ſhe turned to walk, and feeding her with the honey they had gathered for themſelves.

The hive was large enough for more than their number. However the female ſeemed to find, it would not be large enough for the family ſhe was to produce. So gathering them all about her, ſhe went out and flew to a neighbouring tree. All followed her, and formed a cluſter about her, in the common way.

The Bees follow their queen wherever ſhe goes. And if ſhe be tied by one of the legs to a ſtick, all the ſwarm will gather in a cluſter about her, and by removing the ſtick may be carried any where.

Nature ſeems to have informed the common Bees that they are to bring up the offspring of this female, therefore they ſerve her in every thing. If by any means ſhe is dirted, all the reſt try who ſhall clean her. And in cold weather they cluſter together about her to keep her warm. Nor do they ſhew this reſpect to one female only. Mr. Reaumer, at ſeveral times, put ſeveral females marked with different colours, into the ſame ſwarm. And all theſe were, for a time, received as well as the proper female.

The

The ſwarm which leaves an old hive, have often three or more females. Theſe have their ſeveral followers. And each with her followers, were the number ſufficient, would form a diſtinct ſwarm. As it is not, they all go into the ſame hive. But all, except one, are ſoon deſtroyed. The reaſon is, the working Bees of an hive have enough to do to prepare cells, for lodging the eggs of one female, and it would be impoſſible for them to prepare twice or thrice that number.

Sometimes in two parts of a ſwarm, there are more than two female Bees. In this caſe too, as ſoon as they are lodged in the hive, all are killed but one. Nature deſigns but one female for each ſwarm. But as many things may deſtroy the egg or worm of this ſingle female, it was needful, that proviſion ſhould be made for accidents. So that there are often twenty females which live to maturity with the Bees of one ſwarm. But one only is then ſpared, whether they go out with the ſwarm, or remain within.

As ſoon as the ſwarm is gone out, the firſt work of the remaining bees, is to deſtroy the young females. Theſe are all immediately killed and carried out of the hive: and it is common, the morning after the going out of a ſwarm, to ſee ſix, eight or more female bees, lying dead at ſome diſtance from the hive. What determines the bees in favour of one, is her having eggs ready to be hatched. Accordingly, if new made cells be examined, ſhe will be found the very next day, to have laid eggs in many, if not all. Whereas if the bodies of the rejected females be examined, there will be found either no eggs at all, or eggs ſo extremely minute, that it muſt have been a long time before any could have been laid.

It is not at all times, however, that the Bees are thus cruel to the ſupernumary females; but only at the time when they are newly eſtabliſhed in their habitation, and in want of all things. At other times they are as kind to ſtrange females as to their own. Mr. Reaumur tried the experiment, by putting a ſtrange female into an hive, where the combs were perfect, and filled with honey. And the bees ſhewed the ſame reſpect to her, as to their proper ſovereign.

The Bee that comes loaded to any cell, ſoon diſcharges his honey into it. No ſooner is he gone, than another comes, and ſo on, till the whole cell is filled. But that which lies uppermoſt is always of a different appearance from the reſt of the honey. It is a kind of cream, which both keeps the honey moiſt, and prevents its running out by accident.

This cruſt or cream was not, as one would think, voided laſt, but was gathering from the firſt. For the Bee which comes loaded to the cell, does not at once diſcharge his honey, but entering into it as deep as may be, thruſts out his fore-legs, and pierces an hole through the cruſt. Keeping this open with his feet, he diſgorges the honey in large drops from his mouth. He then cloſes the hole, and this is regularly done by every bee that contributes to the common ſtore.

But every bee that comes loaded to the hive, does not depoſit his honey in the cell. They often diſpoſe of it by the way. Inſtead of going to any cell, they often go to thoſe that are at work, and call them to feed upon the honey they have brought, that they may not be obliged to intermit their work, on the account of hunger. Theſe feed on the ſtore of the friendly Bee, by putting their trunk

into

into her mouth, exactly in the ſame manner as they do into the bottom of flowers.

Some cells in every hive contain honey for immediate conſumption, as in caſe of bad weather. And theſe are always open at the top. Others contain their proviſion for the winter. Theſe are all cloſed down with a ſtrong lid, not eaſily to be removed. Such is the wiſdom which the great Author of Nature has imparted to ſome of the moſt inconſiderable of his creatures.

24. The kind of ſea-ſhrubs, as they are formerly accounted, uſually termed Corallines, are in reality no other than caſes for various ſpecies of Inſects. A French Gentleman was the firſt who diſcovered this. Obſerving a great number of Inſects lodged in ſeveral parts of theſe marine productions, he ſoon inferred, that theſe were only caſes made by theſe creatures for their habitations: and many of them have ſince been found to be the covers of marine Polypus: a ſtrange kind of animal, ſo nearly partaking the nature of ſome vegetables, that new, perfect Polypus, perpetually grow like branches from the trunk of the parent. Yea, if a Polypus be cut in pieces, every piece will grow into a perfect Polypus.

A late writer informs us, "At the iſle of Sheppey, I had the opportunity of ſeeing ſeveral branched Corallines, alive in ſea-water, by the help of a commodious microſcope, and was fully aſſured, that theſe apparent plants were real animals, in their proper caſes, which were fixt to the ſhells of oyſters and other ſmall ſhell-fiſh. And at Brighthelmſtone, I ſaw thoſe Corallines in motion, whoſe Polypus are contained in cups ſupported by a long ſtem that appears full of rings, or twifted in form of a fcrew. In the middle of the tranfparent ftems or cafes, I could eafily difcern the thread like a tender part of the animals. On feveral parts of thefe Corallines there are little bodies, which through the microfcope appear as fo many bladders. To the ufe of thefe I was quite a ftranger before: but I now difcovered, they are habitations of young Polypes, which are produced here and there on the fides of the parent, as in the frefh-water Polypus: only in the marine ones they are protected by this veficular covering. Thefe veficles appear at a certain feafon of the year, according to the different fpecies of Corallines, and fall off, like the bloffoms of plants, as foon as the Polypus arrive at maturity.

But Corallines are cafes not of Polypes only, but of various forts of animals: which occafions their being made of various materials, and in great variety of forms. Some are united clofely and compactly together, forming irregular branches, like trees. Others rife in tufts, like the tubular fort of plants, diftinct from one another. Some Maltefe Corallines are of a peculiar kind. The animals inclofed in thefe, refemble the many-legged fpiders, ufually known by the name of Scolopendræ. Their outfide coats are formed of an afh-coloured earthy matter, and clofely united to an inner coat, which is tough, horny, tranfparent, and extremely fmooth. The cavity of the tube is quite round, though the animal is of a long figure, like a leech extended. It can turn itfelf in this tube, and move up and down the better to attack and fecure its prey.

It has two remarkable arms. The left much larger than the right. Thefe are doubly feathered. The

The number of its feet on each ſide of the body exceeds an hundred and fifty.

As barnacles ſeem to be a medium between birds and fiſhes, although they more properly belong to the former, ſo is a Polypus, (although it is doubtleſs an animal, between animals and plants.

In a Polypus, life is preſerved, after it is cut into ſeveral pieces, ſo that one Animal is by ſection immediately divided into two, three, or more compleat animals, each enjoying life and continuing to perform the proper offices of its ſpecies.

The common operations both of the animal and vegetable world, are all in themſelves aſtoniſhing. Nothing but daily experience makes us ſee without amazement, an animal bring forth young, or a tree bear leaves and fruit. The ſame experience makes it familiar to us, that vegetables are propagated not only from the ſeed, but from cuttings. So the willow-twig cut off, and only ſtuck in the ground, preſently takes root, and is as perfect a tree as that whence it is taken. This is common in the vegetable kingdom, and we have a rare example of it in the animal.

The Polypus is an aquatic animal, to be found in ditch-water. It is very ſlender, and has on the fore part ſeveral horns, which ſerve it for legs and arms. Between theſe is the mouth; it opens into the ſtomach, which takes up the whole length of the body: indeed the whole body is but one pipe, a ſort of gut which opens at both ends.

The common Polypus is about three quarters of an inch long: but there are many ſpecies of them: ſome of which can extend themſelves to the length of ſix or ſeven inches. Even in the ſame ſpecies, the number of legs and arms is not always the ſame: but they have ſeldom fewer than ſix. Both the body and arms may be inflated all manner of ways, and hence it is, that they put themſelves into ſo great a variety of figures.

They do not ſwim, but crawl on the ground, or on any body they meet with in the waters. They uſually fix their poſterior end to ſomething, and ſtretch their bodies, and arms into the water. With theſe arms they catch numberleſs inſects, which are ſwimming up and down. A Polypus, having ſeized its prey, uſes one or more arms to bring it to his mouth. He can maſter a worm thrice as long as himſelf, which he ſwallows whole; and having drawn all that is nutritive from it, then throws out the ſkin.

" I have cut a Polypus in two, between ſeven and eight in the morning, and before three in the afternoon, each part was a compleat animal, able to eat a worm as long as itſelf. If a Polypus be cut lengthways, beginning at the head, but not quite to the tail, there is a Polypus with two heads, two bodies, and one tail. Some of theſe heads and bodies may ſoon be cut lengthways again. Thus I have produced a Polypus with ſeven heads, ſeven bodies and one tail. I cut off the heads of this new hydra, ſeven others grew up, and each of theſe cut off became a Polypus.

" I cut a Polypus croſs-ways into two parts; put them together again, and they re-united. I put the poſterior part of one, to the anterior of another, they ſoon united into one Polypus, which ate the next day, and ſoon put forth young ones, from each part.

" As the body of a Polypus is but one gut, I have turned it inſide out. The inſide ſoon after became

became the outſide, and it fed and multiplied as before. They do not copulate at all; but each Polypus has the faculty of multiplying itſelf: yea, before it is ſevered from its parent. I have ſeen a Polypus while growing out of the ſide of its parent, bring forth young ones: nay, and thoſe young ones themſelves have alſo brought forth others."

Cut a Polypus acroſs, and the ſame day the anterior end lengthens itſelf, creeps and eats. The lower part which has no head, gets one, forms itſelf a mouth, and puts forth arms. It is all one, in whatever part the body is cut; cut it into three or four parts, and each becomes a compleat Polypus.

Cut one lengthways, ſlitting it quite in two, ſo as to form two half pipes. It is not long before the two ſides of them cloſe, they begin at the poſterior part, and cloſe upward, till each half pipe becomes a whole one. All this is done in leſs than an hour, and the Polypus produced from each of thoſe halves, differs nothing from the firſt, only it has fewer arms. But theſe too are ſoon ſupplied!

But as ſtrange animals as all Polypus are, the Cluſtering Polypus are more ſtrange than the reſt. One ſpecies of theſe are of a bell-like form. Their anterior part, in which is their mouth, is hollowed inward, and reſembles the open end of a bell. Their other extremity ends in a point, to which is fixt a ſtalk or pedicle. The Polypus when it is ready to divide, firſt draws in its lips into the cavity: it then by degrees grows round, and preſently after divides itſelf into two other round bodies. Theſe in a few moments open, loſe their ſpherical form, and put on that of a bell, or compleat Polypus. This is the manner in which Clustering Polypi are multiplied. The whole operation is performed in three quarters of an hour. The cluster which they form, rests upon a stem, which is fixt to some other body at its lower extremity, and from it arise other branches: other branches again shoot out from these in different places; from these last other new ones, and so on. At the extremity of each branch, is a Polypus. The assemblage of all these branches with the Polypi at their extremities, form a cluster much resembling a tuft of flowers. The stem which carries all the cluster, is capable of a remarkable motion, each branch contracts when it is touched: each can contract itself alone, though this seldom happens, for in contracting it commonly touches another, which then immediately contracts with it. When the main stem which bears the whole cluster contracts, all the branches contract together, and the whole becomes entirely closed. A moment after, the branches and the stem again extend themselves, and the whole cluster recovers its ordinary figure. A cluster is formed thus: a single Polypus detaching from the cluster, swims about in the water, till it meets with some proper body, to fix itself upon. It then has a pedicle, but which is no longer than the Polypus itself; but it becomes eight or nine times as long in four and twenty hours, and is to be the main stem of the new cluster. In a day after it is fixt, it divides itself into two, each of which in a few hours divides into two more. These soon after put out branches, and all this is re-iterated several times. Thus a principal branch is formed, provided with several lateral ones, which afterwards

wards become principal ones, with regard to others that ſpring from them.

When a cluſter is nearly ſtript of its Polypi, the branches are no longer able to contract. When but a few Polypi remain, none can contract but thoſe to which they are fixed. Hence it appears, that this motion in the ſtem and branches of a cluſter, is entirely derived from the Polypi. Indeed at firſt ſight one would imagine, that the Polypi fixed to the branches of a cluſter, ſpring from them, in the ſame manner as the leaves, the flowers and the fruit of a vegetable ſpring from it. On the contrary the branches compoſing the cluſters of Polypi, ſpring from the Polypi, which are at their extremities, and theſe Polypi, which at firſt appear to be fruits, may rather be termed the roots of them.

The nature of Corallines, and the mechaniſm of their Polypi, (ſays Dr. Peyſſonel) made me conjecture, that it was the ſame with reſpect to Sponges; that animals neſted in the inteſtices of their fibres, and gave them their origin and growth: but I had not yet ſeen the inſects. Sponges appeared to me only as ſkeletons, and I at length diſcovered the worms which form them. They are of four ſpecies. 1. The tube-like Sponge. 2. The cord-like Sponge. 3. The fingered Sponge. 4. The honey-comb Sponge.

Theſe four kinds only differ in form; they have the ſame qualities, and are made by the ſame kinds of worm; they are all compoſed of hard firm, dirty fibres, ſometimes brittle, ſeparated one from another, having large hollow tubes diſperſed through their ſubſtance: theſe tubes are ſmooth within. Theſe fibres, which conſiſt of the twiſted doubles of the Sponge, form as it were a labyrinth filled with worms, which are eafily crufhed: but having carefully torn the Sponges, and their grofs fibres, I difcovered the living worms.

Thefe fpecies of Sponge commonly grow upon fandy bottoms. At their origins we perceive a nodule of fand, or other matter, almoft petrified, round which the worms begin to work, and round which they retire, as to their laft refuge, where I had the pleafure of feeing them play, exercife themfelves, and retire, by examining them with the microfcope.

The worms are about one third of a line thick, and two or three lines in length. They are fo tranfparent that one may difcern their vifcera through their fubftance, and the blood may be feen to circulate. They have a fmall black head, furnifhed with two pincers; the other extremity is almoft fquare, and much larger than the head. Upon the back may be feen two white ftreaks, as if they contained the chyle: thefe two canals are parallel to each other from the head to the other extremity, where they come together, In the middle, where the belly and vifcera ought to be placed, a blackifh matter is perceivable, which has a kind of circulation; fometimes it fills all the body of the worm, fometimes it gathers towards the head, or at the other end, and fometimes it follows the motion of the animal. This vermicular motion begins at the pofterior extremity, and ends at the head. They have no particular lodge, they walk indifferently into the tubular labyrinth. Thefe Sponges are attached to fome folid body in the fea. Some kinds are fixed to rocks, others to heaps of fand, or to pieces of petrified matter: and the fea putting in motion the fand, and the little parcels of broken fhells, forces them into the holes of the Sponge.

So

So far the Doctor. But ſtill I doubt, whether the worms form the Sponge, or only lodge therein (though I think, the former more probable.)

The ſame doubt I have with regard to what follows, "The Belemnites is a foſſile, a kind of ſtony ſhell, which has hitherto perplexed the naturaliſts of all countries. Strait ones are common in Sweden, Livonia and Germany, thoſe that are curved are more common in France and England. The Nucleus of it ſeems to be a ſtrait concamerated ſhell, which is ſurrounded by a huge ſolid ſubſtance. Now how was this formed? And how is it that ſome have a nucleus, others not? Again, how is it that in ſome, the cavities containing it, are very ſmall, in others not viſible?

In order to underſtand this, we may conſider, that many bodies which we always took for vegetable, are really animal. So the ſeveral coralline ſubſtances, hitherto reputed marine plants, are now generally believed, to be the ſhells of Polypi. Is it not then highly probable, that the teſtaceous tribe in general are generated like flies, the latter from a maggot, the former from a Polipus? It muſt be ſo with many: and as corals in general ſeem to be conſtructed by Polipi, are they not the primary ſtate of all, or moſt of the teſtaceous tribe? If ſo, it is almoſt beyond a conjecture, that the body called a Belemnites, (which on being put into acids is found to ferment in like manner as corals) is formed likewiſe by a Polypus, from which the nucleus ſeems to be the laſt ſtate. And does not this concamerated body, of which the belemnites is only the habitation, lead us into the connection and manner of generation (perhaps particular to the teſtaceous tribe) by remaining within its nidus all its life, whereas the generality quit their nidi as ſoon as they are able to ſhift for themſelves.

The Polypus is an animal of the vermicular kind; the bodies of ſome are long and ſlender, like a fine fibre, extremely tender, and from the head proceed a variety of claws or arms, with which it catches its food, and prepares its habitation. They are of various ſhapes and textures; according to the ſpecies of the animal that is to proceed from them, and very wonderful it is, how ſo ſmall an animal ſhould form ſo large a body as the Belemnites! Some animals in the terreſtial parts of the creation, naturally aſſociate together, others ſeek ſolitude. The ſame diſpoſitions we find in the aquatic, then why not among the Polypi? Is not this evidently ſeen from the variety of coral bodies? It ſeems in ſome as if thouſands acted in concert together; in others each acts for itſelf; of which latter is the Belemnites. The ſhape of the Belemnites is generally conic, terminating in a point, and of various colours, according to the juices of the Stratum in which it lay; it has uſually a ſeam running down the whole length of it. Its interior conſtitution ſeems compoſed of ſeveral cruſts, which when broken tranſverſely proceed on rays from the ſeam to the centre. This ſeam I take to have been the habitation of the animal in its Polypi ſtate, and in which the body was affixed. The animals of the teſtaceous tribe in general, as they increaſe in age, increaſe their ſhells in thickneſs, until they have lived their ſtated time, and that is done by adding a new cruſt to, as ſeveral, if not all the tubuli; the oyſters, and the nautili, witneſs. By length of time they grow inactive and dead, the effect

effect of extreme old age suffering other marine bodies, as worms and oysters, to affix themselves to their outer coat. The like appearance we frequently meet with on Belemnitæ, when the animal within was either waxed old, or dead.

One might enlarge upon the analogies which may be found, between the origin of these minute animals, the origin of plants, and that of those other animals, which we are more acquainted with. But we shall be better able to judge of those analogies, when we come to know more both of plants and animals.

The surprizing facts which the study of natural history lays before us day by day, may convince us, that the nature of plants and animals, is as yet but very imperfectly known: indeed much more imperfectly, than many have been apt to imagine. All we know is very little, in comparison of what remains unknown. And this consideration, as it should prompt us, still more diligently to enquire after truth, so it should make us exceeding cautious how we judge of the nature of things from so few principles as we are at present masters of.

25. One circumstance more is worthy our observation, with regard not only to insects, but in some measure to the whole animal creation, namely the various Transformations they undergo. Those kinds of animals which are viviparous, which produce their young alive, undergo the slightest alteration; yet even these have some. Growth itself is the lowest step of this ladder: and this is common to all animals. Man himself, lordly as he is, at his perfect growth, is not only the most helpless

helplefs at his birth, but continues fo longer than any other member of the animal world. However, except that of growth, he undergoes no confiderable alteration in this life.

Quadrupeds undergo a greater change yearly, by the lofs and renovation of their outward covering. This change however is gradual, and almoft infenfible, the latter being of the fame fubftance, and even colour as the former. But there is an exception to this, in thofe which undergo this change twice in the year, as do the bears, hares, and foxes in Greenland and other extremely cold countries: and the ermins, which are frequent in Yorkfhire, and feveral other parts of England, their hair changes white at the approach of winter, and in fpring refumes its former colour.

One clafs however of viviparous animals undergo a more fudden alteration, namely, the ferpent kind. Thefe having no hair or fur to lofe gradually, caft their whole covering at once, and are fo dexterous therein, though they have neither feet nor claws, that their whole fkins are frequently found entire, without even the cornea or outward cafe of the eyes, which accompanies the other exuviæ, being broken.

Next to thefe are the oviparous animals. Thefe make their firft appearance in a ftate of entire inaction, but being gradually ripened by natural or artificial heat, burft out, fome in their compleat ftate, as lizards, fpiders, and fifh in general: and others, as birds, requiring like viviparous animals, the addition of the extrementious parts. Almoft all the fpecies of thefe which we know, need the fame farther change with the viviparous. All birds moult their feathers, and many in cold countries change the colour of them in the winter. Lizards drop their fkins like fnakes; one

kind

kind of them, water newts, every two or three weeks. Spiders, crabs, and all whose outward covering is eruſtaceous, and therefore incapable of diſtenſion, caſt their ſhells once a year, at which time nature provides them with ſuch ſupplementary juices, by a kind of exudation from their pores, as form a new ſhell beneath.

Proceed we to thoſe animals, whoſe Transformations are more compleat, which being fully poſſeſt of life in one figure, afterwards aſſume another, or being firſt in one, afterwards inhabit a quite different element.

To give an inſtance of each, the egg of a frog being laid in the water, produces a lively animal which we call a Tad-pole. He has a thin ſlimy tail, which ſteers him in the water, in which he wholly reſides. But after a while, legs and feet burſt through the ſkin; the tail drops off, he is a perfect quadruped. He leaps upon the earth, and ranges over that ground, on which ſome time ſince it would have been death to him to be caſt.

The Beetle claſs is an inſtance of the other change and, particularly the cock-chaffer. The female depoſites her egg below the ſurface of the earth, which hatches into a grub, with two or three pair of ſtrong forcipes, whereby it is enabled to force its way through the mould where it was lodged, and to cut and tear in pieces for its nouriſhment any ſmall roots which come in its way. After ſtaying here two whole years, a ſhelly covering forms over its ſoft body, a pair of fine wings grow on its back, to ſecure which from danger, when not uſed, a pair of ſtrong caſes are provided. And now forcing his way out of the ground, he becomes a lively inhabitant of the air.

CHAP. VI.

General Obſervations and Reflections.

1. AS to the number of animals, the ſpecies of beaſts, including alſo ſerpents, are not very numerous. Such as are certainly known and clearly deſcribed, are not above an hundred and fifty. And yet probably not many that are of any conſiderable bigneſs, have eſcaped the notice of the curious.

The ſpecies of birds, known and deſcribed, are near five hundred, and the ſpecies of fiſhes, ſecluding ſhell-fiſh, as many: but if the ſhell-fiſh are taken in, above ſix times the number. How many of each genus remain undiſcovered, we cannot very nearly conjecture. But we may ſuppoſe, the whole ſum of beaſts and birds to exceed by a third part, and fiſhes by one half, thoſe that are known.

The inſects, taking in the exſanguious, both terreſtrial and aquatic, may for number vie even with plants themſelves. The exanguious alone, by what Dr. Liſter has obſerved and delineated, we may conjecture cannot be leſs (if not many more) than three thouſand ſpecies. Indeed this computation ſeems to be much too low: for if there are a thouſand ſpecies in this iſland and the ſea near it; and if the ſame proportion hold between the inſects native of England, and thoſe of the reſt

reſt of the world (about a tenth:) the ſpecies of inſects on the whole globe, will amount to ten thouſand.

Now if the number of creatures even in this lower world, be ſo exceeding great: how great, how immenſe muſt be the power and wiſdom of Him that formed them all! For as it argues far more ſkill in an artificer, to be able to frame both clocks and watches and pumps and many other ſorts of machines, than he could diſplay in making but one of thoſe ſorts of engines: ſo the Almighty declares more of his wiſdom, in forming ſuch a multitude of different ſorts of creatures, and all with admirable and unreproveable art, than if he had created but a few.

2. Again, The ſame ſuperiority of knowledge would be diſplayed, by contriving engines for the ſame purpoſes after different faſhions, as the moving clocks or other engines by ſprings inſtead of weights: and the infinitely wiſe Creator, has ſhewn by many inſtances, that he is not confined to one only inſtrument, for the working one effect, but can perform the ſame thing by divers means. So though moſt flying creatures have feathers, yet hath he enabled ſeveral to fly without them, as the bat, one ſort of lizard, two ſorts of fiſhes, and numberleſs ſorts of inſects. In like manner, although the air-bladder in fiſhes ſeems neceſſary for ſwimming: yet are many ſo formed as to ſwim without it, as firſt, the Cartilaginous kind, which nevertheleſs aſcend and deſcend at pleaſure, although by what means we cannot tell, Secondly, The Cetaceous kind: the

air

air which they receive into their lungs, in ſome meaſure anſwering the ſame end.

Yet again. Though God has tempered the blood and bodies of moſt fiſhes to their cold element, yet to ſhew he can preſerve a creatureas hot as beaſts themſelves in the coldeſt water, he has placed a variety of theſe cetaceous fiſhes in the northermoſt ſeas. And the copious fat wherewith their bodies is incloſed, by reflecting the internal heat, and keeping off the external cold, keeps them warm even in the neighbourhood of the pole.

Another proof that God can by different means produce the ſame effect, is the various ways of extracting the nutritious juice out of the aliment in various creatures.

In Man and Beaſts the food firſt chewed, is received into the ſtomach, where it is concocted and reduced into chyle, and ſo evacuated into the inteſtines, where being mixed with the choler and pancreate juice, it is farther ſubtilized, and rendered ſo fluid, that its finer parts eaſily enter the mouth of the lacteal veins.

In Birds there is no chewing : but in ſuch as are not carnivorous, it is immediately ſwallowed into the crop, or anti-ſtomach (which is obſerved in many, eſpecially piſcivorous birds) where it is moiſtened by ſome proper juice, and then transferred to the gizzard, by the working of whoſe muſcles, aſſiſted by ſmall pebbles, which they ſwallow for that purpoſe, it is ground ſmall, and ſo tranſmitted to the inteſtines.

In oviparous Reptiles, and all kind of Serpents, there is neither chewing nor comminution in the ſtomach, but as they ſwallow animals whole, ſo they void the ſkins unbroken, having extracted the nutritious juices. Here, by the by, we may obſerve

obſerve the wonderful dilatability of the throats and gullets of ſerpents. Two entire adult mice have been taken out of the ſtomach of an adder, whoſe neck was no bigger than one's little finger.

Fiſhes, which neither chew, nor grind their meat, do, by means of a corroſive juice in their ſtomach, reduce ſkin, bones, and all into chyle. And yet this juice ſhews no acidity to the taſte. But how mild ſoever it taſtes, it corrodes all animal ſubſtances, as aqu-afortis does iron.

3. Several eminent men have been of opinion, that all brutes are mere machines. This may be agreeable enough to the pride of man; but it is not agreeable to daily obſervation. Do we not continually obſerve in the brutes which are round about us, a degree of reaſon? Many of their actions cannot be accounted for without it: as that commonly noted of dogs, that running before their maſters, they will ſtop at the parting of the road, till they ſee which way their maſters take. And when they have gotten what they fear will be taken from them, they run away and hide it. Nay, what account can be given, why a dog being to leap on a table, which he ſees he cannot reach at once, if a ſtool or chair ſtands near it, firſt mounts that, and thence proceeds to the table? If he were mere clock-work, and his motion cauſed by a material ſpring, that ſpring being once ſet to work, would carry the machine in a right line, towards the object that put it in motion.

Were it true, that brutes were mere machines, they could have no perception of pleaſure or pain. But how contrary is this, to the doleful ſignifications

ſignifications they give, when beaten or tormented? How contrary to the common ſenſe of mankind? For do we not all naturally pity them, apprehending them to feel pain juſt as we do? Whereas no man is troubled to ſee a plant torn, or cut, or mangled how you pleaſe. And how contrary to ſcripture? *A righteous man regardeth the life of his beaſt: but the tender mercies of the wicked are cruel.* Prov. xii. 10. The former clauſe is uſually rendered, *A good man is merciful to his beaſt.* And this is the true rendering, as appears by the oppoſite clauſe, That *the wicked is cruel.* Cruelty then may be exerciſed toward beaſts. But this could not be, were they mere machines.

4. The Natural Inſtinct of all creatures, and the ſpecial proviſion made for ſome of the moſt helpleſs, do in a particular manner demonſtrate the great Creator's care.

Firſt, What an admirable principle is the natural affection of all creatures toward their young! By means of this, with what care do they nurſe them up, thinking no pains too great to be taken for them, no danger too great to be ventured upon, for their guard and ſecurity! How will they careſs them with their affectionate notes, put food into their mouths, ſuckle them, cheriſh and keep them warm, teach them to pick and eat, and gather food for themſelves: and in a word, perform the whole part of ſo many nurſes, deputed by the ſovereign Lord of the world, to help ſuch young and ſhiftleſs creatures till they are able to ſhift for themſelves.

Other

Other animals, insects in particular, whose offspring is too numerous for the parent's provision, are so generated, as to need none of their care. For they arrive immediately at their perfect state, and so are able to shift for themselves. Yet thus far the parental instinct, (equal to the most rational fore-sight) extends, that they do not drop their eggs any where, but in commodious places, suitable to their species. And some include in their nests, sufficient and agreeable food, to serve their young till they come to maturity.

And for the young themselves. As the parent is not able to carry them about, to cloath them and dandle them, as Man doth: how admirably is it contrived, that they can soon walk about, and begin to shift for themselves! How naturally, do they hunt for their teat, suck, pick and take in their proper food!

On the other hand, the young of man, (as their parent's reason is sufficient, to help, to nurse, feed and cloath them) are born utterly helpless, and are more absolutely than any creature, cast upon their parent's care.

Secondly, What admirable provision is made for some of the most helpless creatures, at a time when they must otherwise utterly perish! The winter is an improper season to afford food to insects and many other animals. When the fields, trees, and plants are naked, and the air is chilled with frost; what would become of such animals, whose tender bodies are impatient of cold, and who are nourished only by the produce of the spring or summer? To prevent their total destruction, the Wise Preserver of the world has so ordered, that in the first place, those which are im-

patient

patient of cold, ſhould have ſuch a peculiar ſtructure of body, as during that ſeaſon, not to ſuffer any waſte, nor conſequently need any recruit. Hence many ſorts of birds, and almoſt all inſects, paſs the whole winter without any food. And moſt of them without any reſpiration. It ſeems all motion of the animal juices is extinct. For though cut in pieces they do not awake, nor does any fluid ooze out at the wound. This ſleep therefore is little leſs than death, and their waking, than a reſurrection: when the returning ſun revives them and their food together.

The next proviſion is for ſuch creatures as can bear the cold, but would want food. This is provided againſt in ſome, by a long patience of hunger, in others by their wonderful inſtinct, in laying up food before hand, againſt the approaching winter. By ſome of theſe, their little treaſuries are at the proper ſeaſon well ſtocked with proviſions. Yea, whole fields are here and there beſpread with the fruits of the neighbouring trees laid carefully up in the earth, and covered ſafe by provident little animals.

5. And what a prodigious act is it of the Creator's indulgence to the poor, ſhiftleſs irrationals, that they are already furniſhed with ſuch cloathing, as is proper to their place and buſineſs! With hair, with feathers, with ſhells, or with firm armeture, all nicely accommodated, as well to the element wherein they live, as to their ſeveral occaſions there. To beaſts, hair is a commodious cloathing; which together with the apt texture of their ſkin, fits them in all weathers to lie on the ground, and to do their ſervice to man. The thick and warm fleeces of others,

are

are a good defence againſt the cold and wet, and alſo a ſoft bed: yea, and to many a comfortable covering for their tender young.

All the animals near Hudſon's-Bay, are cloathed with a cloſe, ſoft, warm fur. But what is ſtill more ſurprizing, and what draws all attentive minds to admire the wiſdom and goodneſs of Providence, is, that the very dogs and cats which are brought thither from England, on the approach of winter change their appearance, and acquire a much longer, ſofter, and thicker coat of hair than they originally had.

And as hair is a commodious dreſs for beaſts, ſo are feathers for birds. They are not only a good guard againſt wet and cold, but nicely placed every where on the body, to give them aneaſy paſſage through the air, and to waft them through that thin medium. How curious is their texture for lightneſs, and withal cloſe and firm for ſtrength! And where it is neceſſary they ſhould be filled, what a light, medullary ſubſtance are they filled with? So that even the ſtrongeſt parts, far from being a load to the body, rather help to make it light and buoyant. And how curiouſly are the vanes of the feathers wrought, with capillary filaments, neatly interwoven together, whereby they are ſufficiently cloſe and ſtrong, both to guard the body againſt the injuries of the weather, and to impower the wings, like ſo many ſails, to make ſtrong impulſes on the air in their flight.

No leſs curious is the cloathing of Reptiles. How well adapted are the rings of ſome, and the contortions of the ſkin of others, not only to fence the body ſufficiently, but to enable them to creep, to perforate the earth, and to perform all

all the offices of their ſtate, better than any other covering?

Obſerve, for inſtance, the tegument of the Earth-worms, made in the compleateſt manner, for making their paſſage through the earth, where-ever their occaſions lead them. Their body is made throughout of ſmall rings, which have a curious apparatus of muſcles, that enable them with great ſtrength to dilate, extend, or contract their whole body. Each ring is likewiſe armed with ſtiff, ſharp prickles, which they can open at pleaſure, or ſhut cloſe to their body. Laſtly, under their ſkin there is a ſlimy juice, which they emit as occaſion requires, to lubricate the body, and facilitate their paſſage into the earth. By all theſe means they are enabled, with eaſe and ſpeed, to work themſelves into the earth, which they could not do, were they covered with hair, feathers, ſcales, or ſuch cloathing as any of the other creatures.

How wiſely likewiſe are the inhabitants of the waters cloathed! The ſhells of ſome Fiſhes, are a ſtrong guard to their tender bodies, and conſiſtent enough with their ſlow motion: while the ſcales and fins of others afford them an eaſy and ſwift paſſage through the waters.

6. Admirable likewiſe is the ſagacity of brute-animals, in the conveniency and method of their habitations. Their architectonic ſkill herein, exceeds all the ſkill of man. With what inimitable art do ſome of theſe poor, untaught creatures, lay a parcel of rude ugly ſticks or ſtraws together! with what curioſity do they line them within, yea, wind and place every hair, feather, or lock of wool, to guard and keep warm the tender bodies, both

both of themſelves and their young? And with what art do they thatch over and coat their neſts without, to deceive the eye of the ſpectators, as well as to guard and fence them againſt the injuries of the weather?

Even Inſects, thoſe little, weak, tender creatures, what artiſts are they in building their habitations? How does the bee gather its comb from various flowers, the waſp from ſolid timber? With what accuracy do other inſects perforate the earth, wood, yea, ſtone itſelf? Farther yet, with what care and neatneſs do moſt of them line their houſes within, and ſeal them up and fence them without? How artificially do others fold up the leaves of trees; others glue light bodies together, and make floating houſes, to tranſport themſelves to and fro, as their various occaſions require!

