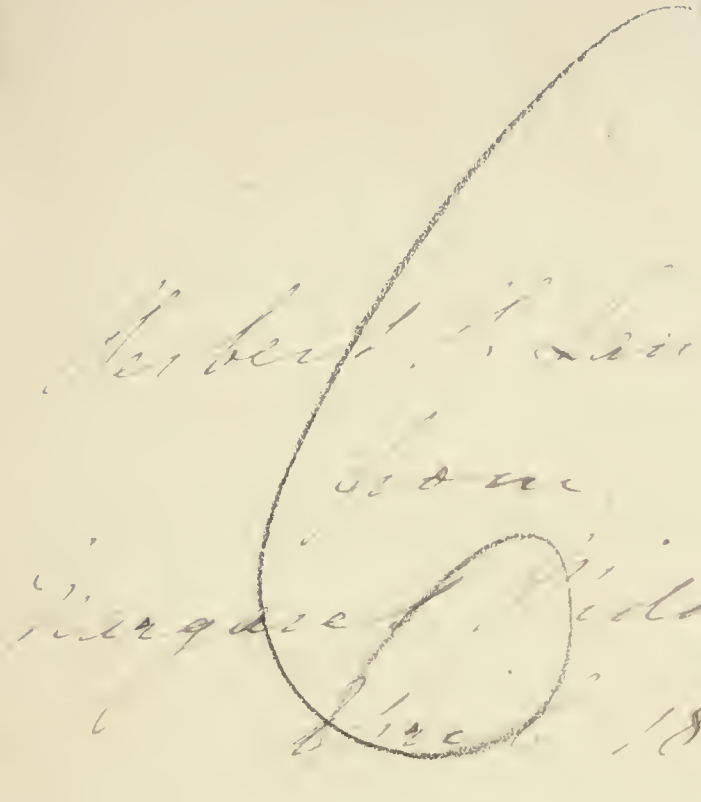

THE

HISTORY OF INSECTS.

WILLIAM TYLER,
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CAPTURING INSECTS.

THE

HISTORY OF INSECTS.

All things that are, though they have several ways,
Yet in their being join, with one advice,
To honour God: and so I give Thee praise!
But who hath praise enough? Nay, who hath any?
None can express Thy works but he that knows them.

HERBERT.

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HISTORY OF

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CHAPTER I.

INTEREST EXCITED BY THIS PART OF THE WORKS OF GOD.

Attention has been given to the insect tribes from a very distant period. Moses, probably, obtained some knowledge of them from the sages of Egypt. Sometimes they are represented as Divinely employed to distress the enemies of Israel, and at others, to punish that people when they wandered from God. Solomon also treated, in his book of "creeping things," and spake of the spider as "exceeding wise."

Passing from those who were guided by Divine inspiration, Hippocrates, who lived in the fifth century before Christ, wrote on insects. The following age gave

birth to Aristotle; and, on this interesting part of the natural world, that eminent philosopher distinctly dwells. From the time of Pliny, who ably advocated the study of insects some centuries after, and of Ælian, who often mentions them, several hundred years elapsed during which scarcely any thing was done for natural history.

In the middle of the sixteenth century, however, appeared a folio volume, of several hundred pages, forming part of a work on animals, by the learned and industrious Aldrovandus, professor of medicine in the university of Bologna; to whom insects furnished a favourite study. During the space of thirty years, he annually gave a liberal sum to a painter, who was solely occupied in their delineation.

A regard to them appears to have slightly advanced with the art of engraving. About the time to which reference has just been made, a better taste, as well as a desire for more expensive embellishments in works of this description, began to operate. Accordingly, engravings on copper were substituted for cuts on wood, and that with considerable success. Still, for a long period they were only sparingly used. Another circumstance had some influence. Exotic plants were much esteemed, affording an ample field for the labours of those artists

who were employed in portraying them; but though insects afterwards presented many charms in connexion with them, they were, at first, introduced but rarely into pictures, and then only as secondary objects. It was afterwards seen that they enlivened the representations of the unfolding blossoms about which they sported, and hence they were more freely imitated. In some cases, casual observation led to inquiry in reference to these creatures, amply gratifying the curiosity they awakened; while artists created a congenial taste among their patrons, and by this means the knowledge of insects was on the increase.

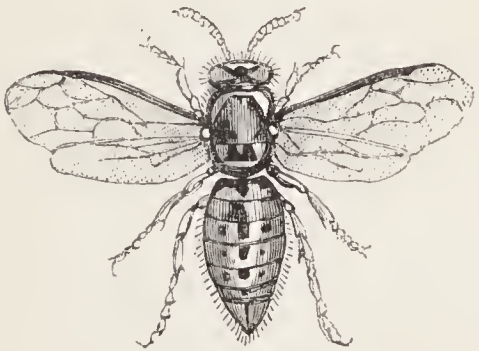
A further impulse was given by the invention of the microscope; furnishing as it did a new opportunity of examining the natural world, and of observing accurately the most delicate organs of the minor tribes of animals, which, from their minuteness, had hitherto escaped notice. Aided by this powerful instrument, Leeuwenhoeck displayed astonishing assiduity, and contributed more than any one, except Swammerdam, to disclose the hidden wonders of the creation. His communications, which appear in the "Philosophical Transactions," led to many papers by different writers, whose efforts also tended still further to elucidate the subject.

