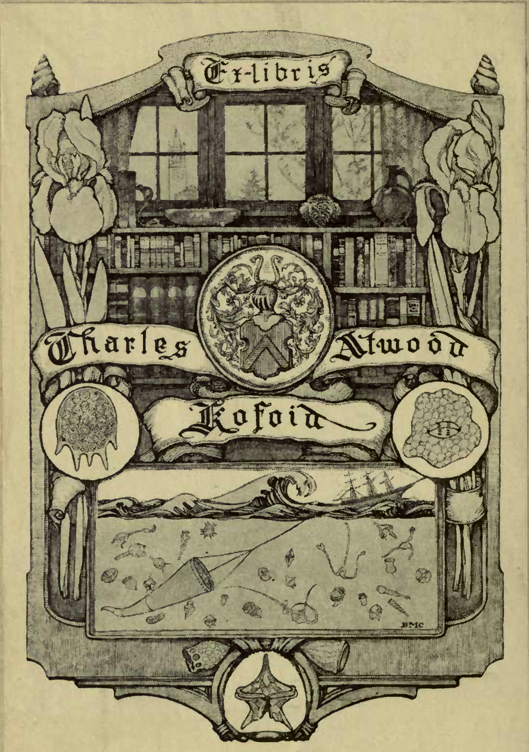
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A

# SURVEY

OF THE

# WISDOM OF GOD

IN THE

# CREATION:

OR,

## *A COMPENDIUM*

OF

## Natural Philosophy.

IN FIVE VOLUMES.


By JOHN WESLEY, A. M.



A NEW EDITION, REVISED AND CORRECTED.


VOL. II.

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

MILTON.


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## OF FISHES.

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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 a 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, by a kind of glue. If you open these bladders gently, you see a sort of embrios, 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 towards the British Islands, 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 crowd together in such numbers, that they may be taken up by pailfulls.

A large shoal of herrings reaches (according to the fisherman's account) a hundred or two hundred fathoms 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 the 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 others, according to the severity or mildness of the winter.

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 coast, 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 column 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 coasts 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 Zuderzee. 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 to Scotland, and dividing again into two columns, one 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 strew in vast quantities on the sea along the coasts: this always brings thither 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 on 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. It is 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; their heart also resembles that of beasts driving red and warm blood in circulation through the body.

As these animals breathe the air, they cannot bear to be long under water. They are constrained every two or three minutes to come up to the surface to take breath, as well as to spout out through their nostril (for they have but one) the water which they sucked in while gaping for their prey.

The senses of these animals seem also superior to those of other fishes. The eyes of other fishes are covered only with that transparent skin that covers the rest of the head; but in all the cataceous kinds they are covered by eye-lids as in man: this keeps that organ in a more perfect state, by giving it intervals of relaxation. The other fishes that are very staring, must see, if for no other reason, more feebly, as their organs of sight are always exerted.

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

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

But it is in the circumstances in which they continue their kind, that these animals shew an eminent superiority. Other fish deposit their spawn, and leave the success to accident; these never produce above one young or two at the most, and this the female suckles entirely in the manner of quadrupedes, her breasts 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 parallel 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 feet 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 feet 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 about the under lip it is found two or three feet 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 any of the hidden rocks that are in the shallows, he fractures his skull, and comes instantly floating up dead.

So that there is no creature in the world so great or strong so as to be exempt from calamities!

The Whalebone-whale is about 70 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. Whenever 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 a hundred in a swarm, and are great travellers. In autumn the whalebone-whales go westward; in spring eastward again. The several kind 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 clap-boards entirely 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 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 auditorius 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 seven 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 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 perseverance; 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 unwieldly 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 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 uncontrolled master of the river, and all others fly from its approach or 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 as 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.

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 no where 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 almost all the rest of his time under water. He has to feed under water, yet is the most unwieldly 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 course along the bottom, as easy and unconcerned as if it were 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 on them 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 White Shark is found from twenty to thirty feet long. Some assert, 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 a 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 about 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 a hundred and twenty. 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 animals no sooner leave 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 motion. They have neither tongue nor teeth, nor any offensive weapon. How then can they take, how can 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-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 dried one, which is two feet 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 bird's beak; above this stand 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 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 coast 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 a 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 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 flowder-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, much like that produced by nettles. Hence it has its name. However it is no vegetable, but evidently 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 fixed 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 perceptible 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 fixed to a barren spot. Water is the proper dissolvant 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 it is 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 it would move, it has only to discharge a small quantity of this water, and the cement immediately dissolves and sets it at liberty. The other tubercles doubtless contain the viscous matter; so that when the animal would fix itself, it needs only to squeeze one set of its tubercles, and when it would loose itself, the other.

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

What an abundance of fish do the waters produce? In these I seem to discern nothing but a head and a tail: they have neither feet nor hands, nor have they any neck; so that their head cannot be turned at all, any otherwise than by turning the whole body. Were I to consider their figure only, I should think they were destitute of all that was necessary for the preservation of their life. But with these few outward organs they are more nimble and dexterous than if they had several hands and feet; and by the use they make of their tail and fins, they are carried along like arrows.

But as almost all fishes prey upon each other, and cannot sustain their own lives, any otherwise than by continually destroying those of their own species, how can the inhabitants of the water subsist? How can many species escape utter destruction? God has guarded against this, by multiplying them in so prodigious a manner. More than three hundred thousand eggs have been counted in the roe of a single salmon. By this means, let them be destroyed ever so fast, still their increase is equal to their consumption.

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. IV.

### *OF REPTILES.*



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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, 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 a 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 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 undulatory 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 serpent's 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 is 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 little serpent at the Cape of Good Hope is not above three inches, and covers whole sandy deserts 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 cartilaginous, and they are consequently capable of great extension; 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 the 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 recals 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 vertebre, 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 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 a 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 no 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 be able to kill their prey, and feed themselves as soon as they are born.

The poison of a Rattle-snake is equally fatal, and more swift 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 considerably loud; so that a man, if he has presence of mind, may easily get out of its way. When it bites a hare, he is observed to lick her all over before he takes her into his mouth, probably, that having moistened and smoothed her skin, he may the more easily swallow her.

It is very remarkable, that he frequently stays under a tree, on which a bird or squirrel is hopping about, with his mouth wide open. And the event constantly is, the creature in awhile drops into it. Sir Hans Sloane thinks, he has wounded it first; and that he then waits under the tree, till the poison works and the animal drops down into the mouth of its executioner.

But this is not the case, as plainly appears, from what many have been witnesses of. A swallow pursuing his prey in the air, if he casts his eye on a snake beneath him, waiting with his mouth wide open, alters his course, and flutters over him in the utmost consternation, till sinking gradually lower and lower, he at last drops into his mouth.