7. Another inſtance of the wiſdom of him that made and governs the world, we have in the balance of creatures. The whole ſurface of the terraqueous globe, can afford room and ſupport, to no more than a determinate number of all ſorts of creatures. And if they ſhould increaſe to double or treble the number, they muſt ſtarve or devour one another. To keep the balance even, the great author of nature has determined the life of all creatures to ſuch a length, and their increaſe to ſuch a number, proportioned to their uſe in the world. The life indeed of ſome hurtful creatures is long; of the lion in particular. But then their increaſe is exceeding ſmall: and by that means they do not overſtock the world. On the other hand, where the increaſe is great, the lives of thoſe creatures are generally ſhort. And beſide this, they are of great uſe to man, either for food,

 or

or on other occaſions. This indeed ſhould be particularly obſerved, as a ſignal inſtance of divine providence, that uſeful creatures are produced in great plenty: others in ſmaller numbers. The prodigious increaſe of inſects, both in and out of the waters may exemplify the former obſervation. For innumerable creatures feed upon them, and would periſh, were it not for this ſupply. And the latter is confirmed by what many have remarked: that creatures of little uſe, or by their voraciouſneſs, pernicious, either ſeldom bring forth, or have but one or two at a birth.

8. How remarkable is the deſtruction and reparation of the whole animal creation? The ſurface of the earth is the inexhauſtible ſource whence both man and beaſt derive their ſubſiſtance. Whatever lives, lives on what vegetates, and vegetables in their turn, live, on whatever has lived or vegetated: it is impoſſible for any thing to live, without deſtroying ſomething elſe. It is thus only that animals can ſubſiſt themſelves, and propagate their ſpecies,

God in creating the firſt individual of each ſpecies, animal or vegetable, not only gave a form to the duſt of the earth, but a principle of life, incloſing in each, a greater or ſmaller quantity of organical particles, indeſtructible and common to all organized beings. Theſe paſs from body to body, ſupporting the life, and miniſtring to the nutrition and growth of each. And when any body is reduced to aſhes, theſe organical particles, on which death hath no power, ſurvive and paſs into other beings, bringing with them nouriſhment and life. Thus every production, every renovation,

renovation, every increase by generation or nutrition, suppose a preceding destruction, a conversion of substance, an accession of these organical particles, which ever subsisting in an equal number, render nature always equally full of life.

The total quantity of life in the universe is therefore perpetually the same. And whatever death seems to destroy, it destroys no part of that primitive life, which is diffused through all organized beings. Instead of injuring nature, it only causes it to shine with the greater lustre. If death is permitted to cut down individuals, it is only, in order to make of the universe, by the re-production of beings, a theatre ever crouded, a spectacle ever new. But it is never permitted to destroy the most inconsiderable species.

That beings may succeed each other, it is necessary that there be a destruction among them. Yet like a provident mother, nature in the midst of her inexhaustible abundance, has prevented any waste, by the few species of carnivorous animals, and the few individuals of each species; multiplying at the same time both the species and individuals of those that feed on herbage. In vegetables she seems to be profuse, both with regard to the number and fertility of the species.

In the sea indeed all the species are carnivorous. But though they are perpetually preying upon, they never destroy each other, because their fruitfulness is equal to their depredations.

"Thus thro' successive ages stands
Firm fixt thy providential care!
Pleas'd with the works of thine own hands
Thou dost the wastes of Time repair."

9. I add

9. I add a few more reflections on the world in general. The same wise Being, who was pleased to make man, prepared for him also an habitation so advantageously placed, that the heavens and the rest of the universe might serve it both as an ornament and a covering. He constructed likewise the air which man was to breathe, and the fire which was to sustain his life. He prepared also metals, salts, and all terrestrial elements to renew and maintain throughout all ages, whatever might be on any account necessary for the inhabitants of the earth.

The same Divine Ruler is manifest in all the objects that compose the universe. It is he that caused the dry-land to appear, above the surface of the ocean, that guaged the capacity of that amazing reservoir, and proportioned it to the fluid it contains. He collects the rising vapours, and causes them to distil in gentle showers. At his command the sun darts his enlivening rays, and the winds scatter the noxious effluvia, which if they were collected together might destroy the human race.

He formed those hills and lofty mountains which receive and retain the water within their bowels, in order to distribute it with œconomy to the inhabitants of the plains, and to give i such an impulse, as might enable it to overcome the unevenness of the lands, and convey it to the remotest habitations.

He spread under the plains beds of clay, or compact earths, there to stop the waters, which after a great rain, make their way through innumerable little passages. These sheets of water frequently remain in a level with the neighbour-ing

ing rivers, and fill our wells with their redundancy, or as those subside, flow into them again.

He proportioned the variety of plants in each country, to the exigencies of the inhabitants, and adapted the variety of the soils, to the nature of those plants.

He endued numerous animals with mild dispositions, to make them the domestics of man: and taught the other animals to govern themselves, with an aversion to dependence, in order to continue their species without loading man with too many cares.

If we more nearly survey the animal and vegetable world, we find all animals and plants, have a certain and determined form, which is invariably the same. So that if a monster ever appear, it cannot propagate its kind, and introduce a new species into the universe. Great indeed is the variety of organized bodies. But their number is limited. Nor is it possible to add a new genus either of plants or animals, to those of which God has created the germina, and determined the form.

The same Almighty power has created a precise number of simple elements, essentially different from each other, and invariably the same. By these he varies the scene of the universe, and at the same prevents its destruction, by the very immutability of the nature and number of these elements. So that the world is for ever changed, and yet eternally the same.

Yet if we would account for the origin of these elements, we are involved in endless uncertainty. We can only say, he who has appointed their different uses in all ages, has rendered those uſes infallible, by the impoſſibility of either deſtroying or increaſing them.

Herein we read the characters of his power, which is invariably obeyed; of his wiſdom, which has abundantly provided for every thing; and of his tender kindneſs toward man, for whom he has provided ſervices equally various and infallible. It is an additional proof of his continual care of his creatures, that though every thing be compoſed of ſimple elements, all placed within our reach, yet no power is able to deſtroy the leaſt particle of them. Nothing but the ſame cauſe which was able to give them birth, can annihilate them, or change their nature. In truth, the deſign and will of the Creator, is the only phyſical cauſe of the general œconomy of the world: the only phyſical cauſe of every organized body, every germen that flouriſhes in it; the only phyſical cauſe of every minute, elementary particle, which enters into the compoſition of all.

We muſt not then expect ever to have clear and full conception of effects, natures, and cauſes. For where is the thing which we can fully conceive? We can no more comprehend either what body in general is, or any particular body, ſuppoſe a maſs of clay, or a ball of lead, than what a ſpirit, or what God is.

If we turn our eyes to the minuteſt parts of animal life, we ſhall be loſt in aſtoniſhment! And though every thing is alike eaſy to the Almighty, yet to us it is matter of the higheſt wonder, that in thoſe ſpecks of life, we find a greater number of members to be put in motion, more wheels and pullies to be kept going, and a greater variety of machinery, more elegance and workmanſhip (ſo to ſpeak) in the compoſition, more beauty and ornament in the finiſhing, than are ſeen in the enormous

enormous bulk of the crocodile, the elephant, or the whale. Yea, they seem to be the effects of an art, as much more exquisite as the movements of a watch are, than those of a coach or waggon.

Hence we learn, That an atom to God is as a world, and a world but as an atom: just as to him, one day is as a thousand years; and a thousand years but as one day. Every species likewise of these animalculæ may serve to correct our pride, and shew how inadequate our notions are, to the real nature of things. How extremely little can we possibly know, either of the largest or smallest part of the creation? We are furnished with organs capable of discerning, to a certain degree, of great or little only. All beyond is as far beyond the reach of our conceptions, as if it had never existed.

Proofs of a wise, a good and powerful being are indeed deducible from every thing around us: but the extremely great and the extremely small, seem to furnish us with those that are most convincing. And perhaps, if duly considered, the fabric of a world, and the fabric of a mite, may be found equally striking and conclusive.

Glasses discover to us numberless kinds of living creatures, quite indiscernable to the naked eye. And how many thousand kinds may there be, gradually decreasing in size, which we cannot see by any help whatever? Yet to all these we must believe God has not only appointed the most wise means for preservation and propagation but has adorned them with beauty equal at least to any thing our eyes have seen.

In short, the world around us is the mighty volume wherein God hath declared himself. Human languages and characters are different in different nations. And those of one nation are not understood by the rest. But the book of nature is written in an universal character, which every man may read in his own language. It consists not of words, but things, which picture out the Divine perfections. The firmament every where expanded, with all its starry host, declares the immensity and magnificence, the power and wisdom of its Creator. Thunder, lightning, storms, earthquakes and volcanos, shew the terror of his wrath. Seasonable rains, sun-shine and harvest, denote his bounty and goodness, and demonstrates how he opens his hand, and fills all living things with plenteousness. The constantly succeeding generations of plants and animals, imply the eternity of their first cause. Life subsisting in millions of different forms, shews the vast diffusion of this animating power, and death the infinite disproportion between him and every living thing.

Even the actions of animals are an eloquent and a pathetic language. Those that want the help of man have a thousand engaging ways, which, like the voice of God speaking to his heart, command him to preserve and cherish them. In the mean time the motions or looks of those which might do him harm, strike him with terror, and warn him, either to fly from or arm himself against them. Thus it is, that every part of nature directs us to nature's God.

10. The reader will easily excuse my concluding this chapter also, with an extract from Mr. Harvey.

" In all the animal world, we find no tribe, no individual neglected by its Creator. Even the ignoble

ignoble creatures are most wisely circumstanced and most liberally accommodated.

They all generate in that particular season, which supplies them with a stock of provisions, sufficient not only for themselves, but for their increasing families. The sheep yean, when there is herbage to fill their udders, and create milk for their lambs. The birds hatch their young, when new-born insects swarm on every side. So that the caterer, whether it be the male or female parent, needs only to alight on the ground, or make a little excursion into the air, and find a feast ready dressed for the mouths at home.

Their love to their offspring, while they are helpless, is invincibly strong: whereas the moment they are able to shift for themselves, it vanishes as though it had never been. The hen that marches at the head of her little brood, would fly at a mastiff in their defence. Yet within a few weeks, she leaves them to the wide world, and does not even know them any more.

If the God of Israel inspired Bezaleel and Aholiah *with wisdom and knowledge in all manner of workmanship*, the God of nature has not been wanting, in his instructions to the fowls of the air. The skill with which they erect their houses, and adjust their apartments is inimitable. The caution with which they hide their abodes from the searching eye, or intruding hand, is admirable. No general, though fruitful in expedients, could build so commodious a lodgment. Give the most celebrated artificer the same materials, which these weak and unexperienced creatures use. Let a Jones or a Demoivre have only some rude stones or ugly sticks, a few bits of dirt or scraps of hair, a lock of wool, or a coarse sprig of moss: and what works could they produce?

We extol the commander, who knows how to take advantage of the ground; who by every circumſtance embarraſſes the forces of his enemy, and advances the ſucceſs of his own. Does not this praiſe belong to the feathered leaders? Who fix their penſile camp, on the dangerous branches that wave aloft in the air, or dance over the ſtream? By this means the vernal gales rock their cradle, and the murmuring waters lull the young, while both concur to terrify their enemies, and keep them at a diſtance. Some hide their little houſhold from view, amidſt the ſhelter of intangled furze. Others remove it from diſcovery, in the center of a thorny thicket. And by one ſtratagem or another they are generally as ſecure, as if they intrenched themſelves in the earth.

If the Swan has large ſweeping wings, and a copious ſtock of feathers, to ſpread over his callow young, the Wren makes up by contrivance what is wanting in her bulk. Small as ſhe is, ſhe will, be obliged to nurſe up, a very numerous iſſue. Therefore with ſurpriſing judgment ſhe deſigns, and with wonderful diligence finiſhes her neſt. It is a neat oval, bottomed and vaulted over with a regular concave: within made ſoft with down, without thatched with moſs, only a ſmall aperture left for her entrance. By this means the enlivening heat of her body is greatly increaſed during the time of incubation. And her young no ſooner burſt the ſhell, than they find themſelves ſcreened from the annoyance of the weather, and comfortably repoſed, till they gather ſtrength in the warmth of a bagnio.

Perhaps we have been accuſtomed to look upon Inſects, as ſo many rude ſcraps of creation. But if we examine them with attention, they will

appear

appear ſome of the moſt poliſhed pieces of divine workmanſhip. Many of them are decked with the richeſt finery. Their eyes are an aſſemblage of microſcopes: the common Fly, for inſtance, who ſurrounded with enemies, has neither ſtrength to reſiſt, nor a place of retreat to ſecure herſelf. For this reaſon ſhe has need to be very vigilant, and always upon her guard. But her head is ſo fixed that it cannot turn to ſee what paſſes, either behind or around her. Providence therefore has given her, not barely a retinue, but more than a legion of eyes. Inſomuch that a ſingle fly is ſuppoſed to be miſtreſs of no leſs than eight thouſand. By the help of this truly amazing apparatus, ſhe ſees on every ſide, with the utmoſt eaſe and ſpeed, though without any motion of the eye, or flexion of the neck.

The Dreſs of inſects is a veſture of reſplendent colours, ſet with an arrangement of the brighteſt gems. Their wings are the fineſt expanſion imaginable, compared to which lawn is as coarſe as ſackcloth. The caſes, which encloſe their wings, glitter with the fineſt varniſh, are ſcouped into ornamental flutings, are ſtudded with radiant ſpots, or pinked with elegant holes. Not one but is endued with weapons to ſeize their prey, and dexterity to eſcape their foe, to diſpatch the buſineſs of their ſtation, and enjoy the pleaſure of their condition.

What if the Elephant is diſtinguiſhed by his huge Proboſcis? The uſe of this is anſwered in theſe his meaner relations, by their curious feelers, remarkable, if not for their enormous ſize, yet for their ready flexion and quick ſenſibility. By theſe they explore their way in the darkeſt road: by theſe they diſcover and avoid, whatever might defile their neat apparel, or endanger their tender lives.

Every one admires the majeſtic Horſe. With how rapid career does he bound along the plain? Yet the Graſs-hopper ſprings forward with a bound abundantly more impetuous. The Ant too, in proportion to his ſize, excels him both in ſwiftneſs and ſtrength: and will climb precipices, which the moſt courageous courſer dares not attempt to ſcale. If the Snail moves more ſlowly, ſhe has however no need to go the ſame way twice over: becauſe whenever ſhe departs, wherever ſhe removes, ſhe is always at home.

The Eagle it is true, is privileged with pinions that out-ſtrip the wind. Yet neither is that poor outcaſt, the groveling Mole, diſregarded by divine providence. Becauſe ſhe is to dig her cell in the earth, her paws ſerve for a pick-axe and ſpade. Her eye is ſunk deep into its ſocket, that it may not be hurt by her rugged ſituation. And as it needs very little light, ſhe has no reaſon to complain of her dark abode. So that her ſubterranean habitation, which ſome might call a dungeon, yields her all the ſafety of a fortified caſtle, and all the delights of a decorated grot.

Even the Spider, though abhorred by man, is the care of all-ſuſtaining heaven. She is to ſupport herſelf by trepanning the wandering fly. Suitably to her employ, ſhe has bags of glutinous moiſture. From this ſhe ſpins a clammy thread, and weaves it into a tenacious net. This ſhe ſpreads in the moſt opportune place. But knowing her appearance would deter him from approaching, ſhe then retires out of ſight. Yet ſhe conſtantly keeps within diſtance; ſo as to receive immediate intelligence when any thing falls into

her

her toils, ready to ſpring out in the very inſtant. And it is obſervable, when winter chills the air, and no more inſects rove through it, knowing her labour would be in vain, ſhe leaves her ſtand, and diſcontinues her work.

I muſt not forget the inhabitants of the hive. The Bees ſubſiſt as a regular community. And their indulgent Creator has given them all imple-ments neceſſary either for building their combs, or compoſing their honey. They have each a portable veſſel, in which they bring home their collected ſweets: and they have the moſt com-modious ſtore-houſes, wherein they depoſit them. They readily diſtinguiſh every plant, which af-fords materials for their buſineſs: and are com-plete practitioners in the arts of ſeparation and refinement. They are aware that the vernal bloom and ſummer ſun continue but for a ſeaſon. Therefore they improve to the utmoſt every ſhin-ing hour, and lay up a ſtock ſufficient to ſupply the whole ſtate, till their flowery harveſt returns.

If the maſter of this lower creation is ennobled with the powers of reaſon, the meaneſt claſſes of ſenſitive beings, are endued with the faculty of inſtinct: a ſagacity which is neither derived from obſervation, nor waits the finiſhing of experi-ence: which without a tutor teaches them all neceſſary ſkill, and enables them without a pat-tern to perform every needful operation. And what is more remarkable, it never miſleads them, either into erroneous principles, or pernicious practices: nor ever fails them in the moſt nice and difficult of their undertakings.

Let us ſtep into another element, and juſt viſit the watry world. There is not one among the innumerable myriads, that ſwim the boundleſs ocean,

ocean, but is watched over by the ſovereign eye, and ſupported by his almighty hand. He has condeſcended even to beautify them. He has given the moſt exact proportion to their ſhape, the gayeſt colours to their ſkin, and a poliſhed ſurface to their ſcales. The eyes of ſome are ſurrounded with a ſcarlet circle: the back of others diverſified with crimſon ſtains. View them when they glance along the ſtream, or when they are freſh from their native brine, the ſilver is not more bright, nor the rainbow more glowing than their vivid, gloſſy hues.

But as they have neither hands nor feet, how can they help themſelves, or eſcape their enemies? By the beneficial, as well as ornamental furniture of fins. Theſe when expanded, like maſts above, and ballaſts below, poiſe their floating bodies, and keep them ſteadily upright. They are likewiſe greatly aſſiſted by the flexibility and vigorous activity of their tails: with which they ſhoot through the paths of the ſea, ſwifter than a veſſel with all its ſails. But we are loſt in wonder at the exquiſite contrivance and delicate formation of their gills: by which they are accommodated, even in that denſe medium, with the benefits of reſpiration! A piece of mechaniſm this, indulged to the meaneſt of the fry: yet infinitely ſurpaſſing, in the fineneſs of its ſtructure and operation, whatever is curious in the works of art, or commodious in the palaces of Princes.

PART

PART the THIRD.

Of PLANTS *and* FOSSILS.

CHAP. I.

Of PLANTS.

1. *What we mean by Plants.*
2. *Their liquid Parts.*
3. *Their ſolid Parts.*
4. *Of the Bark.*
5. *The Wood.*
6. *The Pith.*
7. *The Root and Branches.*
8. *The Leaves.*
9. *The Nutrition of Plants.*
10. *Water not the Element of Plants.*
11. *The Motion of the Nutritive Juice.*
12. *The Deſcent and Aſcent of the Sap.*
13. *Of the Increaſe of Grain and Seeds.*
14. *Of Male and Female Plants.*
15. *Of the Sleep of Plants.*
16. *Of the Agreement between Plants and Animals.*
17. *Of the Generation of Plants.*
18. *Of their Flowers.*
19. *Their Seeds.*
20. *Their Fruits.*
21. *Of the Perſpiration of Plants.*
22. *Trees inverted will grow.*
23. *Of the Propagation of ſeveral Plants.*
24. *Of Grain planted in various Subſtances.*

1. BY Plants we mean organized bodies, deſtitute of ſenſe and motion, fixed in the earth, and drawing their nouriſhment from it by their roots. Touching theſe, we may conſider, firſt,

first, the structure of their parts, and then their nutrition and generation.

2. The Parts of which they are composed are either Liquid or Solid. The Liquid are usually divided into Juices and Tears. The Juice is to the Plant, what blood is to an animal, and is various in the various kinds of Plants. Tears are liquors which are emitted from them, whether they sweat out of them naturally: or are drawn out of them, either by art, or by the heat of the sun. Some of these remain liquid; others grow by degrees into a firm consistence.

3. Plants consist of three *dissimilar*, *solid* Parts, the Root, the Trunk, and the Branches. In each of these we may observe three *similar* parts, the Bark, the Wood, and the Pith.

4. To begin with the Trunk. Here we may first observe the Bark; whose surface consists of little bladders, which surround the trunk like a ring. These, which are commonly filled with some kind of juice, being removed, there occur various ranks of woody fibres, curiously wrought in a kind of net-work, one row above another. The intervals also between those fibres, are all filled with little vessels. The use of the Bark seems to be, not only like skin, to cover the wood and pith, but also to concoct the nutritive juice, and forward the growth of the Plant. And as to the nutrition of the Plant, it is probable the juice ascends from the root, through the fibres, and is sustained by the unevenness therein, till it is lodged in the vessels. In these the new juice being mixed, with that they contained before, is fermented

fermented and rarefied to ſuch a degree, as is needful for its nouriſhment.

It has been a common opinion, that trees only live by the aſcent of the ſap in the Bark, or between the Bark and the wood. But this evidently appears to be a vulgar error, from the inſtance of a large, old elm, in Magdalen College Grove at Oxford, which was quite diſbarked all round, at moſt places two feet, at ſome four feet from the ground. Notwithſtanding this, it grew and flouriſhed many years, as well as any tree in the grove. What is more, it was likewiſe without all pith, being hollow within as a drum. Add to this, that the plane and cork-trees, diveſt themſelves every year of all their old bark, (as ſnakes do of their ſkins) and acquire a new one. Now during the change from one to the other, it is clear they are not nouriſhed by the Bark. Therefore there muſt be other veſſels, beſides thoſe of the Bark, capable of conveying the ſap. It is probable, the Bark may ordinarily do this; but that when the ordinary conveyance fails, ſome of the woody parts, (which were all ſap-veſſels once) reſume their ancient office: ſo far, at leaſt, as to keep the tree alive, though not to increaſe its bulk. Perhaps this is the uſe of the ſap-veſſels in the wood different from that of thoſe in the Bark. Theſe are deſigned for the continuation of a tree, thoſe in the Bark for its augmentation.

It ſeems the Bark in fruit-trees is principally deſigned for the augmentation of the tree itſelf, while the finer veſſels of the woody part, ſtrain and prepare the juices for the fruit. A gentleman near Cork, obſerving that his peach-tree grew exceedingly, but bore no fruit, cut off the Bark almoſt quite round, for the breadth of

two

two fingers. The next year the tree hardly grew at all, but bore abundance of fruit.

Again. As animals are furnifhed with a Panniculus Adipofus, ufually replete with fat, which invefts and covers all the flefhy parts, and fcreens them from external cold : fo plants are incompaffed with a Bark, replete with fatty juices, by means whereof even the winter cold is kept off, and hindered from freezing the juices in the veffels. And thofe fort of trees, whofe Bark abounds with oil, remain green all the year round.

5. In the Wood likewife there are obferved concave fibres, woven as it were of various veficles, and ftretching all the length of the wood, as do the fibres of the bark. Thefe have intervals between them, in which are tranfverfe veficles, reaching to the very pith. There are other fibres, which run obliquely, and are far larger, but not fo numerous as the former. In fome trees there are alfo feveral rows of tubes, which emit a thick milky liquor.

6. The Pith is in the middle of the wood. It confifts of various rows of hollow globules, covered with a fine membrane. In fome trees it contains a peculiar juice, which fometimes hardens, or grows black. In tender fhoots the Pith (which is frequently hexagonal) is not exactly in the middle: but is nearer the bark on the fouth-fide, than on the north-fide of the plant. It is a conftant obfervation, that the Pith leffens as the tree grows. Some have imagined it to be the heart of the plant : but this cannot be. For fome trees will flourifh and bear fruit, after the Pith is taken out. Befides this, there is in fome trees a *Blea*, a

white

white and a tender ſubſtance, between the bark and the wood.

7. The Root has nearly the ſame veſſels as the trunk. Through it the juice paſſes that nouriſhes the plant. The roots of ſome plants are full of hollow threads, which tranſmit nouriſhment to the upper parts. This in other plants inſinuates itſelf through the pores that are in the bark of the root. The Branches of a plant agree with the trunk, in all the eſſential parts of its ſtructure.

If no moiſture come to the roots of trees they cannot grow; but if it comes only to the points of the root, though all the reſt remain dry, they grow well. For the root ſhoots out yearly a ſharp pointed tender part, ſomewhat like the ſharp bud on the end of a ſprig, by which it not only inlarges itſelf in breadth, as the branches do above, but alſo receives its nouriſhment. And that tender part moves toward the ſoft and moiſt earth. So that to looſen the earth at the points of the roots, much helps the growth of all plants.

8. On the ſmalleſt part of the branches grow the Leaves; of theſe we may obſerve, 1. The Fibres of the leaf ſtand not on the ſtalk in an even line, but always in an *angular* or *circular* poſture; and their vaſcular fibres or threads, are three, five, or ſeven. The reaſon of this poſition is, for the more erect growth, and for the greater ſtrength of the leaf: as alſo for the ſecurity of its ſap. 2. The accurate poſition of theſe fibres, which often take in the eighth part of a circle, as in mallows; in ſome plants a tenth; but

but in most a twelfth. 3. The art in *folding* up the leaves before the eruption, is incomparable both for elegance and security. They take up the least room their form will bear; and are so conveniently couched, as to be capable of receiving protection from other parts, and of giving it to each other.

Leaves consist of fibres continued from the trunk of the tree. They are cloathed with an extremely thin pellicle which is covered with the finest down. Their skin or coat is only that of the branches extended, as gold is by beating. In the bud they are folded up, almost in the manner of a fan, sometimes in two, sometimes in several plaits. But if they are too thick to plait commodiously in two, and to be ranged against each other, or if they are too small a number, or their fibres too delicate; instead of being plated, they are rolled up, and form either a single roll, or two rolls, which begin at each extremity of the leaf, and meet in the middle. There are also some plants, as fern in particular, which form three rolls.

The chief use of leaves seem to be, 1. To catch the dew and rain, and so convey more nourishment to the plant, than the root alone could do. 2. To take in air; (of which more hereafter:) and 3. To minister to a kind of insensible perspiration, by which redundancies may be thrown off.

9. The Nutrition of plants seems to be performed thus. As the earth abounds with particles of every sort, those which suit each plant, being dissolved by moisture and agitated by heat, enter the root through its threads or pores, ascend through the woody fibres, and being in the vesicles

vesicles of the plant mixed with its native juice, and subtalized by fermentation, insinuate themselves into all parts of it. Part of this nourishes the plant and forms the fruit; the residue transpires. But as all particles are not equally fit to enter the pores of every plant, neither can all be fermented into a juice proper to nourish it: the reason is plain, why every plant will not flourish in every soil.

It is remarkable, that trees of very different kinds, draw their whole sustenance from the moisture they find in the same piece of ground, and from the ambient air and dews. Hence we may infer, that the very contexture of their bodies form the first seed, are the natural limbecs, where the common water and air, are digested into so many different leaves and fruits.

We see also, that an handful of moss, sometimes above a span long, grows out of a small oyster-shell, without any earth, as do trees out of bare rocks, Hence we easily learn, that the seeds first, and then the roots, stems, and leaves of trees, are the strainers which secrete and generate their peculiar saps and juices. These are at first little else than pure air and water, till they are concreted in peculiar salts, by more curious strainers, and more subtle boilers than art has ever devised.

10. The antients generally supposed the earth to produce vegetables; many of the moderns ascribe it to water alone. But it is a doubt whether the experiment ever was made with the nicety that is requisite. And it proves nothing, unless that water be quite pure from any terrestrial mixture. For if it be not, the plant may owe its whole growth to that terrestrial matter.

Who

Who can find any water, newly taken out of the ſpring, which does not exhibit even to the naked eye, great numbers of ſmall terreſtrial particles, diſperſed through every part of it? Theſe are of two general kinds. Some are of a mineral nature, others of a vegetable. Of the latter ſome are fit to nouriſh one plant, or one part of it, and ſome another. All water is much charged with vegetable matter, which is fine, light, and eaſily moveable. Spring water contains more of it than river water, river water more than rain water.

To which of theſe waters, or the matter ſuſtained therein, do vegetables owe their growth? In order to decide this, the following experiments were made. Several phials of the ſame ſhape and ſize were filled with equal quantities of water. Over each was tied a piece of parchment, with an hole in it juſt large enough for the ſtem of the plant, to prevent the water from evaporating, or aſcending any way but through the plant. Several plants being exactly weighed, were then placed in theſe phials, and as they imbibed the water, more was added from time to time. Each glaſs was marked with a different letter, and all ſet in the ſame window, from July 20, till October 1. Then they were taken out, the water in each phial weighed, and the plant with the leaves that had fallen off. It then appeared how much each plant had gained, and how much water had been expended upon it.

Letters on the glasses.	Weight of the plant put in.	Weight when taken out.	Weight gained in 77 days.	Expence of Water.	Proportion of the increase to the expence of water.
	gr.	gr.			
A. Spear-mint set in spring-water.	27	42	15	2558	1 to 170
B. Spear-mint in rain-water.	28	45	17	3004	1 to 171
C. Spear-mint in Thames-water.	28	54	26	2493	1 to 95
D. Night-shade in spring-water.	49	106	57	3708	1 to 65

The water ascends through the vessels of plants, as through a filtre. And a larger filtre draws more water than a smaller. Therefore plants that have more or larger vessels, draw more than those that have fewer and smaller.

But the greatest part of the water imbibed by plants, passes through their pores into the atmosphere. Hence the least proportion of water expended is to the increase of the plant, as 46 or 50 to one. In some it is 100, 200, nay, in one, 700 times as much as the increase of the plant.

Nor does this water pass off alone, but bears with it many particles of the plant. The grosser indeed are not so easily borne up into the atmosphere, but are usually deposited on the surface of the flowers, leaves, or other parts of the plant. Hence our honey-dews, and other gummous exudations.

dations. But the finer eaſily aſcend into the atmoſphere, and are conveyed to our organs of ſmell.

Great part of the terreſtrial matter mixt with the water, aſcends into the plants. After the experiment, there was much more of it in the glaſſes which had no plants in them, than in thoſe that had. Indeed, this matter, being ſo fine and light, attends water in all its motions: ſo that filtre it ever ſo often, ſome will remain.

The plant increaſes more or leſs as the water it ſtands in, contains more or leſs of this matter. So the mint in the glaſs C, was of much the ſame bulk and weight with thoſe in A and B. But ſtanding in river-water, which contained more terreſtrial matter, than the ſpring or rain water wherein they ſtood, it increaſed almoſt double to either of them, yea, and with leſs expence of water.

But all vegetable matter is not proper for the nouriſhment of every plant. Although ſome parts in all may owe their ſupply to the ſame common matter, yet others require a peculiar ſort of matter, and cannot be formed without it. Yea, different ingredients go to the compoſition of one and the ſame plant. If therefore the ſoil wherein a plant is ſet, contains all, or moſt of thoſe ingredients, it will grow there, otherwiſe not. If there be not as many ſorts of particles, as are requiſite for the eſſential parts it will not grow at all. If they be there, but not enough of them, it will not grow to its natural ſtature. If the leſs eſſential particles be wanting, it will be defective in ſmell, taſte, or ſome other way. But though ſome land may not contain matter proper for ſome plants, yet it may for others, All this ſhews, that plants owe their increaſe, not to water only, but to a particular terreſtrial matter: elſe there would be no need

of

of manure, or of tranſplanting them from place to place. The rain falls on all places alike: on this field and that, this garden or orchard and another. Vegetables therefore are not formed of water. One plant drew up 2501 grains of this; yet increaſed only three grains and a half. The mint in B. took thirty nine grains of water a day, which was much more than the whole weight of the original plant. And yet it gained not one fourth of a grain, in a day and night.

Water then is only a vehicle to the terreſtrial matter, which forms vegetables. Where this is wanting, the plant dôes not increaſe, though ever ſo much water aſcend into it. This is only the agent which conveys that matter to them, and diſtributes it to their ſeveral parts for their nouriſhment. It is fitted for this office, by the figure of its parts, which are exactly ſpherical; therefore eaſily ſuſceptible of motion, and conſequently capable of conveying other matter that is not ſo voluble. Beſide, the conſtituent particles of water are abſolutely ſolid, and do not yield to the greateſt external force: therefore their intervals are always alike. By this quality water is diſpoſed to receive matter into it: by the former, to bear it along with it.

It is farther qualified to be a vehicle of this matter, by the fineneſs of its particles. We ſcarce know a fluid in nature, except fire, whoſe conſtituent parts are ſo exceeding ſmall. They paſs pores which air itſelf cannot paſs. This enables them to enter the fineſt veſſels of plants, and to introduce the terreſtrial matter to all parts of them; each of which, by means of peculiar organs, aſſumes the particles ſuitable to its own nature, letting the reſt paſs on through the common ducts.

11. As to the motion of the nutritive juice, ſome

think it afcends by the wood, and defcends by the bark. But it is not eafy to fhew, by what particular tubes it either afcends or defcends. Neither after all our refearches does it appear, what is the principle of this motion? Whether there be any fuch thing as an attractive force in the plant itfelf: or whether it be performed on the mere principles of mechanifm, by the expanfion of the air contained in the juice, which moves and propels the particles of it into every part of the plant.

However, that the Sap in plants does circulate is made probable by an eafy experiment. On a branch of a plain jeffamine, whofe ftem fpreads into two or three branches, inoculate in Autumn, a bud of the yellow ftriped jeffamine. When the tree fhoots the next fummer, fome of the leaves will be ftriped with yellow, even on the branches not inoculated. And by degrees, the whole tree will be ftriped, yea, the very wood of the young branches.

It is probable the circulation is performed thus. The wood of plants confifts of fine, capillary tubes, which run parallel with each other from the root, and may be looked upon as arteries. On the outfide of thefe, between the wood and the inner bark, are larger tubes, which may do the office of veins. Now the root having imbibed juice from the earth, this is put into motion by the heat. Hereby it is rarefied and caufed to afcend in the form of a fteam or vapour; till meeting the mouths of the arterial veffels, it paffes through them to the top, and to the extreme parts of the tree with a force anfwerable to the heat whereby it is moved. When it arrives there, meeting with the cold of the external air, it condenfes into a liquor, and in that form returns by its own weight, to the root of the venal veffels.

12. That

12. That the Sap does circulate, appears farther from hence, that the graft will either corrupt or heal the ſtock. Nay, it changes the very way of the growing of the root, which it could not do, but by ſending down its ſap thither. Crab-ſtocks grafted with fruit, which the ſoil does not like, will canker, not only in the graft, but the ſtock alſo. But graft them again with fruit it does like, and it will quickly heal. Farther: graft twenty young pear-ſtocks with one ſort of pear, and twenty with another. The roots of one ſort will grow all alike, and ſo will thoſe of the other. Yet ever-greens grafted on trees which drop their leaves, as the ever-green oak of Virginia upon the common English oak, hold their leaves all the winter. Does not this ſhew, that the juices circulate in winter, as well as ſummer, even in the plants which drop their leaves? Otherwiſe thoſe grafted on them muſt ſoon die.