In the earlier part of the eighteenth century, however,

Entomology, as the science of insects has been latterly named, was cultivated with the happiest success. Among the valuable works of that period are those of our own countrymen, Ray and Lister, and also of Reaumur, an eminent French naturalist. Linnæus was the original founder of a distinct and applicable order of names, and others have suggested various improvements in it. Of late years, important additions have been made to our scientific treasures, among which the work on insects by Messrs. Kirby and Spence is deservedly conspicuous.

In this fact there is reason for satisfaction; inasmuch as the study of these creatures is not merely calculated to amuse; for while it supplies entertainment, it may be rendered conducive to moral purposes. With this conviction the reader is now invited either to enter on it, or, by a brief and general view of the subject, to refresh his recollection. And here it may be premised, that the term *insect* is often used very loosely. It is applied not only to the fly, the grasshopper, and the beetle, in common with similar creatures, but to other small animals, such as slugs and worms. If, however, one of the former be examined, its body will appear *insected*, or divided, as it were, into three principal pieces; and it is only where such a division is more or less obvious, that this name can properly be given. A

remembrance that the word insect is probably a corruption or contraction of a Latin term, meaning *cut between*, will fully guard against mistake; while of its right use, its application to the common wasp may afford a familiar example.



The insects distributed over the surface of the globe are estimated at 400,000 species; and it is said 100,000 are to be found in our cabinets. Of British insects 10,000 are enumerated; and of these 4000 belong to one class. It has also been calculated that the number of plants supposed to exist is about 44,000 species; of which 38,000 have been described. A description of 16,712 indigenous, cultivated, or exotic plants, which are now found, or have been introduced into this country, has been published. The native plants of Great Britain, exclusive of one class—that of vegetables

of the lowest kinds—according to Professor Henslow, amount to 1501 species, and 1625 varieties, of which 98 are supposed to have been naturalized. Thus it appears, that the ratio of the species of British insects to that of plants is more than six to one.

That each insect of the immense swarms belonging to our globe is the work of God, furnishes of itself a sufficient reason for our present attention to their history. It was long since said by one of the fathers of the church:—"If you speak of a fly, a gnat, or a bee, your conversation will be a sort of demonstration of His power whose hand formed it; for the wisdom of the workman is commonly perceived in that which is of little size. He who has stretched out the heavens, and dug up the bottom of the sea, is also He who has pierced a passage through the sting of a bee for the ejection of its poison." This saying is well deserving remembrance, "The Lord of hosts is wonderful in counsel, and excellent in working."

It has been the opinion, indeed, of many eminent men, that a higher degree of perfection should be assigned to the insect race, than to other classes of animals. Reaumur, for instance, expressed their sentiments, when he said:—"Why should we fear to praise too much the works of the Supreme Being? A machine

appears to us so much the more admirable, and so much the more honour accrues to its inventor, when, notwithstanding its simplicity, yet, in order to accomplish the desired end, it is formed of a great number of parts, and among these various differences prevail. These machines, therefore, though they are small, should awaken more regard than those of large animals."

And well is it, when amidst so much without and within, tending to obscure, and even conceal, our Creator, Benefactor, and Redeemer, even an insect awakens a sense of his being and perfections. Science may thus become the handmaid of religion, and as the view is extended, the works of the Supreme may throw light on his word; the garden, the field, the hedge, may become the scene of communion with the Most High: it may be, indeed, as if every spot were a temple, and every object demanded a tribute of praise and an acknowledgment of dependence.

Apart from subserving the highest ends, other objects may be gained by the study of insects. Often do they gratify, for instance, by peculiar beauty and extraordinary splendour. Much has been said of the vivid colours of tropical birds, yet their brilliancy is equalled by many moths and butterflies. The words of Mrs. Barbauld strikingly exhibit them, though the wish

is suggested, that, instead of speaking of *nature*, all writers would distinctly recognise God.

"Lo! the bright train their radiant wings unfold,
With silver fringed, and freckled o'er with gold;
On the gay bosom of some fragrant flower,
They, idly fluttering, live their little hour;
Their life all pleasure, and their task all play,
All spring their age, and sunshine all their day.
What atom forms of insect life appear!
And who can follow nature's pencil there?
Their wings with azure, green, and purple gloss'd,
Studded with coloured eyes, with gems emboss'd;
Inlaid with pearls, and marked with various stains
Of lively crimson through their dusky veins."