To the same purpose is the famous experiment of Dr. Sprenger, mentioned in the Hamburgh magazine. He let loose a mouse on the ground, at a little distance from a common snake. It made a few turns, and squeeked a little, and then ran directly into the mouth of the snake, which all the while lay still, 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 its 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 its 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 any leap, she takes in the head, and afterward the whole body.

A common snake will avoid a man, but a rattlesnake 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 steel 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 right up to 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 ground, 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 that 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 bleeding and feverish four days. The pain raged still 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 spotted like a snake all the summer. In autumn my arm swelled, gathered, and burst, so away went poison, spots and all.

But the most surprising circumstances were my dreams. In all sicknesses before these were always pleasant. But now all were horrid. Often I was rolling among old logs; sometimes I was a white oak cut in pieces. Frequently my feet would be growing into two hickary trees; so that it was a terror to me, to think of going to sleep."

5. It is a wonderful provision which is made for those snakes, who are inhabitants of the waters. A water-snake has no air bladder like fishes: 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 pleasure by an aperture which it can shut so close, that the least globule of water cannot enter.

By this means it can enlarge or lessen 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 History of Norway, which he talks of as being five or six hundred yards long, and as rearing his head higher than the main mast of a man of war, I presume it is very nearly related to the Craken of the same author; a sea-monster, to which a whale is but a shrimp, larger than twenty men of war put together. And this 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 their body, the 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 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 a 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 Cameleon (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 substance that enclosed it. So that its assuming all the colours it comes near, is a groundless imagination.

The Cameleon at London, was of several colours, like a mottled colt. The most discernable 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 Cameleons, 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 faint 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 back-bone 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 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 its 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 fixed 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 size, 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 sorts 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 Cameleons 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, through 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, 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 became 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 it 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 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 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 like 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 entire. 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 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 reproduced. The tail, besides a complete apparatus of nerves, muscles, glands, arteries, and veins, has vertebre 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 vertebre, new bones are produced, a phenomenon 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 parts 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 reproduced 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 salamander ninety and nine bones. In the four regenerated legs there is the same number. The form and internal structure of the reproduced bones, and 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 reproduced in the same manner and at the same time, whether the creature is fed or kept fasting.

When their jaws are cut off, the same thing happens. New bones are reproduced, 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 Tadpoles. 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 Tadpoles. 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 Tadpole keeps its tail.

If no nourishment is given Tadpoles, 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 the Abbe calls an aquatic boat-worm. It is composed of rings like the 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, forms 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 reproduction is like a small round 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 centre 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 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 reproduction, 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, pointing 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 the whole Tape-worm, and every part of it seems to be a complete animal. In every joint there is a mouth for receiving food, and doubtless organs for digesting it. Single joints, as well as larger pieces, are frequently voided alive. All these pieces are almost equally turgid with chyle. Now it is not probable, that a single worm, should in voiding, be broke in so many pieces, and had it been done sometime before, they would be emaciated. There seems then to be an analogy between this jointed worm and knotted grass, each joint of which is a complete plant, and propagates itself. It is indeed a zoophyton, a plant-animal, bred in animal bodies, since so large and frequent detruncations, do not destroy the life of it.

9. Not only vegetables and animals have their respective insects, to which they afford food as well as

habitation, but stones themselves. Those kind of worms called Lithophagi, are a proof of this, one might think it incredible that these little creatures should subsist by gnawing stones. And yet nothing is more certain, these worm-eaten stones being found almost every where. These are generally lime-stones. Grit and free-stones are seldom eaten in this manner. Yet there is an ancient wall of free-stone in the Benedictine abbey at Caen in Normandy, so eaten with worms, that one may put one's hands into many of the cavities. The wormsare covered with a greenish shell, having flat heads, a wide mouth, and four black jaws. And they lay their eggs in those cavities, which they gnaw in the stone.

One more Reptile we may examine a little more minutely, in which the wisdom 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 centre 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 membraneous 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 large 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, 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 sprout 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 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 less than a day, having changed its figure, changes its appetites also. So extraordinary is this transformation, that the food it fed upon so greedily but a few days before, is now utterly rejected. It would even starve, if supplied with no other. As soon as the animal acquires its perfect state, it becomes carnivorous, and lives entirely upon worms and insects. But as the water cannot supply these, it is obliged to quit its native element, and seek for food upon land, where it lives by hunting worms, and taking insects by surprise.

"Concerning the Toad, says Mr. Arocott, that lived with us so many years, and was so great a favourite, the greatest curiosity was its being so remarkably tame; it had frequented some steps before our hall door, some years before my acquaintance commenced with it, and had been admired by my father for its size, (being the largest I ever met with) who constantly paid it a visit every evening. I knew it myself above thirty years, and by constantly feeding it, brought it to be so tame that it always came to the candle and looked up, as if expecting to be taken up and brought upon the table, where I always fed it with insects of all sorts. It would follow them, and when within a proper distance would fix its eyes, and remain motionless for near a quarter of a minute, as if preparing for the stroke, which was an instantaneous throwing its tongue at a great distance upon the insect, which stuck to the tip, by a glutinous matter. The motion is quicker than the eye can follow. I cannot say how long my father had been acquainted with the toad before I knew it; but when I was first acquainted with it, he used to mention it as the old toad. I 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 laid 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 its 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 unvenomous, and seek 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 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 clothed 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 cases when they do not use them; and yet always ready to be extended for flight.

2. The structure of the eye is in all creatures an admirable piece of mechanism. But this is peculiarly observable in that of an insect. Its hardness is an excellent guard against external injuries; and its outer coat is all over beset with curious, transparent inlets, enabling it to see every way without any loss of time, or trouble to move the eyes.

And their feelers, besides their use in cleaning the eyes, are a good guard to them in their walk or flight, enabling them by the sense of feeling to discover annoyances, which, by their nearness, might escape the sight.

The eye of a fly is in truth an assemblage of multitudes, often many thousands of small eyes. Nature has given each fly two large reticular eyes (that are covered with a kind of net-work.) And as each contains such a multitude of smaller eyes, one would imagine this might suffice. Yet some flies have four reticular eyes; the two smaller are placed as usual, the two larger are behind the other on the upper part of the head.

In different species the reticular eyes are of different colours. Some are brown, some yellow, green, red, and this in all the different shades of those colours. And some have the gloss of metals highly polished.