It ſeems that the Sap does not riſe by the pith: becauſe ſome large trees are without that part, and yet continue to put forth branches. Indeed no pith is found in thoſe branches of a tree, which exceed two or three years growth. And the pith which is in a branch of this year, is diſtributed into thoſe boughs which are formed the next ſeaſon.

Many believe, the tree does not receive its nouriſhment by the bark; becauſe trees that have loſt that part, continue to grow. But they ſuppoſe a tree has but one bark; whereas every branch has four diſtinct coverings. The two outermoſt of theſe may be taken from a tree without much damage. But if the two others be taken off, it will infallibly kill the tree.

Some affirm, that the Sap neither riſes nor falls in the woody part of the tree, becauſe when a branch is cut, they cannot diſcern any Sap iſſue out of it. Certainly they cannot; becauſe thoſe tubes are not large enough, to receive any thing more groſs than vapour. The root receives chiefly in Autumn its proper juices, which the warmth in ſpring raiſes into a vapour, that gradually aſcends through thoſe fine tubes, and by that means cauſes vegetation.

13. Some have objected to our Lord's ſpeaking of corn increaſing an hundred fold, that this is impoſſible. So far from it, that a grain of barley, has been known to produce two hundred and forty-nine ſtalks, containing above eighteen thouſand grains.

A ſtill more curious experiment was made with turnip ſeed, at Sutton-Coldfield, in Warwickſhire. In leſs than three days after it was ſown, the turnips were above ground. In three weeks the roots were as big as walnuts: in leſs than five weeks, as large as apples. Auguſt 12th, one of them weighed two pounds fourteen ounces. At the ſame time was weighed an ounce of the ſeed, which had been ſown, and it was found to contain fourteen thouſand ſix hundred ſingle grains. This being multiplied by forty-ſix (the ounces that the turnip weighed) produces ſix hundred and ſeventy-one thouſand ſix hundred, viz. the number of ſingle grains required to equal the weight of the turnip. Hence it follows, that (ſuppoſing the increaſe was uniform) the grain when it was ſown, weighing but $\frac{1}{14600}$th part of an ounce, increaſed in the following proportions:

In ſix weeks —	671600	Times its own weight.
A week — —	111933	
A day — —	15990	
An hour — —	660	
A minute — — —	11	

In

In June 1766 Mr. Miller ſowed ſome grains of common red wheat. On Auguſt 8, a plant was taken up and divided into eighteen parts. Each of theſe was placed ſeparately. Theſe plants having ſhot out ſeveral ſide ſhoots, by the middle of September, they were taken up and divided again. This ſecond diviſion produced ſixty-ſeven plants. Theſe remained through the winter. Another diviſion of them made in the ſpring, produced 500 plants, They were then divided no farther.

The whole number of ears, which by the proceſs were produced from one grain, was 21109. And from a calculation made, by counting the whole number of grains in one ounce, might be about 576840.

14. Some plants are male and ſome female. Mr. Miller ſeparated the Male plants of Spinach from the Female. The ſeed ſwelled as uſual, but did not grow when he ſowed it. Yet it might have been impregnated another way, as appeared from another experiment. He ſet twelve tulips about ſix yards from any other, and as ſoon as they flowered, carefully took out the ſtamina. Two days after he ſaw bees working on other tulips, and coming out loaded with the duſt. They flew into the firſt tulips, and left therein duſt enough to impregnate them, which accordingly bore good ſeed. Thus we ſee the farina may be carried by inſects, and lodged on flowers, which it is fit to impregnate.

Afterwards he bought and ſowed ſome Savoy ſeed, and planted out the plants, but was ſurprized at the production. For he had ſome red cabbage, ſome white, ſome ſavoys with red ribs, and ſome a mixture of all together in one plant. The gardener aſſured him, he had carefully ſaved the ſeed.

Being asked, where he had set the plants for seed, he shewed him, and said, He planted first a dozen white cabbages, next a dozen savoys, and then a dozen red cabbages. Is it not plain that here the effluvia of one sort, impregnated the other? For did each grain of the farina impregnate only its own kind, this mongrel sort could never be produced.

An instance of the same kind has been observed with regard to Indian Corn: this is of several colours, as white, red and yellow. If each of these be planted by themselves, they produce their own colour. But if you plant the blue corn in one row, and the white or yellow in the next, they will interchange colours: some of the ears in the blue corn rows, are white or yellow, and some in the white or yellow rows, are blue. That this is caused by the effluvia of one impregnating the other, is manifest from hence. Place a close, high fence, between the corn of different colours, and there is no change of colour in any of them.

The Holly is described by all naturalists, as bearing hermaphrodite flowers. But by late observations it has appeared, that some trees bear male, some female flowers. Yet there is a vast variety. In Chelsea-garden, some Hollies bear female, some hermaphrodite flowers. But some trees bear only male flowers; some only female, some only hermaphrodite. Others bear both male and female, both male and hermaphrodite, or female and hermaphrodite. And others bear male, female, and hermaphrodite, all at the same time.

15. That the leaves of certain plants assume at night a disposition different from that of the day, is

is well known. This has been usually termed, The *Sleep*. But to what is this owing? Not to the variation of heat or cold, moisture or dryness. For however these are varied, the same thing happens with equal regularity. It is light alone that occasions this change, which by the smallness of its particles, is capable of entering bodies, and by its activity, of producing great changes in them. It changes the position of the leaves of plants, by a motion it excites among the fibres. The natural position of the lobes in these leaves is drooping. This is their posture of repose. But vegetation is very imperfectly performed, while they remain in it. It is light which alters that position, by its quick vibrations.

In the evening, August 7, (in order to make a full experiment) Dr. Hill placed a plant of Abrus, in a room where it had moderate day-light, without the sun shining upon it. The lobes of the leaves were then fallen perpendicularly from the middle rib, and closed together by their under sides. Thus they continued all night. Half an hour after day-break, they began to separate, and a quarter of an hour after sun-rise, were perfectly expanded. Long before sun-set they began to droop again, and toward evening were closed as at first.

Next day the plant was set, where there was less light. The lobes were raised in the morning, but not so much. And they drooped earlier at evening.

The third day it was set in a south window, open to the full sun. Early in the morning the leaves had attained their horizontal situation: by nine o'clock they were raised above it, and continued so till evening. Then they fell to the horizontal situation, and thence gradually to the usual state of rest.

The fourth day the plant ſtood in the ſame place, but the ſun did not appear. The lobes early attained their horizontal ſituation, but did not riſe beyond it, and in the evening cloſed as uſual.

Theſe experiments prove, that the whole change is occaſioned by light only. To put this beyond diſpute, in the evening of the ſixth day, the plant was ſet in a book-caſe, on which the morning ſun ſhone, the doors ſtanding open. The next day was bright. The lobes which had cloſed in the evening, began to open early in the morning, and by nine o'clock, they were raiſed in the uſual manner. I then ſhut the doors of the book-caſe: on opening them an hour after, the lobes, were all cloſed as at midnight. On opening the doors, they opened again, and in twenty minutes they were fully expanded. This has ſince been many times repeated, and always with the ſame ſucceſs. We can therefore, by admitting or excluding the light, make the plant put on all its changes. Hence we are certain, that what is called the Sleep of Plants, is cauſed by the abſence of light alone, and that their various intermediate ſtates are owing to its different degrees.

It has been ſuppoſed that the daily motions of the Senſitive Plant, were likewiſe owing to light and darkneſs; becauſe it expands itſelf in the morning, and cloſes again in the evening. From the main branches of this plant ſpring ſeveral ſmaller ones, and from theſe others ſtill leſs, which ſupport the leaves ranged on each ſide, in pairs over-againſt one another. Several other plants are of the ſame form, and all theſe cloſe their leaves in the evening, and open them in the morning, which therefore is not peculiar to the Senſitive Plant. But this cloſes them at any time of the day, if touched, and ſoon after opens them again. You can

can ſcarce touch the leaf of a vigorous Senſitive Plant ſo lightly, as not to make it cloſe. The large rib which runs along its middle, is as an hinge on which the two halves of the leaf move, when they turn upon being touched, till they ſtand erect, and by that means meet one another. The ſlighteſt touch gives this motion to one leaf; if a little harder, it gives the ſame motion to the leaf oppoſite. If the touch be ſtill rougher, the whole arrangement of leaves on the ſame rib cloſe in the ſame manner. If it be ſtronger ſtill, the rib itſelf moves upward toward the branch on which it grows. And if the touch be yet more rough, the very branches ſhrink up toward the main ſtem. The motion which has the greateſt effect of all others upon it, is the ſhaking one. Winds and heavy rain alſo cauſe this plant to cloſe its leaves; but not gentle ſhowers: the contraction being cauſed by the agitation of the wind, and the ſtrokes given by the large drops.

The natural ſhutting and opening of its leaves at night and morning, are not ſo fixed, as not to be variable by many circumſtances. In Auguſt a Senſitive Plant was carried in a pot into a dark cave. The ſhaking in the carriage ſhut up its leaves, ſo that they did not open for four and twenty hours. And when they did open, they cloſed no more for three days and nights. Being then brought again into the open air, they recovered their natural motions, ſhutting at night and opening in the morning, as variouſly as ever. While in the cave, it was as much affected by the touch, as in the open air.

By this and many experiments it appears, that it is not the light that opens theſe plants, nor the darkneſs which ſhuts them. Neither is it owing to the increaſe of heat or cold. Indeed, great heat will affect them a little, but not in any consider- able degree. Concerning the real cause, we may form many conjectures: but nothing certain can he known.

Nearly related to the Sleep of Plants, is that which Linnæus called the Awaking of Flowers. The flowers of most plants, after they are once opened, continue so night and day, until they drop off, or die away. Others, which shut in the night-time, open in the morning sooner or later, according to their situation in the sun or shade, or as they are influenced by the manifest changes of the atmosphere. There are another class of flowers, which make the subject of these observations, which observe a more uniform law in this particular.

These open and shut constantly at certain hours, exclusive of any manifest changes in the atmosphere; and this with so little variation in point of time, as to render the phænomenon worth observation. Linnæus's observation extends to near fifty species which are subject to this law. We will enumerate some of these, and mention the time when the flowers open and shut. The little blue Convolvulus, or Bindweed, opens its flowers between five and six in the morning. and shuts them in the afternoon. The flowers of the Day-Lilly open about five in the morning, ing, and shut at seven or eight in the evening. The lesser Water-Plantain, during its flowering-time, only opens its flowers each day about noon. The flowers of the Proliferous Pink, expand about eight in the morning, and close again about one in the afternoon. Purple Spurrey, expands between nine and ten in the morning, and closes between two and three in the afternoon. This little plant is common among the corn in sandy soils and flowers in June. Common Purslain, opens its flowers about nine or ten in the morning,

morning, and closes them again in about an hour's time. The white Water-Lilly grows in rivers, ponds and ditches, and the flowers lie upon the surface of the water. At their time of expansion, which is about seven in the morning, the stalk is erected, and the flower more elevated above the surface. In this situation it continues till about four in the afternoon, when the flower sinks to the surface of the water, and closes again. Yellow Goats Beard, or Go-to-bed-at-noon (the latter of these names was given to this plant long since, on account of this remarkable property) opens its flowers in general about three or four o'clock, and close again about nine or ten in the morning. These flowers will perform their vigiliæ, if set in a phial of water, within doors, for several mornings successively. Sometimes they are quite closed, from their utmost state of expansion, in less than a quarter of an hour.

16. From what has been said it plainly appears, that there is a considerable *agreement between plants and animals*, as well with regard to their nutrition, as to the structure of their parts. Some extend this farther, and think there is something in plants answerable to respiration in animals. They suppose the spiral fibres to be in the place of lungs, and to serve this very purpose: that in each of these there is a spiral lamina, which is extended or contracted, as it is impelled this way or that, by the elastic air it includes: that these fibres ascending strait through the trunk, are dispersed through all the branches, and thence into the leaves, where they are woven together in a kind of net-work. By this means the more subtle parts of the air are strained through those spiral fibres, to keep the juices of the plant fluid, and

 perhaps

perhaps to supply them with nitre or æther, to assist their fermentation.

The air enters vegetables various ways, by the trunk, leaves, roots and branches. For the reception as well as expulsion of it, the pores are very large in some plants. So one sort of walking canes seem full of large pin-holes, resembling the pores of the skin in the ends of our fingers. In the leaves of the pine, if viewed through a glass, they make an elegant show, standing as it were, in rank and file, throughout the length of the leaves.

Air vessels are found in the leaves of all plants, and in many are visible to the naked eye. For on breaking the chief fibres of the leaf, the likeness of a fine woolly substance, or rather of curious, small cobwebs may be seen to hang at both the broken ends. Now these are the fibres of the air vessels, loosed from their spiral position, and drawn out in length.

The pores in the leaves of plants are almost innumerable. Mr. Lewenhoek found above an hundred and seventy two thousand, on one side of a leaf of box. The leaves of Rue are as full of holes as an honey-comb. Those of St. John's wort likewise appear full of pin-holes to the naked eye. But the places where those holes seem to be, are really covered with a thin and white membrane. Through a microscope the backside of the herb Mercury, looks as if rough with silver; and all the ribs are full of white, round transparent balls, fastened by slender stalks, like so many grapes. A Sage-leaf appears like a rug or shag, full of tufts of silver thrumbs, and embellished with round chrystal beads, fastened by tender foot-stalks. The prickles of a Nettle are formed for acting just as the sting of animals.

Every

Every one of them is hollow, and terminates in a fine point, with an opening near its end. At the bottom of each prickle lies a pellucid bag, containing a clear liquor, which upon the leaſt touching the prickle, is ejected at the little out-let, and if it enters the ſkin, cauſes pain and inflammation by the pungency of its ſalts.

The leaves of plants are of great conſequence to their life. At theſe the air paſſes in, and goes through the whole plant, and out again at the roots. If the leaves have no air, the plant will die, as is eaſily proved by the air-pump: whereas if the leaves be left on the outſide of the receiver (parted by a hole cemented with wax) while theſe have air, the plant will thrive and grow, though its roots and ſtalks are kept in vacuo. The leaves likewiſe chiefly perform the neceſſary work, (but who can explain the manner!) of altering the water received at the roots, into the nature of the juices of the plant. And hence it is, that the life of plants depends ſo immediately upon their leaves. The huſbandman often ſuffers, for want of this knowledge. A crop of Saint-foin is valuable; and its roots being perennial, will yield an increaſe for many years. But it is often deſtroyed at firſt, by ſuffering it to be fed upon by ſheep. For if they eat up all the leaves, the root cannot be ſupplied with air, and ſo the whole periſhes. Leaves being ſo neceſſary to all perennial plants, a reverſionary ſtock of them is provided. The leaves of theſe plants are always formed in Autumn, though not unfolded till the following ſpring. They then open and increaſe in proportion to the motion of the ſap, and the quantity of nouriſhment the plant receives. Theſe leaves alſo, though not yet appearing out of the bud, may ſuffice for the extremely

ſmall

ſmall motion, which the ſap of thoſe perennial plants, that drop their leaves, has in winter.

But beſides theſe Autumnal leaves, there is another ſet formed in ſpring and expanding till Midſummer. Theſe are of infinite ſervice to many ſort of trees, particularly to the mulberry, as they ſave its life, when the firſt ſet of leaves have been all eaten up by the ſilk worms.

The analogy between the parts of plants and thoſe of animals may now more fully appear. The parts of plants are 1. The Root, compoſed of abſorbent veſſels, analogous to the lacteals in animals: indeed performing the office of all thoſe parts of the abdomen, that miniſter to nutrition: 2. The wood, compoſed of capillary tubes running parallel from the roots, although the apertures of them are commonly too minute to be ſeen. Through theſe, which are analogous to arteries, the ſap aſcends from the root to the top: 3. Thoſe larger veſſels, which are analogous to veins. Through theſe it deſcends from the top to the root. 4. The bark, which communicates with the pith by little ſtrings, paſſing between the arteries. 5. The pith, conſiſting of tranſparent globules, like the bubbles that compoſe froth.

The ſap enters the plant in the form of pure water, and the nearer the root, the more it retains of that nature. The farther it goes, the more it partakes of the nature of the Plant. In the trunk and branches it remains acid. In the buds it is more concocted. It is farther prepared in the leaves, (as blood in the lungs) which being expoſed to the alternate action of heat by day, and cold by night, are alternately dilated and contracted.

Is not then the motion of the Sap in plants, (like that of the blood in animals) produced chiefly by the action of the air? All plants have the two orders

orders of veſſels, 1. Thoſe which convey the nutritious juices, 2. Air-veſſels, hollow tubes, within which all the other veſſels are contained. Now the leaſt heat rarefies the air in theſe air-veſſels, thereby dilating them, and ſo cauſing a perpetual ſpring, which promotes the circulation of the juices. For by the expanſion of the air-veſſels, the ſap-veſſels are preſſed, and the ſap continually propelled. By the ſame propulſion it is comminuted more and more, and ſo fitted to enter finer and finer veſſels: while the thicker part is depoſited in the lateral cells of the bark, to defend the plant from cold, and other injuries.

Thus is every plant acted on by heat in the daytime, eſpecially in ſummer; the ſap protruded, then evacuated, and then exhauſted. In the night the air-veſſels being contracted by the cold, the ſap-veſſels are relaxed, and diſpoſed to receive freſh food, for the next day's digeſtion. And thus plants do, as it were, eat and drink during the night-ſeaſon.

The veſſels themſelves conſiſt of mere earth, cemented by oil and water: which being exhauſted by fire, air, or age, the plant returns to its earth. Thus in plants, burnt by the fierceſt fire, the matter of the veſſels is left entire: which conſequently is neither water, air, ſalt, nor ſulphur, but earth alone. The ſap conſiſts of ſome ſaline parts: others derived from air, rain and putrified plants or animals. Conſequently in plants are contained, ſalts, oils, water, earth: and probably all metals too. In fact, the aſhes of all vegetables yield ſomething, which the loadſtone attracts.

There is a conſiderable difference as to the time when different plants revive after the winter.

No

No ſooner does the ſun begin to warm the earth, than the vernal flowers appear, and the trees, one after another, open their buds, and cloathe themſelves with leaves. But why do many wood-plants, as colts-foot, pile-wort, violets, and many garden-plants, as ſnow drops, aſſara-bacca, crocus, flower in the very beginning of ſpring, when we cannot by any pains or care, bring them to flower after the ſummer ſolſtice? Nay, theſe very plants, which are ſo patient of cold in ſpring, are in the autumn ſo very weak and tender, that they die on the firſt touch of froſt. Why on the contrary, do thiſtles and many other plants, never flower before the ſummer ſolſtice?

In the ſame manner, trees obſerve fixed laws, and a certain order in their leafing. Does the cauſe lie in the different depth of their roots? If ſo, ſhrubs would have leaves before trees of the ſame kind. But they have not. We can only ſay, the fact we know, but the reaſon of it we know not.

The order of the leafing of ſeveral trees and ſhrubs, obſerved in Norfolk in 1755, was as follows.

1.	Honey Suckle, — —	January	15.
2.	Gooſeberry, currant. elder, —	March	11.
3.	Birch, weeping-willow, — —	April	1.
4.	Raſberry, bramble, — — —		3.
5.	Briar, — — — — — —		4.
6.	Plum, apricot, peach, — — —		6.
7.	Filbird, ſallow, alder, — — —		7.
8.	Sycamore, — — — — —		9.
9.	Elm, Quince, — — — — —		10.
10.	Marſh-Elder, — — — — —		11.
11.	Wych-Elm, — — — — —		12.
12.	Horn-beam, — — — — —		13.

13. Apple-

13. Apple-tree, — — — April 14.
14. Abel, Chesnut, — — — — 16.
15. Willow, — — — — — — 17.
16. Oak, Lime, — — — — — 18.
17. Maple, — — — — — — 19.
18. Walnut, plane, black poplar, beech, 21.
19. Ash, Carolina Poplar, — — — 22.

Indeed the leafing of several of these varies much, as the spring is earlier or later. But others of them, be the winter ever so mild, do not put out before their time. This also depends on some secret properties, which man is not able to explain.

17. As to the Generation of plants, first the tree produces Buds, which afterwards expand into leaves, flowers, or branches. In the buds entire plants are contained. A small stalk, consisting of woody and spiral fibres, springs out of the middle of the plant, wherein the bud inheres. It is involved in a thin bark, which may be divided into various leaves, lying one upon another like scales.

18. Buds are followed by leaves and flowers. In flowers we may consider, 1. The Calix or outer Cup, designed to be a security to the other parts of the flower. Those whose leaves are firm and strong, as tulips, have no calix at all. Carnations, whose leaves are strong but slender, have a calix of one piece. Others have it consisting of several pieces, and in divers rounds. 2. The Foliation or Petala, the Flower-leaves, which are properly the flower itself. In these not only the admirable beauty, and luxuriant colours are observable, but also their curious Folding in the Calix, before they are expanded.

It

It is remarkable, that many, if not moſt vegetables, eſpecially thoſe of a tender kind, expand their flowers, or down, every day, if it be warm, ſun-ſhiny weather. But they cloſe them as the evening approaches; and ſome, at the approach of rain. This is particularly done at the begining of flowering, while the ſeed is young and tender: as is eaſily ſeen in the down of Dandelion, and eminently in the flower of Pimpernel. Theſe ſerve as a weather glaſs to the countryman: by the opening or ſhutting of theſe, he can tell without any danger of being deceived, whether the weather will be foul the next day.

The flower is as it were the womb, which contains the eggs or ſeeds of plants, and in due time brings them forth. It's near the bud, and lies hid with it during the winter, till it is brought out by the heat of the ſummer. The moſt ſimple plants bear a bud, which contains a ſeed of an oval figure. We may eaſily diſtinguiſh from the flower itſelf, the Leaves of the Covering which involves the bud. From theſe ariſe the Leaves of the Flower, ſerving for the laſt concoction of the ſap; in which are both woody and ſpiral fibres, with various rows of utricles. In the middle of flowers Filaments and little Pillars ariſe, whoſe extremities are covered with a kind of Duſt. Theſe pillars are hollow, and have veſicles full of liquor, and the rudiments of ſeeds, which gradually grow and harden.

That duſt is of two kinds, male and female. The male duſt is formed in the top of the filaments, where when it is ripe, it burſts its caſe, and is ſpilt on the heads of the pillars, and thence conveyed to the utricle or matrix thereof, to impregnate the female duſt contained therein.

This

This duſt in any one plant being viewed with a microſcrope, every particle is of the ſame ſize and figure. But in different plants, the colour, ſize, and figure are widely different. In ſome it is clear and tranſparent, as chryſtal; in others white and opake: in ſome blue, purple or red, and in others, fleſh-coloured. And its colour varies in the ſame ſpecies, ſuppoſe tulips, according to the colour of the flower.

The moſt general figure is the oval, more or leſs ſharp at the ends, with one or more furrows running lengthways. But the ſeeds of Melilot are cylinders. Thoſe of the Panſy are priſms, with four irregular ſides. Others repreſent two chryſtal globules faſtened together. Thoſe of the Junquil are in the form of a kidney. But indeed the varieties are not poſſible to be numbered. The office of the Bloſſom is partly to protect, partly to draw nouriſhment to the embryo, fruit or ſeed. The gourd, pumkin, melon, cucumber, and moſt bearing trees, have both male and female bloſſoms on the ſame plant. Male-bloſſoms, (uſually called Catſkins) may be diſtinguiſhed from female, by having no piſtil or rudiment of fruit about them; but only a large thrum, covered with duſt in their middle. The female bloſſoms have always a piſtil, within the flower-leaves; and the rudiments of the fruit are always apparent, at the bottom of the fruit before it opens.

But there is a ſpecies of willow, which appears to change its ſex every year. One year it produces male bloſſoms, and female bloſſoms the next.

19. The Seed, when it is ripe, is incloſed in a peculiar covering. In ſome plants it ſo increa-

ſes,

ſes, as to become a fruit. And in theſe alſo we find fibres and utricles diſperſed with endleſs variety.

Various are the methods which the wiſdom of God takes for ſowing Seeds of various kinds. Thoſe of Arum and Poppy are heavy enough to fall directly to the ground. Others that are light, have hooks to ſtop them, from ſtraying too far from their proper place. So have Agrimony and Gooſe-Graſs, the one wanting a warm bank, the other a hedge for its ſupport.

On the other hand many Seeds have wings, that the wind may carry them off the plant, and may ſcatter them aſunder, that they may not fall together, and come up too thick. The kernals of Pines have very ſhort wings, juſt enabling them to flutter on the ground. But ſome Seeds have many long feathers, by which they are wafted about every where.

Others are lodged in elaſtic caſes, which dart out the Seed to convenient diſtances. Thus Wood-ſorrel having a running root, needs to have its Seed ſown diſtant from each other. And this is done, by means of a tendinous cover, which when it begins to dry, burſts open on one ſide in an inſtant, and is violently turned inſide out. The Seed of Harts-Tongue is diſperſed in a different manner. It has a ſpring wound round its caſe. When it is ripe, this ſuddenly breaks the caſe in two halves, and ſo throws out the ſeed. Equally remarkable is the way wherein Fern-ſeed is ſcattered. If a quantity of this be laid on a paper, the ſeminal veſicles burſt, and are ſeen by a microſcope projecting the ſeeds to a conſiderable diſtance.

The Seeds of the ſeveral ſpecies of Fern, were wholly unknown to the ancients. But it is now well

well known, that in the female fern, the whole ſurface of the leaf on the under-ſide is covered with a congeries of ſeeds, ſo that they guard one another, and need no other covering. And in the common male fern, there are found at the proper ſeaſon, ſeveral brown ſpots, placed in a very regular manner. Theſe are a fungous matter, round which the ſmall ſeed veſſels are inſerted.

The fruitfulneſs of plants, in producing Seeds, tranſcends all imagination. An elm living an hundred years, ordinarily produces thirty-three millions of ſeeds. Add, that if its head be cut off, it puts forth as many branches within half an inch of the place where it was cut as it had before. And at whatever height it is cut off, the effect will be the ſame. Hence it appears, that the whole trunk, from the ground to the riſe of the branches, is full of embryo-branches, each of which will actually ſpring forth, if the head be lopped off juſt over it. Now if theſe had ſprung out they would have born an equal number of ſeeds, with thoſe that did. Theſe ſeeds therefore are already contained in them: and if ſo, the tree really contains 15840000000 ſeeds, wherewith to multiply itſelf as many times. But what ſhall we ſay, if each ſeed contain another tree, containing the ſame number of ſeeds? And if we can never come, either at a ſeed which does not contain trees, or a tree which does not contain ſeed.

Timber-trees of any kind, might certainly be planted to more advantage than they generally are. There is a foreſt two miles from St. Loe in Normandy, planted chiefly with oaks, many of which are but of a moderate height, though of a large circumference. But near its entrance from St. Loe

Loe, there is a plantation, about twenty-five years old, wherein none of the oaks are under ſeventy, and ſome an hundred feet high. They are ſet ſo cloſe, that they almoſt ſeem to touch one another, and are no more than four or five inches in diameter. This timber is of great uſe, both for making charcoal, and many other purpoſes. And the owners may reap four crops of them in an hundred years.

This foreſt belongs to the king of France, who ordered the plantation to be made by way of trial. And his miniſters have cauſed ſeveral of the trees, an hundred feet high, to be tranſplanted, to leave ſtanding proofs of the wonderful effects of the experiment.

As to ſowing, the perfection of agriculture conſiſts, in ſetting plants at due diſtances, and giving a ſufficient depth to the roots, that they may ſpread and receive due nouriſhment. Yet this is little regarded, but all ſorts of grain are ſown by handfuls caſt at random. By this means four parts in five of the ſeed is utterly loſt. To remedy this, a Spaniſh gentleman contrived an engine (deſcribed in the Philoſophical Tranſactions, under the name of the Spaniſh Simbrador) which being faſtened to the plow, the whole buſineſs of plowing, ſowing, and harrowing, is performed at once; and the grain is ſpread at equal diſtances, and equally deep in the furrow. An experiment being made, land which uſually produced five fold, by this means produced ſixty fold. One ſtalk is all that ſprings immediately from one grain: but on the ſides of this, near, if not within the ground, iſſue ſeveral lateral ſtalks. And ſome of theſe ſend forth roots, whence one or ſeveral other ſtalks ſpring, if they are early formed, the

oil.

ſoil good, and the weather favourable. By this means one grain of wheat planted in a garden has produced ninety, yea an hundred ears. If then each ear, taking one with another, contain fifty grains, a ſingle grain may produce five thouſand. Nay, a gentleman in Yorkſhire, who made the experiment in his garden ſome years ago, counted upwards of eight thouſand grains, which ſprung from a ſingle one.

After all that has been ſaid and wrote for ſo many centuries, on the generation or propagation of plants and animals, a late author (to whom the French naturaliſts in general ſubſcribe) totally denies the whole, and cenſures all who pretend to diſcover any animalcula in the ſemen of animals. He will by no means allow, that every animal or plant, proceeds from an egg lodged in the parent plant or animal. On the contrary, he ſuppoſes, " there are in matter certain organical parts, diſpoſed for the formation of animal and vegetable ſubſtances, which by coalition conſtitute the firſt ſtamina of all animal and vegetable bodies. Theſe are ſimple, uniform, common to all, and conſequently to be found more or leſs in every portion of the nutritive juice. From thence they are digeſted, and when the ſubject becomes adult, ſecreted for the formation of the ſeed of every plant and animal. Theſe organical parts, moving when diſengaged, and thence imagined to be alive, are extremely ſimple in their compoſition, being perhaps, only elaſtic ſprings, more or leſs compreſſed, more or leſs diverſified in the direction of their force.

" All microſcopic animals, ſo called, are indeed no other than ſuch organical particles. Seeds macerated in water, firſt diſunite into ſmall particles,

ticles, which ſoon after move, and ſeem alive, though they are not ſo. The ſame may be obſerved of the juices of animals, as mutton-gravy and the like. And as to the common imagination, that the male ſemen, while in the veſſels, contains millions of animalcula like tadpoles, it is certain, they are produced, after the evacuation of the fluid, and riſe from principiles contained therein, by a real vegetation, and a ſubſequent change from the vegetable to the animal life.

" Semen immediately evacuated is an homogeneous fluid. In a few moments it begins to ſeparate, and after this a kind of vegetable filaments grow in it, and ſhoot out ramifications on every ſide. Theſe open and divide into moving globules, which trail after them ſomething like long tails; which are in truth only ſtrings of the viſcid matter, from among which the globules were ſeparated. By degrees the globules get rid of them, and then move at eaſe.

" This vegetable power of ſhooting into filaments, is in all animal and vegetable ſubſtances, down to the leaſt microſcopic point. And to this is really owing, all that is called animal life, in the fluids produced from vegetables.

" In all our obſervations on theſe ſubſtances, the whole quantity of matter, after a ſeparation of ſome volatile and ſaline parts, always divides into filaments, and vegetates into numberleſs zoophytes, which afterwards yield all the ſpecies of microſcopic animals. After this, thoſe ſuppoſed animals themſelves ſubſide to the bottom of the liquor, become motionleſs, reſolve into a gelatinous filamentous ſubſtance, and then afford new zoophytes or animals of a ſmaller kind.

" Hence

"Hence we may obſerve, that every animal or vegetable ſubſtance, advances as faſt as it can, to reſolve into one common principle, which is the ſource of all: a kind of univerſal ſemen, from which each atom may again aſcend to a new life. Theſe animalculæ then in the ſemen of animals, and in the infuſions and juices of animal and vegetable ſubſtances, are not of the nature of any other beings, nor to be ranked with them. They conſtitute a claſs apart from all others, the characteriſtic of which is, that they neither are generated, nor ſubſiſt by nutriment, like other plants or animals, nor do they generate in the ordinary way."

What then becomes of this whole boaſted branch of modern philoſophy? If this be ſo, moſt of our microſcopic diſcoveries vaniſh into air.

Blue-flowered Gentianella requires wet weather to be ſown in. As ſoon as any rain touches the ſeed-veſſels, they burſt open and throw the ſeed on every ſide. Cardamines burſt their pods and dart out their ſeed on as light touch of the hand: nay, the Cardamine Impatiens does ſo, even by the approach of the hand. Other ſeeds by their agreeable taſte or ſmell, invite birds to feed upon them, who drop them again, fertilized by paſſing through their body. So Miſſelto is uſually ſown.

The berries of Miſſelto have within their viſcid pulp, a kernel covered with a thin, whitiſh ſkin. One placed theſe berries within the bark of oak, aſh, beech, pear, and apple-trees, by making ſeveral cuts in the ſides of the trees, but the whole berries would not ſtay in any of them. And when he broke them, the ſeed always ſlipt out to the edge of the cut, and there ſtuck to the bark by its viſcous covering. He ſtuck one ſeed to the bark without any cutting at all, which ſucceeded beſt, and yielded two plants. The viſcous matter drying away, drew the ſeeds cloſe to the bark, and on theſe with two more on an apple-tree and one on a pear-tree, there began in ſpring to ſhoot out at the end of the ſeed next the eye of the berry, a ſmall deep-green ſhoot, like a little claſper of a vine. At firſt it roſe upward, then turning again, ſwelled out ſomewhat bigger round the end: yet leaving the tip quite flat, forming as it were a foot to ſtand upon. This foot in June came to the bark, and fixed itſelf thereon. Being thus faſtened at both ends, it formed a little arch, whoſe diameter was as long as the ſeed. Thus it remained till March following. Then the other end let go its hold, and raiſing itſelf upward became the head of the plant, while the end which ſprung out firſt, became the root. 'Tis not uncommon, for the ſeeds of ever-greens to be two years before they ſpring out of the ground. But this was ſurprizing, the change of the ends, firſt one ſhooting out, and then the other. Yet we find nature is uniform, and even in this ſtrange plant, acts as in other vegetables, firſt carrying the ſap to form the root, then turning the courſe of it back again, to ſend out the upper parts of the plant. The ſtrangeſt circumſtance is, that the rooting end ſhould firſt ſhoot into the air, and then turn down to find a place to fix on. This it is, which has kept the world ſo long in ignorance about the growing of this ſeed. For by requiring a new, ſmooth part of the bark whereon to fix the rooting part, it has fruſtrated all attempts of ſowing it as we do other ſeeds.

In Strawberries and Raſberries the hairs which grow on the ripe fruit, are ſo many tubes leading to the ſeveral ſeeds. And therefore we may

may obſerve, that in the firſt opening of the flower, the whole inward area is like a little wood of theſe hairs: and when they have received and conveyed their globules, the ſeeds ſwell and riſe in a fleſhy pulp.

The manner wherein Moſſes in general feed, is exceeding little underſtood. But in one ſpecies at leaſt, it may be clearly explained, from a number of obſervations. The head of this Moſs appears to the naked eye, ſmooth and of a pale brown colour. The top of this is bounded by an orange-coloured ring, which is a Calix, containing ſixteen pyramidal ſtamina, loaded with a white Farina. Theſe bend towards each other, and when the head is nearly ripe, almoſt meet in a point at their tops. Immediately under the arch formed by theſe ſtamina, is placed a ſlender, hollow piſtil, through which the Farina makes its way, and is diſperſed among the ſeeds in the head. The external membrane of the head, is a continuation of the outward covering of the ſtalk. A ſection of the head ſhews, that this membrane includes a ſeed veſſel ſo large as to fill it every way. This is filled with perfect and beautiful ſeeds. They are round and tranſparent when unripe, but afterwards they are opake, and of a beautiful green. The number of ſeeds in one of theſe heads, is not leſs than 13,800.