Lander, the traveller, in reference to his journey from Badagry to Basha, in Africa, observes:—"One beautiful sight was that of an incredible number of butterflies, fluttering about like a swarm of bees. They were variegated by the most brilliant tints and colourings imaginable. The wings of some were of a shining green, edged and sprinkled with gold; others were of sky-blue and silver; others of purple and gold, delightfully blending into each other; and the wings of several were like dark silk velvet, trimmed and braided with lace." The scene will be found on another page.

Some insects, moreover, are remarkable for their phosphorescence. Of this the glow-worm is a familiar example. But, however beautiful the effect produced

AFRICAN BUTTERFLIES.

by the British species, and by the fire-flies, which are still more abundant over Italy and the rest of the south of Europe, their splendour, according to Humboldt, is not to be compared with that of the innumerable scattered and moving lights that embellish the nights of the torrid zone. Southey describes their effect on the earliest visitors of the new world, when he says :—

——————— "Sorrowing we beheld
The night come on; but soon did night display
More wonders than it veiled; innumerous tribes
From the wood-cover swarmed, and darkness made
Their beauties visible: one while they streamed
A bright blue radiance upon flowers that closed
Their gorgeous colours from the eye of day;
Now motionless and dark, eluded search,
Self-shrouded; and anon, starring the sky,
Rose like a shower of fire."

The fire-fly is also very abundant in Jamaica. It flies in the piazzas of the houses, as soon as the evening closes in; and the light is of a fiery orange colour, differing much from the mild blue silvery light of the glow-worm. These insects are occasionally used by the inhabitants as a substitute for lamps in the chambers, a few being confined together; and it is said that a lady, prior to her passage to England, placed a number of fire-flies in a wide-mouthed

phial, with some rotten wood, covering the mouth with gauze; and that she thus obtained a substitute for a lamp on board, by shaking the phial and disturbing the insects, which immediately sent forth an abundant light: they, however, perished when the ship arrived in northern and colder climates.

The lantern-fly is equally remarkable. Parts of it are formed into armlets and necklaces, fastened together by means of fine metallic thread, and worn by ladies of high rank in Brazil, by whom its splendour is much prized.

CHAPTER II.

THE CHANGES OF INSECTS—ILLUSTRATIONS OF INSTINCT—RAVAGES OF THESE CREATURES—ADVANTAGES ARISING FROM THEM.

The changes experienced by insects are very remarkable. You open a nut, for instance, and you find it the dwelling of a maggot; it is, in fact, an insect in the larva, or caterpillar state. You kill it, perhaps, or leave it to perish; but had you not broken into its abode, it would have remained there until fully grown, and, having gnawed a passage out, entered the earth, and resided there for a few months in quietude, it would have come forth a beautiful beetle, with two wings and two wing-cases, adorned with yellow bands, six feet, and a long and slender ebony beak. How unlike the little resident in the kernel of a nut!

To take another instance. "See," says Linnæus, "the large, elegant, painted wings of the butterfly, four in number, covered with delicate feathery scales. With these it sustains itself in the air a whole day, rivalling the flight of birds, and the brilliancy of the peacock.

Consider this insect through the wonderful progress of its life; how different is the first period of its being from the second, and both from the parent insect! Its changes are an inexplicable enigma to us. We see a green caterpillar, furnished with sixteen feet, feeding upon the leaves of a plant; this is changed into a chrysalis, smooth, of golden lustre, hanging suspended to a fixed point, without feet, and subsisting without food. This insect again undergoes another transformation, acquires wings, and six feet, and becomes a gay butterfly, sporting in the air, and living by suction on the honey of plants."

Such changes may sometimes occur under our own observation. When Mr. Howitt, in his "Rural Life in England," is describing "Midsummer in the fields," he speaks of the "midges as celebrating their airy and labyrinthine dances with an amazing adroitness;" and then adds:—"These little creatures pass through a metamorphosis, as they settle on you in your summer walks by river sides, that must strike the careful observer with admiration. You may sometimes see a column of them by the margin of the river, like a column of smoke; and when you come near, numbers of them, as in the engraving, will settle on your clothes—small, white, and fleecy creatures. Observe them carefully, and you

SUMMER INSECTS.

will see them shake their wings, as in a little convulsive agony, press them to the sides of their body, and fairly creep out of their skins. These skins—fine white films, drawn like a glove from their bodies, and from their very legs, which are but like fine hairs themselves, they leave behind, and dart off into the air as to a new life, and with an accession of new beauty."