But beside these, many species of flies have a sort of eyes, which are not reticular, but of a perfectly smooth and even surface, and far smaller than the reticular. Three of these are on the back of the head of vast numbers, which are triangularly placed. Some have more, and some have less than three. Gnats have none of them. Their heads are in a manner covered with their reticular eyes, so as to leave no room or occasion for smooth ones.

Nor are these smooth eyes peculiar to flies. Other insects also have them: the grasshopper in particular has two, which are placed near the nose.

3. The species of insects are almost innumerable. All of these some suppose to have no heart, as they have no sensible heat, none that can be perceived either by the touch, or by any other experiment. But this is a mistake. Many indeed have not such a heart as other animals have: but all have something analogous to it, something that answers the same purpose.

Some likewise have thought that insects have no respiration. But later experiments shew, that there is no species of them which has not lungs, and these larger in proportion than other animals. In most of them they lie on, or near the surface of the body. And hence it is, that if flies are besmeared with oil, or any other unctuous matter, they die in a short time, their respiration being stopt, so that they are properly suffocated.

4. Some also have imagined, that insects were generated out of mere putrefaction, because they observed worms come out of putrified flesh, which afterwards turned to flies. But it is certain, if putrifying flesh be shut up close, no worms are ever generated from it. Hence we learn that flies lay their eggs in flesh, which hatch when it putrifies: so that the animal just comes to life when its food is ready for it. All insects 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, enclosed in a case; and these dying, a fly or butterfly succeeds.

Some Aurelia 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 formed 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 Aurelia, and the whole appears gilded, without any real gilding.

To trace these wonderful changes a little, in one kind of inseets. 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 this admirable work. This his is 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.*

Ea h of these nipples contains many smaller nipples, invissible to the naked eye; through the several perforations whereof, numberless finer threads are drawn.

* 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.

Before the spiders begin to spin, they apply more or fewer of the large nipples to the body whence the web is begun. 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 kind 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 a hundred of them be put together, in a few hours scarce twenty will be 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 and beads, and the tip of each goes winding toward 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 kind 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 house, 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 probable, 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 spiders that spin, young as well as old, cast out their threads, and sail thereby in the air. And the threads themselves shew the use thereof, being usually 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. It is plain this happens from the threads meeting and entangling 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 ofter another, trying as it were, how she likes them. When she has darted one several yards, she will of 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 too. 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 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 enraged as to fly upon any that come within its reach.

The bite causes a pain, like that by the stinging of a bee. In a few hours the patient feels 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 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 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. These 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 a hundred, gather round a person that was blowing a French horn, and seeming to testify an awkward 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 bagpipe, 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 his 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 spide

more mischievous than even the Tarantula, chiefly in the vallies of Neyba, and others within the jurisdiction of Popayon. It is called a Coya. It is much less than a bug, and is of a fiery red colour. It is found in the corners of walls and among the herbage. On squeezing it, if any moisture from it falls on the skin of either man or beast, it immediately penetrates the flesh, and causes large tumours, which are soon followed by death.

The only remedy is, on the first appearance of a swelling, to singe the person all over the body with a flame of straw, or of the long grass growing on those plains. This the Indians perform with great dexterity, some 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 so delicate a texture, that it would immediately burst. But let them tell the Indian what they feel, and he comes and blows it away.

The beasts which feed there, are taught by instinct, before they touch the herbage with their lips, to blow on it with all their force, in order to clear it of these pernicious vermin. And when their smell informs them that a coya's nest is near, they immediately leap and run to some other part. Yet sometimes a mule after all his care has taken in a coya with his pasture. In this case after swelling to a frightful degree, it expires upon the spot. Thus does even he irrational creation "groan and travel in pain together," until it shall be "delivered into the glorious "liberty of the children of God!"

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 some time 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 with 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 make it such, and to preserve its vital actions ? It is hard to conceive, how in so narrow a compass, there is a 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 Hartsoeker carries the matter still farther. If, says he, according to our present system of generation, all animals were formed from the beginning of the world, and enclosed 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 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 flee 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 this? Or what is the swiftness of a greyhound or a race-horse, to that of such an animalcule.

The body of a flee 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 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 a hair. It has no other mouth than this.

The skin of the breast is transparent, and from the under part of it proceeds 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 a 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 a 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, ear-wigs 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. Besides 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 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 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 coat 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 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 I 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 frightened 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 a 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 semperviva, orpine, and house-leak; may not the same or the like particles supply nourishment to some species of animals? In the amazing plan of nature, the animal, vegetable, 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 subsistence; 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 carelessness 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 immersed, 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 enclosed in a frame. The use of this frame is, to 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 caterpillars 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 caterpillar, 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 aurelia, and afterward into the form of the parent-fly, in which state they easily make their way out of the ground.

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 aurelia, 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 a 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 insects 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 becomes 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 into 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 gnawed 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 centre is a case, with a white worm therein, which afterwards 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 enclosed 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 egg is shaped like a nine-pin: the thicker end of these are placed downward; they are firmly joined together by their middles, and the 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 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 enclosed 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 is a small insect found in May and June, on the stalks or 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 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 in with its proboscis.

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.

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 great 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 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 covers 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 emit 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 direct 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 becomes a fly, it exists three years as a worm in 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 a 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 open 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 up and down on the water. Every time they darted down they ejected a cluster of eggs; they then 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 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 aurelia, and having passed 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 subsistence 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 a 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 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; 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 carelessly 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 one only 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, mixed with their own hair, with pieces of bark, leaves, wood, or paper.

There is one sort that build in wood, and gives its case a 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, where-with he cuts the wood into a number of small frag-ments. 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 accord-ingly, 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 creature's 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 leaves before they change into aurelia. The nicest hands could not roll these up so regularly, as they do with-out hands or any thing like them. They perform it thus; the caterpillar places itself on the upper side of the 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. Mean time 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 aurelia, others separate as soon as able to crawl, and hunt their fortune single, and others live in 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 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 caterpillar 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 complete insect, presenting us with all the external parts of a living animal. If the caterpillar 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 this time approaches, all the colours of the skin grow faint, and lose 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 enclosed; 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 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 enclosed 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.

It is 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 an 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 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 instead 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 enclosing 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 awhile 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 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.

20. 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 aurelia 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 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 time, 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 ant's 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 aurelia 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 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 deposits 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 other aliments. And they that have carefully observed their excursions from and return to their colonies, could never observe that they returned with any wheat corn, or any other vegetable seed: though they would eagerly attack a pot of honey, or a jar of sweetmeats.

But is it not said, Prov. vi. 8. *She provideth her meat in the summer, and gathereth her food in the harvest?* It is: but this does not necessarily mean any more than that she collects her food in the proper season. Nor is any thing more declared, ch. xxx. 35, than that ants carry food into their repositories: that they do this against winter, is not said; neither is it true in fact.