The Seed veſſels of Mahogany-trees are of a curious form. They conſiſt of a large cone, which ſplitting into five parts, diſcloſes its winged ſeeds. None would think, that ſo tall and ſo large trees, could grow on ſolid rocks. They are four feet and upwards in diameter. The manner of their growth is as follows. The Seeds fly along the ſurface of the ground, and ſome falling into the chinks of the rocks, ſtrike root, then creep out upon the ſurface, and ſeek another chink. In this they ſwell to ſuch a ſize and ſtrength, that the rock ſplits and makes way for the root to ſink deeper. And with this little nouriſhment the tree in a few years grows to that ſtupendous ſize.

The progreſs of Germination was accurately obſerved by Malpighi in the Seed of a Gourd. The day after it was committed to the ground, he found the outer coat a little ſwelled: and in its tip a ſmall cleft appeared, through which the ſperm was ſeen. The ſecond day the outward coat was much ſofter, the inner torn and corrupted, the Germ ſomewhat longer and more ſwelled and the beginning of the root appeared. The third day the root had made itſelf a paſſage through the coat, near the former cleft. The Germ and ſeed-leaves alſo were now grown much bigger. On the ſixth more of the ſeed-leaves had broken through, and were found thicker and harder. The root had ſhot out many fibres, and the ſtem grown a finger's length. About the twenty-firſt day the plant ſeemed compleat, from which time the ſeed-leaves began to droop, till they died away.

20. The Parts of different Fruits are different: but in all the eſſential parts of the Fruit, are only continuations of the fibres, obſerved in the other parts of the tree. And there is a direct communication between the fruit and the remoteſt part of the tree. Thus an apple cut croſs-ways appears to conſiſt of four parts, Firſt the Skin, derived from the outer bark of the tree. 2. The Pulp,

Pulp, which is an expanſion of the inner bark. 3. Ramifications of the woody part of the tree, diſperſed throughout the pulp. To theſe are faſtened the coats of the kernels. And theſe being at firſt extended to the flower, part of them directly, and part obliquely, furniſh it with its nouriſhment. But the Fruit increaſing intercepts the aliment: and then the flower is ſtarved and falls off. 4. The Core, which is a production of the pith of the plant, ſtrengthened by fibres of the wood intermixed. This is a caſe for the kernels, filtrates the juice of the pulp, and conveys it to them.

Fruit ſerve not only for the food of animals, but to guard and nouriſh the ſeed incloſed; to filtrate the coarſer part of the nutritious juice, and tranſmit only the pureſt for the ſupport and growth of the plantule.

In every ſort of Grain, wheat, barley, or any other, there are three particulars obſervable, 1. The outer coat, which contains all the reſt. This in the ſame ſpecies of grain, is of a very different thickneſs in different years, as alſo in different ſoils. 2. The Germ or Bud. This is always hid in the grain, and is the plant in miniature. And 3. The Meal, which is incloſed in the ſkin, that ſurrounds the Germ, and gives it nouriſhment, when firſt put into the earth, before it is capable of drawing it from the earth itſelf.

The whole ſtructure of the plant which produces theſe grains is equally admirable. The chaffy Huſk is well adapted to defend the grain, as long as that is neceſſary, and then to let it fall. The Stalk, hollow and round, is at once light and ſtrong, capable of ſuſtaining the ear, without abſorbing too much of the juices deſtined for its nouriſhment. And the Beards are a defence againſt the Birds, that would otherwiſe deſtroy the grain before it ripened. The covering of the grain is formed of fibres, which meet in a line and form a kind of furrow. This is the place at which the ſeed, when moiſtened, is to burſt open. Were not this means prepared for the germ's coming out, the toughneſs of the outer coat, would have kept in both the meal and the germ, till they had rotted together.

Nor is this the only uſe of this place of opening. The grain is deſigned not only for ſeed, but for food alſo. Men have art enough to erect machines, for reducing it to powder. But the birds eat it as it is, and it would paſs them whole without doing them any good, were it not, that when it is moiſtened, it burſts open at the furrow and yields them nouriſhment.

The meal is compoſed of an infinite number of round, white, tranſparent bodies. Theſe incloſe the young plant, and by their figure being eaſily put in motion, as ſoon as affected by the heat and moiſture of the earth, they inſinuate into the veſſels of the plant, and give it increaſe, till it is in a condition to feed on the juices of the earth. The ſame proceſs of nature is obſervable, when grains of corn grow out of time, on being thrown careleſly together, in a moiſt place.

21. Plants do likewiſe perſpire. To find the quantity imbibed and perſpired by plants; Dr. Hale took a pot with a large ſun-flower planted in it, and by various experiments found, the greateſt perſpiration in a very warm day, to be one pound fourteen ounces; the middle perſpiration one pound four ounces. It perſpired three ounces in a warm

a warm night, when there was no dew. If ſmall dew fell, it perſpired nothing, if a large dew it gained two or three ounces.

The weight of the flower was three pounds: the weight of a well-ſized man is one hundred and ſixty. The flower perſpires twenty-two ounces in twenty-four hours: the man about twenty-five; (beſides ſix ounces, which are carried off by reſpiration from the lungs).

A middling man eats and drinks in twenty-four hours, about four pounds ten ounces. The plant imbibed and perſpired in the ſame time twenty-two ounces. But taken bulk for bulk, the plant imbibes ſeventeen times more food than the man. For deducting five ounces for fæces, there will remain but four pounds, five ounces, which enter the veins, and paſs off in twenty-four hours. And ſince taken bulk for bulk, the plant imbibes ſo much more food than the man, it was neceſſary by giving it an extenſive ſurface, to provide for a plentiful perſpiration, ſince it has no other way of diſcharging ſuperfluities as a man has. It was neceſſary likewiſe that the plant ſhould imbibe a larger quantity of freſh fluid than the man, becauſe the fluid filtrated through its roots does not contain ſo many nutritive particles, as the chile which enters our veins.

But there is a latitude of perſpiration both in men and plants. In this flower it varied from ſixteen to eighteen ounces during twelve hours day, as it was watered leſs or more: in an healthy man it varies from a pound and a half to three pounds.

Ever-greens perſpire far leſs than other plants. In proportion, they need leſs nouriſhment: hereby they are better able to bear the winter: like infects, which as they perspire little, live the whole winter without food.

In order to try whether any sap rose in winter, he made various experiments: from all which it appeared, it does rise then also, but in small quantities. And hence we see why an ever-green grafted on an oak will remain verdant, when the oak-leaves drop. Perspiring less, it needs less nourishment than the oak, and so is sufficiently fed by the sap that rises even in winter.

In summer, when hot sun-shine follows a shower, the vines in the middle of a hop-ground, are often all scorched up, almost from one end of a large ground to the other: at the same time the vapours ascend plentifully. The scorching of the vines seems to be caused by these scorching vapours, which ascend most in the middle of the ground, the air there being more dense, and consequently hotter than on the outsides.

The white clouds likewise which appear in summer-time, occasion a vehement heat, by reflecting many of the solar rays, which otherwise would not touch the earth. And if the sun be on one side, and the clouds on the other, they are perfect burning-glasses.

Sometimes there is a kind of hollow clouds, full of hail or snow. During the continuance of these the heat is extreme, since by such condensation they reflect more strongly. By these likewise those blasts may be produced, as well as by the reflection of dense vapours.

The sun-flower being tender, if the sun rises clear, faces to the east. The sun continuing to shine, at noon it faces to the south, and at six in the evening to the west. The cause is, that side

of

of the ſtem which is next the ſun, perſpires the moſt, and thereby ſhrinks.

"What degree of heat will plants bear?" The common temperate point in the Thermometer is eighteen degrees.' The external heat of an human body, will raiſe it to fifty-four degrees. Very hot ſun-ſhine will raiſe it to eighty-eight. Plants endure a conſiderably greater heat than this, near the line, for ſome hours a day. But the hanging of the leaves of many of them ſhews, they could not long ſubſiſt under it.

The winter heat is from the freezing point to ten degrees; the vernal and autumnal from ten to twenty. The May and June heat is from ſeventeen to thirty, in which the generality of plants flouriſh beſt. The heat of July is, in the ſhade, about thirty-eight degrees; in the ſun-ſhine, at noon, about fifty. The heat of an hot-bed, when too hot for plants, is eighty-five or more: and near this is the heat of the blood in high fevers. The dew heat of an hot-bed is fifty-ſix degrees; and the ſame heat hatches eggs.

A continual ſteam is aſcending during the ſummer: the ſun-beams giving the moiſture of the earth, at two foot depth, a briſk, undulating motion, which rarefied by heat, aſcends in the form of vapours. And the vigour of warm and confined vapour (ſuch as is that which is two or three feet deep in the earth) muſt be great, and penetrate the roots with ſome vigour; as we may reaſonably ſuppoſe, from the vaſt force of confined vapour in the engine for raiſing water by fire.

Tho' vegetables have not, like animals, an engine which by its alternate dilatations and contractions, drives their juices through them, yet has nature contrived other means, powerfully to raiſe the ſap and keep it in motion. And their roots are covered with a very fine thick ſtrainer, that nothing may enter but what can be readily carried off by perſpiration.

That there is a lateral communication of the ſap-veſſels in plants, as of the blood-veſſels in animals, plainly appears from the experiment of inarching trees. For when three wall-trees are thus incorporated, the root of the middlemoſt may be dug up, and the tree will grow ſtill, as receiving nouriſhment from the trees with which it is connected. And hence elders, willows, vines and moſt ſhrubs, will grow with their tops downward in the earth. For the ſame reaſon, if you frequently, in an evening, waſh the bodies of new-planted trees, they will grow quicker and better than any others of the ſame plantation.

22. If the top of a Viburnum is planted in the ground, it becomes roots, and the roots turned up become branches; and the plant grows exactly as well as it did in its natural poſition; whether the veſſels which fed the branches have changed their courſe, or whether the juices go up and down the ſame veſſels.

23. I cannot better conclude this chapter, than by tracing the Analogy between the Propagation of animals and that of vegetables. The roes of fiſhes, the eggs of inſects, birds, and all other animals nearly reſemble each other. They are compact bodies of ſuch forms as beſt ſuit their natures. They all have integuments nobly contrived for their preſervation, with firm coverings to ſecure them from outward injuries. Thoſe to be kept in the body have coverings alſo; but ſoft and membranous. Every kind contains its peculiar ſub-

ſtance,

ſtance, differing from that of every other kind. And all theſe characters belong alſo to Seeds of every kind. They have their coverings, more or leſs compact, according to their neceſſities. Their forms are convenient. The ſubſtances they contain are ſpecifically different from each other: and their offspring proceeds from them in the ſame manner, as animals proceed from their eggs.

But beſide the ſubſtances peculiar to each ſeed, there is a peculiar organization treaſured up in each, which is the rudiment of the future plant, capable of being propagated into ſuch a plant as it ſprung from, and no other. So in every one of the nut-kind, there is a viſible organization, peculiar to each ſpecies. And if ſuch an organization appear in every ſeed, which is large enough to be viewed clearly, we cannot reaſonably doubt of their exiſtence, even in thoſe which are ſo ſmall as to eſcape our ſight. There are multitudes of ſeeds, which produce large plants, and yet appear only like duſt, and a vaſt number, which we cannot ſee, but by the microſcope. And yet theſe doubtleſs have all their peculiar forms, and their organizations as well as the larger.

But from what are theſe organizations produced? How does every plant or animal, bring forth a freſh one after its kind? A little of this we may underſtand, if we trace a tree and an animal through every ſtage from the egg to their utmoſt growth.

See a young tree puſhing out its leaves and flowers, till it has extruded an entire ſet of boughs and branches. One part regularly opens after another from the firſt ſhoot till it comes to perfec-

 tion.

tion. Then and not before, it produces ſeeds, containing the rudiments of other trees like itſelf. The fibres of its general organization grow into little knots, ſome to form leaves, ſome the calix, ſome the petals, ſome the piſtil and utricle, ſome again the little ſeeds, each growing from its own pedicle. For the male parts, other fibres are formed into ſtamina, and from theſe terminate into apices: and again from theſe others terminate into the minute grains, commonly called the Farina fæcundans; each grain growing on its own pedicle, juſt as the leaves or fruits of trees.

See an animal, exactly in the ſame manner, unfolding itſelf by degrees, till its parts are explicated entirely, and it is compleat in every organ. Then and not before each female is capable of producing eggs, each being a continuation of the general organization, and growing upon its own pedicle. Each male likewiſe, when at its ſtate of perfection, is capable of producing from itſelf the fæcundating matter, neceſſary for the propagation of the ſpecies.

Let us again view a full grown tree or plant, putting forth its parts for fructification. Obſerve the apices on the ſtamina, loaden with the globules of the farina fæcundans, the pulp of each globule containing an exalted fluid, and conveying it to one of the papillæ of the piſtil. The utricle is now filled with green, ſoft ſeeds, ready to be impregnated by the globule, and containing a fluid, which afterward becomes a hard covering to each. And within this the little organization gradually increaſe.

As then a refined fluid from the ſeminal matter of the male, impregnates the organization in the egg of a female animal, mingles with the ſubtle fluids

fluids contained therein and promotes its growth and progress; so the refined part of the pulpy fluid contained in the globule, impregnates the organization in the seed of a plant, mixes with its juices, and gradually promotes its growth into a perfect plant. And doubtless both the impregnating effluvia of animals and vegetables, and the innate juices of the organization, have qualities peculiar to themselves. Hence the offspring of a black and a white parent, is of a colour between both. And thus if the farina of one sort of flower impregnate the egg of another, the colour of the flower produced thereby is variegated proportionably.

The juices imbibed by a plant, being composed of innumerable various substances, after every part has attracted its kindred particles, the superfluous ones are carried off by perspiration: chiefly by the leaves, which are the emunctories, that throw off those juices which have no kindred particles in the plant. Accordingly when the warm sun begins to rarefy the fluids, which during the winter were condensed and inactive, the new leaves then begin to put forth, from their several organizations. When winter comes, as no more fluids ascend in trees, so there is no perspiration. Consequently most of them need leaves no longer, which therefore fall off. Nor are they succeeded by others, till the vegetable begins to receive fresh nourishment, and has occasion therefore for excretory vessels to carry off superfluities. Just so the superfluous juices in animals, are continually carried off by perspiration: an obstruction of which is equally pernicious to animals and vegetables.

But is there any thing in the vegetable kingdom analogous to that strange animal the Polypus, which multiplies by being cut in pieces? There

is

is. View, for inſtance, a young willow. This is an organized body, capable of growing, till it come to its perfect growth by means of the vegetative principle. The Polypus is an organized body, capable of being extended till it comes to its perfect growth, and of feeding and loco-motion, by its animating principle. The willow as it grows, is gradually ſending off new branches, which are its fætuſes, proceeding from the organizations lodged in every part. The Polypus in like manner gradually ſends off new fætuſus; from organizations placed in every part of it. If the willow be cut in pieces and planted, each piece will be explicated into a tree, and then ſend forth new fætuſes, like its parent. And if the Polypus be cut in pieces, each piece will be explicated into a Polypus, and then extrude new fætuſes: ſo that cutting it in pieces, is but anticipating the propagation of thoſe organizations in the pieces, which would, if let alone for a while, themſelves iſſue from the ſides of the parent.

If we obſerve the extreme tenderneſs of this animal, liable to be wounded, nay torn in pieces, by any hard body, which is carried down the ſtreams, or moved in the ponds, wherein they dwell: we ſee the providential reaſon, for this contrivance to propagate them: as perhaps no other animal is of ſo tender a texture, and ſo eaſily deſtroyed, having neither ſagacity to avoid danger, nor ſtrength to bear the leaſt violence.

Other trees have been propagated by a ſtill more ſurprizing way. One having cauſed ſome aſhen pipes, that had brought water to his fountain twelve years to be taken up, they were left in the yard, where they rotted almoſt entirely.

tirely. But in their room there ſhot up a young foreſt of aſhes, which are now about four feet high. There is no aſh-tree within a great diſtance of the yard. Where then were the ſeeds from which they ſprung?

24. Mr. Bonet of Geneva was inclined to try whether plants would grow, when planted in moſs inſtead of earth. So he filled ſeveral garden-pots with moſs, and compreſſed it more or leſs, as he judged the ſeveral plants might require, a cloſer or a looſer ſoil.

He then ſowed therein wheat, barley, oats, and peas. And he found firſt, That all the grains thus ſown, came to maturity later than thoſe of the ſame ſorts, which had been ſown in mould. 2. That the ſtems from the ſeeds ſown in moſs, were generally taller than thoſe ſown in earth. 3. That there came more blades from the grains ſown in moſs, than from thoſe ſown in the ground. 4. The grains ſown in moſs produced more plentifully than the others. 5. The grains gathered from the corn which grew in the moſs, having been ſown again partly in moſs, and partly in earth, ſucceeded well in both.

He alſo planted in moſs, pinks, daiſies, tulips, junquils, and ſeveral other ſorts of flowers. And all theſe ſucceeded full as well, as thoſe of the ſame ſort which he planted in mould. He alſo placed in moſs, cuttings and layers of vines, all which grew up into vines. And theſe in a while were larger than thoſe which came from cutting and layers planted at the ſame time in the ground.

Mr. Kraft ſowed oats and hemp-ſeed in rich earth, in ſand throughly dried, in ſhreds of paper,

paper, in pieces of woollen cloth, in chopt hay. He afterwards watered them daily, and they grew near as well in one ſubſtance as an other.

The huſbandry of Figs, as it is ſtill practiſed in many parts, is one of the greateſt curioſities in nature. There are two ſorts of fig-trees, the wild and the garden fig-tree. The wild bear three kinds of fruit, Fornites, Cratitires, and Orni: and all theſe are neceſſary to ripen the garden-fig. The Fornites appear in Auguſt, and hold to November without ripening. Herein breed ſmall worms, which turn to a kind of gnats, no where to be ſeen but about theſe trees. In November theſe gnats make a puncture in the Cratitires, which do not appear till towards the end of September, and the Fornites gradually fall off, after the gnats have left them. The Cratitires remain on the tree till May, and incloſe the eggs depoſited in them. In May the Orni appear, which after they grow to a certain ſize, are pricked by the gnat iſſuing from the Caititires.

None of theſe are good to eat, but only to ripen the fruit of the garden fig-tree in the following manner. In June and July, the peaſants take the Orni, when their gnats are juſt ready to break out, and carry them to the garden fig-tree. If they do not mind the time exactly, the Orni drop and the garden-fruit not ripening, for want of its proper puncture, will likewiſe fall ſoon after. Therefore they carefully inſpect the Orni every morning, and transfer ſuch of them as are proper. By this means the garden-figs become ripe, in about ſix weeks after they have received the puncture of the inſect. When they have dried them in the ſun, they put them into ovens, to deſtroy the eggs of the gnats laid in them, from whence

otherwiſe

otherwiſe worms would be produced, which would conſume the fruit.

What an expence of time and pains is here! Who can but admire the patience of the Greeks, buſied above two months in carrying theſe prickers from one tree to another! But how do theſe contribute to the ripening of the garden-figs? Perhaps by cauſing the nutritious juice to extravaſate, whoſe veſſels they tear aſunder, in depoſiting their eggs. Perhaps too they leave with their eggs ſome kind of liquor, proper to ferment with the milk of the fig, and make it tender. Figs in Paris ripen ſooner, for having their buds pricked with a ſtraw dipped in oil.

CHAP.

CHAP. II.

1. *Of some particular plants:*
2. *Sugar not unwholesome:*
3. *Maple Sugar:*
4. *Molasses from apples:*
5. *Of Ambergris:*
6. *Of the corruption of plants and animals:*
7. *General Reflections:*
8. *Essay on the production, &c. of plants and animals.*

1. IT remains to give a short account of some remarkable productions of the Vegetable kind.

The grass of the Submarine Meadows is not a span long, and is of a green approaching to a yellow. The Tortoises seem to live wholly on this; but they bite much more of it than they swallow. Hence the sea is covered with this grass, wherever they feed at the bottom. About once in half an hour they come up, fetch one breath like a sigh, and sink again. They breathe somewhat oftener, when on shore; if you hurt them, the tears will trickle from their eyes. They will live out of water twenty days and be fat, if they have twice a day half a pint of salt-water.

A submarine Sensitive Plant has been observed on the Irish Coast. It consists of a long slender tube about as thick as the barrel of a goose quill, growing about six or eight inches out of the crevices of the rocks, especially in such hollows as the

the ſalt water remains in, after the tide ebbs away. In the middle of the tube ſprings up a ſlender ſtalk. The top of which is a reddiſh, round veſicle. If you point a finger to this, as ſoon as you are near touching it, the ſtalk withdraws to the very bottom of the tube, and the tube itſelf bends and becomes flaccid. The plant has no branches, nor can the root be ſeparated from the rock without breaking it. On the Corniſh ſhores, there grows a kind of Senſitive Fucus. Bring this ſo near the fire as juſt to warm, and its edges ſhrink up. In this ſtate, move a finger toward them, and they ſhrink from it, but if the finger is removed, recover their former ſituation. Placed on a warm hand, it moves perpetually to and from the hand, like an animal ſtruggling for life. It ſeems this odd effect is owing to the ſtructure of theſe plants. They are ſo extremely thin that they yield to the perſpiration of the hand; the effluvia, being of force ſufficient to repel the leaves when they are near.

The Vines of Hops wind about the poles with the ſun, thoſe of kidney-beans againſt the ſun, and that ſo obſtinately, that although the one or the other be over-night wound the oppoſite way, yet in the morning it will be found to be got back again to its natural bent.

The Herb of Paraguay, as it is called, is the leaf of a tree, of the ſize of a middling Apple-tree. It is ſent to Peru and Spain, in great quantities, well dried and almoſt reduced to powder, being uſed by the miners and many others, as we uſe wine, and the Turks Opium to raiſe the ſpirits. Indeed the Spaniards believe it to be a preſervation

tion from, and remedy for all their diſorders. It is opening and diuretic, and what is ſurprizing produces very different effects at different times. It purges ſome, and nouriſhes others: it gives ſleep to the reſtleſs and ſpirits to the drowſy. Thoſe who are accuſtomed to the uſe of this herb, can ſcarce ever leave it off, or even take it moderately though when uſed to exceſs, it brings on moſt of thoſe diſorders that attend the too free uſe of ſtrong liquors. They prepare it nearly as we do tea; but ſeldom uſe any ſugar with it. Sometimes they take it by way of vomit: then they drink it lukewarm.

The Caa-Tree (that is its proper name) thrives beſt in the marſhy bottoms between the mountains of Maracayu, eaſt of Paraguay, in about twenty five degrees twenty five minutes ſouth latitude. They ſometimes ſend to Peru alone in a year, an hundred thouſand arobes, (an arobe is 28 pounds,) and each arobe is worth ſeven French crowns.

By the whole account, this appears to be a ſpecies of tea, little differing from ſome of thoſe which grow in China. The leaf is a third part leſs than that of Bohea-tea, but much hardier: for it bears the Engliſh froſt, which that will not. Bohea-tea has a ſmaller and a darker leaf than Green; which is as large and as bright as a bay-leaf, and endures all weathers. All theſe appear to be of the lawrel kind: and I doubt, if lawrel or bay leaves properly cured, would not equal any of them.

The Coco-tree grows ſtrait, without any branches, thirty or forty foot high. Near the top it bears twelve leaves, each ten foot long, and half

half a foot broad. These are used in making mats, covering houses, and for many other purposes. Above the leaves grows a large excrescence, in the form of a cabbage. But the taking it off kills the tree. Between the leaves and the top grow several shoots, as thick as a man's arm, which when cut, yield a white, sweet, agreeable liquor, serving as wine, and equally intoxicating. Yet at the end of four and twenty hours, it becomes a strong vinegar. As long as this liquor distils, the tree bears no fruit: but when these shoots are suffered to grow, it puts forth a large bunch, wherein the Coco-nuts are to the number of ten or twelve. In each there is first about half a pint of clear, cooling water. In a little while this becomes a white, soft pulp, which afterwards condenses into a nut. The tree yields fruit thrice a year. Some of the nuts are as large as a man's head.

The Cacao Tree is of a middling size; the wood is porous, the bark smooth, and of a cinnamon colour. The flower grows in bunches between the stalks and the wood, of the form of roses, but without scent. The fruit containing the Cacao is a sort of pod, of the size and shape of a cucumber. Within this is a pleasant, acid pulp, which fills up the interstices of the nuts till they are ripe. Then they lie close together, in a regular and elegant order. They have a tough shell; within which is the oily substance, whereof the Chocolate is made. This fruit grows differently from our European fruits, which always hang upon the small branches: whereas this grows along the body of the great ones, principally at the joints. None are found on the small; a manner

ner of vegetation ſtrange here; but which prevails in ſeveral other plants within the Tropics.

The Tallow-tree, which grows plentifully in China, is about the height of a cherry-tree. Its bark is very ſmooth, and its leaves of a deep ſhining red. Its fruit grows in a pod, like a cheſnut, conſiſting of three white grains: each of which is about the ſize, and of the form of a ſmall nut. In each is a little ſtone, ſurrounded with a white pulp, in conſiſtence, colour, and even ſmell like tallow. And this it is, of which the Chineſe in general make their candles.

The Horſe Cheſnut contains a ſaponaceous juice, uſeful not only in bleaching, but alſo in waſhing linens and ſtuffs. Peel and grind them; then the meal of twenty nuts, is ſufficient for ten or twenty quarts of water. Either linen or woollen may be waſhed in the infuſion, without any other ſoap. It takes out ſpots of all kinds, rinſing the clothes afterwards in ſpring-water.

If you grind the nut, ſteep the meal in hot water, and then mix it with an equal quantity of bran, both hogs and poultry will eat it. Both horſes and cows will eat the nut itſelf, mixt with other food.

The Sago Tree is between 20 and 30 feet high, and about 5 or 6 round. It grows in the Molucca Iſlands. Its outward bark is about an inch thick: under this are ligneous fibres, which cover a maſs of a kind of gummy meal. When this is ripe, a whitiſh duſt tranſpires through the leaves. The Malais then cut down the tree, ſcoop out the mealy ſubſtance, dilute it with water, and ſtrain it it through a fine cloth. It afterwards gradually dries and hardens, and will keep good for many years.

Palm Trees are male and female. In March or April, when the sheaths that inclose the young clusters of the flowers and fruit begin to open, (at which time the Dates are formed) they take a sprig of the male cluster, and insert it into the sheath of the female; or else take a whole cluster of the male tree, and sprinkle the farina of it over several clusters of the female. Where they use the former method, one male suffices to impregnate 4 or 500 females.

The palm tree is in its greatest vigour about 30 years after transplantion, and for 70 years longer bears yearly, 15 or 20 clusters of dates, each of 15 or 20 pounds weight. Afterward they gradually pine away, and usually fall about the latter end of their second century.

To procure the honey of the Palm Tree, they cut off its head, and scoop the top of the trunk into the shape of a bason. The sap ascending lodges in this cavity, for the first ten or twelve days, three quarts or a gallon a day. Then it gradually diminishes, till in six or eight weeks, the juices are consumed, and the tree is fit only for firewood. This liquor is a thin syrup, of a more luscious sweetness than honey. Hence our Poet mentions

"Fruit of Palm-Tree, pleasant to thirst
And hunger both:"

Though one would imagine, a liquor of that kind, would not be very proper to quench thirst.

I find of the number of Sicilian Plants, says a late writer, the Cinnamon, Sarsaparilla, Sassafras, ſras, Rhubarb, and many others commonly thought not to be natives of Europe. The Palma Chriſti too, that plant ſo much celebrated of late, from the ſeed of which the Caſtor Oil is made, grows in many places of Sicily in the greateſt abundance. Our Botaniſts have called it Ricinus Americanus, ſuppoſing it only to be produced in that part of the world.

But the moſt uncommon of all the vegetable productions of Sicily, are ſome of the trees that grow on the ſides of Mount Ætna. Three of theſe are nearly of one ſize; but one is rather taller than the other two. It riſes from one ſolid ſtem to a conſiderable height; after which it branches out. I meaſured it about two feet from the ground, and found it ſeventy-ſix feet round. All theſe grow on a thick rich ſoil, formed originally of aſhes thrown out by the mountain.

The Balſam-Tree grows on rocks, and frequently on the limbs or trunks of other trees. This is occaſioned by birds, ſcattering or voiding the ſeeds, which being glutinous, like thoſe of Miſſelto, take root and grow; but not finding ſufficient nouriſhment, the roots ſpread on the bark till they find a decayed hole wherein is ſome ſoil. Into this they enter and become a tree. But the nouriſhment of this ſecond ſpot being exhauſted, one or two of the roots paſs out of the hole, and fall directly to the ground, though at forty feet diſtance. Here again they take root, and become a much larger tree than before. They flouriſh on the Bahama Iſlands, and many other of the hot parts of America.

In Italy are many Coppice Woods, of what our gardeners call the Flowering Aſh. Manna is procured

procured by piercing the bark, and catching the ſap, as we do that of birch trees, to make birch wine. It begins to run in the beginning of Auguſt, and in a dry ſeaſon, runs for five or ſix weeks. But we have no need to be beholden to the king of Naples. For the tree grows as well in England as in Italy. What ſtupidity is it then, to import, at a large expence, what we may have at our own doors? The leaves of this tree are the proper Sena, and better than any brought from Apulia.

Peruvian Bark comes from a tree, about the bigneſs of a plumb-tree. Its leaves are like ivy, and are always green. It is gathered in Autumn, the rind is taken off all round, both from the boughs and the tree, and grows again in four months. It bears a fruit, not unlike a cheſnut, except its outward ſhell. This ſhell is properly called China-China, and is eſteemed by the natives, far above the bark, which is taken from the trunk or boughs. And it ſeems this only was in uſe, till the demand for it ſo increaſed.

The tree which produces Cotton is common in ſeveral parts both of the Eaſt and Weſt Indies. The fruit is oval, about the ſize of a nut. As it ripens, the outſide grows black, till opening in ſeveral places by the heat of the ſun, it diſcovers the cotton, of an admirable whiteneſs.

Pepper grows on a ſhrub in ſeveral parts of the Eaſt-Indies, which is of the reptile kind; and for that reaſon is uſually planted at the foot of ſome larger tree. It grows in cluſters, which at firſt are green. As the grains ripen, they grow reddiſh;

and after being expofed a while to the fun, become black. To make White Pepper, they moiften it with fea-water, and then expofing it to the fun, diveft the grains of the outer bark, which of confequence leaves them white.

The tree that bears Jamaica Pepper, is about thirty feet high, and covered with a grey, fmooth, fhining bark. It fhoots out abundance of branches, which bears large leaves, like thofe of the bay-tree. At the very end of the twigs grow bunches of flowers, each ftalk bearing a flower, which bends back. To thefe fucceeds a bunch of berries, larger when ripe than juniper berries. They are then black, fmooth, and fhining; but they are taken from the tree when unripe, and dried in the fun. They have a mixed flavour of many kinds of fpice, and hence they are called All-fpice.

The plant which affords Ginger, refembles our reed, both in its ftem and leaves. The root fpreads itfelf near the furface of the ground, in form not unlike a man's hand. When it is ripe they dig it up, and dry it either in the fun, or in an oven.

Nutmegs are inclofed in four different covers: the firft, thick and flefhy, like that of our walnuts: the fecond is a thin, reddifh coat, of an agreeable fmell, called Mace. The third is a hard blackifh fhell. The fourth is a greenifh film. In this the nutmeg is found, which is properly the kernel of the fruit.

The Wild-pine, as it is called, is a wonderful inftance of the wife providence of God. The leaves

leaves of it are channelled, to catch and convey water into their reſervoirs. Theſe reſervoirs are ſo made, as to contain much water. And they cloſe at the top when they are full, to hinder its evaporation. Theſe plants grow on the arms of the trees in the woods, as alſo on the bark of their trunks. Another contrivance of nature in this vegetable is very admirable. The ſeed has many long and fine threads, that it may be carried every where by the wind, and that by theſe, when driven through the boughs, it may be held faſt, and ſtick to the arms or trunks of trees. As ſoon as it ſprouts, although it be on the under part of a bough, its leaves and ſtalk riſe perpendicular, becauſe if it had any other poſition, the ciſtern made of hollow leaves could not hold water. In ſcarcity of water, this reſervoir is not only neceſſary and ſufficient for the plant itſelf, but likewiſe uſeful to men, birds, and inſects. Hither they then come in troops, and ſeldom go away without refreſhment.

Theſe leaves will hold a pint and an half, or a quart of rain-water. When we find theſe pines, ſays Captain Dampier, we ſtick our knives into the leaves, juſt above the root; and that lets out the water, which we catch in our hats, to our great relief.

The ſame providential deſign is anſwered by the Water-withy of Jamaica. This, which is a kind of vine, grows on dry hills in the woods, where no water is to be found. Its trunk, if cut into pieces, two or three yards long, and held by either end to the mouth, affords a limpid, innocent and refreſhing ſap, as clear as water: and that in ſo great abundance, as gives new life to the weary and thirſty traveller.

An admirable inſtance of the ſame good providence we have in the Fountain Tree, which grows on Hierro, one of the Canary Iſlands. In the rocky cliff which ſurrounds the iſland, is a narrow gutter, which begins at the ſea, and continues to the ſummit of the cliff, where it falls into a valley, which is bounded by the ſteep front of a rock. On the top of this grows a tree, which has continued many years. Its leaves conſtantly diſtil as much water as is ſufficient for the drink of every living creature on the iſland. It ſtands by itſelf a league and a half from the ſea, and no one knows of what ſpecies it is. Its trunk is about nine feet round, in diameter about three. It is thirty feet high; the circumference of all the branches together is about ninety. The branches are thick, the loweſt of them is about an ell from the ground. Its fruit reſembles an acorn, its leaves reſemble thoſe of the laurel, but are longer and broader. They come forth in perpetual ſucceſſion, ſo that the tree is always green. On the north ſide of it are two ciſterns of rough ſtone, each fifteen feet ſquare, and twelve deep: one of which contains water for the drink of the inhabitants: the other, for their cattle and all other purpoſes.

Every morning, near this part of the Iſland, a miſt riſes from the ſea. This the South and Eaſterly winds drive againſt the fore-mentioned cliff, which it gradually aſcends, and thence advances to the end of the valley. Being ſtopt there by the front of the rock, it reſts upon the leaves and branches of the tree, whence it diſtils the remainder of the day.

But

But trees yielding water are not peculiar to the iſland of Hierro. One of the ſame kind grows on the Iſland of St. Thomas, in the gulph of Guinea. And of the ſame nature is that near the mountains of Vera Pogz, whereof we have the following account in Cockburne's Voyages.