The instinct of insects, too, exhibits much that is marvellous. A popular volume was published some time since, entitled "Art in Nature," in which a resemblance is traced between the movements of inferior creatures and many of the operations of men. It is shown that among these little tribes there are paper-makers, confectioners, silk-manufacturers, architects, musicians, geometricians, carpenters, masons, boat-builders, aeronauts, upholsterers, miners, soldiers, and tailors. A mind to which the subject was new, would be particularly struck by the statements thus made; and the association of kindred facts is always interesting and instructive.

Dr. Darwin was walking one day in his garden, and observed the following circumstances. A wasp was on the gravel walk with a large fly, which it had caught, —nearly as big as itself. As the doctor knelt down, he saw it cut off the head and abdomen, and then taking up with its feet the trunk, or middle portion of the

body, to which the wings remained attached, it flew away. But a breeze acting on these, turned round the wasp with its burden, and impeded its progress. On this it alighted again on the gravel walk, deliberately sawed off first one wing, and then the other; and having thus removed what was troublesome, flew off with its booty. Remarkable as this process seems, there is reason to suppose that it was only an ordinary display of the wasp's ingenuity.

An astonishing application of instinct, however, sometimes occurs, in a departure from the ordinary course, in order to remove an existing evil. The following instance of such sagacity is furnished by Huber. A comb, not being originally well fastened at the top of a glass hive, fell during the winter among other combs, but continued parallel with them. How was this evil to be remedied? The bees could not fill up the space between its upper edge and the top of the hive, because they never construct combs with old wax, and they had not an opportunity of procuring new. At a more favourable season, they would not have hesitated to build a new comb upon the old one, but it being inexpedient at that time to expend their honey in the making of wax, they provided for the stability of the fallen comb by another process. Furnishing themselves with wax from the

other combs, by gnawing away the rims of the cells which were longer than the rest, they then hastened in crowds, some settling on the edges of the fallen comb, others within its sides, and those of the adjoining combs, and there securely fixed it, by constructing several *ties* of different shapes between it and the glass of the hive. Some were pillars, others buttresses, and others beams; artfully disposed and adapted to the surfaces which were joined.

Nor did these clever little builders content themselves with repairing the injury they had sustained; they provided against others which might occur. The other combs had not been displaced, and appeared to be solidly attached, whence Huber was not a little surprised to see the bees strengthen their principal parts of connexion by making them much thicker than before with old wax, and forming numerous ties and braces to unite them more closely to each other, and to the walls of their habitation. What was still more extraordinary, all this happened in the middle of January, when the bees ordinarily cluster at the top of the hive, and do not engage in labours of this kind.

Lieutenant-colonel Sykes, in describing some new Indian ants, says, "However incredible the fact may appear, I will not omit to notice an instance of their instinct,

literally bordering upon human intelligence. It was the practice in my family to leave the dessert, consisting of fruit, cakes, and particularly China preserved fruits, constantly standing upon a sideboard, in an enclosed verandah, off the dining hall: a cloth was thrown over it, and, to prevent the access of insects, the legs of the table were placed on low pedestals, in little stone pans filled with water. When I first took possession of the house, the inhabited part was not infested with this species of ant, but the attractions of the sideboard soon occasioned their introduction.

"The channel of water surrounding the pedestals did not prove a sufficient barrier: the pans were shallow, and the channel not wider than two lengths of medium sized ants. When the water was low, they waded across; and when the pans were full, they boldly pushed over, and succeeded in catching hold of the opposite bank with their forelegs ere they sunk; and once over, they soon reached the rich repast by the legs of the table, and in the morning I found hundreds congregated on the China sweets. They were put to death, but each succeeding day presented similar hordes of equally bold and successful adventurers.

"I now had the legs of the table surrounded daily with a belt of turpentine, just above the level of the

water, and this proved effectual. For some days the sweets were unmolested, but eventually the ants found their way back to them, although not in such numbers as before, and I did not readily discover by what means. The edge of the table was about an inch distant from the wall, and with greater facilities of access, they did not risk the danger of passing the gulf between the table and the wall, but, reduced to extremities by my precautions, the largest ants now essayed to pass it, holding on the wall by the hind legs, whilst the front legs were stretched out to touch the edge of the table, and the contact enabled very many to cross.

"The table was now removed from the wall, beyond the stretch of the largest ants, and I flattered myself I had triumphed over their perseverance and ingenuity; but, to my great surprise, in a few days the sweets teemed as usual with the intruders, and I was puzzled in no small degree to account for their re-appearance. Accidentally passing the table, I observed an ant upon the wall, about a foot above the level of the sweets: it fell, and instead of passing between the wall and the table, and alighting upon the ground, the insect fell upon the table. Can it be possible, I said to myself, that this fall is designed? I stood to observe with the most intense curiosity: another ant ascended, and dropped

with similar success; another and another followed; and there was no longer doubt that instinct—if instinct I must call it—had made them, in this instance, a match for reason."