In England, ant-hills are formed with but little apparent regularity. In the southern provinces of Europe they are constructed with wonderful contrivance. They are generally formed in the neighbourhood of some large tree and a stream of water: the one is the proper place for getting food, the other for supplying the animals with moisture, which they cannot well dispense with. The shape of the ant-hill is that of a sugar-loaf, about three feet high, composed of various substances; leaves, bits of wood, sand, earth, bits of gum, and grains of corn: these are all united into a compact body, perforated with galleries down to the bottom, and winding ways within the structure. From this retreat to the water, as well as to the tree, in different directions, there are many paths worn by constant assiduity, and along these the busy insects pass and repass continually, so 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 sufficiency of food: they live upon various provisions, as well of the vegetable as the animal kind. Small insects they kill and devour; sweets of all kinds they are particularly fond of. They seldom, however, think of their community till themselves are first satiated. Having found a juicy fruit, they swallow what they can, and then tearing it in pieces, carry home their load. If they meet with an insect above their match, several of them will fall upon it at once, and having torn it to pieces, each will carry off a part of the spoil. If they meet with any thing that is too heavy for one to bear, and yet which they are unable to divide, several of them endeavour to force it along, some dragging, others pushing. If any one of them makes a lucky discovery, it immediately gives advice to others, and then at once the whole republic put themselves in motion. If in these struggles one of them happens to be killed, some survivor carries him off to a great distance, to prevent the obstructions his body might give to the general spirit of industry.

In autumn they prepare for the severity 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 substances with which they furnish their hill, are only meant as fences to keep off the rigour of the weather. They pass four or five months without taking any nourishment, and seem to be dead all that time. It would be to no purpose therefore for ants to lay up corn for the winter, since they lie that time without motion, heaped upon each other, and are so far from eating, that they are utterly unable to stir. Thus what authors have dignified by the name of 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 honeycomb 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.

22. One of the most dreadful enemies of the ant 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 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 ensnare 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 degree 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. 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 backward to the stone, and getting his backside 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 edges of his pit, and if they have suffered any injury, repairs it carefully. He then immediately buries himself again in the centre, 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 encloses 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.

23. 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 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 formation 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 it brushes off with its two hind legs, and kneads 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 mould 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 quantities, the bees pinch the point 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 dies.

Honey is extracted from that part of the flowers called the nectareum. 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 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 in 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 a 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 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 those 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 a 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 flesh, bees often leave their stings behind them, if they are disturbed before they have time to withdraw their spears into the 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 once in a year, so that she may literally be said, to be the mother of her people. In a 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 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 the 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 his hinder part appears. The meaning hereof is, each of these open cells contains at the bottom a bee-worm. Certain bees daily 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 awhile 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 side 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 dirtied, 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. Reaumur, 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 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 a 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 provisions 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 supernumerary 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 a 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 a 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 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 were 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 Polypi, a strange kind of animal, so nearly partaking the nature of some vegetables, that new perfect polypi 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 polypi.

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 fixed to the shells of oysters and other small shell-fish. And at Brighthelmstone, I saw those corallines in motion, whose polypi are contained in cups supported by a long stem that appears full of rings, or twisted in form of a screw. In the middle of the transparent stems or cases, I could easily discern the thread like a tender part of the animals. On several parts of these corallines, there are little bodies, which through the microscope appear as so many bladders. To the use of these I was quite a stranger before, but I now discovered they are habitations of young polypes, which are produced here and there on the sides of the parent, as in the water polypus: only in the marine ones they are protected by this vesicular covering. These vesicles appear at a certain season of the year, according to the different species of corallines, and fall off, like the blossoms of plants, as soon as the polypi arrive at maturity.

But corallines are cases, not of polypes only, but of various sorts of animals, which occasion their being made of various materials, and in great variety of forms. Some are united closely and compactly together, forming irregular branches like trees. Others rise in tufts, like the tubular sort of plants, distinct from one another. Some Maltese corallines are of a peculiar kind. The animals enclosed in these,resemble the many-legged spiders, usually known by the name of Scolopendræ. Their outside coats are formed of an ash-coloured earthy matter, and closely united to an inner coat, which is tough, horny, transparent,and extremely smooth. The cavity of the tube is quite round, though the animal is of a long figure, like a leech extended. It can turn itself in this tube, and move up and down the better to attack and secure its prey.

It has two remarkable arms. The left much larger than the right. These are doubly feathered. The number of its feet on each side of the body exceeds a 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 complete 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.

One sort of 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 complete 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 has but one gut, I have turned it inside out. The inside soon after 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 complete 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 polypi are, the clustering polypi 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 fixed 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 complete 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 fixed 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 fixed, 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 reiterated several times. Thus a principal branch is formed, provided with several lateral ones, which afterwards 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. Beysonnel) made me conjecture, that it was the same with respect to sponges; that animals nested in the intestines 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 easily crushed, but having carefully torn the sponges, and their gross fibres, I discovered the living worms.

These species of sponge commonly grow upon sandy bottoms. At their origins we perceive a module of sand, or other matter, almost petrified, round which the worms begin to work, and round which they retire, as to their last refuge, where I had the pleasure of seeing them play, exercise themselves, and retire, by examining them with the microscope.

The worms are about one third of a line thick, and two or three lines in length. They are so transparent that one may discern their viscera through their substance, and the blood may be seen to circulate. They have a small, black head, furnished with two pincers, the other extremity is almost square, and much larger than the head. Upon the back may be seen two white streaks,as if they contained the chyle, these 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 viscera ought to be placed, a blackish matter is perceivable, which has a kind of circulation,sometimes it fills all the body of the worm, sometimes itgathers towards the head or at the other end and sometimes it follows the motion of the animal. This vermicular motion begins at the posterior extremity,and ends at the head. They have no particular lodge, they walk indifferently into the tubular labyrinth. These sponges are attached to some solid body in the sea. Some kinds are fixed to rocks, others to heaps of sand, or to pieces of petrified matter; and the sea putting in motion the sand, and the little parcels of broken shells, forces them into the holes of the sponge.

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 polypus? It must be so with many, and as corals in general seem to be constructed by polypi, 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 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 particularly 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 terrestrial 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 this not 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 polypus 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 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 surprising 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 at his birth, but continues so longer than any other member of the animal world. However, except that of growth, he undergoes no considerable alteration in this life.