" In the morning of the fourth day, we came out on a large plain, in the midſt of which ſtood a tree of an unuſual ſize. Its trunk was above five fathoms round; the ſoil it grew on was very ſtony. And on the niceſt enquiry we could afterwards make, both of the Spaniards and the Natives, we could not learn, that any other ſuch tree had been known in all New Spain.

" Perceiving the ground under it wet, we were ſurprized, knowing that according to the certain courſe of the ſeaſon in that latitude, there had no rain fallen for ſix months, and that it could not be owing to the dew, for this the ſun entirely dried up, in a few minutes after its riſing. At laſt, to our great amazement, as well as joy, we perceived water dropping from the end of every leaf; after we had been labouring four days through extreme heat, and were almoſt expiring for thirſt, we could not look upon this, but as liquor ſent from heaven, to relieve us in our extremity. We catched it in our hands, and drank ſo plentifully, that we could ſcarce tell when to give over.

The Manchineel apple is moſt beautiful to the eye, agreeable to the ſmell, and pleaſant to the taſte, but the whole tree is ſo poiſonous, that the wood of it while green, if rubbed againſt the hand, will raiſe bliſters.

The wood is good for tables, cabinets, and all other curious work. But the virulent nature of the ſap, calls for great caution in felling the tree. I was cutting down one of them, ſays Mr. Cateſby, when ſome of the milky juice ſpurting in my eyes, I was two days totally blind, my eyes and face being much ſwelled. For four and twenty hours, I felt a violent pricking pain, which then gradually abated.

Indeed it is reported, and generally believed of this tree, that the wound of an arrow dipped in its juice is mortal, that the rain which waſhes the leaves, will raiſe bliſters on the ſkin; and that even its ſhadow is ſo noxious, that the bodies of thoſe that ſleep under it ſwell. Yet a pregnant woman ate three of the apples without any inconvenience; and a robuſt man of about forty-five years of age, ate more than two dozen without being diſordered more than twenty four hours. About an hour after he had eaten them, his belly ſwelled, and he complained of a burning heat in his bowels. He could not keep his body in an erect poſture; his lips were ulcerated, and he was ſeized with cold ſweats: but he was relieved from all theſe ſymptoms by a decoction of the leaves of Ricinus, the Avellana purgatrix, in water, which being drank plentifully, produced a violent vomiting and purging, for four hours, after this he was made to walk about, and ſome rice gruel perfected the cure.

The Negroes in Africa uſe a poiſon of an extraordinary nature. The doſe is very ſmall, and hath no ill taſte. The ſymptoms are various, according as the doſe is. It kills ſometimes in a few hours, ſometimes in months; at others, in ſome

ſome years. If a great quantity is given, death follows in ſix or ſeven hours. (The Negroes turn white.) If the doſe is but ſmall, the ſick loſes his appetite, feels pain in his head, arms, and limbs, a wearineſs all over, ſoreneſs in his breaſt, difficulty in breathing, and at laſt dies languiſhing. Probably it is the ſame poiſon which is uſed in Spain and Italy. This hath but one ſpecific antidote, the knowledge of which a famous Negroe-poiſoner, was at length perſuaded to impart. The antidote is the root of the Senſitive Plant. Take none of the root but what is in the ground; waſh it well, and ſplit it in two. Take a good handful of theſe ſplit roots; ſteep them in three quarts of fair water, in an earthen glazed pot, having a cover. Uſe but a moderate fire, that it may boil gently. The decoction has no ill taſte; you may add ſugar, as you think beſt. Give the patient a good glaſs of this decoction as warm as he can drink it; an hour after give another, and ſo for ſome time, till you make a perfect cure. There is no danger of giving too much, it can do no harm at all.

In the Valley of the Lancy, which runs between the mountains of Jurin, grows a plant like the Doronicum, near the roots whereof is found pure quickſilver, running in ſmall grains like pearls. One would not imagine the plant had any influence on this, but for the following experiment. Expreſs the juice: expoſe it to the air in a clear night, and there will be found as much Mercury as there is loſt of juice.

But of all productions of the vegetable kind, there is none more remarkable than the Aloe. It grows exceeding ſlowly. But the ſlowneſs of its growth is afterwards compenſated, by the bulk to which it arrives, the velocity with which it ſhoots, and the prodigious number of flowers it produces, which ordinarily amount to ſeveral thouſands. It uſually takes up three months, May, June, and July, from the firſt budding of the ſtem, to the finiſhing of the flowers. There are however exceptions to this rule. The Aloe in the garden of Cardinal Farneſe at Rome, ſhot up in the ſpace of one month, to the height of twenty-three feet. Another at Madrid grew ten feet in one night, and twenty-five more in the night following.

The progreſs of the Venetian Aloe, in the garden of Signior Papatava, was as follows. It began to ſhoot its ſtem on the 20th of May, which by the 19th of June, was riſen four Paduan feet and an inch. On the 24th it had gained ten inches more, and on the 29th eight more, on which day it began to emit branches. On the 6th of July it had gained one foot one inch: on the 17th one foot eight inches more; on the 7th of Auguſt, one foot and a half. From that day to the 30th, it grew very ſlowly, but continued emitting branches and flowers. The trunk was at the bottom a foot thick; the branches were twenty-three in number. On the top of each was a knot or collection of flowers. On each of the firſt branches there were an hundred and twelve: on others an hundred and ten, and on others an hundred. They yielded little ſmell: but what was of it was agreeable.

When the tree has once flowered, it quickly dies, being quite exhauſted by ſo copious a birth. They ſeldom flower till they are of a conſiderable confiderable age, when they are of a large fize and a great height. As foon as the flower-ftem begins to fhoot from the middle of the plant, it draws all the nourifhment from the leaves, fo that as that advances, thefe decay. And when the flowers are fully blown, fcarce any of the leaves remain alive. But whenever this happens, the old root fends forth a numerous quantity of off-fets for increafe.

Perhaps there is fcarce any plant in the creation which is of fo general ufe. The wood of it is firm, and ferves for fences, and for the ufe of the carpenter. The leaves makes coverings for houfes: the ftrings and fibres ferve, in the room of hemp, flax and cotton. Of the prickles are made nails and awls, as alfo pins and needles. And from a large Aloe, when rightly tapped, may be drawn three or four hundred gallons of juice, which by diftillation grows fweeter and thicker till it becomes fugar.

If there be a more beautiful flower than that of the Aloe, it grows on a fpecies of Cereus (or Prickly Pear, as they call it, in America) which grows well in our ftoves: about the middle of July the flower is grown to its bignefs. Till then it appears like a bit of wool on a dead ftem. It ufually begins to open about five in the evening, and is full blown about eight, and continues fo till about four the next morning. It then gradually clofes, and is fhut up about fix o'clock, covered with a cold moifture. The calyx or empalement is a foot diameter, divided into fixty fegments; the outfide of a fine gold colour, the infide of a fplendid yellow, fpreading like the rays of a ftar. The petals are about thirty, in form of a cup, of a pure white. There is one ſtyle ſurrounded by a great number of ſtamina. It ſends forth a very fragrant perfume, like the Gum Benjamin while in bloſſom; the empalement and petals open one by one with great elaſticity.

There is not in nature any flower of greater beauty, or that makes a more magnificent appearance. What pity, that it is only an Ephemeran! Literally the creature of a day!

It has been before obſerved, That as all animals are from eggs, ſo all vegetables are from ſeeds. But many have ſuppoſed there is one ſort of vegetable, which is an exception to this: namely Muſhrooms, the ſeeds whereof have been long ſought in vain. And it is certain, if you only range in April, balls of horſe-dung, as big as one's fiſt, in lines three feet diſtant from each other, and one foot under the ground, covering them all over with mould, and that again with horſe-dung in the beginning of Auguſt the upper pieces of dung will begin to grow white; being covered with fine white threads, woven about the ſtraws whereof the dung is compoſed. By degrees the extremities of theſe threads grow round into a kind of button: which enlarging itſelf by little and little, at length forms itſelf into a muſhroom. At the foot of each, when at its full growth, is an infinity of little ones. The white threads of the dung preſerve themſelves a long time without rotting, if kept dry. And if they are laid again in the ground, they will produce new muſhrooms.

" Are theſe then any thing elſe than the mouldineſs or putrefaction of horſe-dung?" Yes certainly. Indeed all Mouldineſs, ſo called, is a congeries

congeries of very ſmall plants. And theſe in particular, like all other plants, have their origin from ſeeds. But before the ſeeds can vegetate, there are required, certain juices, proper to penetrate their coats, to excite a fermentation in them, and to nouriſh the minute parts thereof. Hence ariſes that vaſt diverſity of places; wherein different ſorts of this plant are produced. Some will only grow on other particular plants, whoſe trunk or roots have the juices proper for them. Nay, there is one ſort which grows only on the fillets and bandages of the patients in the hoſpital at Paris. It is not therefore at all ſurpriſing that horſe-dung ſhould be a fit ſoil for common Muſhrooms. It is probable the ſeeds of theſe are ſpread in numberleſs places, well nigh throughout the whole earth. And the ſame may be ſaid concerning the ſeeds of many plants, as well as the eggs of many inſects: more eſpecially of thoſe which are ſo minute, that we can ſcarce diſcern them even with glaſſes: ſeeing the ſmaller they are, the more eaſily may the leaſt wind convey them hither and thither. So that in truth the earth is full of an inconceivable number both of animals and vegetables, perfectly formed in all their parts, and deſigned as it were in minature; only waiting for certain favourable circumſtances to enable them to make their appearance at large. How rich then muſt that hand be, which hath ſown them with ſo much profuſion!

It may not be improper before concluding this head, to deſcribe one more ſpecies of ſea-plants. Coral grows chiefly in grottoes, which open to the ſouth, and whoſe concave arch is nearly parallel to the ſurface of the earth. It will not grow at all, but where the ſea is quiet as a pond.

It vegetates the contrary way to all other plants; its root adhering to the top of the grotto, and its branches ſhooting downward. The root takes the exact form of the ſolid it grows to, and covers it (as far as it goes) like a plate: and this is a probable proof, that its ſubſtance was originally fluid. Accordingly corals ſometimes line the inſide of a ſhell, which they could not have entered but in a fluid form. All its organiſm, with regard to vegetation, ſeems to conſiſt in its rind, in the little tubes whereof the juice runs to the extremities of the branches. And this juice petrifying both in the cells, that encompaſs the coraline ſubſtance, and in thoſe at the extremity of the branches, whoſe ſubſtance is not yet formed, by this means inlarge the plant to its full dimenſions, both in height and bulk. It is vulgarly believed, that coral is ſoft while in the water. But experiment proves the contrary.

It is obſervable that all Sea-plants, (except the Alga) are without roots. Nor have they any longitudinal, capillary ſap-veſſels, through which rooted plants draw nouriſhment to every part. But the whole ſubſtance of Sea-Plants is compoſed of veſicles, which receive their nouriſhment immediately from the ſurrounding water. Conſequently they can have no circulation of the ſap, having no veſſels to convey it from one end of the plant to the other.

2. Many phyſicians affirm, That Sugar is unwholeſome, and moſt, that it deſtroys the teeth. But how will this agree with the following account? " My grandfather, ſays Dr. Slare, took as much ſugar as his butter ſpread upon bread would receive,

receive, for his daily breakfaſt. He put ſugar into all his ale and beer, and into all the ſauces he uſed to his meat. At eighty years old he had all his teeth ſtrong and firm (having never had the tooth-ach) and never refuſed the hardeſt cruſt. In his 82d year one of his teeth came out, and in two or three years all the reſt. But others filled up their room, and in a ſhort time he had a new ſet quite round. His hair alſo from very white became dark. He continued in health and ſtrength, and died without any diſeaſe, in his ninety-ninth or hundredth year.

3. It is not only from the canes that ſugar is extracted. In New England much of it is made from the juice of the Upland Maple. They firſt make a hole in the tree, within a foot of the ground, ſhelving inward, ſo as to hold about a pint. Then they tap this hole, and by a reed draw off the liquor into a veſſel. A large tree will yield between the beginning of February and the end of April twenty gallons of juice. A gallon in boiling ſixteen hours is reduced to three pints, and yields more than two pounds of ſugar, which our phyſicians prefer to all other for medicinal uſes.

4. Moloſſes likewiſe may be procured without ſugar-canes. This was diſcovered a few years ago by Mr. Chandler, of Woodſtock, in New-England, an inland town, where the common Moloſſes is ſcarce and dear. Ever ſince both he and his neighbours ſupply themſelves with it, out of their own orchards. The apple that produces it, is a ſummer ſweeting, of a middling ſize, and full of juice. They grind and preſs the apple, and then

then gently boil the juice for about six hours. In that time it comes to the sweetness and consistency and answers all the purposes of other Molosses.

5. There is one Sea-production, if it may be so termed that is not commonly understood. Some have maintained, that Ambergris was a substance naturally bred in one species of whales, in a bag three or four feet long. But this bag is in truth only the bladder of the whales, and the supposed Ambergris is only a calculus of the bladder. The largest of these ever found in a whale, weighed twenty-one pounds. But pieces of Ambergris have been found, which were six feet long, and weighed above 180 pounds.

It seems, 1. That Ambergris, like yellow amber, comes out of the earth into the sea. 2. That it comes not like Napththa, but in a thicker viscid and tenacious consistence. 3. That in the first formation thereof, a liquid Bitumen or Napththa is mixed with it. 4. That large pieces may be generated at the same time; but usually a small one rises first, to which another soon adheres, and so more and more, forming irregular figures, under which it is soft, so that various substances stick to it; but it gradually hardens to the consistence of wax.

However, one would not be positive, as to the manner of its generation. For who can explain in what manner amber is produced? Or how metals, semi-metals, precious stones, and innumerable other mineral substances, are generated? We know what they are, but how they are formed, we know not with any degree of certainty.

3. The

6. The principle of Corruption in plants and animals, is probably the very ſame, which during a ſtate of circulation, is the principle of life: namely the air, which is found in conſiderable quantities, mixed with all ſorts of fluids. This has two very different motions; an expanſive one, ariſing from its natural elaſticity, by which it gives their fluids an inteſtine motion, and gradually extends the parts that contain them: and a progreſſive motion. It does not appear that this is eſſential to it. Rather it is occaſioned by the reſiſtance of the ſolid parts. This reſtraining its expanſion, obliges it to take the courſe that is more free and open, which is through the veſſels of plants and animals.

When this courſe is ſtopped, the expanſive motion remains, and ſtill continues to act, till it has ſo fully overcome the including bodies, as to bring itſelf to the ſame degree of expanſion with the outward air. But this it cannot do, without deſtroying the texture and continuity of thoſe ſolids, which we call Corruption.

This deſtructive quality of the air is promoted, either by weakening the tone or coheſion of the including parts; as when fruit is bruiſed, which corrupts in that part much ſooner than in the others: or by increaſing the expanſive force of the air, by heat or ſome other co-operating circumſtance.

And certainly there is no corruption or putrefaction, without air. Hence either vegetable or animal bodies buried deep in the earth or water, remain for ages entire, which when expoſed to the air, quickly moulder away. And hence ſuch vegetables as are moſt apt to putrify, remain unchanged in vacuo.

Yet various experiments ſeem to ſhew, that air muſt be impregnated by water, before it can occaſion putrifaction, either in animal or vegetable ſubſtances. For take a pound of freſh fleſh, and keep it in a moderate heat, and it will throughly putriſy in a few days. But if you firſt extract the moiſture, it will harden like a ſtone. And it may then be kept for ages, without any putrifaction. Even blood, if you deprive it of its watry part, may be kept for fifty years. But if you then diſſolve it in water, and place it in a gentle warmth, it will putriſy immediately.

The proceſs of putrefaction may be learned from an eaſy experiment. Take the green, juicy parts of any freſh vegetable, throw them together in a large heap, in a warm air, and lay a weight upon them. The middle part of the heap will ſoon conceive a ſmall degree of heat. It will grow hotter and hotter, till it comes to a boiling heat, and is perfectly putrified.

In three days from the firſt putting them together, the heat will equal that of an human body in health. By the fifth day, the heat will be ſuch as the hand can hardly bear. By the ſeventh or eighth, all the juices are generally ready to boil. Sometimes the matter will even flame, (as does moiſt hay) till it burns away. But commonly it acquires a cadaverous taſte and ſmell, and turns into one ſoft, pulpy maſs, much reſembling human excrements in the ſcent, and putrified fleſh in the taſte.

If this be diſtilled, there will come from it, 1. An urinous ſpirit, perfectly like that obtained from animals, and ſeparable by freſh diſtillation into pure water, and a large quantity of white, dry, volatile ſalt, not to be diſtinguiſhed from animal

animal ſalts. 2. An oily ſalt, which ſhoots into globes. 3. A thick, fætid oil, both which are entirely like thoſe of animals. 4. The remainder being calcined in an open fire, yields not the leaſt particle of fixed ſalt: juſt as if the ſubject had been of the animal, not the vegetable kingdom. And this proceſs holds equally in all kinds of vegetables, though of ever ſo different natures. Yea, in dry vegetables, ſo they be moiſtened by water, before they are thrown into heaps.

By this means the difference between one vegetable and another is entirely taken away. By this proceſs, they are all reduced to one common nature: ſo that wormwood for example, and ſage, become one and the ſame thing. Nay, by this means the difference between vegetables and animals is quite taken away: putrified vegetables being no way diſtinguiſhable from putrified fleſh, Thus is there an eaſy and reciprocal tranſition of animal into vegetable, and vegetable into animal.

So true it is, that matter, as matter, has no concern, in the qualities of bodies. All depend on the arrangement of the particles, whereof each body conſiſts. Hence water, though taſteleſs, feeds aromatic mint, and the ſame earth gives nouriſhment to bread and poiſon.

As to this arrangement, the firſt view of a vegetable gives us an idea, of infinitely numerous and various parts: and ſo complex, that many have been diſcouraged from proſecuting the reſearch. But upon examination, the parts which appear ſo numerous, are reduced to a very ſmall account. For a careful maceration in ſoft water will ſhew, that the parts really diſtinct are only ſeven. Theſe are 1. An outer bark, 2. an inner rind, 3. a blea, 4. a fleſhy ſubſtance, 5. a pith.

There

There is between the flesh and the blea, 6. a vascular series, and 7. cones of vessels take their course within the flesh.

Whatever part of the plant we examine, we find these, be it a fibre, the root or the stem. We never find more: and tracing these, we see the other parts of the plants are only the productions of them. Thus the root, its descending fibre, and the ascending stalk, we find are one, not three substances. The same seven parts are continued from one to the other, and what are supposed at its summit, to be many new and strange parts, are found to be no more than the terminations of these seven. The external parts are also seven. 1. The cup, 2. The outer petals, 3. The inner petals, 4. The nectaria, either distinct, or connected in one ring, 5. The filaments, 6. The receptacle of seeds, and 7. The seed-vessels or seeds. And these are only the terminations of the seven constituent substances of the plant. The outer bark terminates in the cup, the inner rind in the outer petals; the blea forms the inner petals, the vascular series ends in the nectaria, and the flesh in the filaments: the cones form the receptacle, the pith, the seed, and their capsules. These are universal in plants, though their course be less plain in some, and their terminations less distinct in others.

Every piece therefore cut from a plant transversely contains all the parts of the plant, ready to grow in length into a stalk upwards, and into a root downwards, and to separate at a due height from the root, into the several parts of the flower.

Thus we see the arrangement of the common particles of matter into a vegetable body, although it it be a work worthy of his hand who formed it, yet is not ſo complex a thing as it appears. And this arrangement being once made in one individual, the ſpecies is created for ever. For growth is the conſequence of the arrangement, when it has heat and moiſture.

Upon the whole: if we conſider every part of a plant, we ſhall find none without its uſe. The Root draws nouriſhment from the earth: the Fibres convey the ſap: the larger veſſels contain the ſpecific juice of the plant: others carry air for ſuch a reſpiration as it needs. The outer and inner Bark in Trees, defend them from heat and cold and drought, and convey that ſap which is required for the annual increaſe of the tree. And in truth every tree may in ſome ſenſe be ſaid to be an annual plant. For both leaf, flower and fruit proceed from the coat that was ſuperinduced over the wood the laſt year. And this never bears more, but together with the old wood ſerves as a block to ſuſtain the ſucceeding annual coat. The Leaves ſerve, before the bud unfolds, to defend the flower and fruit, which is even then formed; and afterward to preſerve them and the branches from the injuries of the ſummer ſun. They ſerve alſo to hinder the too haſty evaporation of the moiſture about the root. But their chief uſe is to concoct the ſap, for the nouriſhment of the whole plant: both that they receive from the root, and that they take in from the dew, the rain, and the moiſt air. Add to this, that they are as lungs, which ſupply the plant with the neceſſary quantity of air, and as excrementory ducts, which throw off ſuperfluities by inſenſible perſpiration. And ſo neceſſary is their

their ſervice, that moſt trees, if quite ſtript of their leaves, will die. And if in ſummer you ſtrip a vine-branch of its leaves, the grapes will never come to maturity. Not that they are hurt by the ſun: expoſe them to this as you pleaſe, ſo the leaves remain, and they will ripen well.

Another point worthy our conſideration is, the immenſe Smallneſs of the Seeds of ſome Plants. Some are ſo extremely minute, as not at all to be diſcovered by the naked eye. Hence the number of ſeeds produced by ſome plants, is beyond imagination. A Plant of Redmace, for inſtance, and many ſorts of Fern, produce above a million: a convincing argument of the infinite underſtanding of the Former of them.

And it is remarkable, that ſuch Moſſes as grow upon walls, the roofs of houſes and other high places, have ſeeds ſo exceſſively ſmall, that when ſhaken out of their veſſels they appear like ſmoke or vapour. Theſe therefore may either aſcend of themſelves, or by an eaſy impulſe of the wind be raiſed to the tops of walls, houſes, or rocks. And we need not wonder how the Moſſes got thither, or imagine they ſprung up ſpontaneouſly.

Concerning Vegetables in general we may farther remark, 1. That becauſe they are intended to be food for numberleſs ſpecies of animals, therefore nature has taken ſo extraordinary care, and made ſo abundant proviſion, for their propagation and increaſe. So that they are propagated and multiplied, not only by the ſeed, but alſo by the root: producing ſhoots or off-ſets in ſome,

creeping

creeping under-ground in others. Some likewise are propagated by ſlips or cuttings; and ſome by ſeveral of theſe ways. Secondly; for the ſecurity of ſuch ſpecies as are produced only by ſeed, moſt ſeeds are endued with a laſting vitality: ſo that if by reaſon of exceſſive cold or drought, or any other accident, they happen not to ſpring up the firſt year, they may continue their fruitfulneſs, I do not ſay, ſix or ſeven only, but even twenty or thirty years. Nay, after this term, if the hindrance be removed, they will ſpring, and bring forth fruit. Hence it is, that plants are ſometimes loſt for a conſiderable time, in places wherein they abounded before. And after ſome years appear anew. They are loſt, either becauſe of the unfavourable ſeaſons, becauſe the land was fallowed; or becauſe plenty of weeds, or other plants, prevented their coming up. And as ſoon as theſe impediments are removed, they ſpring up again. Thirdly, Many vegetables are armed with prickles or thorns, to ſecure them from the browzing of beaſts; as alſo to defend others, which grow under their ſhelter. Hereby likewiſe they are made particularly uſeful to man, either for quick or dead fences. Fourthly, Such vegetables as are weak and not able to ſupport themſelves, have a wonderful faculty, to uſe the ſtrength of their neighbours, embracing and climbing up upon them, and uſing them as crutches to their feeble bodies. Some twiſt themſelves about others like a ſcrew: ſome lay faſt hold upon them, by their curious Claſpers or Tendrils, which herein are equivalent to hands. Some ſtrike in a kind of root: others by the emiſſion of a natural glue, firmly adhere to any thing which has ſtrength ſufficient to ſupport them.

Claſpers

Claſpers are of a compound nature, between a root and a branch. Sometimes they ſerve for ſupport only; as in the Claſpers of Vines, whoſe branches being long and ſlender, would otherwiſe ſink with their own weight: ſometimes, for a ſupply of nouriſhment alſo; as in the trunk roots of ivy; which mounting very high, and being of a cloſe and very compact nature, the ſap would not be ſufficiently ſupplied to the upper ſprouts, unleſs theſe aſſiſted the mother root. Fifthly, The beſt of all grain, and what affords the moſt wholeſome and agreeable nouriſhment is Wheat. And it is moſt patient in all climates, bearing the extremes both of heat and cold. It grows, and brings its ſeed to maturity, not only in the temperate countries, but alſo in the cold regions of Scotland, Denmark, Norway, and Muſcovy, on the one hand, and on the other, in the ſultry heat of Spain, Egypt, Barbary, Mauritania, and the Eaſt Indies. Nor is it leſs obſervable, that nothing is more fruitful. One buſhel when ſown in a proper ſoil, having been found to yield an hundred and fifty, and in ſome inſtances abundantly more.

7. It may be of uſe to ſubjoin here, firſt a general view of Vegetation, ſecondly, ſome additional Reflections on the vegetable kingdom.

And firſt. As to Vegetation itſelf, we are ſenſible all our reaſonings about the wonderful operations of nature, are ſo full of uncertainty, that as the wiſe man truly obſerves, *Hardly do we gueſs aright at the things that are upon earth and with labour do we find the things that are before us.* This is abundantly verified in vegetable

vegetable nature. For though its productions are so obvious to us, yet are we strangely in the dark concerning them, because the texture of their vessels is so fine and intricate, that we can trace but few of them, though assisted with the best microscopes. But although we can never hope to come to the bottom and first principle of things, yet may we every where see plain signatures of the hand of a Divine Architect.

All vegetables are composed of water - and earth, principles which strongly attract each other: and a large portion of air, which strongly attracts when fixed, but strongly repels when in an elastic state. By the combination, action, and re-action of those few principles all the operations in vegetables are effected.

The particles of air distend each ductile part, and invigorate their sap, and meeting with the other mutually attracting principles, they are by gentle heat and motion enabled to assimilate into the nourishment of the respective parts. Thus nutrition is gradually advanced, by the nearer and nearer union of these principles, till they arrive at such a degree of consistency, as to form the several parts of vegetables. And at length by the flying off of the watry vehicle, they are compacted into hard substances.

But when the watry particles again soak into and disunite them, then is the union of the parts of vegetables dissolved, and they are prepared by putrefaction, to appear in some new form, whereby the nutritive fund of nature can never be exhausted.

All these principles are in all the parts of Vegetables. But there is more oil in the more exalted parts of them. Thus seeds abound with oil,

oil, and consequently with sulphur and air. And indeed as they contain the rudiments of future Vegetables, it was necessary they should be stored with principles, that would both preserve them from putrifaction, and also be active in promoting Germination and Vegetation.

And as oil is an excellent preservative against cold, so it abounds in the sap of the more northern trees. And it is this by which the ever-greens are enabled to keep their leaves all the winter.

Leaves not only bring nourishment from the lower parts within the attraction of the growing fruit, (which like young animals is furnished with proper instruments to suck it thence) but also carry off redundant watry fluid, while they imbibe the dew and rain, which contain much salt and sulphur: for the air is full of acid and sulphureous particles; and the various combinations of these, are doubtless very serviceable in promoting the work of Vegetation. Indeed so fine a fluid as the air, is a more proper medium, wherein to prepare and combine, the more exalted principles of Vegetables, than the gross watry fluid of the sap. And that there is plenty of these particles in the leaves is evident, from the sulphureous exudations often found on their edges. To these refined aëreal particles, not only the most racy, generous taste of fruits, but likewise the most grateful odours of flowers, yea, and their beautiful colours are probably owing.

In order to supply tender shoots with nourishment, nature is careful to furnish, at small distances, the young shoots of all sorts of trees, with many leaves throughout their whole length, which as so many jointly acting powers, draw plenty of sap to them.

The

The like provision has nature made, in the corn, grass, and reed-kind: the leafy spires, which draw nourishment to each joint, being provided long before the stem shoots: the tender stems would easily break, or dry up, so as to prevent their growth, had not these scabbards been provided, which both support and keep them in a supple and ductile state.

The growth of a young bud to a shoot, consists in the gradual dilatation and extention of every part, till it is stretched out to its full length. And the capillary tubes still retain their hollowness, notwithstanding their being extended, as we see melted glass-tubes remain hollow, though drawn out to the finest thread.

The pith of trees is always full of moisture, while the shoot is growing, by the expansion of which, the tender, ductile shoot is distended in every part. But when each year's shoot is fully grown, then the pith gradually dries up. Mean time nature carefully provides for the growth of the succeeding year, by preserving a tender, ductile part in the bud, replete with succulent pith. Great care is likewise taken to keep the parts between the bark and wood always supple with slimy moisture, from which ductile matter the woody fibres, vesicles, and buds are formed.

The great variety of different substances in the same Vegetable proves, that there are peculiar vessels for conveying different sorts of nutriment. In many vegetables some of those vessels are plainly seen full of milky, yellow, or red nutriment.

Where a secretion is designed to compose an hard substance, viz. the kernel or seed of hard-stone fruits, it does not immediately grow from the stone, which would be the shortest way to convey

convey nouriſhment to it. But the umbilical veſſel fetches a compaſs round the concave of the ſtone, and then enters the kernel near its cone. By this artifice the veſſel being much prolonged, the motion of the ſap is thereby retarded, and a viſcid nutriment conveyed to the ſeed, which turns to an hard ſubſtance.

Let us trace the Vegetation of a tree, from the ſeed to its full maturity. When the ſeed is ſown, in a few days it imbibes ſo much moiſture, as to ſwell with very great force, by which it is enabled both to ſtrike its roots down, and to force its ſtem out of the ground. As it grows up, the firſt, ſecond, third, and fourth order of lateral branches ſhoot out, each lower order being longer than thoſe immediately above them: not only as ſhooting firſt, but becauſe inſerted nearer the root, and ſo drawing greater plenty of ſap. So that a tree is a complicated engine, which has as many different powers as it has branches. And the whole of each yearly growth of the tree, is proportioned to the whole of the nouriſhment they attract.

But leaves alſo are ſo neceſſary to promote its growth, that nature provides ſmall, thin, expanſions, which may be called primary Leaves, to draw nouriſhment to the buds and young ſhoots, before the leaf is expanded. Theſe bring nutriment to them in a quantity ſufficient for their ſmall demand: a greater quantity of which is afterward provided, in proportion to their need, by the greater expanſion of the leaves. A ſtill more beautiful apparatus we find in the curious expanſions of bloſſoms and flowers, which both protect and convey nouriſhment to the embryo, fruit and ſeeds. But as ſoon as the calix is formed into a ſmall fruit, containing a minute, ſeminal

ſeminal tree, the bloſſom falls off, leaving it to imbibe nouriſhment for itſelf, which is brought within the reach of its ſuction, by the adjoining leaves.

I proceed to make ſome additional Reflections upon the vegetable kingdom.

All plants produce ſeeds: but they are entirely unfit for propagation, till they are impregnated. This is performed within the flower, by the duſt of the Antheræ falling upon the moiſt Stigmata, where it burſts and ſends forth a very ſubtle matter, which is abſorbed by the ſtyle, and conveyed down to the ſeed. As ſoon as this operation is over, thoſe organs wither and fall. But one flower does not always contain all theſe: often the male organs are on one, the female, on another. And that nothing may be wanting, the whole apparatus of the antheræ and ſtigmata is in all flowers contrived with wonderful wiſdom. In moſt, the ſtigmata ſurround the piſtil, and are of the ſame height. But where the piſtil is longer than the ſtigmata, the flowers recline, that the duſtmay fall into the ſtigma, and when impregnated riſe again, that the ſeeds may not fall out. In other flowers the piſtil is ſhorter, and there the flowers preſerve an erect ſituation. Nay, when the flowering ſeaſon comes on, they become erect tho' they were drooping before. Laſtly, when the male flowers are placed below the female, the leaves are very ſmall and narrow, that they may not hinder the duſt from flying upwards like ſmoke: and when in the ſame ſpecies one plant is male, and the other female, there the duſt is carried in abundance by the wind from the male to the female. We cannot alſo without admiration obſerve, that moſt flowers expand themſelves when the ſun ſhines, and cloſe when either rain, clouds, or evening is coming on, left the genital duſt ſhould be coagulated, or otherwiſe rendered uſeleſs. Yet when the impregnation is over, they do not cloſe, either upon ſhowers, or the approach of evening.

For the ſcattering of ſeed nature has provided numberleſs ways. Various berries are given for food to animals; but while they eat the pulp, they ſow the ſeed. Either they diſperſe them at the ſame time; or if they ſwallow them, they are returned with intereſt. The miſleto always grows on other trees; becauſe the thruſh that eats the ſeeds of them, caſts them forth with his dung. The junipers alſo, which fill our woods, are ſown in the ſame manner. The croſs-bill that lives on fir-cones, and the haw-finch which feeds on pine-cones, ſow many of thoſe ſeeds, eſpecially when they carry the cone to a ſtone or ſtump, to ſtrip off its ſcales. Swine likewiſe and moles by throwing up the earth, prepare it for the reception of ſeeds.

The great Parent of all decreed that the whole earth ſhould be covered with plants. In order to this he adapted the nature of each to the climate where it grows. So that ſome can bear intenſe heat, others intenſe cold. Some love a moderate warmth. Many delight in dry, others in moiſt ground. The Alpine plants love mountains whoſe tops are covered with eternal ſnow. And they blow and ripen their ſeeds very early, leſt the winter ſhould overtake and deſtroy them. Plants which will grow no where elſe, flouriſh in Siberia, and near Hudſon's Bay. Graſs can bear almoſt any temperature of the air: in which the good providence of God appears: this being ſo neceſ-

ſary

ſary all over the globe, for the nouriſhment of cattle.

Thus neither the ſcorching ſun nor the pinching cold hinders any country from having its vegetables. Nor is there any ſoil which does not bring forth ſome. Pond-weed and water-lillies inhabit the waters. Some plants cover the bottom of rivers and ſeas: others fill the marſhes. Some clothe the plains: others grow in the drieſt woods, that ſcarce ever ſee the ſun. Nay, ſtones and the trunks of trees are not void, but covered with liver-wort.

The wiſdom of the Creator appears no where more, than in the manner of the growth of trees. As their roots deſcend deeper than thoſe of other plants, they do not rob them of nouriſhment. And as their ſtems ſhoot up ſo high, they are eaſily preſerved from cattle. Their leaves falling in autumn guard many plants againſt the rigor of winter: and in the ſummer afford both them and us a defence againſt the heat of the ſun. They likewiſe imbibe the water from the earth, part of which tranſpiring through their leaves, is inſenſibly diſperſed, and helps to moiſten the plants that are round about. Laſtly, the particular ſtructure of trees contributed very much to the propagation of inſects. Multitudes of theſe lay their eggs upon their leaves, where they find both food and ſafety.