Insects are sometimes productive of much annoyance. "I met," says Mr. Arthur Young, in his Travels in France, "between Pradelles and Thuytz, mulberries and flies at the same time: by the term *flies*, I mean those myriads of them which form the most disagreeable circumstance of the southern climates. They are the first torments in Spain, Italy, and the olive district of France: it is not that they bite, sting, or hurt; but they buzz, tease, and worry: your mouth, eyes, ears, and nose, are full of them: they swarm on every eatable—fruit, sugar, milk, every thing is attacked by them in such myriads, that if they are not incessantly driven away by a person who has nothing else to do, it is impossible to eat a meal. They are, however, caught on prepared paper, and other contrivances, with so much ease, and in such quantities, that were it not from negligence, they could not abound in such incredible quantities. If I farmed in these countries, I think I should manure four or five acres every year with dead flies."

Motives of policy may, therefore, engage attention to some of these apparently inconsiderable creatures.

Mankind are frequently sufferers to a great extent from the ravages of insects, and especially in their invasion of the produce of the fields. Wheat, for instance, is exposed to their depredations, from the time at which it issues from the ground, till after it is housed in the barn. Its earliest assailant is a grub; one, it is believed, of the beetle tribe, which eats into the young plant, devours its central part, and thus occasions its destruction. Out of fifty acres sown with this grain in 1802, ten were destroyed by this grub as early as October.

Another caterpillar of a beetle frequently in our fields will also attack young wheat. In the spring of 1813, not less than twelve German hides, equal to two hundred and thirty English acres, were destroyed by it near Halle. And while the grub, probably continuing in that state for three years, is thus injurious, the beetle itself attacks the grain when in the ear, clambering up the stems at night in vast numbers.

When the wheat is in bloom it is infested by an orange coloured gnat, which pierces the centre of the blossom, and there lays its eggs: when these are hatched, the caterpillars prevent the growth of the grain, and sometimes destroy it in large quantities.

Should it be supposed that in the granary the valuable produce is perfectly safe, even here the weevil

devours it. A single pair of these enemies will, in one year, become the parents of 6000 descendants. The stored wheat has also three other adversaries: one a minute species of moth, to which the name of "the wolf" has been given; the second is similar, and at one time committed great ravages in France; and the third, the grub of a kind of beetle, is said to do more mischief than either the weevil or the wolf.

Numerous instances of the attacks to which vegetables are exposed will in a subsequent chapter demand attention; it must now suffice to observe, that effects equally startling are produced in widely different circumstances. Wilson, the historian of American birds, inquires, "Would it be believed that the larvæ, that is, the grubs or caterpillars of an insect or fly, no larger than a grain of rice, should silently, and in one season, destroy some thousand acres of pine trees, many of them from two to three feet in diameter, and a hundred and fifty feet high? In some places, the whole woods, as far as you can see around you, are dead, stripped of the bark, their wintry looking arms and bare trunks bleaching in the sun, and tumbling in ruins before every blast."

It is also stated, that a small ant devours paper and parchment, and destroys every book and manuscript in one part of the earth. Many of the provinces of Spanish

America cannot, in consequence, show a written document of a hundred years' existence. "What development," it is asked by Humboldt, "can the civilization of a people assume, if there be nothing to connect the present with the past; if the depositories of human knowledge must be constantly renewed; if the monuments of genius and wisdom cannot be transmitted to posterity?"

The depredations of the white ants have become proverbial. Mr. Forbes locked up a room during an absence of a few weeks, and on examining it he observed a number of their works in various directions towards some prints and drawings in English frames: the glasses appeared to be very dull, and the frames covered with dust. "On attempting," he says, "to wipe it off, I was astonished to find the glasses fixed to the wall, not suspended in frames as I left them, but completely surrounded by an incrustation cemented by the white ants, who had actually eaten up the deal frames and back boards, and the greater part of the paper, and left the glasses upheld by the incrustation, or covered way, which they had formed during their depredations."

The Albion, a British ship of the line, was also attacked by these creatures; and notwithstanding the efforts of the commander and his crew, had not the ship been firmly lashed together, it is thought she would

have foundered on her voyage home. When brought into port, being no longer fit for service, it was necessary she should be broken up.

It cannot be doubted, however, that the wood-destroying insects often confer a benefit on man. In a land like ours, indeed, where timber is not equal to the demand, we could dispense with their services; but to observe their value, we must go where forests cover hundreds or thousands of acres. Though many trees fall victims to the slow ravages of time, or the more sudden and violent action of lightnings and hurricanes, yet the vast majority long retain their verdure.