Quadrupeds undergo a greater change yearly; by the loss and renovation of their outward covering. This change however is gradual, and almost insensible, the latter being of the same substance, and even colour as the former. But there is an exception to this in those 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 Yorkshire, and several other parts of England, their hair changes white at the approach of winter, and in spring assumes its former colour.

One class however of viviparous animals undergo a more sudden alteration, namely, the serpent-kind. These having no hair or fur to lose gradually, cast their whole covering at once, and are so dexterous therein, though they have neither feet nor claws, that their whole skins are frequently found entire, without even the cornea or outward case of the eyes, which accompanies the other exuviæ, being broken.

Next to these are oviparous animals. These make their first appearance in a state of entire inaction, but being gradually ripened by natural or artificial heat, burst out, some in their complete state, as lizards, spiders, and fish in general, and others as birds, requiring like viviparous animals, the addition of the extrementitious parts. Almost all the species of these which we know, need the same 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 skins like snakes; one kind of them, water newts, every two or three weeks. Spiders, crabs, and all whose outward covering is crustaceous, 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 complete, which being fully possessed 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 Tadpole. He has a thin slimy tail, which steers him in the water, in which he wholly resides. But after awhile, 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 deposits 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 a 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 andaquatic, may for number vie even with plants themselves. The exsanguious 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 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 unreprovable 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 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 creature as hot as beasts themselves in the coldest water, he has placed a variety of these cetaceous fishes in the northernmost seas. And the copious fat wherewith their bodies are enclosed, 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 pancreatic 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 bye, we may 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 aqua fortis 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 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 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 the young till they come to maturity.

And for the young themselves. As the parent is not able to carry them about, to clothe 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 clothe 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 impatient 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 clothing, as is proper to their place and business! With hair, with feathers, with shells, or with firm armature, all nicely accommodated, as well to the element wherein they live, as to their several occasions there. To beasts, hair is a commodious clothing; which together with the apt texture of their skin, fit them in all weathers to lie on the ground, and to do their service to man. The thick and warm fleeces of others, 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 clothed with a close, soft, warm fur. But what is still more surprising, 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 an easy 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, nearly intervoven 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 clothing 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 the offices of their state, better than any other covering?

Observe, for instance, the tegument of the earthworms, made in the compleatest manner, for making their passage through the earth, wherever 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 clothing like any of the other creatures.

How wisely, likewise, are the inhabitants of the waters clothed! 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 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 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 subsistence. 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 original particles, indestructible and common to all organized beings. These pass from body to body, supporting the life, and ministering to the nutrition and growth of each. And when any body is reduced to ashes, these original particles, on which death hath no power, survive and pass into other beings, bringing with them nourishment and life. Thus every production, every renovation, every increase by generation or nutrition, supposes 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 reproduction of beings, a theatre ever crowded, 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 through 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 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 gauged 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 it 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 neighbouring 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 this he varies the scene of the universe, and at the same time prevents its destruction, by the very immutability of the nature and number of these elements. So that the whole 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 a 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 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, than 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 animalcula 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 indiscernible 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 demonstrate 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. Hervey.

In all the animal world, we find no tribe, no individual neglected by its Creator. Even the 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 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 household from view, amidst the shelter of entangled furze. Others remove it from discovery in the centre 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 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 the 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 scooped 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 the 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 its 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 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 implements 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 commodious store-houses, wherein they deposit them. They readily distinguish every plant, which affords materials for their business ; and are complete 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 shining 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 experience : which without a tutor teaches them all necessary skill, and enables them without a pattern 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 watery world. There is not one among the innumerable myriads, that swim the boundless ocean, but is watched over by the sovereign eye, and is 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 ballast 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 THE THIRD.

## *Of PLANTS and FOSSILS.*

## CHAP. I.

### *Of PLANTS.*



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

Again. As animals are furnished with the cellular membrane, which invests and covers all the fleshy parts, and screens them from external cold, so plants are encompassed with a bark, replete with fleshy juices, by means whereof even the winter cold is kept off, and hindered from freezing the juices in the vessels; and those sorts of trees, whose bark abounds with oil, remain green all the year round.

5. In the Wood likewise there are observed concave fibres, woven as it were of various vesicles, and stretching all the length of the wood, as do the fibres of the bark: these have intervals between them, in which are transverse vesicles reaching to the very pith. There are other fibres, which run obliquely, and are

far larger, but not so numerous as the former. In some trees there are also several rows of tubes, which emit a thick milky liquor.

6. The Pith is the middle of the wood. It consists of various rows of hollow globules, covered with a fine membrane. In some trees it contains a peculiar juice, which sometimes hardens or grows black. In tender shoots the pith (which is frequently hexagonal) is not exactly in the middle, but is nearer the bark on the south side than on the north side of the plant. It is a constant observation, that the pith lessens as the tree grows. Some have imagined it to be the heart of the plant, but this cannot be; for some trees will flourish and bear fruit after the pith is taken out. Besides this, there is in some trees a blea, a 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 comes 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 enlarges 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 al-

ways 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 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 clothed 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 plaited, 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 of the plant mixed with its

native juice, and subtilized 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 a 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 advised.

10. The ancients generally supposed the earth to produce vegetables; many of the moderns ascribe it to water alone; but it is a doubt whether the experiment 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 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 less 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 a 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. But the finer easily ascend into the atmosphere, and are conveyed to our organs for 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 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 does 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 ascends by the wood, and descends by the bark. But it is not easy to shew by what particular tubes it either ascends or descends. Neither after all our researches does it appear what is the principle of this motion? Whether there be any such thing as an attractive force in the plant itself, or whether it be performed on the mere principles of mechanism, by the expansion 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 easy experiment. On a branch of a plain jessamine, whose stem spreads into two or three branches, inoculate in autumn, a bud of the yellow striped jessamine. When the tree shoots the next summer, some of the leaves will be striped with yellow, even on the branches not inoculated, and by degrees the whole tree will be striped, yea, the very wood of the young branches.

It is probable the circulation is performed thus: the wood of plants consists of fine capillary tubes, which run parallel with each other from the root, and may be looked upon as arteries. On the outside of these, 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 rarified and caused to ascend in the form of a steam or vapour, till meeting the mouths of the arterial vessels, it passes through them to the top, and to the extreme parts of the tree, with a force answerable to the heat whereby it is moved. When it arrives there, meeting with the cold of the external air, it condenses into a liquor, and in that form returns by its own weight to the root of the venal vessels.

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 a 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 of an ounce, increased in the following proportions:

| | | |
|---|---|---|
| In six weeks - | 671,600 | Times its own weight. |
| A week - - | 111,933 | |
| A day - - | 15,990 | |
| An hour - - | 660 | |
| A minute - | 11 | |

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 21,109. And from a calculation made, by counting the whole number of grains in one ounce, might be about 576,840.