Many plants and ſhrubs are armed with thorns, to keep the animals from deſtroying their fruits. At the ſame time theſe cover many other plants, under their branches, ſo that while the adjacent grounds are robbed of all plants, ſome may be preſerved to continue the ſpecies.

The Mosses which adorn the most barren places, preserve the smaller plants when they begin to shoot from cold and drought. They also hinder the fermenting earth from forcing the roots of plants upward in the spring, as we see happen annually to trunks of trees. Hence few Mosses grow in southern climates, not being necessary there to these ends.

Sea-Matweed will bear no soil but pure sand. Sand is often blown by violent winds, so as to deluge as it were meadows and fields. But where this grows, it fixes the sand, and gathers it into hillocks. Thus other lands are formed, the ground increased, and the sea repelled, by this wonderful disposition of nature.

How careful is nature to preserve that useful plant grass? The more its leaves are eaten, the more they increase. For the author of nature intended, that vegetables which have slender stalks and erect leaves should be copious and thick set, and thus afford food for so vast a quantity of grazing animals. But what increases our wonder is, that although grass is the principal food of such animals, yet they touch not the flower and seed bearing stems, that so the seeds may ripen and be sown.

The Caterpillar of the Moth, which feeds upon grass to the great destruction thereof, seems to be formed in order to keep a due proportion between this and other plants. For grass when left to grow freely, increases to that degree as to exclude all other plants, which would consequently be extirpated, unless the insect sometimes prepared a place for them. And hence it is, that more species of plants appear, when this caterpillar has laid waste the pasture the preceeding year, than at any other time.

But

But all plants sooner or later, must submit to death. They spring up, they grow, they flourish, they bear fruit, and having finished their course, return to the dust again. Almost all the black mould which covers the earth is owing to dead vegetables. Indeed after the leaves and stems are gone, the roots of plants remain: but these two at last rot and change into mould. And the earth thus prepared, restores to plants what it has received from them. For when seeds are committed to the earth, they draw and accommodate to their own nature the more subtle parts of this mould: so that the tallest tree is in reality nothing but mould wonderfully compounded with air and water. And from these plants when they die, just the same kind of mould is formed as gave them birth. By this means fertility remains continually uninterrupted: whereas the earth could not make good its annual consumption, were it not constantly recruited.

In many cases, the crustaceous Liverworts are the first foundation of vegetation. Therefore however despised, they are of the utmost consequence, in the œconomy of nature. When rocks first emerge out of the sea, they are so polished by the force of the waves, that hardly any herb is able to fix its habitation upon them. But the minute crustaceous liverworts soon begin to cover these dry rocks, though they have no nourishment but the little mould and imperceptible particles, which the rain and air bring thither. These Liverworts dying turn into fine earth, in which a larger kind of Liverworts strike their roots. These also die and turn to mould: and then the various kinds of mosses find nourishment. Lastly, these dying yield such plenty of mould, that herbs and shrubs easily take root and live upon it.

That trees, when dry or cut down, may not remain uselefs to the world, and lie melancholy spectacles, nature hastens on their destruction, in a singular manner. First the Liverworts begin to strike root in them; afterward the moisture is drawn out of them, whence putrefaction follows. Then the mushroom-kind find a fit place to grow on, and corrupt them still more. A particular sort of beetle next makes himself a way between the bark and the wood. Then a sort of caterpillar and several other sorts of beetles, bore numberless holes through the trunk. Lastly, the wood-peckers come, and while they are seeking for insects, shatter the tree already corrupted, and exceedingly hasten its return to the earth from whence it came. But how shall the trunk of a tree, which is emersed in water, ever return to earth? A particular kind of worm performs this work, as sea-faring men well know.

But why is so inconsiderable a plant as thistles, so armed and guarded by nature? Because it is one of the most useful plants that grows. Observe an heap of clay, on which for many years no plant has sprung up: let but the seeds of a thistle fix there, and other plants will quickly come thither, and soon cover the ground. For the thistles by their leaves attract moisture from the air, and by their roots send it into the clay, and by that means not only thrive themselves, but provide a shelter for other plants.

I shall add only one observation more, concerning the difference between Natural and Artificial Things. If we examine the finest needle by the microscope, the point of it appears about a quarter of an inch broad, and its figure neither round,

round, nor flat, but irregular and unequal. And the furface, however fmooth and bright it may feem to the naked eye, is then feen full of raggednefs, holes, and fcratches, like an iron bar from the forge. But examine in the fame manner the fting of a bee, and it appears to have in every part a polifh moft amazingly beautiful, without the leaft flaw or inequality, and ends in a point too fine to be difcerned by any glafs whatever. And yet this is only the outward fheath of far more exquifite inftruments.

A fmall piece of the fineft lawn, from the diftance and holes between its threads, appears like a lattice or hurdle. And the threads themfelves feem coarfer than the yarn wherewith ropes are made for anchors. Fine Bruffels lace will look as if it were made of a thick, rough, uneven hair.line, intwifted or clotted together in a very aukward and unartful manner. But a filk-worm's webb on the niceft examination appears perfectly fmooth and fhining, and as much finer than any fpinfter in the world can make, as the fmalleft twine is than the thickeft cable. A pod of this filk winds into nine hundred and fixty yards. And as it is two threads twifted together all the length, fo it really contains one thoufand eight hundred and fixty: and yet weighs but two grains and an half. What an equifite finenefs! and yet this is nothing to the filk that iffued from the worm's mouth when newly hatched.

The fmalleft dot which can be made with a pen, appears through, a glafs, a vaft irregular fpot, rough, jagged and uneven about all its edges. The fineft writing (fuch as the Lord's Prayer in the compafs of a filver penny) feems as fhapelefs and uncouth as if wrote in Runic characters. But the fpecks of moths, beetles, flies, and other infects, are moft acrately circular; and all the lines and marks about them are drawn, to the utmoſt poſſibility of exactneſs.

Our fineſt miniature paintings appear before a microſcope, as mere daubings, plaiſtered on with a trowel. Our ſmootheſt poliſhings are ſhewn to be mere roughneſs, full of gaps and flaws. Thus do the works of art ſink, upon an accurate examination. On the contrary, the nearer we examine the works of nature, even in the leaſt and meaneſt of her productions, the more we are convinced, nothing is to be found there, but beauty and perfection. View the numberleſs ſpecies of inſects, what exactneſs and ſymmetry ſhall we find in all their organs? What a profuſion of colouring, azure, green, vermillion; what fringe and embroidery on every part! How high the finiſhing, how inimitable the poliſh we every where behold! Yea, view the animalculæ, inviſible to the naked eye, thoſe breathing atoms ſo ſmall, they are almoſt all workmanſhip: in them too we diſcover the ſame multiplicity of parts, diverſity of figures, and variety of motions, as in the largeſt animals. How amazingly curious muſt the internal ſtructure of theſe creatures be! How minute the bones, joints, muſcles, and tendons! How exquiſitely delicate the veins arteries, nerves! What multitudes of veſſels and circulations muſt be contained in this narrow compaſs! And yet all have ſufficient room for their ſeveral offices, without interfering with each other.

The ſame regularity and beauty is found in vegetables. Every ſtalk, bud, flower, and ſeed, diſplays a figure, a proportion, an harmony, beyond the reach of art. There is not a weed whoſe

whose every leaf does not shew a multiplicity of pores and vessels curiously disposed for the conveyance of juices, to support and nourish it, and which is not adorned with innumerable graces to embellish it.

But some may ask, to what purpose has nature bestowed so much expence on so insignificant creatures? I answer, this very thing proves they are not so insignificant, as we fondly suppose. This beauty is given them either for their own sake, that they themselves may be delighted with it: or for ours, that we may observe in them the amazing power and goodness of the Creator. If the former, they are of consequence in the account of their Maker, and therefore deserve our regard. If the latter, then it is certainly our duty to take notice of, and admire them.

In short, the whole universe is a picture, in which are displayed the perfections of the Deity. It shews not only his existence, but his unity, his power, his wisdom, his independence, his goodness. His unity appears in the harmony we cannot but see in all the parts of nature; in that one simple end to which they are directed, and the conformity of all the means thereto. On every side we discern either simple elements or compound bodies, which have all different actions and offices. What the fire inflames, the water quenches: what one wind freezes, another thaws. But these and a thousand other operations, so seemingly repugnant to each other, do nevertheless all concur in a wonderful manner, to produce one effect. And all are so necessary to the main design, that were the agency of any one destroyed, an interruption of the order and harmony of the creation must immediately ensue.

Suppoſe, for inſtance, the wind to be taken away, and all Society is in the utmoſt diſorder. Navigation is at a ſtand, and all our commerce with foreign nations deſtroyed. On the other hand the vapours raiſed from the ſea would remain ſuſpended juſt where they roſe. Conſequently we ſhould be deprived of that uſeful covering the Clouds, which now ſcreens us from the ſcorching heat: yea, and of the fruitful rains. So our land would be parched up, the fruits of the earth wither, animals die, through hunger and thirſt, and all nature languiſh and droop. All the parts of Nature therefore were conſtituted for the aſſiſtance of each other, and all undeniably prove the Unity of their Omniſcient Creator.

His Power appears in the whole frame of creation, and his Wiſdom in every part of it. His Independence is pointed out in the inexhauſtible variety of beaſts, birds, fiſhes and inſects: and his Goodneſs, in taking care of every one of theſe, *opening his hand, and filling all things living with plenteouſneſs.*

Every thing is calculated by Divine Wiſdom, to make us wiſer and better. And this is the ſubſtance of true philoſophy. We cannot know much. In vain does our ſhallow reaſon attempt to fathom the myſteries of Nature, and to pry into the ſecrets of the Almighty. *His ways are paſt finding out.* The eye of a little worm is a ſubject capable of exhauſting all our boaſted ſpeculations. But we may love much. And herein we may be aſſiſted by contemplating the wonders of his Creation. Indeed he ſeems to have laid the higheſt claim to this tribute of our love, by the care he has taken to manifeſt his goodneſs in the moſt conſpicuous manner, while at the ſame time he

has

has concealed from us the moſt curious particulars, with regard to the eſſences and ſtructure of his works. And to this our ignorance it is owing, that we fancy ſo many things to be uſeleſs in the Creation. But a deep ſenſe of his goodneſs will ſatisfy all our doubts, and reſolve all our ſcruples.

8. I cannot conclude this part, better than with an Eſſay on the Production, Nouriſhment, and Operation of Plants and Animals.

SECT. I.

Creatures produce their own kind.

WHEN I ſurvey the works of Nature with an attentive eye, I am ſurprized to find with what marvellous exactneſs every Creature draws its own picture, or propagates its own likeneſs, though in different manners of operation. The fox produces a living fox; the gooſe drops her egg, and hatches the young gooſe; and the tulip lets fall its ſeed into the earth, which ferments and ſwells, and labours long in the ground, till at laſt it brings forth a tulip.

Is it the natural ſagacity of foxes that enables them to form their own image ſo accurately? By no means; for the gooſe and the flower do the like: the ſprightly and the ſtupid, the ſenſible and the ſenſeleſs, work this wonder with equal regularity and perfection; and the Plant performs as well as the Animal.

'Tis not poſſible that any of them ſhould effect this by any peculiar rules of art and contrivance: for neither the one nor the other are at all acquainted with the compoſition or progreſs of their

their work. The bird is entirely ignorant of the wondrous vital ferment of her own egg, either in the formation of it, or the incubation: and the mother-plant knows as much of the parts of the young plant, as the mother-animal knows of the inward ſprings and movements of the young little animal. There could be no contrivance here: for not any of them had any thought or deſign of the final production: they were all moved, both the beaſt, bird and flower, by the material and mechanical ſprings of their own nature to continue their own ſpecies, but without any ſuch intent or purpoſe.

Give ſouls to all the animal race, and make thoſe ſouls as intelligent as you can; attribute to them what good ſenſe you pleaſe in other affairs of their puny life; allow the brutes to be as rational and as cunning as you could wiſh or fancy, and to perform a thouſand tricks by their own ſagacity; yet in this matter, thoſe intellectual powers muſt all ſtand by as uſeleſs: the ſenſeleſs vegetable has as much ſkill here as the animal; the gooſe is as wiſe as the fox or the greyhound; they draw their own portraits with as exquiſite art and accuracy, and leave as perfect images behind them to perpetuate their kind. Amazing proof and inconteſtable argument of ſome Superior Wiſdom! Some tranſcendent contriving mind. Some Divine Artificer that made all theſe wondrous machines, and ſet them at work! The animal and the vegetable in theſe productions are but mere inſtruments under his Supreme Ruling Power; like artleſs pencils in a painter's hand, to form the images that his thought had before deſigned: and 'tis that God alone, who before all worlds contrived theſe models of every ſpecies in his

his own original idea, that appoints what under-agents he will employ to copy them.

In the week of the Creation, he bad the *earth* teem with beasts and plants: and the *earth* like a common mother brought forth the lion, the fox, and the dog, as well as the cedar and the tulip, Gen. i. 11. 24. He commanded the *water* to produce the first fish and fowl; behold the *waters* grow pregnant; the trout and the dolphin break forth into life; the goose and the sparrow arise and shake their wings, Gen. i. 20, 21. But two common parents, *earth* and *water* to the whole animal and vegetable world! A God needs no more. And though he was pleased to make use of the water and the earth in these first productions, yet the power and the skill were much the same as if he had made them immediately with his own hands.

Ever since that week of Creative Wonders, God has ordered all these creatures to fill the world with inhabitants of their own kind; and they have obeyed him in a long succession of almost six thousand years. He has granted (shall I say) a Divine Patent to each creature for the sole production of its own likeness, with an utter prohibition to all the rest; but still under the everlasting influence of his own Supreme Agency upon the moving atoms that form these plants or animals. God himself is the Creator still.

And 'tis evident that he has kept a reserve of sovereignty to himself, and has displayed the ensigns of it in some important hours. Egypt was once a glorious and tremendous scene of this sovereignty: 'twas there that he ordered the rod of Moses, a dry and lifeless vegetable, to raise a swarm

ſwarm of living animals, to call up a brood of lice in millions without a parent, and to animate the duſt of the ground into a noiſom army.

It was there he bid Aaron wave the ſame rod over the ſtreams and the ponds, and the ſilent rod under divine influence would bring forth croaking legions out of the waters without number.

But theſe are his works of miracle and aſtoniſhment, when he has a mind to ſhew himſelf the ſovereign and the controuller of nature: without his immediate commiſſion not one creature can invade the province of another, nor perform any thing of this work but within its own peculiar tribe. Even Man the glory of this lower creation and the wiſeſt thing on earth, would in vain attempt to make one of theſe common vegetables, or theſe curious animated moving machines. Not all the united powers of human nature, nor a council of the niceſt artificers with all their enginry and ſkill, can form the leaſt part of theſe works, can compoſe a fox's tail, a gooſe quill, or a tulip-leaf. Nature is the art of God, and it muſt for ever be unrivalled by the ſons of men.

Yet *man can produce a man*. Admirable effect but artleſs cauſe! A poor limited, inferior agent! The plant and the brute in this matter are his rivals, and his equals too. The human parent and the parent bird form their own images with equal ſkill, and are confined each to its own work. So the iron ſeal transfers its own figure to the clay with as much exactneſs and curioſity as the golden one: both can transfer only their own figure.

This appears to me a glorious inſtance wherein the wiſdom and power of God maintain their own ſupremacy, and triumph over all the boaſted

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reaſon and intellectual ſkill of men; that the wiſeſt ſon of Adam in this nobleſt work of nature, can do no more than a flower or a fly; and if he would go out of his own ſpecies, and the appointed order of things, he is not able to make a fly, or a flower; no, not a worm, nor a ſimple bulruſh. In thoſe productions wherein mankind are merely the inſtruments of the God of Nature, their work is vital and divine; but if they would ſet up for prime artificers, they can do nothing: a dead ſtatue, a painted ſhadow on a canvaſs, or perhaps a little brazen clock-work is the ſupreme pride of their art, their higheſt excellence and perfection.

Let the atheiſt then exert his utmoſt ſtretch of underſtanding: let him try the force of all his mechanical powers, to compoſe the wing of a butterfly, or the meaneſt feather of a ſparrow: let him labour, and ſweat and faint, and acknowledge his own weakneſs: then let him turn his eye, and look at thoſe wondrous compoſures, his ſon, or his little daughter, and when their infant tongues ſhall enquire of him, and ſay, *Father, who made us?* Let him not dare aſſume the honour of that work to himſelf, but teach the young creatures that *there is a God*, and fall down on his face, and repent and worſhip.

It was God who ſaid at firſt, *Let the earth bring forth graſs, and the herb yielding ſeed—after his kind—and the living creature after his kind*; and when this was done, then with a creating voice he bid thoſe herbs and thoſe living creatures, *be fruitful and multiply* to all future generations. *Great things doth he which we cannot comprehend.—But he ſealeth up the hand of every man, that all*

all men may know his divine *work*. Gen. i. 11. 25. Job xxxvii. 5. 7.

SECT. II.

The Laws of Nature ſufficient for the Production of Animals and Vegetables.

WILL you ſuppoſe that it derogates from the glory of divine Providence, to repreſent the great engine of this viſible world, as moving onward in its appointed courſe, without the continual interpoſure of his hand? 'Tis granted, indeed, that his hand is ever active in preſerving all the parts of matter in all their motions according to theſe uniform laws: but I think it is rather derogatory to his infinite wiſdom, to imagine that he would not make the vegetable and animal, as well as the inanimate world, of ſuch ſort of workmanſhip, as might regularly move onward in this manner for five or ſix thouſand years, without putting a new hand to it ten thouſand times every hour: I ſay *ten thouſand times* every hour; for there is not an hour nor a moment paſſes, wherein there are not many millions of plants and animals actually forming in the Southern or Northern climates.

He that can make a clock, with a great variety of beauties and motions, to go regularly a twelvemonth together, is certainly a ſkilful artiſt; but if he muſt put his own hand to aſſiſt thoſe motions every hour, or elſe the engine will ſtand ſtill, or the wheels move at random, we conceive a much meaner opinion of his performance and his ſkill. On the other hand, how glorious and divine an artificer would he be call'd that ſhould have made

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two of theſe pieces of clock-work above five thouſand years ago, and contrived ſuch hidden ſprings and motions within them, that they ſhould have joined together, to perpetuate the ſpecies, and thus continue the ſame ſort of clocks in more than a hundred ſucceſſions down to this day? though each of their ſprings might fail in forty years time, and their motions ceaſe, or their materials decay, yet that by the means of theſe two original engines, there ſhould be engines of the ſame kind multiplied upon the face of the earth, by the ſame rules of motion which the artiſt had eſtabliſhed in the day when he firſt formed them?

Such is the workmanſhip of God; for *nature* is nothing but his *art*. Such is the amazing penetration of divine ſkill, ſuch the long reach of his foreſight, who has long ago ſet his inſtruments at work, and guarded againſt all their poſſible deficiences; who has provided to repleniſh the world with plants and animals to the end of time, by the wondrous contrivance of his firſt creation, and the laws he then ordained.

Thus every whale, eagle and apple-tree, every lion and roſe, fly and worm in our age, are as really the work of God, as the firſt which he made of the kind. It is ſo far from being a derogation to his honour, to perpetuate all the ſpecies by ſuch inſtruments of his agency for many ages, that it rather aggrandizes the character of the Creator, and gives new luſtre to Divine Wiſdom: for if any thing can be ſaid to be eaſier or harder in this ſort of almighty work, we may ſuppoſe it a more glorious difficulty for a God to employ a ſparrow or an oyſter, to make a ſparrow or an oyſter, than to make one immediately with his own hand. Perhaps there is not a waſp or a butterfly now in the

the world, but has gone through almoſt ſix thouſand anceſtors, and yet the work of the laſt parent is exquiſitely perfect in ſhape, in colour, and in every perfection of beauty, but it is all owing to the firſt cauſe.

This is wiſdom becoming a God. and demands an eternal tribute of wonder and worſhip.

SECT. III.

Of the Nouriſhment and Growth of Plants.

IN the beginning of time and nature, at the command of God, the earth brought forth plants and herbs, and four-footed animals in their various kinds; but the birds of the air, as well as the fiſhes, were produced by the ſame command out of the waters. This was intimated in a former ſection. The water and the earth were the firſt appointed *mothers*, if I may ſo expreſs it, of all the animal and vegetable creation. Since that time they ceaſe to be *parents* indeed, but they are the common *nurſes* of all that breathes, and of all that grows. Nor is the wiſdom of God much leſs conſpicuous in conſtituting two ſuch plain and ſimple beings as the earth and water, to be the ſprings of nouriſhment and growth to ſuch an innumerable variety of creatures, than it was in the formation of them out of two ſuch materials. Is it not counted an admirable piece of divine contrivance and wiſdom, that the ſingle principle of gravitation ſhould be employed by the Creator, to anſwer ſo many millions of purpoſes among the heavenly bodies in their regular revolutions, as well as among the inhabitants, and the furniture of this earthly globe where we dwell? And

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may it not be esteemed as astonishing an effect of the same supreme wisdom, that two such simple things as water and earth should be the common materials out of which all the standing ornaments, the vegetable beauties, and the moving inhabitants of this our world, whether flying or creeping, walking or swimming, should receive their continual sustenance, and their increase?

Let us first consider this as it relates to the vegetable part of the creation. What a profusion of beauty and fragrancy, of shapes and colours, of smells and tastes, is scattered among the herbs and flowers of the ground, among the shrubs, the trees, and the fruits of the field! Colouring in its original glory and perfection triumphs here; red, yellow, green, blue, purple, with vastly more diversities than the rainbow ever knew, or the prism can represent, are distributed among the flowers and blossoms. And what variety of tastes, both original and compounded, of sweet, bitter, sharp, with a thousand nameless flavours, are found among the herbs of the garden? What an amazing difference of shapes and sizes appears amongst the trees of the field and forest in their branches and their leaves? And what a luxurious and elegant distinction in their several fruits? How very numerous are their distinct properties, and their uses in human life? And yet these two common elements, earth and water, are the only materials out of which they are all composed, from the beginning to the end of nature and time!

Let the gardener dress for himself one field of fresh earth, and make it as uniform as he can; then let him plant therein all the varieties of the vegetable world, in their roots or in their seeds,

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as he ſhall think moſt proper; yet out of this common earth, under the droppings of common water from heaven, every one of theſe plants ſhall be nouriſhed, and grow up in their proper forms; all the infinite diverſity of ſhapes and ſizes, colours, taſtes and ſmells, which conſtitute and adorn the vegetable world, (would the climate permit) might be produced out of the ſame clods. What rich and ſurprizing wiſdom appears in that Almighty Operator, who out of the ſame matter ſhall perfume the boſom of the roſe, and give the garlick its offenſive and nauſeous powers? Who from the ſame ſpot of ground, ſhall raiſe the liquorice and the wormwood, and dreſs the cheek of the tulip in all its glowing beauties? What a ſurprize, to ſee the ſame field furniſh the pomegranate and the orange-tree with the juicy fruit, and the ſtalks of corn with their dry and huſky grains? To obſerve the oak raiſed from a little acorn, into its ſtately growth and ſolid timber, out of the ſame bed of earth that ſent up the vine with ſuch ſoft and feeble limbs? What a natural kind of prodigy is it, that chilling and burning vegetables ſhould ariſe out of the ſame ſpot? That the fever and the frenzy ſhould ſtart up from the ſame bed, where the palſy and the lethargy lie dormant in their ſeeds? Is it not exceeding ſtrange, that healthful and poiſonous juices ſhould riſe up in their proper plants out of the ſame common glebe, and that life and death ſhould grow and thrive within an inch of each other?

What wondrous and inimitable ſkill muſt be attributed to that Supreme Power, that Firſt Cauſe, who can ſo infinitely diverſify effects, where the ſervile ſecond cauſe is always the ſame?

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It is not for me in this place to enter into a long detail of Philoſophy, and ſhew how the minute fibres and tubes of the different ſeeds and roots of vegetables take hold of, attract, and receive the little particles of earth and water proper for their own growth; how they form them at firſt into their own ſhapes, and ſend them up aſpiring above ground by degrees, and mould them ſo as to frame the ſtalks, the branches, the leaves and the buds of every flower, herb, and tree. But I preſume the world is too weary of ſubſtantial forms, and plaſtic powers, to be perſuaded that theſe mere creatures of fancy ſhould be the operators in this wondrous work. It is much more honourable to attribute all to the deſign and fore-thought of God, who formed the firſt vegetables in ſuch a manner, and appointed their little parts to ferment under the warm ſunbeams, according to ſuch eſtabliſhed laws of motion, as to mould the atoms of earth and water which were near them into their own figure, to make them grow up into trunk and branches, which every night ſhould harden into firmneſs and ſtability; and again, to mould new atoms of the ſame element into leaves and bloom, fruit and ſeed, which laſt being dropt into the earth, ſhould produce new plants of the ſame likeneſs to the end of the world.

It is eaſier for the ſons of men to ſtand and wonder, and adore God the Creator, than to imitate, or even to deſcribe his admirable works. In the beſt of their deſcriptions and their imitations of this divine artifice, they do but chatter like Hottentots, and paint like Goths and Vandals.

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SECT. IV.

Of the nouriſhment and growth of animals.

LET us proceed in the next place to ſurvey new wonders. All the animals of the creation as well as the plants, have their original nouriſhment from theſe ſimple materials, earth and water. For all the animal beings which do not live upon other animals, or the produce of them, take ſome of the vegetables for their food; and thus the brutes of prey are originally indebted to the plants and herbs, i. e. to the earth for their ſupport, and their drink is the watery element. That all fleſh is graſs, is true, in the literal, as well as the mataphorical ſenſe. Does the lion eat the fleſh of the lamb? Doth the lamb ſuck the milk of the ewe? But the ewe is nouriſhed by the graſs of the field. Does the kite devour the chicken, and the chicken the little caterpillars or inſects of the ſpring? But theſe inſects are ever feeding on the tender plants, and the green products of the ground. The earth moiſtened with water is the common nurſe of all. Even the fiſhes of the ſea are nouriſhed with vegetables that ſpring up there, or by preying on leſſer fiſhes which feed on theſe vegetables.

But let us give our meditations a looſe on this entertaining ſubject, and we ſhall find numerous inſtances of wonder in this ſcene of Divine contrivance.

1. What very different animals are nouriſhed by the ſame vegetable food! The ſelf-ſame herbage or fruits of the earth by the divine laws of nature and providence, are converted into animated bodies of very different kinds. Could you imagine that half the fowls of the air, as different

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as they are, from the crow to the tit-moufe, fhould derive their flefh and blood from the productions of the fame tree, where the fwine watches under the boughs of it, and is nourifhed by the fruit? Nor need I ftay to take notice what numerous infects find their nefts and their food all the fummer feafon from the fame apples or apricots, plumbs or cherries, which feed hogs and crows, and a hundred fmall birds. Would you think that the black and the brindled kine, with the horfes both grey and bay, fhould clothe themfelves with their hairy fkins of fo various colours, out of the fame green pafture where the fheep feeds, and covers himfelf with his white and woolly fleece? And at the fame time the goofe is cropping part of the grafs to nourifh its own flefh, and to array itfelf with down and feathers. Strange and ftupendous texture of the bodies of thefe creatures, that fhould convert the common green herbage of the field into their different natures, and their more different cloathing! But this leads me to another remark.

2. What exceeding great diverfity is found in the feveral parts, limbs, and coverings even of the fame creature? An animated body is made up of flefh and blood, bones and membranes, long hollow tubes, with a variety of liquors contained in them, together with many ftrings and tendons, and a thoufand other things which efcape the naked fight, and for which anatomy has hardly found a name: yet the very fame food is by the wondrous fkill and appointment of the God of nature formed into all thefe amazing differences. Let us take an ox to pieces, and furvey the wondrous compofition. Befides the flefh of this huge living ftructure, and the bones on which it is

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built, what variety of tender coats and humours belong to that admirable organ the eye? How solid and hard are the teeth which grind the food? How firm the general ligaments that tie the joints of that creature together? What horny hoofs are his support, and with what different sort of horny weapons has nature furnished his forehead? Yet they are all framed of the same grassy materials: the calf grazes upon the verdant pasture, and all its limbs and powers grow up out of the food to the size and firmness of an ox. Can it be supposed, that all these copuscles, of which the several inward and outward parts of the brute are composed, are actually found in their different and proper forms in the vegetable food? Does every spire of grass actually contain the specific parts of the horn and the hoof, the teeth and the tendons, the glands and membranes, the humours and coats of the eye, the liquids and solids, with all their innumerable varieties in their proper distinct forms? This is a most unreasonable supposition. No, it is the wisdom of the God of nature that distributes this uniform food in the several parts of the animal by his appointed laws, and gives proper nourishment to each of them.

Again, 3. If the food of which one single animal partakes of be never so various and different, yet the same laws of motion, which God has ordained in the animal world, convert them all to the same purposes of nourishment for that creature. Behold the little bee gathering its honey from a thousand flowers, and laying up the precious store for its winter food! Mark how the crow preys upon a carcase: anon it crops a cherry from the tree, and both are changed into the flesh and feathers of a crow. Observe the kine in the meadows,

meadows, feeding on an hundred varieties of herbs and flowers; yet all the different parts of their bodies are nouriſhed thereby in a proper manner: every flower in the field is made uſe of to increaſe the fleſh of the heifer, and to make food for men: and out of all theſe varieties, there is a noble milky juice flowing to the udder, which provides nouriſhment for young children.

So near a-kin is man, the lord of the creation, in reſpect of his body, to the brutes that are his ſlaves, that the very ſame food will compoſe the fleſh of both, and make them grow up to their appointed ſtature. This is evident beyond doubt in daily experiments. The ſame bread-corn which we eat at our tables will give rich ſupport to ſparrows and pigeons, to the turkey, and the duck, and all the fowls of the yard: the mouſe ſteals it and feeds on it in his dark retirements; while the hog in the ſty and the horſe in the manger, would be glad to partake. When the poor Cottager has nurſed up a couple of geeſe, the fox ſeizes one of them for the ſupport of her cubs, and perhaps the table of the landlord is furniſhed with the other to regale his friends. Nor is it an uncommon thing to ſee the favourite lap-dog fed out of the ſame bowl of milk, which is prepared for the heir of a wealthy family, but which nature had originally deſigned to nouriſh a calf. The ſame milky material will feed calves, lap dogs, and human bodies.

How various are our diſhes at an entertainment? How has luxury even tired itſelf in the invention of meats and drinks in an exceſſive and endleſs variety? Yet when they paſs into the common boiler of the ſtomach, and are carried thence through the inteſtines, there is a white juice ſtrained out of the ſtrange mixture called chyle, which from the lacteal veſſels is converted into the blood, and by the laws of nature is conveyed into the ſame crimſon liquor. This being diſtributed through all the body by the arteries, is farther ſtrained again through proper veſſels, and becomes the ſpring of nouriſhment to every different part of the animal. Thus the God of nature has ordained, that how diverſe ſoever our meats are, they ſhall firſt be reduced to an uniform milky liquid, that by new contrivances, and Divine art it may be again diverſified into fleſh and bones, nerves and membranes.

How conſpicuous, and yet how admirable are the operations of Divine Wiſdom in this ſingle inſtance of nouriſhment! But it is no wonder that a God who could create ſuch aſtoniſhing and exquiſite pieces of machinery as plants and animals, could preſcribe ſuch laws to matter and motion, as to nouriſh and preſerve the individuals, as well as to propagate the ſpecies, through all ages to the end of time.

SECT. V.

The ſimilar Operations of Plants and Animals.

IT is with admiration and pleaſure we take notice of the regular actions of animals even in their earlieſt hours of life, before they can poſſibly be taught any thing by remark or imagination. Obſerve the young ſparrows in the neſt: ſee how the little naked creatures open their mouths wide to their dam, as though they were ſenſible of their dependance on her care for food and nouriſhment.

ment. But the chicken juſt releaſed from the priſon of the ſhell, can pick up its food with its own bill, and therefore it doth not open its mouth to beg food of the hen that hatched it. Yet the chicken ſeems to ſhew its dependance too: for when the firſt danger appears, you ſee it run and fly to the wing of its dam for protection; as though it knew, that though it could feed itſelf, yet it was not able to defend itſelf, but muſt truſt to better ſecurity and a parent's wing.

We admire theſe little creatures, and their remarkable ſagacity; we are ſurprized to find that they diſtinguiſh ſo happily, and purſue their proper intereſt; that they are ſo ſoon acquainted with their abilities and their wants, and come to uſe their underſtanding ſo very early; for it is evident, that the mere faculty of ſenſe, that is, the paſſive reception of images or ideas, can never be ſufficient to account for theſe wondrous imitations of reaſon; ſenſe has nothing to do but with the preſent impreſſion, and includes no reflection or proſpect of the paſt or the future, no contrivance of means to an end, nor any action in order to obtain it.

But what ſhall we ſay, or how ſhall we account for it, if we are told there are inſtances almoſt as admirable as theſe to be found in the vegetable world, where we never ſuſpect ſenſe or reaſon? The vine, as though it were ſenſible of its own weakneſs, thruſts forth its long tendrils, which curl round the branches of any ſtronger tree that ſtands near, and thus it hangs its weighty cluſters upon the arms of the elm that ſupport it. Nay, every cluſter has a tendril belonging to it, and if any ſtronger twig of its own be within its reach, it hangs itſelf there by this tendril for ſupport. The hop and the lupin, or French bean, as though they knew they could not ſtand by themſelves, find another way to raiſe their heads on high; they twine the whole length of their bodies round the poles or the rods which are planted near them; and thus their growth and their fruit are upheld from rotting upon the ground. The ivy, for the ſame reaſon, but by another contrivance, climbs up the oak, and ſticks cloſe to its ſides: and the feeble plant which we vulgarly call the creeper, that can hardly raiſe itſelf three foot high alone, thruſts out its claws at proper diſtances, fixes them faſt in the neighbouring wall or building, and mounts by this means to the tops of the higheſt houſes. What variety of artifice is found here among theſe feeble vegetables to ſupport themſelves!

Yet we believe theſe plants have no underſtanding, and mankind are all agreed they have no ſuch thing as ſenſe belonging to them; and we immediately recur to the wiſdom of God the Creator, and aſcribe the contrivance and the honour of it to Him alone. It was he, (we ſay) who gave the vine its curling tendrils, and the creeper its hooky claws: it was he inſtructed the one to bind itſelf with natural winding cords to the boughs of a ſtronger tree, and he taught the other as it were, to nail itſelf againſt the wall. It was he ſhewed the ivy to aſcend ſtraight up the oak; and the hop and the lupin, in long ſpiral lines, to twine round their proper ſupporters.

Let us enquire now, What do we mean by ſuch expreſſions as theſe? Truly nothing but this; that God formed the natures of theſe vegetables in ſuch a manner, as that by certain and appointed

appointed rules of mechanical motion, they ſhould grow up and move their bodies and their branches ſo, as to raiſe and to uphold themſelves and their fruit. Thus the wiſdom of God, the great Artificer, is glorified in the vegetable world.