Almost a century would elapse before the removal from the face of nature of one of the hard-wooded tropical trees, by the mere influence of the elements. But how speedily does it decay under the power of insects! As soon as a tree has fallen, one tribe attacks its bark, and thousands of openings into the solid wood are made by others. Thus the rain insinuates itself into every part, and the action of heat promotes decomposition. Various fungi now take possession, and assist in the process, which is followed up by the incessant attacks of other insects that feed only on wood when beginning to decay. And thus, in a few months, the mighty mass which seemed inferior in hardness only to iron, is

COLLECTING CHRYSALISES.

mouldered into dust, and its place occupied by younger trees, full of life and vigour.

Man, intent on gain, is constantly indebted to inferior creatures. The shepherds of Russia ingeniously avail themselves of the attachment of ants to their young, for obtaining with little trouble a collection of the pupæ, or chrysalides, which they sell as a dainty food for nightingales. They scatter an ant's nest on a dry plot of ground, surrounded with a shallow trench of water, and place on one side of it, as the engraving shows, a few fir branches; under these the ants, having no other alternative, carefully arrange all their pupæ, and in an hour or two the shepherd finds a large heap, clean and ready for market.

Various are the advantages conferred by insects. Silk, an article of dress, giving employment and the means of subsistence to millions of human beings, is the produce of the silk-worm. In the eastern parts of the world it is of as much consequence to the people as the fleecy coat of the sheep is to us.

Locusts are spoken of as an article of food in the sacred Scriptures. The inhabitants of Fez, Morocco, and adjacent countries, eat them to this day; and it is said that the Hottentots hail their coming with delight.

In many warm countries, at present, as well as in ancient times, the honey of bees, both of the wild and the

domestic kinds, is used for food. From this, too, a wholesome and delicious beverage, called mead, is made; for which some countries have long been famous. The Russians also obtain hydromel, an excellent beverage, from the same production of the bee.

Wax has been extensively used for many ages, but it is not generally understood, that this substance is not the produce of the bee alone. The wax insect of China is a very different creature: it is the caterpillar of a species of cicada, and with the addition of a vegetable oil, forms the mixture of which the candles in that country are made.

Ink, so important in our mutual communications, and in the preservation of knowledge, is chiefly made from gall-nuts, produced on trees by a small insect called the gall-fly.

Kermes, the most brilliant scarlet dye known prior to the discovery of the New World, is an insect found abundantly in the south of Europe; and cochineal, the most valuable and beautiful of dyes, is an insect brought from Mexico, and other parts of America.

Cantharides, the principal ingredient of blisters, and therefore of great value, is the name given to beetles collected from ash and other trees in the south of Europe; and which, being merely dried and pounded, are fit for use.

Lac is the produce of an insect found so abundantly on various trees in India, that were the consumption ten-fold, it could be readily supplied. Sometimes it is used there in the manufacture of rings, beads, and other female ornaments; and at others, mixed with sand, it forms grindstones; when added to lamp or ivory black first dissolved in water, with the addition of a little borax, it composes an ink not easily acted on when dry, either by damp or water. In this country it is called *stick* lac, when, in its native state, it is not separated from the twigs to which it adheres; *seed* lac, when separated, pounded, and deprived of the greater part of the colouring matter; *lamp* lac, when wetted and made into cakes; and *shell* lac, when strained and formed into transparent plates. At first it was used in the composition of varnishes, japanned ware, and sealing-wax; but latterly as a substitute for cochineal, in dying scarlet.

Here, then, insects have many claims to notice, while it is worthy of remark, that other parts of the creation are greatly indebted to them: there is scarcely a bird or a fish but devours them with avidity, and they also contribute to the fruitfulness of plants. Yet even at this point we must not stop. A most important service is rendered by insects, in their removal of putrid *animal* substances. These are attacked by an inconceivable

host: some immediately begin to devour them, others deposit in them their eggs, from which larvæ are speedily hatched, and concur in the same office with ten-fold voracity. Thus the air we breathe, which would otherwise become pestilential, is preserved from taint.

The power exerted in such cases would not easily be conceived. Redi ascertained that the larvæ of some flesh-flies, in the space of twenty-four hours, will devour so much food, and grow so quickly, as to increase their weight two hundred-fold. In five days after being hatched, they arrive at their full growth and size;—a remarkable instance of the care of a gracious Providence, in fitting them for the part they are thus intended to act: for were a longer time required for their growth, their food would not be a fit aliment for them, or they would occupy too much time in their work. All their circumstances are wisely arranged, and so efficient are these creatures, that there is some ground for the assertion of Linnæus,—"Three flies of one species will devour a dead horse as quickly as would a lion."

A similar office is discharged as to the *vegetable* kingdom. The interior of rotten trees is inhabited by the larvæ of a particular kind of crane-fly, and also by other insects, which there find appropriate nourishment.

Some are always found, moreover, under heaps of putrid vegetables; and a lesser number may be met with in decomposing fungi, which seem to form a kind of subsistence, just between what is animal and vegetable.

Putrid exhalations from stagnant waters, and consequently fatal disorders, are also prevented, by the innumerable larvæ of gnats and other insects, which live in them, and abstract the injurious part of their contents.