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 surprised 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 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 sunrise, 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 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 regularly 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 considerable degree. Concerning the real cause, we may form many conjectures, but nothing certain can be 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 phenomenon 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, 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, 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 flowers 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 closes 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 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 a hundred and seventy-two thousand on one side of a leaf of Box. The leaves of Rue are as full of holes as a 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 crystal beads, fastened by tender foot-stalks. The prickles of a nettle are formed for acting just as the sting of animals; 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 by 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 root, 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 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 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 f 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 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 day time, 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 sooner does the sun begin to warm the earth, than the vernal flowers appear, and the trees one after another open their buds, and clothe 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. | Plumb, Apricot, Peach | - | 6 |
| 7. | Filbert, Sallow, Alder | - | 7 |
| 8. | Sycamore - | - | 9 |
| 9. | Elm, Quince - | - | 10 |
| 10. | Marsh Elder - | - | 11 |
| 11. | Wych-Elm - | - | 12 |
| 12. | Horn-Beam - | - | 13 |
| 13. | Apple-Tree - | - | 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 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 beginning 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 is 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 cases and is split on the head of the pillars, and thence conveyed to the utricle or matrix thereof, to impregnate the female dust contained therein.

This dust in any one plant being viewed with a microscope, 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 crystal; 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 jonquille 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 cat-skins) 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 flower 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 enclosed in a peculiar covering. In some plants it so increases, 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 kernels 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 the 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 tendinouscover,which when it begins todry, 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 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 seed, transcends all imagination. An elm living a 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 borne an equal number of seeds with those that did. These seeds therefore are already contained in them; and if so, the tree really contains 15 810,000,000 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, there is a plantation, about twenty-five years old, wherein none of the oaks are under seventy, and some a 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 a hnndred 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, a 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 sembrador) 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 soil good, and the weather favourable. By this means one grain of wheat planted in a garden has produced ninety, yea, a hundred ears. If then, each ear taking one with another, contains 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, 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 principles contained therein, by a real vegetation, and a subsequent change from the vegetable to the animal life.

"Semen immediately evacuated is an homogenous 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 we may observe, that every animal or vegetable substance, advances as fast 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 animalcula 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 each side. Cardamines burst their pods and dart out their seed on a 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 Mistletoe is usually sown.

The berries of Mistletoe 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. It is not uncommon, for the seeds of ever-greens to be two years before they spring out of the ground. But this was surprising, 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 part of the plant. The strangest circumstance is, that the rooting end should first shoot in 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 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 seed, 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, disclose their 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 andmore swelled,and the beginning ofthe 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 complete, 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 of part the tree. Thus an apple cut crossways appears to consist of four parts. First the skin, derived from the outer bark of the tree. 2. The 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 serves not only for the food of animals, but to guard and nourish the seed enclosed, 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 enclosed in the skin, that surrounds the germ, and gives it nourishment, when first put into the earth, before it is capable of drawing 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, and 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 these 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 enclose 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 carelessly 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 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; (beside 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 chyle 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 a 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 insects, 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 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 a 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 a 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 due heat of a 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 feet 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.

Though 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 form 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 con-

tains its peculiar substance, 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 perfection. 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 other terminate into the minute grains, commonly called the farina fœcundans ; 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 complete 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 fecundating 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, loaded with the globules of the farina fœcundans, 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 increases.

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 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, he 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 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 needs 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. View, for instance, a young willow. This is an organized body, capable of growing, till it comes 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 fœtuses, proceeding from the organizations lodged in every part. The polypus in like manner gradually sends off new fœtuses, 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 fœtuses, like its parent. And if the polypus be cut in pieces, each piece will be explicated into a polypus and then extrude new fœtuses: so that cutting it in pieces, is but anticipating the propagation of those organizations in the pieces, which would if let alone for awhile, 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 surprising 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. 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 on 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, jonquilles, 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, cutters and layers of vines, all which grew up into vines. And these in a while were larger than those which came from cuttings and layers planted at the same time in the ground.

Mr. Kraft sowed oats and hemp-seed in rich earth, in sand thoroughly dried, in shreds of paper, in pieces of woollen cloth, in chopped hay. He afterwards watered them daily, and they grew near as well in one substance as in another.

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 g ats, nowhere to be seen but about these trees. In Novemb r 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 enclose 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 cratitires.

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 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. II.



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 colour. 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 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 a 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 from, and remedy for all their disorders. It is opening and diuretic, and what is surprising, 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 a vomit; when they drink it luke warm.

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, a 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 a laurel kind, and I doubt if laurel or bay leaves properly cured, would not equal any of them.

The Coco-tree grows strait, without any branches, thirty or forty feet high. Near the top it bears twelve leaves, each ten feet long, and 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 grows 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 cocoa-nuts are to the number of ten or twelve. In each there is 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 twice 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 is 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 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, mixed 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 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 transplantation, 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 our 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, 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 Mistletoe, 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 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 in 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. But as fine cotton is now made in Ireland from flax, as ever grew on the cotton tree.

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 exposed awhile to the sun, become black. To make white pepper they moisten it with sea water, and then exposing it to the sun, divest the grains of the outer bark, which of consequence leaves them white.

The tree that bears Jamaica Pepper is about thirty feet high, and covered with a grey, smooth, shining bark. It shoots out abundance of branches, which bears large leaves, like those of the bay-tree. At the very end of the twigs grow bunches of flowers, each stalk bearing a flower which bends back. To these succeeds a bunch of berries, larger when ripe than Juniper berries. They are then black, smooth, and shining, but they are taken from the tree when unripe, and dried in the sun. They have a mixed flavour of many kinds of spice, and hence they are called all-spice.

The plant which affords ginger resembles our reed, both in its stem and leaves. The root spreads itself near the surface 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 sun, or in an oven.

Nutmegs are inclosed in four different covers; the first, thick and fleshy like that of our walnuts; the second is a thin reddish coat, of an agreeable smell, called mace. The third is a hard blackish shell. The fourth is a greenish 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 instance of the wise providence of God. The 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 a 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 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 acco ut 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 inquiry 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 surprised, 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 intirely 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, produc
lent vomitting 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 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 Juria, grows a plant like the Doronicum, near the roots whereof is found pure quick-silver, 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 a hundred and twelve; on others a hundred and ten, and on others a 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 age, when they are of a large size and a great height. As soon as the flower stem begins to shoot from the middle of the plant, it draws all the nourishment from the leaves, so that as that advances, these decay. And when the flowers are fully blown, scarce any of the leaves remain alive. But whenever this happens, the old root sends forth a numerous quantity of offsets for increase.