And why ſhould we not give God the Creator the ſame honour of his wiſdom in the animal world alſo? Why may we not ſuppoſe that he has formed the bodies of brute creatures, and all their inward ſprings of motion, with ſuch exquiſite art, as even in their youngeſt hours, without reaſoning and without imitation, to purſue thoſe methods as regularly which are neceſſary for their life and their defence, by the ſame laws of motion and the ſame unthinking powers? This is nature, when God has appointed it. This ſeems to be the true idea, and the cleareſt explication of that obſcure word, Inſtinct.

If we allow theſe young animals to perform all their affairs by their own contrivance and ſagacity, why do not we aſcribe the ſame ſagacity and artifice to vines and ivy, that we do to young ſparrows or chicken? The motions of the plants are ſlower indeed, but as regular and rational as thoſe of the animals; they ſhew as much deſign and contrivance, and are as neceſſary and proper to attain their end.

Beſides, if we imagine theſe little young birds to practiſe their different forms of motion for their nouriſhment or defence by any ſprings of reaſon, meaning or deſign in themſelves, do we not aſcribe underſtanding to them a little too ſoon, and confeſs their knowledge is much ſuperior to our own, and their reaſon of more early growth? Do we not make men, or rather angels of them, inſtead of brute creatures? But if we ſuppoſe them to be actuated by the peculiar laws of animal motion, which God the Creator by a long foresight has established amongst his works, we give him the honour of that early and superior reason, and we adore the Divine Artificer. Psalm cxlv. 10. *All thy works shall praise thee, O Lord.*

But we are lost among these wonders of thy wisdom! We are ignorant of thy divine and inimitable contrivances! What shall we say to thee, thou All-wise, Creating Power! Thy works surprize us: the plants and the brutes puzzle and confound our reasonings: we gaze at thy workmanship with sacred amazement: thy ways in the kingdom of nature are untraceable, and thy wonders past finding out.

But what will some readers say when they peruse these discourses? Are plants and brutes so very near a-kin to each other, creatures which we have always distinguished into the sensible and the senseless? Have birds and beasts no more perception or feeling, knowledge or consciousness, understanding or will than the herbs, the trees and the flowers? Is the grass of the field as wise a thing as the animal which eats it? Excuse me here, my friends: I dare assert no such paradoxes. What if some of the early actions of brute creatures are merely the effects of such machinery and instinct as I before described? It does not follow thence, that all the actions and operations of their lives must be ascribed to such a mechanical principle. Even in human nature, where there is an undoubted principle of sense and reasoning, there are some early actions which seem to be the proper effects of such instinct or mechanism, and are owing to the wondrous divine artifice in the contrivance of their

their animal bodies, and not to any exercise of their own reasoning powers. How doth the infant hunt after the breast, and take it into its mouth, moving the lips, tongue and palate in the most proper forms for sucking in the milk to nourish it? How does it readily shut the eyes, to cover them from any danger near? How does it raise its cries and wailings aloud for help when it is hurt? These are certainly the effects of instinct in their outward members, as much as the circulation of their blood and digestion of their food in their bowels and inward parts.

It is certain, there are several operations in the lives of brute creatures, which seem to be more perfect imitations of reason, and bid fairer for the real effect of a reasoning principle within them, than these early actions which I have mentioned. What strange subtilty and contrivance seem to be found in the actions of dogs and foxes? What artifices appear to be used both by birds and beasts of prey, in order to seize the animals which were appointed for their food, as well as in the weaker creatures, to avoid and escape the devourer? How few are there of the passions, as well as the appetites of human nature, which are not found among several of the brute creatures? What resentment and rage do they discover? What jealousy and fear, what hope and desire, what wondrous instances of love and joy, of gratitude and revenge? What amazing appearances of this nature are observed in birds and beasts of the more docile and domestic kind? Such as puzzle the wisest of philosophers to give a plain, fair and satisfactory account how all these things can be performed by mechanism, or the mere laws of matter and motion? But how many actions soever may be performed by brute creatures, without any principle of ſenſe or conſciouſneſs, reaſon or reflexion, yet theſe things can never be applied to human nature. It can never be ſaid, that man may be an engine too, that man may be only a finer ſort of machine, without a rational and immortal ſpirit. And the reaſon is this. Each of us feel and are conſcious within ourſelves, that we think, that we reaſon, that we reflect, that we contrive and deſign, that we judge and chuſe with freedom, and determine our own actions: we can have no ſtronger principle of aſſent to any thing than preſent, immediate, intellectual conſciouſneſs. If I am aſſured of the truth of any inference whatſoever, it is becauſe I am ſure of my conſciouſneſs of the premiſes, and of my conſciouſneſs that I derive this inference from them. My conſciouſneſs of theſe premiſes therefore is a prior ground of aſſurance, and the foundation of all my certainty of the inferences. Let a thouſand reaſons therefore be laid before me, to prove that I am nothing but an engine, my own inward preſent conſciouſneſs of this propoſition, that I have thoughts, that I have reaſoning powers, and that I have a will and free choice, is a full evidence to me that theſe are falſe reaſonings, and deceitful arguments: I know and am aſſured, by what I feel every moment, that I have a ſpirit within me capable of knowing God, and of honouring or diſhonoring my Maker, of chuſing good or evil, of practiſing vice or virtue, and that I hereby am bound to approve myſelf to the Almighty Being that made and governs me, who will reward me in ſome future ſtate or other, according to my behaviour in this.

And as I can certainly determine this truth, with

with regard to my own nature, so when I see creatures round about me of the very same species with myself, I justly infer the same truth concerning them also: I conclude with assurance, that they are not mere engines, but have such reasonable and immortal spirits in them, as I find in myself. It is this inference of similar and equal causes from similar and equal effects that makes a great part of the science of mankind.

Besides, I daily hear men discoursing with me on any subject, and giving as regular and reasonable answers to my enquiries, as I do to theirs; I feel within myself, it is impossible for me to do this without thinking, without the careful exercise of my intellectual and reasoning faculties, superior to all the powers of mechanism; and thence I infer, it is as impossible for them to practise the same discourse or conversation, without the powers of a rational and intelligent spirit, which in its own nature is neither material nor mortal.

Let the question therefore which relates to brute creatures be determined to any side, it does not at all affect the nature, the reason, or the religion of mankind. It is beyond all doubt, that man is a creature which has an intelligent mind to govern the machine of his body; that man has knowledge, and judgment, and free choice; and unless he approve his conduct to the eyes of his Creator and his Judge, in this state of mortality and trial, he exposes himself to the just vengeance of God in his future and immortal state.

It is certain, that the All-wise and All-righteous Governor of intelligent creatures, will not appoint the very same fate and period to the pious and the profane ; neither his wiſdom, his equity, nor his goodneſs, will ſuffer him to deal out the ſame bleſſings and the ſame events in every ſtate of exiſtence, to thoſe who have loved him with all their ſouls, and thoſe who have hated and blaſphemed his name. It is the glory and the intereſt of the Supreme Ruler of the univerſe, to make a conſpicuous and awful diſtinction in one world or another, between thoſe who have endeavoured to ſerve him, and to render his majeſty honourable among men, and thoſe who have impiouſly abuſed all his favours, ridiculed his thunder, and robbed him of his choiceſt honours. But if philoſophy ſhould fail us here, if it were poſſible for creatures of ſuch different characters to have nothing in their own natures which was immortal, yet it is a very reaſonable thing, that the great Judge of all ſhould prolong their beings beyond this mortal ſtate, that the ſons of vice might not go triumphant off the ſtage of exiſtence, and that the men of virtue might not be always oppreſſed, nor come to a period of their being, without ſome teſtimony of the approbation of the God that made them.

CHAP.

CHAP. III.

Of Metals, Minerals, and other Foſſils.

AMONG the bodies that remain to be conſidered, thoſe which ſeem to bear the anereſt reſemblance to plants, are Foſſils, comprehending under the name, all bodies that are dug out of the earth. Theſe have frequently been, for order's ſake, divided into three claſſes; ſuch as are capable of liquefaction, ſuch as are reducible to a calix, and ſuch as are inflammable. Of the firſt claſs are Metals, Gold, Silver, Platina, Copper, Iron, Tin, Lead, Quickſilver. However, theſe differ in other reſpects, they all agree

agree in the following particulars, That they are heavier than any other bodies yet known, that they are malleable, and that they are capable of liquefaction.

2. It is not improbably supposed, all Metals consist of particles so heavy, that they cannot be wholly torn asunder or dissipated by fire, or put into so rapid a motion as to inflame. It only separates them so far as not to resist so hard a body, which is what we term Liquefaction. Their Malleableness, or bearing to be wrought by the hammer, may spring from the figure of their parts, perhaps oblong or square, which may occasion their cohering so strongly, as not easily to be separated. And it is probable the pores either of their constituent particles, or of the whole mass, are few and small; which may account for their being so much heavier than any other known bodies.

This is the radical character of Metals. The weight of gold to that of glass is as nine to one. And the weight of tin, the lightest of all Metals, is to that of gold as seven to nineteen: which considerably surpasses the weight of all stones and other the most solid bodies. Nor is there any body in nature but a Metal, that is one third of the weight of gold.

The specific weight of the several Metals, and of the granate water and air, stands thus:

Gold	19636	Iron	7852
Quickfilver	14019	Tin	7321
Lead	11345	Granate	3978
Silver	10535	Water	1000
Copper	8843	Air	$\frac{3}{11}$

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3. The Nutrition of Metals seems to consist only in the accretion of homogeneous parts, which is not improbably supposed to continue, while they lie in their native bed. Many suppose, they have lain there ever since the flood, if not ever since the creation. Whether they have or not, they seem to grow as long as they remain therein. And after these beds have been emptied by miners, in a time they recruit again. Yea, the earth or ore of allum will recruit again above ground, if it be exposed to the open air. And so in the forest of Deane the best iron, and in the greatest quantities, is found in the old cinders melted over again.

However, it has been long disputed, whether Metals are generated, or were all originally produced at the creation: and whether there be any general Seed of Metals, as some suppose Antimony to be. This is indeed a Fossil of a very peculiar nature. It is a kind of undetermined, metallic substance, mixed with stony and sulphureous particles, so that it is hard to reduce it to any class. It is found in mines of all Metals, but chiefly in silver or lead mines. That in gold mines is counted the best. It has also its own peculiar mines. It lies in clods of several sizes, nearly resembling black-lead, but is full of small shining threads, like needles, brittle as glass. It melts in the fire, though with some difficulty. Its uses are very numerous. It is a medicine of sovereign use in many cases, when warily and properly administered. It is a common ingredient in burning concaves, serving to give the composition a finer texture. It makes a part in bell-metal, in order to render the sound more clear. It is mingled with tin, to make it more hard, as well as of a brighter

brighter colour, and with lead, in casting of Printers Letters, to render them more smooth and firm. It is also a general help in the casting of Metals, and especially in casting cannon-balls.

4. Gold is either found in small grains in the sand of rivers, (formerly in several of the rivers of Europe) or is dug out of the earth, in small pieces of a tolerable purity. Sometimes it is also found, like the ore of other Metals, in a mass of earth, stone, or sulphur. In this state it is of all colours, red white, blackish, making no ostentation of its real value.

The chief properties of Gold are, 1. It is the heaviest, though not the hardest, of bodies. 2. It is the most ductile and malleable of all Metals, of which gold-beaters and wire-drawers give us an abundant proof. But this depends altogether (incomprehensible as it is) on its being free from sulphur. For mix but one grain of sulphur with a thousand of gold; and it is malleable no longer. 3. It is more fixed in the fire than any other Metal. Lay a quantity of gold two months in the intensest heat, and when it is taken out, there is no sensible diminution of its weight. And yet in the focus of a large burning glass, it volatilizes and evaporates. Yea, many thousands of moidores were wholly consumed, others half, or a quarter consumed, by the flames which broke out of the earth, during the late earthquake at Lisbon. Gold may likewise by a glass be fused into a sort of calx, and then vitrified. But if the same be fused again with grease, it is restored into gold. 4. It is dissolvible by no menstruum known, but Aqua Regia and Mercury. The basis of Aqua Regia is sea-salt, the only salt which has any effect on gold. But this has its effect, however applied, whether

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in a fluid or ſolid form. 5. It readily and ſpontaneouſly attracts and abſorbs Mercury. But as ſoon as the Mercury enters it, the gold becomes ſoft like paſte. 6. It withſtands the violence both of lead and antimony. All Metals but gold and ſilver, melted with lead, periſh with it and evaporate; and all but gold, if melted with antimony. Thus melt gold, ſilver, copper and tin with antimony, and all the reſt riſe to the top, and are blown off with bellows, but the gold remains behind. Hence antimony is uſed as the teſt of gold.

The malleableneſs or ductility of gold, is beyond all imagination. By exact weighing and computation it has been found, that there are gold leaves, which in ſome parts of them are ſcarce 350000th part of an inch thick. And yet this is a notable thickneſs in compariſon of that of the gold ſpun on ſilk in gold-thread. It has been proved, that the breadth of theſe gold plates is only the 96th part of an inch, and their thickneſs, the 3072d: ſo that an ounce of gold is here extended to a ſurface of 1190 ſquare feet.

How thin muſt it be when thus extended! In ſome parts it has been computed, its thickneſs is only the 3,150,000th part of an inch! And yet with this amazing thinneſs, it is ſtill a perfect cover for the ſilver: nor can the beſt eye, or even the beſt microſcope diſcern the leaſt chaſm or diſcontinuity. Nay, there is not an aperture to admit Alcohol of wine, one of the ſubtleſt fluids in nature: no, nor light itſelf. So cloſely connected are the particles, notwithſtanding their inconceivable thineſs.

Silver approaches the neareſt to gold in ductility and reſiſting fire. Like the ore of all other Metals,

Metals, it is found in the earth, under different forms and colours. But it usually affects somewhat of a pointed regular form like chrystals. It is never found in sand or grains, as native gold is. It is sometimes ash-coloured, sometimes spotted with red and blue, sometimes of changeable colours, many times almost black.

Although the history of Fossils has been diligently cultivated, especially by the moderns, yet it must be owned, that amidst the vast variety of them, there is still room for new enquiries. No wonder therefore, that among the great variety of salts, ores and other concretes, new mixtures should daily be discovered. But that among bodies so simple as Metals, any should still remain unknown, will appear extraordinary.

Yet so it is: there has been discovered in New Spain, an original Metal between gold and silver. The Spaniards call it Platina, from the resemblance in colour which it bears to silver. It is of an uniform texture, bright and shining. It takes a fine polish, and does not tarnish nor rust. It is very hard and compact, but extremely brittle, and malleable but in a small degree.

It is found chiefly in small grains, yet not pure, but mixed with a shining black sand. There are likewise usually mixed with it, a few shining particles of a golden colour.

When exposed by itself to the fire, it is extremely hard to melt. It has been kept for two hours in an air furnace, in a heat that would melt cast iron in fifteen minutes, without being either melted or wasted. But when exposed to a proper heat with gold, silver, copper, lead, or tin, it readily melts and incorporates with them. Hav-

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ing been kept in an affay-furnace with lead for three hours, till all the lead was wrought off, it was found remaining at the bottom, without having fuffered any alteration or diminution. A piece of it was put into ftrong aqua-fortis, and kept in a fand-heat for twelve hours, yet when taken out, it was no ways corroded, and was of the fame weight as when put in. It has been faid to be heavier than gold: but that is a miftake. Its fpecific gravity is to that of water, as fifteen to one. Yet an equal mixture of gold and platina, was near as heavy as gold itfelf, being to water as nineteen to one. It appears then, that no known body comes fo near gold in fixednefs and folidity. If it could be made as ductile as gold it would not eafily be diftinguifhed from it.

Platina is likewife found in large hard maffes; thefe maffes are with great labour, reduced into fmall grains, which are afterwards ground with mercury to extract the gold; and it is not to be brought into fufion by the greateft degree of fire procurable in the ordinary furnaces. It entirely refifts the vitriolic acid, which diffolves or corrodes every other known metallic body except gold. Nay, it refifts the marine fumes, and the regal cement, fo called, from its being fuppofed to purify gold from all heterogeneous metallic matters. It alfo refifts the force of the vitriolic and nitrous acids, though applied in fuch a manner as to be capable of perfectly diffolving all other known metallic bodies. It follows from other experiments, that Platina contains no gold; for it cannot any more than the common metallic fubftances, prevent a fmall portion of gold mixed with it from being difcoverable. It farther appears, that Platina, like gold, is not acted on by the

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ſimple acids which diſſolve every metallic body beſides: that aquæ regiæ, the ſolvents of gold, prove menſtrua for Platina; and that conſequently the common methods for aſſaying or purifying gold by aqua fortis, aqua regia, or the regal cement, can no longer be depended on: that it differs from gold, in giving no ſtain to the ſolid parts of animals, not ſtriking a purple colour with tin, not being revived from its ſolutions by inflammable ſpirits, not being totally precipitable by alcaline ſalts; that in certain circumſtances it throws out gold from its ſolutions; that theſe properties afford means of diſtinguiſhing a ſmall portion of gold mixed with a large one of Platina, or a ſmall portion of Platina with a large one of gold; and that Platina contains no gold excepting the few particles diſtinguiſhed by the eye. That Platina is precipitated from its ſolutions by the vitriolic acid, and by the metallic ſubſtances, which precipitate gold, though ſcarce totally by any: and that its precipitates reſiſt vitrification, and this perhaps in a more perfect manner than precipitates of gold itſelf. It is therefore a ſimple Metal of a particular kind, eſſentially diſtinct from all thoſe hitherto known, though poſſeſſed of ſome properties generally ſuppoſed peculiar to gold. Many of its characters have been already pointed out; others reſult from combining it with the ſeveral Metals, with each of which, notwithſtanding its reſiſtance to the moſt intenſe fires by itſelf, or with unmetallic additions, it melts perfectly; occaſioning remarkable alterations in their colours, texture, and hardneſs. It melts with equal its weight of each of the Metals, with one more readily than with another. With ſome it becomes fluid, in a moderate

moderate fire; but a ſtrong one is requiſite for its perfect ſolution. Compoſitions of ſilver, copper, lead, with about one third their weight of Platina, which had flowed thin enough to run freely in the mould, and appeared to the eye perfectly mixed, on being digeſted in aqua-fortis till the menſtruum ceaſed to act, left ſeveral grains of Platina in their original form. Upon viewing theſe with a microſcope ſome appeared to ſuffer no alteration; others exhibited an infinite number of minute bright globular protuberances, as if they had juſt began to melt. Platina hardens and ſtiffens all metals; one more than another, lead the moſt. In a moderate quantity it diminiſhes, and in a large one deſtroys, the toughneſs of all the malleable Metals, but communicates ſome degree of this quality to caſt iron. Tin bears much the leaſt, and gold and ſilver the greateſt quantity without the loſs of their malleability. A very ſmall portion of Platina ſcarce injures the colour of copper and gold: a larger renders both pale. A far leſs quantity has this effect on copper than on gold. It debaſes and darkens in proportion to its quantity, the colour of the white Metals; that of ſilver much the leaſt, and of lead the moſt. It in good meaſure preſerves iron and copper from tarniſhing; ſcarce alters gold or ſilver in this reſpect; makes tin tarniſh ſoon, and lead exceeding quick.

Copper comes next to ſilver in ductility. Braſs is an artificial Metal, compoſed of copper fuſed with lapis calaminaris. Iron is leſs ductile than any of theſe, and contains more droſs.* It likewiſe

* The Spirit of vitriol being mixed with iron, after fermenting, produces a green vitriol like the natural one. But if for Spirit

wise easily rusts, whereas silver seldom rusts, and gold seldom either rusts or cankers. Tin resembles * lead, but is considerably harder, and not near so heavy. Indeed it seems to be a sort of imperfect metal, generated of two different seeds, that of silver and that of lead, which makes it a kind of compound of both. And it is sometimes found in silver mines, sometimes in lead-mines, though it has also mines of its own. It is the lightest of all Metals, very little ductile or elastic, but the most fusible of all. It is scarce dissolvible with acids, but easily mixes with other Metals.

Of all the substances concurring to form the terrestrial globe, Iron seems to have the greatest share; as it not only abounds in most kinds of stone, but enters greatly into the composition of clay. This may be judged from the similitude of colour between clay, and dry Iron-ore, from the easy vitrification of clay, from the resemblance of vitrified clay to clinkers of Iron, from its deep red colour after calcination, and lastly, from its yielding pure iron, by being burnt with oil.

Dr. Lister has shewn that stones out of the human bladder being calcined, Iron may be extracted

Spirit of vitriol, you use oil of vitriol, which is the most acid part of that mineral, there happens immediately a small fermentation, which is quickly over. That fermentation begins again in a few days, under the form of a white smoke, which rises to the surface, and the whole mass of iron turns into a very white pap which smells like common sulphur. When the fermentation is over, the iron, instead of turning into green vitriol, becomes on a sudden white vitriol. Mean time there is on its surface a black dust, which it has thrown up. It seems this would have made it green. For if white vitriol be mingled with this dust, it acquires a green colour.

* White-Lead is thin plates of lead dissolved in vinegar.

Red Lead is common lead calcined.

Black Lead (very improperly so called) is only a talky kind of earth.

tracted from them by a loadstone. And there is scarce any terrestrial substance either in men, brutes, or plants, which after ustion doth not exhibit some metallic particles. Dr. Bucher says, that out of brick-earth, mixed with any fat or oil, and calcined in the fire, he hath produced iron: for it is only the iron that causes the redness of the bricks: and it can be extracted from them again. Moreover, Metals are dissolved by the salts and moisture in the earth, and so mix with the nutritious juices of vegetables; hence it may in some respects be said, that we eat metals with the greatest part of our food.

The Arbor Martis is a germination of iron, resembling a natural plant. The manner of its discovery was this. One poured oil of Tartar on Iron filings, dissolved in spirit of nitre in a glass. Presently the liquor swelled much, though with little fermentation, and was no sooner at rest, than there arose a sort of branches adhering to the glass, which increased till they covered it all over. And these branches were so perfect, that one might even discover a kind of leaves and flowers thereon. The experiment has since been frequently repeated, and with the same success.

A friend of mine shewed me an experiment of the same kind. In a glass placed over a moderate fire, there was a continual budding of silver, in the form of a branch. When this was clipped off with scissars, and a little crude mercury added, in a small time there arose another branch of true silver, which had sucked in and converted into Metallic sprigs, a considerable portion of the quicksilver. The increment of new Silver branches

branches ceaſed not, as long as the fire was continued and freſh mercury ſupplied, for the due nutriment of this mineral vegetation. The ingredients were only aqua-fortis, quickſilver, and a ſmall quantity of ſilver, far leſs than you may reap in a ſmall time from theſe Silver ſprigs. Yet far more expence is blown away in ſmoke, than can be recovered from this Silver harveſt.

Not much unlike this was an experiment made by a gentleman, who kept in a cabinet ſome pieces of Fire-ſtone from a coal-pit, and ſome large pieces of crude Allum-ſtone, ſuch as it was when taken out of the rock. After a time both theſe had ſhot out tufts of long and ſlender fibres: ſome of which were half an inch long, bended and curled like hairs. And as often as theſe tufts were wiped off, they ſprouted out again.

But both of theſe fall ſhort of what is related by a curious naturaliſt. "Having extracted the ſalts out of a quantity of Fern-aſhes after the common method, moſt of the water being evaporated, I had ſeveral pounds of ſalt, moſt of which being dried, I expoſed the reſt to the air. Having put it into a large glaſs, I forgot it for five or ſix weeks: looking after it then, I was ſaluted with a pleaſing ſpectacle. The lixivium had depoſited a large portion of ſalt, out of which ſprung at a ſmall diſtance from each other, about forty branches, which exactly reſembled Fern, putting out many leaves on each ſide, from one ſtem. They were of different ſizes, but the figures of all were preciſely the ſame. And theſe artificial vegetables, taking care not to ſhake them, I preſerved for many weeks."

And

And yet the following account is ſtranger ſtill. " I mixed equal parts of Sal Ammoniac and Potaſhes which were put into a tall glaſs body, till plenty of volatile ſalt ſublimed. I expected no unuſual appearance from this, having often repeated the operation. Being called out juſt as the ſalt began to appear, how was I amazed at my return, to ſee in the glaſs-head a foreſt in perſpective, ſo delineated, as ſcarce to be equalled by the greateſt maſters. They were a repreſentation of firs, pines, and another ſort of tree which I had never ſeen. But of this delightful ſpectacle I was ſoon deprived by the ſublimation of more ſalts.

" The next day I related this to Sir Robert Murray. He told me, one Daviſon, an experienced Chymiſt at Paris, had frequently ſhewed him in a glaſs a great company of firs and pines, full as lively as any can be painted. But in a little time they diſappeared. He produced them again at pleaſure. But herein his operation differed from mine: the ſubſtance out of which he raiſed thoſe ſhapes was of a more fixed nature; that which afforded mine, was volatile to the higheſt degree. Again, He could conſtantly and regularly produce thoſe beautiful repreſentations: whereas mine unexpectedly appeared; nor have I any hope of ſeeing them again."

Sal Ammoniac is made of the ſoot ariſing from the dung of four-footed animals, as ſheep, oxen and camels, ſo long as they feed only on green vegetables. This dung is collected in the four firſt months of the year, when all theſe feed on freſh ſpring graſs. This in Egypt is a kind of trefoil or clover. But when the cattle are fed on hay, and the camels on bruiſed date-kernels, their excrements are not fit for this purpoſe.

The Nitre of Egypt was well known to the antients. It is produced in two lakes near Memphis. One of them is four or five leagues long and one league broad: the other, three leagues long, and one and an half broad. In both, the Nitre is covered by a foot or two of water. They cut it up with long iron bars, ſharp at the end. And what is taken away, is replaced in one or two years, by new Nitre, coming out of the earth.

5. If iron in melting be carefully purged from its droſs, drawn into plates, and plunged red hot into cold water, it grows harder, and is termed Steel. But it is conſiderably ſoftened again, if it is put into the fire, and afterward left to cool gradually in the air.

6. Quickſilver differs from all metals, in that it is naturally liquid. Its properties are 1. It is the heavieſt of all bodies, but gold and platina. 2. It is the moſt fluid of all. The particles even of water, do not divide ſo eaſily as thoſe of Quickſilver: they have hardly any coheſion. 3. Of all bodies it is diviſible into the minuteſt parts. Being on the fire, it reſolves into an almoſt inviſible vapour. But let it be divided ever ſo much, it ſtill retains its nature. For the vapours of diſtilled Quickſilver, received in water or on moiſt leather, become pure Quickſilver. And if it be mixed with lead or other bodies, in order to be fixed, it is eaſily by fire ſeparated from them again, and reduced to its ancient form. 4. It is extremely volatile, being convertable into a fume, even in a ſand-heat. 5. Of all fluids it is in equal circum-

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ſtances the coldeſt and the hotteſt. This depends on its weight; for the heat and cold of all bodies, is (cæteris paribus) as their weight. 6. It is diſſolvable by almoſt all acids, but vinegar. And hereby we diſcover, if it be ſophiſticated with lead. Rub it in a mortar with vinegar. If it be mixed with lead it grows ſweetiſh: if with copper it turns greeniſh or bluiſh. If there be no adulteration, the Quickſilver and vinegar will both remain as before. 7. It is the moſt ſimple of all bodies, but gold and platina. 8. It has no acidity at all, nor does it corrode any body.

But it may be obſerved of Metals in general, there is great uncertainty and inconſtancy in the Metallic and Mineral kingdoms, both as to colour, figure, and ſituation. A Marcaſite, for inſtance, may have the colour of gold and ſilver, and yet afford nothing but a little vitriol and ſulphur: while what is only a pebble in appearance, may contain real gold.

It is common alſo to find the ſame Metal ſhot into many different forms, as well as to find different kinds of Metal of the ſame form. There is the ſame uncertainty as to their place. Sometimes they are found in the perpendicular fiſſures of the ſtrata, ſometimes interſperſed in the ſubſtance of them; and the ſame Metals in ſtrata of very different natures. They are likewiſe frequently intermixed with each other; ſo that we ſeldom find any of them pure and ſimple, but copper and iron, gold and copper, ſilver and lead, tin and lead in one maſs: yea, ſometimes all ſix together.

What diſtinguiſhes them from all oth bodies as well as from each other, is their heavineſs:

each Metal having its peculiar weight, which no art can imitate.

But who can reckon the various ways, wherein Metals are useful to mankind? Without these we could have nothing of culture or civility; no tillage or agriculture; no reaping or mowing, no plowing or digging, no pruning or grafting, no mechanic arts or trades, no vessels or utensils of houshold stuff, no convenient houses or edifices, no shipping or navigation. What a barbarous and sordid life, we must necessarily have lived, the Indians in the northern parts of America, are a clear demonstration.

And it is remarkable, that those which are of most necessary use, as iron and lead are the most plentiful. Those which may better be spared, are more rare. And by this very circumstance they are qualified to be made the common measure and standard of the value of other commodities, and to serve for money, to which use they have been employed by all civilized nations in all ages.

All Metals are liable to rust. Gold itself rusts, if exposed to the fumes of sea-salt. The great instrument in producing rust is water: air, only by the water it contains. Hence in dry air Metals do not rust; neither, if they are well oiled: water not being able to penetrate oil. Rust is only the Metal under another form. Accordingly rust of copper may be turned into copper again. Iron if not preserved from the air by paint, will in time turn wholly into rust.

7. Mines in general are cavities, within the earth, containing substances of various kinds. These the miners term *loads:* if Metallic, they are said

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to be *alive*; if not, to be *dead loads*. In Cornwall and Devonſhire the loads always run from eaſt to weſt. Mines ſeem to be, or to have been channels of waters within the earth, and have branches opening into them in all directions. Moſt mines have ſtreams running through them: where they have not, probably the water has changed its courſe. The ſprings in theſe parts are always hard, abounding either with ſtony or ſulphureo-ſaline particles. Theſe particles are either of a vitriolic or an arſenical nature. The firſt concretes into white cubes, reſembling ſilver, the ſecond into yellow ones reſembling gold. Both theſe are by the miners termed Mundic.

8. Mundic is variouſly coloured on the outſide with blue, green, purple, gold, ſilver, braſs and copper-colours. But within it is either of the colour of ſilver, of braſs, or gold colour, or brown. The other colours are no more than a thin film or ſediment, which water variouſly impregnated, depoſites upon the ſurface.

There are few copper-loads, if any, but have this Semi-metal (which is a kind of wild mock-copper) attending upon them. Therefore, in ſearching for copper, it is reckoned a great encouragement to meet with Mundic. The Mundic does not intimately incorporate itſelf with the ore of copper; for copper in its mineral ſtate, being uſually of a cloſe conſiſtence, repels the Mundic, which is therefore eaſily ſeparated from the ore.

Corniſh waters are infected by Mundic, more or leſs, according to the quantity which they paſs through, and the diſpoſition of the Mundic, either to retain or to communicate the noxious particles of which it conſiſts. Arſenic, ſulphur, vitriol, and mercury are the conſtituents of Mundic, yet theſe pernicious ingredients are ſo bridled and detained by their mutual action and re-action, and by mixing with other Minerals, that the water is not poiſonous, (generally ſpeaking) even in the mine where it proceeds directly from the Mundic.

Mundic reſembles plants, animals, mouldings, carvings, and ſundry more varieties, too numerous to inſert. Shall we attribute this to a plaſtic power ſuperintending the congreſs of foſſils, and ſporting itſelf with ſuch repreſentations? Or ſhall we rather ſay, that the great Power which contrived and made all things, needing no delegate, artfully throws the flexile liquid materials of the foſſile kingdom into various figures, to draw the attention of mankind to his works, and thence lead them, to the acknowledgment, and adoration of an intelligent Being, inexhauſtibly wiſe, good and glorious? Doubtleſs theſe are the works of that ſame lover of ſhape, colour and uniformity that paints the peacock's train, that veins the onyx, that ſtreaks the zebra: it is the ſame hand whoſe traces we may diſcover even among the meaneſt and moſt obſcure foſſils. God loves ſymmetry, gracefulneſs, elegance, and variety, and diſtributes them for his complacency as well as glory, limits them not to plants, and animals, and open day light, but like a great Maſter habitually imparts them to all his works, though in the deepeſt ocean, and in the moſt ſecret parts of the earth.

9. Although Fiſſures are the natural reſult of a moiſtened and mixed congeries of matter, paſ-

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ſing by approximation of parts into a ſtate of ſolidity, we are by no means to conclude them uſeleſs, or the works of chance. No, the great Architect, who contrived the whole, determined the ſeveral parts of his ſcheme ſo to operate, as that one uſeful effect ſhould become the beneficial cauſe of another. Hence it happens that matter could not contract itſelf into ſolid large maſſes, without leaving Fiſſures between them: and yet the Fiſſures are as neceſſary and uſeful as the ſtrata through which they paſs.—Theſe are the drains which carry off the redundant moiſture from the earth, which but for them, would be too full of fens and bogs for animals to live, or plants to thrive on.——Through theſe Fiſſures the rain which ſinks beneath the channels of rivers, not having the advantage of that conveyance above ground, returns into the ſea, bringing the ſalts and mineral juices of the earth into the ocean, enabling it to ſupply the firmament with proper and ſufficient moiſture, and preſerving that vaſt body the ſea, wholeſome, fit for fiſh to live in, and ſailors to navigate.

In theſe Fiſſures the ſeveral ingredients which form the richeſt loads, by the continual paſſing of waters, and the menſtrua of Metals, are educed out of the adjacent ſtrata, collected and conveniently lodged in a narrow channel, much to the advantage of thoſe who ſearch for and purſue them. For if Minerals were more diſperſed, and ſcattered thinly in the body of the ſtrata, the trouble of finding and getting at Metals (thoſe neceſſary inſtruments of art and commerce, and the ornaments of life) would be endleſs, and the expence of procuring, would exceed the value of the acquiſition:—without theſe, neither Metals, marbles, ſalts, earths, nor ſtones, could be ſo eaſily or in ſuch plenty, provided, as is neceſſary for the uſe of man.