And here we may learn an important lesson. Pride is one of the constantly besetting sins of the human heart. Man would be independent, acknowledging no superior, and imagining all his supplies to be self-derived. But the means of correcting this error are at hand. Confining ourselves to what has already been advanced, it is manifest that we are dependent, not merely on the noblest, but the most inconsiderable creatures of God. Angels are "ministering spirits, sent forth to minister for them who shall be heirs of salvation;" but even insects greatly contribute to our advantage. Only let this part of the creation be destroyed, and the loss defies all calculation.

The charge is one of Divine authority, "Be clothed with humility." Such a spirit is of great value, even in the pursuit of worldly science. Here, "wisdom

is ofttimes nearer when we creep, than when we soar." And indispensable is it in reference to that which is divine. For, as Cowper has truly and impressively said:—

"God never meant that man should scale the heavens
By strides of human wisdom. In his works,
Though wondrous, he commands us in his word
To seek him rather, where his mercy shines.
The mind indeed, enlightened from above,
Views him in all; ascribes to the grand cause
The grand effect; acknowledges with joy
His manner, and with rapture tastes his style.
But never yet did philosophic tube,
That brings the planets home into the eye
Of Observation, and discovers, else
Not visible, his family of worlds,
Discover Him that rules them; such a veil
Hangs over mortal eyes, blind from the birth,
And dark in things divine. Full often too
Our wayward intellect, the more we learn
Of nature, overlooks her Author more;
From instrumental causes proud to draw
Conclusions retrograde and mad mistake.
But, if his word once teach us, shoot a ray
Through all the heart's dark chambers, and reveal
Truths undiscerned but by that holy light,
Then all is plain. Philosophy, baptized
In the pure fountain of eternal love,
Has eyes indeed; and viewing all she sees
As meant to indicate a God to man,
Gives *him* his praise, and forfeits not her own."

CHAPTER III.

STRUCTURE OF INSECTS—THE WORKS OF GOD INFINITELY SUPERIOR TO THOSE OF MAN.

In accordance with those eminent men to whom allusion has already been made, the distinguished naturalist, Latreille, says, that "the wisdom of the Creator never appears to excite our admiration more than in the structure of those minute beings which seem to conceal themselves from observation; and Almighty power is never more strikingly exhibited than in the concentration of organs in such an atom." He adds, "In giving life to such an atom, and constructing in dimensions so minute so many organs, susceptible of different sensations, my admiration of the Supreme Intelligence is much more heightened than by the contemplation of the most gigantic animals."

Let us take one instance, to which an ordinary observer may add numberless analogies: "A yellow insect," says a modern writer, "is now running before me, not bigger than a dot, but as rapid for him as a dog at full

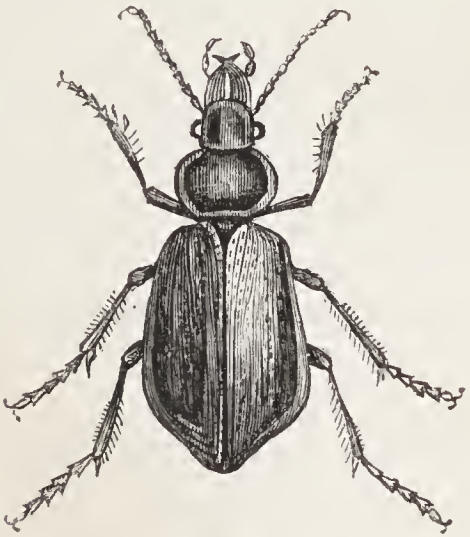
speed. He runs straight forward over my paper, and turns towards the inky letters. What are dry, he runs over; what he finds wet, he stops at, and goes round them; he runs over the white space in a direct line for some time, either obliquely, straight, or in a horizontal one. When I put the feather of my pen in its way, it stops and remains for some time motionless, till, finding no further alarm, it resumes its activity. It certainly paused by its own choice and will. It exerted an act of judgment as it came to the ink; it deemed or felt that to be unsuitable, and repeatedly turned from it; yet it discerned when it was dry, and then ran over what became so. In the space of a small dot, a printer's full stop, it had movable legs and their muscles, and displayed all the activity, power, and thought of a larger animal." Here, as in every similar instance, we perceive—

> "Contrivance intricate, expressed with ease,
> When unassisted sight no beauty sees;
> The shapely limbs, and lubricated joint,
> Within the small dimensions of a point;
> Muscle and nerve miraculously spun;
> His mighty work, who speaks and it is done."

The first thing now demanding attention is the structure of insects, which is properly confined to the description of their systems of organs, and to the functions

they severally perform. The parts performing obvious offices, are commonly called the *organs* of these offices; thus the legs are the *organs of locomotion*, and the eyes the *organs of sight*.