Perhaps there is scarce any plant in the creation which is of so general use. The wood of it is firm, and serves for fences, and for the use of the carpenter. The leaves make coverings for houses: the strings and fibres serve in the room of hemp, flax, and cotton. Of the prickles are made nails and awls, as also pins and needles. And from a large aloe, when rightly tapped, may be drawn three or four hundred gallons of juice, which by distillation grows sweeter and thicker till it becomes sugar.

If there be a more beautiful flower than that of the aloe, it grows on a species of Cereus (or prickly pear as they call it in America), which grows well in our stoves: about the middle of July the flower is grown to its bigness. Till then it appears like a bit of wool on a dead stem. It usually begins to open about five in the evening, is full blown about eight, and continues so till about four the next morning. It then gradually closes, and is shut up about six o'clock, covered with a cold moisture. The calyx or empalement is a foot diameter, divided into sixty segments, the outside of a fine gold colour, the inside of a splendid yellow, spreading like the rays of a star. 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 fragant 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 ephemeron; 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 sough
And it is certain, if you only range in Ap
of horse-dung as big as ones fist in lines thr
distant from each other, and one foot unde
ground, covering them all over with mould, and
again with horse dung, in the beginning of August t
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 of very small plants. And these in particular like 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 nourishthe 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 trunks 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 a hither and thither. So that in truth is full of an inconceivable number both of and vegetables, perfectly formed in all their and designed as it were in miniature, only ig for certain favourable circumstances, to ena- 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 enlarges 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 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 the 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. Molasses 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 molasses 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 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 molasses.

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.

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.

The 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 putrefy, remain unchanged in vacuo.

Yet various experiments seem to shew, that air must be impregnated by water, before it can occasion putrefaction, either in animal or vegetable substances. For take a pound of fresh flesh, and keep it in a moderate heat, and it will thoroughly putrify 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 putrefaction. 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 putrefy 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 come 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 a 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 salts. An oily salt which shoots into globes. 3. A thick, fœtid oil, both which are intirely like those of animals. 5. 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 intirely 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 particle 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 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 vessel 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 outward 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 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 excrementary ducts, which throw off superfluities by insensible perspiration. And so necessary is 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 red mace, 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 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 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 of 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 a 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 which are upon earth, and with labour do we find the things that are before us." This is abundantly verified in 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 of the 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 watery vehicle, they are compacted into hard substances.

But when the watery 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, 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 putrefaction, 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 evergreens 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 watery fluids, 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 watery 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 aerial 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 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 extension 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 a 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 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 a 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 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 intirely 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 dust may 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 though 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, lest 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 mistletoe 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 necessary 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 rigour 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 contributes 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.

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 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 lain waste the pasture the preceding year, than at any other time.

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 too,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 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 useless to the world, and lie melancholy spectacles, nature hastens on to 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 immersed in water, ever return to earth ? A particular kind of worm performs this work, as seafaring 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 a 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, nor flat, but irregular and unequal. And the surface, however smooth and bright it may seem to the naked eye, is then seen full of raggedness, holes, and scratches, like an iron bar from the forge. But examine in the same manner the sting of a bee, and it appears to have in every part a polish most amazingly beautiful, without the least flaw or inequality, and ends in a point too fine to be discerned by any glass whatever. And yet this is only the outward sheath of far more exquisite instruments.

A small piece of the finest lawn, from the distance and holes between its threads, appears like a lattice or hurdle. And the threads themselves seem coarser than the yarn wherewith ropes are made for anchors. Fine Brussels lace will look as if it were made of a thick, rough, uneven hair line, intwisted or clotted together in a very awkward and unartful manner. But a silk worm's webb on the nicest examination appears perfectly smooth and shining, and as much finer than any spinster in the world can make, as the smallest twine is than the thickest cable. A pod of this silk winds into nine hundred and sixty yards. And as it is two threads twisted together all the length, so it really contains one thousand eight hundred and sixty, and yet weighs but two grains and a half. What an exquisite fineness! and yet this is nothing to the silk that issued from the worm's mouth, when newly hatched.

The smallest dot which can be made with a pen, appears through a glass, a vast irregular spot, rough, jagged and uneven about all its edges. The finest writing (such as the Lord's prayer in the compass of a silver penny) seems as shapeless and uncouth as if wrote in Runic characters. But the specks of moths, beetles, flies, and other insects, are most accurately circular, and all the lines and marks above 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 animalcula, 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, a harmony, beyond the reach of art. There is not a weed 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 concealed from us the most curious particulars with regard to the essences and structure of his works. And to 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 surprised 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 it as well as the animal.

It is 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 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 incontestible 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 it is that God alone, who before all worlds contrived these models of every species in his own original idea, that appoints what under-agents he will employ to copy them.

In the week of the creation, he bade 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 just 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 it is 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, it was there that he ordered the rod of Moses, a dry and lifeless vegetable, to raise a 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 noisome army.

It was there he bid Moses 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 work of miracle and astonishment, when he has a mind to shew himself the sovereign and the controller 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 enginery and skill, can form the least gart 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 his 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 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 tongue shall inquire 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 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? It is 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 called that should have made 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, they 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 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 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 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, as he shall think 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 its proper form; 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 surprising wisdom appears in that Almighty operator, who out of the same matter shall perfume the bosom of the rose, and give the garlic its offensive and nauseous powers? Who from the same spot of ground, shall raise liquorice and the wormwood, and dress the cheek of the tulip in all its glowing beauties? What a surprise, to see the same seed 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?

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 forethought of God, who formed the first vegetables in such a manner, and appointed their little parts to ferment under the warm sun-beams, 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 artist, they do but chatter like Hottentots, and paint like Goths and Vandals.

## 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 metaphorical 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 as they are, from the crow to the tit-mouse, should derive their flesh and blood from the productions of the same tree, where the swine watch under the boughs of it, and are nourished by the fruit? Nor need I stay to take notice what numerous insects find their nests and their food all the summer season from the same apples or apricots, plumbs, or cherries, which feed hogs and crows, and a hundred small birds. Would you think that the black and the brindled kine, with the horses both grey and bay, should clothe themselves with their hairy skins of so various colours out of the same green pasture where the sheep feed, and cover themselves with their white and woolly fleece? And at the same time the goose is cropping part of the grass to nourish its own flesh, and to array itself with

down and feathers. Strange and stupendous texture of the bodies of these creatures, that should convert the common green herbage of the field into their different natures, and their more different clothing ; but this leads me to another remark.