Earth is certainly the general food and ſtamen of all bodies, yet we know of itſelf it can do nothing: it muſt be connected by a cement, or it cannot form ſtone; it muſt be ſoftened and attenuated by moiſture and warmth, or it cannot enter into the alimentary veſſels of plants and animals. The parts of earth which conſtitute the ſolids of any plants are exceeding fine, and the common maſs in which we plant trees, is for the moſt part gravel, clay, and ſand, which promote vegetation, but are too groſs to enter into, and become the conſtituent parts of them. Water muſt therefore be conſidered as the vehicle of more ſolid nouriſhment, and the parent of the fluids: the earths, ſalts, and oils, are the great inſtruments of the increaſe of ſolids. To trace fertility a little farther: when the earth is ſoftened and diluted, heat rarefies and evaporates the mixture; the ſalts contained and diſſolved, are always active and promote motion; the elaſticity of the air quickens and continues it: the oils ſupple the paſſages, of which ſome are fitted to ſecrete, arreſt, and depoſit the nutritious particles as they paſs; ſome adapted (by the ſame ſecret hand, which conducts every part of the operation) to throw off the redundant moiſture by perſpiration: the earthly mixture compoſes the hard and ſolid parts, and the genial, little atmoſphere of every plant gives ſpirit, colour, odour and taſte. Herbs and fruits being thus fed and matured, make the earth they contain better prepared to paſs into the ſtill more curious and highly organized parts of animals. It

It is easy to see that this is rather a detail of the several materials, and well known instruments, conducing to fertility, than the cause. Fertility is owing to the concert, fitness, and agreement of all these, with some volatile active principle, of which we know nothing at all. But whence that agreement results, how the materials ferment, replace, connect, and invigorate one another, how the vessels chuse and refuse, (if I may so say,) in order to produce the fertility desired, is known only to the infinitely wise Disposer of all things, ever attentive to the nurture and support of what he has created. But to whatever cause the fertility of earth is to be assigned, earth it must be owned is a most fruitful universal element. Animals, plants, metals, and stones arise out of it, and return to it again; there, as it were, to receive a new existence, and form new combinations, the ruins and dissolutions of one sort affording more and more materials for the production of others.

In stones and Metals, we admire the continuity, hardness and lustre of earth; in plants the rarity, softness, colours, and odours: in animals the flesh, the bone, and an infinite number or fluids, in which this supple element can take place: but the greatest wonder is, that earth is capable of being subtilized to such an exquisite degree, as by uniting and communicating with spirit, to perform all animal functions given it in charge by the soul. This is the highest and utmost refinement, which in this state of being, earth is capable of; but that it may be still farther refined, in order to be qualified for a future, incorruptible, and more glorious state, is one of the greatest truths which we owe to revelation.

10. To the second class of Fossils belong those which are reduced by fire to a calx. Such are 1. Salts, all Fossils which (whether they have a salt taste or no) are soluble in water. Common Salt is heavier than water, and if quite pure, melts when left in the open air. If the water it is dissolved in be boiled and evaporated, it remains in the bottom of the vessel. It is well known to preserve flesh from putrifaction, and to be with great ficultly dissolved by fire. Probably it is composed of pointed particles, which fix in the pores of flesh, and by reason of their figure are easily divided by water, though not by fire. It ever comes purer out of the fire. Yet it will fuse in a very intense heat.

All Salt dissolves by moisture: but moisture only dissolves a certain quantity. Yet when it is impregnated with any Salt, as much as it can bear, it will still dissolve a considerable quantity of another kind of salt. It seems, the particles of this, being of different figures, insinuate into the remaining vacuities. Thus when a cup of water will dissolve no more common salt, alum will dissolve in it. And when it will dissolve no more alum, Salt-petre will dissolve, and after that, Sal Ammoniac.

The most remarkable Salt-mines in the world, are in the village Williscа, five leagues from Cracow in Poland. They were first discovered above 500 years ago, in the year 1251. Their depth and capacity are surprizing. They contain a kind of subterranean republic, which has its laws, polity, carriages, and public roads for the horses which are kept there, to draw the Salt to the mouth

mouth of the quarry. These horses after once they are down, never see the light of the day again. But the men take frequent occasions of breathing the upper air. When a stranger comes to the bottom of this abyss, where so many people are interred alive, and where so many were born, and have never stirred out, he is surprized with a long series of lofty vaults, sustained by huge pillars, which being all rock salt, appear by the light of flambeaux that are continually burning, as so many chrystals, or precious stones of various colours.

11. To this class, Secondly, belong Stones, which are hard, rigid, void of taste, reducible to dust by the hammer, and into a calx by fire. It is probable, that Stones, like Salts and most fossils, are generated from a fluid, which gradually hardens into Stone, by the evaporation of its finer parts.

Mr. Tournefort observed, that in the famous labyrinth of Crete, several persons had engraved their names in the living rock, of which its walls are formed: and that the letters so ingraven, instead of being hollow, as they were at first, stood out from the surface of the rock. This can no otherwise be accounted for, than by supposing the cavities of the letters filled insensibly, with matter issuing from the substance of the rock, even in more abundance than was needful to fill those cavities. Thus is the wound of a knife healed up, much as the fracture of a bone is consolidated, by a callus formed of the extravasated nutritious juice, which rises above the surface of the bone. Such callus's have been observed to be formed on other stones, which were reunited after they had been

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accidentally broken. Hence it is manifeſt, that ſtones grow in the quarry, and conſequently are fed; and that the ſame juice, which nouriſhes them, ſerves to rejoin their parts when broken. There is then no room to doubt, that they are organized, and draw their nutritious juice from the earth, which is firſt filtrated and prepared in the ſurface of the ſtone, and thence conveyed to all the other parts.

Doubtleſs the juice which filled the cavities of thoſe letters was brought thither from the root of the rock, which grew as corals do, or ſea-muſhrooms, which every one allows to grow: and yet they are true ſtones.

Indeed there are ſome ſpecies of ſtones, whoſe generation can no otherwiſe be accounted for, than by ſuppoſing them to come from a kind of ſeeds, which contain its organized parts in miniature. But many ſorts of ſtones were once fluid; witneſs the various foreign bodies ſound therein.

That even pebble ſtones grow, may be proved to a demonſtration, by an eaſy experiment. Weigh a quantity of pebbles and bury them in the earth. After a time dig them up, and on weighing them again, you will find they have gained a very conſiderable addition.

The Vegetable Mould or Surface of the Earth, is made up of ſands, clays, marls, loams, rotten ſtalks and leaves of herbs, ſerving both as a proper bed and covering, and as a receptable and conductor of moiſture to the roots of trees and plants. Sands and pebbles may be conſidered as drains, for carrying off the redundant moiſture, to places where it may be ready to ſupply the place of what is continually riſing in exhalations.

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But left the ſtrata of ſand ſhould be too thick, ſmall ones of clay are often placed between, to prevent the moiſture from departing too far from where it may be of uſe. And leſt theſe thin partitions of clay ſhould let the particles of ſand inſinuate into them, and thereby let the moiſture paſs through, thin cruſts of a ferrugineous ſubſtance are placed above and beneath each of theſe clayey ſtrata; by which means the clay and ſand are effectually kept aſunder.

Suppoſing ſome Stones are organized Vegetables, and are produced from ſeed, yet moſt ſorts of ſtones ſeem to be unorganized Vegetables. Other vegetables grow by a ſolution of ſalts, attracted into their veſſels. Moſt ſtones grow by an accretion of ſalts, which often ſhoot into regular figures. This appears by the formation of chryſtals upon the Alps. And that ſtones are formed by the ſimple accretion of ſalts, appears from the tartar on the inſide of a claret veſſel; and ſtill more clearly, from the formation of a ſtone in the human body. The air is in many places impregnated with ſuch ſalts or ſtony particles: and theſe aſcending from the cavities of the earth, may petrify wood. In this caſe the petrifying quality is not originally, either in the earth or the water: but in the riſing ſteams impregnated with ſaline or ſtony particles.

12. Many waters are generally ſuppoſed to turn other bodies into ſtone. This is aſcribed to the Lake Loghmond in Scotland, and Lough Neagh in Ireland. But it is a miſtake. There is not in reality any ſuch tranſmutation in thoſe bodies. Only the ſtony particles floating in the water, lodge

lodge in the pores, or on the surface of them. Petrefactions therefore are nothing more than incrustations of stony particles, which surround and partly insinuate into the bodies immersed.

With regard to Lough Neagh, the Petrifying Quality, seems to be not only in the water, but in the adjacent soil. Many pieces of petrified wood are thrown up daily, in breaking up new ground, which that water never touched. They are often found two miles from the Lough, in great numbers, and deep in the ground, altogether like the Lough Neagh stones. That these were once wood is certain. They burn clear, and may be cut with a knife, though not so easily as other wood.

Petrifying Springs are impregnated, some with particles of stone, others with ferrugineous and vitriolic particles. When the stony ones drop on wood, or other vegetables, they coagulate upon it, and by degrees cover it with a stony coat. If this be broke before the wood is rotted away, you find it in the heart of the stone. If the wood is rotted, you will find a cavity in the stone; but this also in time will be filled up with stony particles. Sometimes indeed these waters permeate the pores of the wood, fill them up with their stony particles, and by their burning quality proceeding from lime-stone, destroy the wood, and assume the shape of the plant.

Metallic particles mostly act, by insinuating into the pores of wood or other vegetables, without increasing their bulk, or altering their texture, though they greatly increase their weight. Such is the petrified wood in and near Lough Neagh.

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It does not ſhew any outward addition of matter, and preſerves the grain of wood. All the alteration is in the weight and cloſeneſs, by the mineral particles pervading and filling the pores.

That there are Mines near the Lough, we may gather from the great quantity of Iron-ſtones found on its ſhores, and from the yellowiſh ochre and clay in many places near it. Now whatever ſprings run through theſe, will be impregnated with metallic particles. And if they riſe in the middle of a river or lake, and in their courſe meet with wood or other vegetables, theſe particles will inſinuate and lodge themſelves in their pores, and by degrees turn them into ſtone.

That ſuch ſprings are under this Lake, appears from hence, that in the great froſt, 1740, though the Lake was froze over, ſo as to bear men on horſeback, yet ſeveral circular ſpots remained unfrozen. Hence it appears, that this petrific quality is not in all parts of the Lake, but here and there only. As to the trees which are found petrified and buried at a ſmall diſtance from the Lake, probably it was broader once than it is now, ſo that what was then under water, is now dry land. If ſo, theſe trees might have been petrified, in the part which was then overflowed, though it is now dry.

13. It is certain, that water impregnated with metallic particles, when falling on wood or other vegetables, will coagulate upon it, as was obſerved above, and cover it with a metallic coat. It is alſo certain, that the vegetables included therein, are gradually deſtroyed, till the ſame matter which firſt

first formed the cruſt, takes up the whole ſpace which they occupied before. But it is not only wood and other vegetables, which are capable of being thus acted upon, firſt cruſted over and then deſtroyed. A ſhovel of iron ſome years ſince lying in the water, in the County of Wicklow, in Ireland, was obſerved to be incruſted with copper, which gave occaſion to an important diſcovery. A gentleman, who viſited the place on purpoſe to examine the truth of what was commonly reported, obſerves, " I ſaw the iron bars impregnated with copper. I was an eye-witneſs to the change in all its progreſs; and ſo were thouſands beſides. I ſaw the maſons laying a chain of new ſtone troughs, for the copper water to run through. I ſaw the men alſo laying the iron bars, on wooden rafters, in thoſe troughs. I ſaw the iron bars lifted up out of ſome troughs, where they had laid from one to eight months: and ſaw them incruſted over with copper, and corroded more or leſs, (ſome of them to very thin plates) according to the time they had lain in the water. I ſaw ſome of the troughs emptied, wherein the bars were wholly diſſolved: and the labourers were throwing up with ſhovels the copper, which lay on the ſtones in the bottom of them. It was like mud, as it lay wet in the heap, but became duſt as it dried. I alſo ſaw ſeveral pieces of copper, which had been made out of their copper-mud.

" This water is ſuppoſed to flow over a vein of copper in the neighbouring mountain. It is of a ſharp, acid taſte, and of a blue colour. It is received and collected in thoſe troughs, wherein the iron bars are placed; which after lying in the water, often not above three months, are entirely

conſumed:

consumed: then at the bottom of the troughs, a quantity of copper is found, in the form of coarse sand. And it is remarkable, that there is a greater quantity of this copper, than there was of iron.

" But by what principle is this effect produced? In order to discover this, I made the following experiments.

" 1. Some small iron nails put into the water, were in four minutes covered with a substance of a copper colour. And during that time the nails gained four grains in weight. The water had the very same effect on silver and tin, but not on gold. Hence we observe, the colour and increase of weight were owing to the adhesion of the particles of the matter dissolved in the water by an acid, which could not penetrate gold.

" 2. In order to determine the quantity and quality of this matter, I put two drachms of small iron nails into three ounces of the water. After they had lain therein four and twenty hours, I found the surface of the water covered with a thick scum, exactly like that which usually covers a chalybeate spaw. I observed likewise, it had lost the blue colour, and sharp, vitriolic taste. It was quite transparent, and at the bottom lay a brown powder, which when dried, weighed fourteen grains. This powder, melted without any flux, produced twelve grains of pure copper. The nails also (which had lost eight grains) were in several places covered with a solid lamina of pure copper. The water being afterward filtrated and evaporated, afforded a pure green vitriol.

" 3. From the spring water treated in the same manner, I obtained a blue vitriol, the basis of which is copper. From all these experiments it it appears, that a mineral acid is the active principle in this water, which being diffused through the copper ore, unites itself with that metal, and forms a vitriol. This is dissolved by the water, and remains suspended therein, till it meets with the iron in the trough, and by which it is more strongly attracted, than by the copper. Therefore it quits the copper, corrodes the iron, and changes it into a vitriol, which is again dissolved and carried off in the stream. Meantime the copper, deserted by its acid, falls by its specific gravity to the bottom of the trough.

" It appears then upon the whole, that this admirable process of nature, whereby one metal seems to be turned into another, is no more than a simple precipitation of the copper, by means of them."

In the Lower Egypt, there is a vast sandy desert, called The Desert of St. Macarius. One large plain herein is called by a name which signifies, *The Sea without water*. This is strewed over with limbs of trees which are entirely petrified: very probably by means of the nitre, with which this whole country abounds.

The change of wood into stone is not the only wonder here. The sand also is changed into Eagle stones. These stones are found two or three fingers breadth beneath the surface of the earth, in little mines, some paces long and broad, about half a mile from each other. It is thought that in these places, there oozes out of the earth, a sort of Metallic matter, which ferments with the burning sand, and in fermenting assumes some kind of roundish figure, and attaches to itself more

more and coarser sand. Afterward it hardens by degrees, and grows black through the heat of the sun.

The Eagle Stone when in the mine is soft and brittle as an egg, and of a bright yellow or violet colour, but after being exposed to the air, it turns brown or black, and hardens gradually. Likewise after a few days, most of these stones will, if struck, sound like little bells.

Not far off is a vast heap of sand, which they call the Eagle Stone Hill, because it is covered over with great rocks of the very same matter whereof the small eagle stones are formed.

But what shall we judge of those Petrified Shells, which have been dug up in many places? Some indeed are not petrified. Near Reading, in Berkshire, for succeeding generations, a continued body of oyster-shells has been found through the circumference of five or six acres of ground. Beneath is a hard, rocky chalk, on which the shells lie in a bed of green sand, about two feet thick. Above are various strata for at least eighteen feet. The shells are so brittle, that in digging, one of the valves will frequently drop from its fellow. But several are dug out entire; nay, some double oysters, with all their valves united.

In a quarry at the east end of Broughton, in Lincolnshire, there is a clay under the stone, in which are numberless fragments of the Shells of Shell-fish of various kinds. And there are sometimes found whole Shell-fish, with their shells on, in their natural colours, only bruised and broken, and some squeezed flat by the weight of earth, which was cast upon them at the deluge.

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There is another quarry, ſouth of the town, of a blue, hard ſtone, (probably a pure clay in ſome antediluvian lake) in which are numberleſs ſhell-fiſh of various ſorts, but ſo united to the ſtone, that it is hard to get them out whole. They are all in the ſurface of the quarry, within a foot of the top. On the ſurface, there are many ſhell-fiſh half in the ſtone, half out. That part which is within the quarry is whole, but is an hard ſtone. That which is without, is all conſumed, but a little of the edges, which are plain ſhell.

Some of the ſhell-fiſh in this quarry are half open, and filled with the matter of the bed on which they lie. Some of them are broken, others bruiſed: the edge of one fiſh is ſometimes thruſt into the ſides of another. One ſhell of ſome is thruſt half way over the other, and ſo they are petrified together.

Among theſe there are ſeveral great Horſe-muſcles, ſuch as breed in rivers and ponds. And in the fields and ſtones near Bramby and Fordingham is found a ſort of fiſh bending like a Ram's Horn, and creaſed like one on the outſide. The bed wherein, it ſeems, this fiſh bred, is about a foot thick: in which are millions of the fiſh, ſticking half within the ſtone, half without. And this ſhell being extremely durable, even the part ſticking out, is not conſumed, as it uſually is in others, but remains whole and entire.

14. From ſtone burnt to duſt ariſes Lime, which has this remarkable property, that if cold water be poured upon it, it preſently heats and boils up. In order to account for this, ſome have ſuppoſed,

ſuppoſed, that ſome ſubtle matter is lodged in the pores of the Lime, (perhaps many of thoſe particles of fire, whereby the ſtone was reduced to duſt) which when the water inſinuates into thoſe pores, occaſions the ſame kind of ebullition, as if it was poured on any other burning ſubſtance.

15. Moſt Precious Stones are tranſparent, and ſtrike the eye with vivid and various colours. Probably they were once fluid bodies, which while in that ſtate were mixed with metallic or mineral juices. Their tranſparency likewiſe makes this probable, and ſo does their outward configuration. For many bodies hardening into ſolids ſhoot into Chryſtals, juſt as is obſerved of ſeveral kinds of precious ſtones: and to this their inward ſtructure anſwers. For in many we may obſerve the thin plates or coats one over the other, juſt as we ſee in thoſe mineral ſubſtances, which were once fluid. Their colours might be owing to ſome mineral juice or exhalation, which tinctured them before their pores were fully cloſed. This is the more probable, becauſe many gems loſe their colour, if they lie long in the fire: and becauſe generally coloured gems are found over Metallic or Mineral veins.

Dr. Boerhaave takes Chryſtal to be the baſis of all precious ſtones, which aſſume this or that colour, from the Metallic or Mineral ſtreams mixed with the primitive Chryſtalline matter. But how is Chryſtal itſelf formed? An Italian writer gives a particular account of this. In the Val Sabbia (ſays he) I obſerved ſome parts of a meadow bare of all herbs. Here, and no where elſe thereabouts, the Chryſtals are generated. And whenever there is a ſerene and dewy ſky, if all the Chryſtals that can

can be found over night, are taken away, others will be found in the same place in the morning. Having observed, there is no sign of any Mineral stream near, I conclude, they are produced by steams of nitre. These may at the same time hinder vegetation in those places, and coagulate the dew that falls thereon. As nitre is the natural coagulum of water, so it ever retains its sexangular figure. The largest Chrystals known were found in the mountains of Grimiule, between vast strata of stones. The biggest of them was near three feet in length, and little less in circumference. It weighed two hundred and fifty pounds: others weighed less and less, to those of ten pounds, which were the smallest there. They were of the same figure; sexangular columns, terminated by sexangular pyramids at one end, and at the other fixed to the rock. They were in general perfectly clear throughout, but in some the base was foul, in others the point.

If a solution of Alum is permitted to chrystalize quietly, it shoots into planes of eight, six, four and three sides. But beside this, its particles when excited to action by a certain degree of heat, arrange themselves into regular and delightful star-like figures of different sizes. Many of these have long streaming tails, and resemble comets. Others shoot into an infinite number of parallel lines, beautiful beyond description. These configurations are no less constant in their forms, than the Chrystals on which they grow. And they are equally transparent, but the figures produced are so extremely different, that every considerate observer must judge them to be owing to some very different property in nature. But what

property

property? Who can determine? Indeed how little do we know of the moſt common things? The very elements that ſurround us, the fire, the water, the air we breathe, the earth we tread upon, have many properties beyond our ſenſes to reach, or our underſtanding to comprehend.

Dr. Borlaſe ranges Chryſtal itſelf and all gems under the head of Spar, which ſays he, are only finer and purer ſubſtances of the Spar-kind.

All Spar has been in a ſtate of fluidity. In ſome are found ſtraws and other light bodies. Yet time adds nothing to their firmneſs: but they are as hard when firſt conſolidated, as ever they will be. But why do we find no ſpars in their fluid ſtate? Becauſe while the matter of them remains incorporated with the water, it is not to be diſtinguiſhed from it, and as ſoon as it is deſerted by the water wherein it ſwims, it commences ſtone. It is by water that the Sparry atoms are waſhed out of their repoſitories, and collected into a tranſparent or opake juice. As ſoon as the redundant water is drained off or evaporated, the ſtony parts accede to a cloſer union. They are aſſiſted therein, either by cold, compreſſing the parts, or by ſudden evaporating heat. Thus the ſtone is formed, ſo much water reſting in the pores, as is neceſſary to fix it into a conſiſtency. Hence may ariſe ſome queries.

1. Whether Spar is not the univerſal gluten of Stones diſtinguiſhed from each other, by various mixtures of earthy, Mineral, or Metallic particles, but all united by the Sparry liquor? Perhaps there is ſcarce any ſand, ſtone, or ore, which either by the naked eye or glaſſes, may not be diſcerned to

have

have a portion of Spar, clearer or opake, in its composition.

2. Whether these and all other sort of stones are not continually forming in the earth?

3. Whether there are not quarries of stone, which when left unwrought for a considerable time, yield a fresh supply of stone, in those channels, which had been before thoroughly cleared?

A very peculiar kind of precious stone is what is termed a Turquois. It is of the opake kind, and commonly of a beautiful blue colour. And yet it has lately been made very probable, that these shining stones are originally no other than the bones of animals. In the French mines they are frequently found in the figure of teeth, bones of the legs, &c. And Turquoises half formed are composed of laminæ, like those of bones, between which a petrifying juice insinuating, binds them close together. And the more imperfect the Stones are, the more distinguishable are the different directions of the fibres and their laminæ, and the nearer resemblance they bear to fractured bones.

The Blue Turquois, is indeed no other than fossil bone, or ivory saturated with copper dissolved in an alkaline menstruum; the Green Turquois is the same substance, intimately penetrated by a cupreous matter dissolved in an acid menstruum.

16. The Loadstone is found in iron mines, and resembles iron both in weight and colour. Its most remarkable properties are, turning to the poles, and attracting iron. As to the former, when

when it moves without hindrance, it conſtantly turns one end to the north, the other to the ſouth: only declining a little to the eaſt or weſt. If two loadſtones are brought within a certain diſtance of each other, that part of one which is toward the north pole of the earth, recedes from that part of the other which reſpects the ſame pole. But it accedes to it, if the ſouthern pole of the one, be turned toward the ſouth pole of the other. The needle touched with the Loadſtone, when on this ſide the equinoctial line, has its north-point bending downward, on the other ſide, its ſouth-point: under the line, it turns any way, and is of no uſe.

As to its attractive power, it not only ſuſtains another Loadſtone, (provided the north pole of the one be oppoſed to the ſouth pole of the other) but iron alſo. Likewiſe if ſteel-duſt be laid upon a Loadſtone, it will ſo diſpoſe itſelf, as to direct its particles ſtrait to the poles, whence they will be moved round by little and little, till they are parallel to the axis of the Loadſtone. It communicates its virtue to iron, and if it be armed with (that is, fixed in) iron, its force is greatly increaſed. It loſes its force either by fire, or by letting two Loadſtones lie together, with the north pole of one oppoſed to the north, or the ſouth pole of one to the ſouth of the other. Theſe plain phænomena of the Loadſtone we know: the cauſe of them we know not.

From late obſervations it appears, that the Loadſtone is a true iron ore, and is ſometimes found in very large pieces, half Loadſtone, half common ore. In every one, 1. There are two poles, one pointing north, the other ſouth. And

 if

if it be divided into ever ſo many pieces, the two poles will be found in each piece. 2. If two Loadſtones be ſpherical, one will conform itſelf to the other, as either would do to the earth, and will then approach each other: whereas in the contrary poſition, they recede from each other. 3. Iron receives virtue, either by touching, or by being brought near the ſtone: and that variouſly, according to the various parts of it which it touches. 4. The longer the iron touches the ſtone, the longer it retains the virtue. 5. Steel receives this virtue better than iron. 6. In theſe parts the ſouth pole of a Loadſtone lifts more iron than the north pole. 7. A plate of iron interpoſed hinders the operation of the Loadſtone; but no other body, no not glaſs itſelf. 8. A touched wire, if bent round in a ring, quite loſes its virtue. But though bending thus deſtroys its virtue by day, it will not deſtroy it in the evening. Where is the philoſopher in the world, who can account for this? 9. Loadſtones without any known cauſe, act ſometimes at a greater diſtance than other times. That of the Royal Society will keep a key ſuſpended to another, ſometimes at the height of ten feet, ſometimes not above four. As ſtrange it is, the variation of the needle is different at different times of the day. 10. If a touched wire be ſplit, the poles are ſometimes changed (as in a ſplit Loadſtone). And yet ſometimes one half retains the ſame poles, and the other half has them changed. 11. Touch a wire from end to end with the ſame pole of the Loadſtone, and the end firſt touched turns contrary to the pole that touched it. But touch it again from end to end with the other pole of the ſtone, and it will turn juſt the contrary way. 12. Touch a

wire

wire in the middle with one pole of the ſtone, and the pole of the wire will be in that place: the two ends will be the other pole. 13. The poles of a ſmall Loadſtone may preſently be changed, by applying them to the oppoſite poles of a large one. 14. Iron bars which ſtand long in an erect poſition, grow permanently magnetical; the lower end of them being the north pole, and the upper the ſouth pole. 15. The ſame effect follows, if you only hold them perpendicularly: but if you invert them, the poles will ſhift their places. 16. Fire, which deprives a Loadſtone of its attractive virtue, ſoon gives verticity to a bar of iron, if it be heated red hot, and then cooled in an erect poſture, or directly north and ſouth. 17. A piece of Engliſh oker, thus heated and cooled, acquires the ſame verticity. 18. The verticity thus acquired by a bar of iron, is deſtroyed by two or three ſmart blows on the middle of it. 19. Either a piece of iron or a Loadſtone being laid on a cork that ſwims freely in the water, which ever of the two is held in the hand, the other will be drawn to it. This proves that the iron attracts the ſtone, juſt as much as it is attracted by it. 20. Draw a knife leiſurely from the handle to the point over one of the poles of a Loadſtone, and it acquires a ſtrong magnetic virtue. But this is immediately loſt, if you draw it over the ſame pole from the point to the handle. Laſtly, A Loadſtone acts with as great force in vacuo, as in the open air.

The chief laws of magnetiſm are theſe, 1. The load-ſtone has both an attractive and a directive power: iron touched by it has only the former. 2. Iron ſeems to conſiſt almoſt wholly of attractive particles, load-ſtones of attractive and directive

tive together, probably mixed with heterogenous matter, as not having been purged by fire like iron. And hence iron, when touched will lift up a much greater weight than the load-ſtone that touched it. 3. The attractive power of armed Load ſtones, is cæteris paribus, as their ſurfaces. 4. Both poles of the Loadſtone equally attract the needle till it is touched. Then it is that one pole begins to attract one end and repel the other. But even the repelling pole will attract upon contact, or at a very ſmall diſtance. But how odd are the following experiments. I cut a piece, ſays Dr. Knight, of a Loadſtone, into an oblong ſquare. In this I placed the magnetic virtue in ſuch a manner, that the two oppoſite ends were both ſouth poles, and the middle quite round was a north pole. I made the two oppoſite ends of another ſtone, north poles, the oppoſite ſide ſouth poles. An irregular ſtone had two broad, flat ſurfaces oppoſite to each other. I made half of each of theſe ſurfaces a north pole, and the other half a ſouth pole. So that the north pole of one ſurface was oppoſite to the ſouth pole of the other. I took a ſtone that had a grain very apparent, running the length-ways of it. At one end of it I placed a north pole, ſurrounded by a ſouth: at the other a ſouth ſurrounded by a north pole: ſo that the edges of each ſurface had a different pole from that which occupied the middle.

Many varieties of this kind might eaſily be deviſed. But theſe examples are ſufficient to ſhew, how manageable the magnetic virtue is, with reſpect to its direction; and how defective all the hypotheſes are, which are brought to account for the phænomena of the Loadſtone.

Mr

Mr. Howard ſailed to Barbadoes in company with another ſhip, commanded by one Groſton. Suddenly a terrible clap of thunder broke Groſton's fore-maſt, and did ſome damage to his rigging. When the noiſe was paſt, he was ſurpriſed to ſee Mr. Groſton's ſhip ſteering directly homeward. He tacked and ſtood after him, and found that Mr. Groſton did indeed ſteer by the right point of his compaſs, but that the card was turned round, the north and ſouth point having changed places. If he ſet it right with his finger, as ſoon as it was at liberty, it returned to its former poſture. And on examination, he found every compaſs in the ſhip had undergone the ſame change.

An odd diſcovery has been lately made, that not only iron, as has been generally thought, but Braſs too, by being hammered and properly touched, will contract a true magnetic virtue. And perhaps it will be hereafter diſcovered, that other Metals may receive the ſame.

Before cloſing this article, it may be proper to obſerve, firſt, The peculiar qualities wherewith ſome other ſtones are endued; and ſecondly, The remarkable uſes they are of to us. As to the former, we may obſerve, 1. The colour. The Carbunkle and Ruby ſhine with red, the Sapphire with blue, the Emerald with green, the Topaz with a yellow or gold colour; the Amethyſt, is as it were tinctured with wine, the Opal varies its colour like changeable taffeta, as it is variouſly expoſed to the light. Obſerve, 2. The Hardneſs wherein ſome ſtones exceed all other bodies, the Diamond in particular, which is ſo extremely hard, that no art is able to counterfeit it. 3. As to the uſes, ſome are ſerviceable for building, and for many ſorts of veſſels and utenſils; for pillars and ſtatues; for portico's, conduits, palaces, as Free-ſtone and Marble: ſome to burn into lime, ſome (with the mixture of kelp) to make glaſs as common Flints: ſome to cover houſes as Slate; ſome for marking, as Chalk, which ſerves alſo to manure land, and for medicinal uſes; ſome to make veſſels which will endure the fire. I might add the Warming-ſtone, digged in Cornwall: which being once well heated at the fire, retains its heat for a conſiderable time.

17. Of the third claſs are inflammable Foſſils, the chief of which are Sulphur and Bitumen. Both are highly inflammable: but the ſubſtance of Bitumen is more fat and tenaceous; whereas ſulphur may eaſily be broken, and reduced to a fine powder.

The Bitumen of the Latins was by the Greeks called Aſphaltos. It is a black, ſolid, brittle ſubſtance, reſembling pitch. It is chiefly found ſwimming on the Dead Sea, where antiently ſtood Sodom and Gomorrah. It is caſt up from time to time from the bottom to the ſurface, where it gradually condenſes by the heat of the ſun. It burns as violently as Naptha; but is of a firmer conſiſtence.

Aſphaltos is alſo a kind of bituminous ſtone, found near the antient Babylon, and lately in the province of Neufchatel, which properly mixed makes an excellent cement, incorruptible either by air or water. With this it is ſuppoſed, the walls of Babylon were built.

Jet ſeems to be formed in the earth of a bituminous juice. It is a light, ſmooth, pitchy ſtone. It is fiſſile, and works like amber: the beſt in the world

world is ſaid to be found in Yorkſhire. It readily catches fire, flaſhes and yields a bituminous ſmell. Nearly reſembling this, is the Channel-Coal, found in ſeveral parts of Lancaſhire, which burns with an even, ſteady flame, like a candle or torch.

18. Amber is a kind of Foſſil pitch, the veins of which run chiefly at the bottom of the ſea. It is hardened in tract of time, and caſt on ſhore by the motion of the ſea. It was long thought that none could be found but in Pruſſia: but it has ſince been found in Sweden, on the ſhores of the iſle of Beorkoo, though ſituate in a lake whoſe water is ſweet. Nay, it is digged out of the earth, at a conſiderable diſtance from the ſea, and not only in ſandy, but in firm ground.

19. But the moſt extraordinary of all Foſſils is the Aſbeſtos. It ſeems to be a ſpecies of alabaſter, and may be drawn into fine ſilky threads, of a greyiſh or ſilver colour. It is indiſſoluble in water, and remains unconſumed even in the flame of a furnace. A large burning-glaſs indeed will reduce it to glaſs-globules; but common fire only whitens it. Its threads are from one to ten inches long, which may be wrought into a kind of cloth. This the Antients eſteemed as precious as pearls. They uſed it chiefly in making ſhrouds for emperors or kings, to preſerve their aſhes diſtinct from that of the funeral pile. And the princes of Tartary at this day apply it to the ſame uſe. The wicks for their perpetual lamps were likewiſe made of it. A handkerchief of this was long ſince preſented to the Royal Society. It was twice thrown into a ſtrong fire, before ſeveral gentlemen. But in the two experiments it loſt

not above two drachms of its weight. And what was very remarkable, when it was red hot, it did not burn a piece of white paper, on which it was laid.

But there is a kind of Aſbeſtos wholly different from that known to the antients. It is found ſo far as we yet know, only in the county of Aberdeen, in Scotland. In the neighbourhood of Achintore, on the ſide of an hill, in a ſomewhat boggy ſoil, about the edges of a ſmall brook, there is a ſpace ten or twelve yards ſquare, in which pieces of foſſile wood petrified lie very thick. Near this place, if the ground be dug into with a knife, there is found a ſort of fibrous matter, lying a little below the ſurface of the ground, among the roots of the graſs. This the knife will not cut: and on examination it proves to be a true Aſbeſtos. It lies in looſe threads, very ſoft and flexible, and is not injured by the fire.

Yet it is ſometimes collected into parcels, and ſeems to form a compact body. When this however is more nearly examined, it appears not to be a real lump, but a congeries reſembling a pledgit of preſſed lint, and being put into water, it ſeparates into its natural looſe threads.

A ſtranger diſcovery has ſtill been lately made. The proprietor of a forge, upon taking down his furnaces to repair them, found at the bottom a great quantity of a ſubſtance, which upon repeated trial, effectually anſwered all the uſes of the Aſbeſtos. It was equally well manufactured either into linen or paper, and equally well endured the fire. Upon proſecuting the enquiry, it appeared to him, that both the native Aſbeſtos (at leaſt one ſpecies of it) and this obtained from the forge, were nothing more, than what he terms calcined iron, deprived,

whether

whether by nature or by art, of its inflammable part: and that by uniting the inflammable part, either with this, or the foſſile Aſbeſtos, it may at any time be reſtored, to its primitive ſtate of iron.

But it is certain, there is Aſbeſtos which has no relation to iron. Both in Norway and Siberia, there are petrifying waters which, pervading the pores of wood lying therein, fill it with ſtony particles; and when by a coſtic, corroſive power, derived from lime, they have deſtroyed the wood, a proper Aſbeſtos remains, in the form of a vegetable, which is now no more. To which of theſe does the following belong?

Signor Mareo Antonia Caſtagna, ſuperintendant of ſome mines in Italy, has found in one of them a great quantity of Linum Aſbeſtum. He can prepare it ſo as to make it like either a very white ſkin, or a very white paper. Both of theſe reſiſt the moſt violent fire. The ſkin was covered with kindled coals for ſome time: being taken out, it was ſoon as white as before: neither had it loſt any thing of its weight. The paper alſo was tried in the fire, and without any detriment. Neither could any change be perceived, either with regard to its whiteneſs, fineneſs, or ſoftneſs.

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