2. What exceeding great diversity is found in the several parts, limbs, and coverings, even of the same creature? An animated body is made up of flesh and blood, bones and membranes, long hollow tubes, with a variety of liquors contained in them, together with many strings and tendons, and a thousand other things which escape the naked sight, and for which anatomy has hardly found a name, yet the very same food is by the wondrous skill and appointment of the God of nature formed into all these amazing differences. Let us take an ox to pieces, and survey the wondrous composition. Besides the flesh of this huge living structure, and the bones on which it is 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 that food to the size and firmness of an ox. Can it be supposed, that all these corpuscles 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, 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, feeding on a 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 akin 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 of it. 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 lapdog 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 dependence on her care for food and nourishment. 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 if it knew, that though it could feed itself, yet it was not able to defend itself, but must trust to the better security of a parent's wing.

We admire these little creatures, and their remarkable sagacity, we are surprised to find that they distinguish so happily, and pursue their proper interest; that they are 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 his 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 feet 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 that 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 nature of these vegetables in such a manner, as that by certain and 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 chickens? 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 surprise 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 akin to each other? Creatures which we have always distinguished into the sensible and 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 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 wailing 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 the 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 dishonouring 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 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 intent 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. III.

### *Of Metals, Minerals, and other Fossils.*



1. AMONG the bodies that remain to be considered, those which seem to bear the nearest 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 calx, and such as are inflammable. Of the first class, are metals, gold, silver, platina, copper, iron, tin, lead, and quicksilver. However these differ in other respects, they all 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 a hard 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 granite, water, and air, stands thus:

| | | | |
|---|---|---|---|
| Gold | 19636 | Iron | 7852 |
| Quicksilver | 14019 | Tin | 7321 |
| Lead | 11345 | Granite | 3978 |
| Silver | 10535 | Water | 1000 |
| Copper | 8843 | Air | $\frac{3}{11}$ |

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 ciuders melted over again.

However, it has long been disputed, whether metals are generated, or were all originally produced at the creation, and whether there be any general seeds 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 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 colour, and with lead, in casting of printers letters, to render them more smooth or firm. It is also a general help in 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 dissolvable 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 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 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 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 thinness.

Silver approaches the nearest to gold in ductility and resisting fire. Like the ore of all other metals, it is found in the earth, under different forms and colours. But it usually affects somewhat of a pointed regular form like crystals. 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 inquiries. 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 shiny 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. Having been kept in an assay-furnace with lead for three hours, till all the lead was wrought off, it was found remaining at the bottom, without having suffered any alteration or diminution. A piece of it was put into strong aquafortis, and kept in a sand-heat for twelve hours, yet when taken out it was no ways corroded, and was of the same weight as when put in. It has been said to be heavier than gold : but that is a mistake. Its specific gravity is to that of water, as fifteen to one. Yet an equal mixture of gold and platina, was near as heavy as gold itself, being to water as nineteen to one. It appears then, that no known body comes so near gold in fixedness and solidity. If it could be made as ductile as gold it would not easily be distinguished from it.

Platina is likewise found in large, hard masses: these masses are with great labour, reduced into small grains, which are afterwards ground with mercury to extract the gold ; and it is not to be brought into fusion by the greatest degree of fire procurable in the ordinary furnaces. It entirely resists the vitriolic acid, which dissolves or corrodes every other known metallic body except gold. Nay, it resists the marine fumes, and the regal cement, so called, from its being supposed to purify gold from all heterogeneous metallic matters. It also resists the force of the vitriolic and nitrous acids, though applied in such a manner as to be capable of perfectly dissolving all other known metallic bodies. It follows from other experiments, that platina contains no gold ; for it cannot, any more than the common metallic substances, prevent a small portion of gold mixed with it from being discoverable. It farther appears, that platina, like gold, is not acted on by the 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 aquafortis, 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 alkaline 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 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 aquafortis 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 begun 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 less 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 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

* The spirit of vitriol being mixed with iron, after fermenting, produces a green vitriol like the natural one. But if for 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 commonly calcined.

Black-lead (very improperly so called) is only a talky kind of earth.

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 dissolvable 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 from them by a loadstone. And there is scarce any terrestrial substance either in men, brutes, or plants, which after burning 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 nutricious 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 springs, a considerable portion of the quicksilver. The increment of new silver 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 aquafortis, 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 alum-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 resemble 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 yet the following account is stranger still. "I mixed equal parts of sal ammoniac and pot-ashes which were put into a tall glass body, with 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 ancients. 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 a 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 afterwards 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 convertible into a fume, even in a sand-heat. 5. Of all fluids it is in equal circumstances 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 other 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 or household 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 to be alive; if not, to be dead bodies. In Cornwall and Devonshire the loads always runs 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, deposits 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, (general 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, passing 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 particle 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 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 of 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 putrefaction, and to be with great difficulty 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 vacuties. 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 Willisca, five leagues from Cracow in Poland. They were first discovered above 500 years ago, in the year 1251. Their depth and capacity are surprising. 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 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 surprised with a long series of lofty vaults, sustained by huge pillars, which being all rock salt, appear by the light of flambeaus that are continually burning, as so many crystals, 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.

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 out of some troughs, where they had lain 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; 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 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. Mean time 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 is also 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 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 have 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.

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 a 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 away 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 Frodingham 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, 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, occasion 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 crystals, 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 crystal to be the basis of all precious stones, which assume this or that colour, from the metallic or mineral steams mixed with the primitive crystalline matter. But how is crystal 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 crystals are generated. And whenever there is a serene and dewy sky, if all the chrystals that 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 steam 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 crystals 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 crystalize quietly, it shoots into planes, of eight, six, four, and three sides. But beside this, 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 crystals 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? 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 crystal 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 resisting 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 a portion of spar, clearer or opake, in its composition.

2. Whether these and all other sorts 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 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 cupereous 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 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 southern 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 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 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 loadstone 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, loadstones of attractive and directive together, probably mixed with heterogeneous matter, as not having been purged by fire like iron. And hence iron, when touched, will lift up a much greater weight than the loadstone that touched it. 3. The attractive power of armed loadstones, 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 lengthways 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. Howard sailed to Barbadoes in company with another ship, commanded by one Groston. Suddenly a terrible clap of thunder broke Groston's foremast, 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, and 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 carbuncle 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 porticos, 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 tenacious, 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 anciently 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 naphtha; but is of a firmer consistence.

Asphaltos is also a kind of bituminous stone, found near the ancient 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 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 ancients 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 of 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 ancients. 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 a 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 fossil 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 pledget 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 wellendured 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 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 caustic 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.

END OF THE SECOND VOLUME.

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