Instead of having internally a frame-work of bones, insects have their *outer skin* hardened, and furnished with the power that bones possess, of supporting the softer parts, and providing points of attachment for the muscles. This skin completely covers the animal, like a suit of armour, and is variously jointed, that motion may be perfectly free.



The principal portions into which the body of an insect is divided, are the *head*, the *trunk*, and the *abdomen;* each being composed of several segments, as appears in the preceding page, in a representation of one of the beetle tribe.

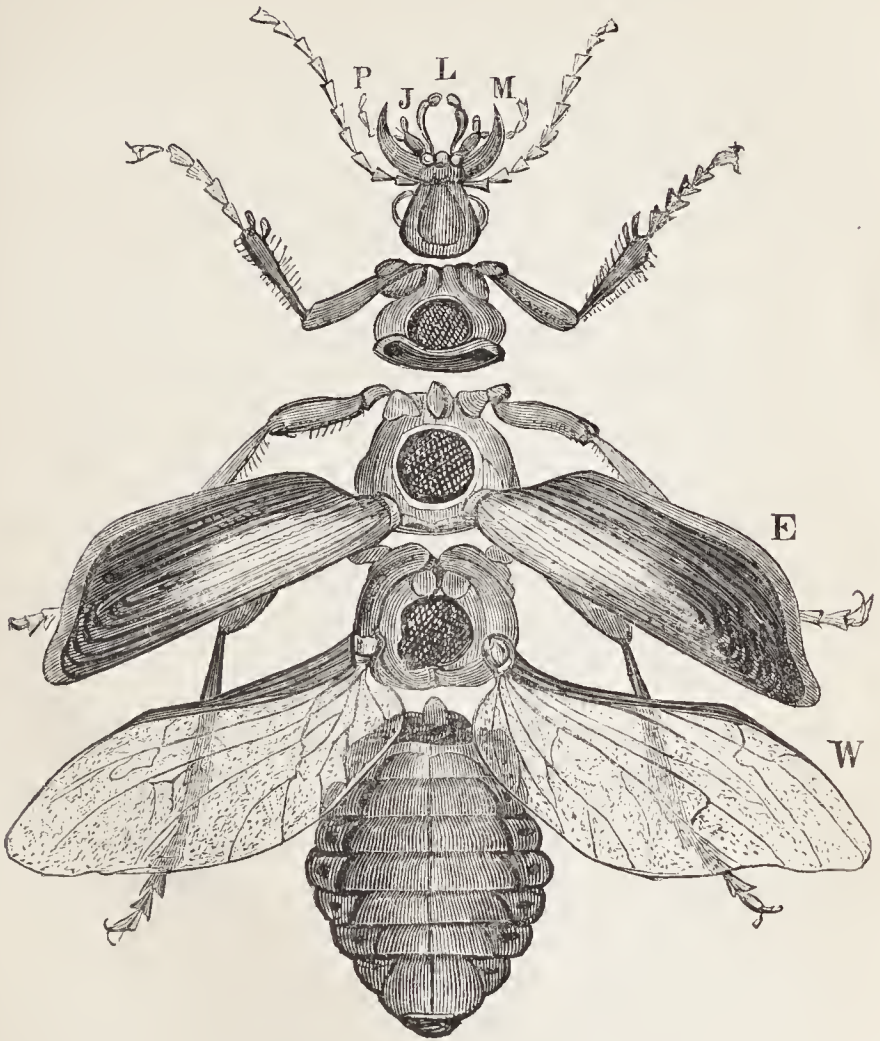
In the annexed figure, the several detached segments of which are represented on an enlarged scale, the head may be considered as formed of three segments, the trunk also of three, and the abdomen of nine.

The size of the *head*, as compared with the rest of the body, greatly varies in different insects. Its covering, called the skull, or cranium, is commonly the hardest part. Though it may seem to consist of a single, undivided piece, it is found to be actually formed of several pieces. Two of the segments belong properly to the face: from the one arise the *mandibles*, M; the *maxillæ*, or *proper jaws*, J; and also the *palpi*, P; from the *labial palpi*, L.

The *trunk*, as appears in the figure, is formed of three segments; in the first originate the first pair of legs; in the second the second pair of legs, and also the first pair of wings, or, as in the present case, the elytra, or wing-cases, E; while the third supports the third pair of legs, and the second pair of wings, W.

The third division of the body is called the *abdomen*,

it is composed of all the remaining segments. It



appears that the skeleton of insects has always the same number of elements, having the same relative situations

and order of arrangement, and that the endless diversity of form is owing to the various development of these elements. It has also been observed by Victor Audouin, that when one part is expanded, in others there is commonly a corresponding diminution.

As the food of insects is hard and solid, or of a more soft and fluid nature, many tribes of insects have a mouth fitted to tear and masticate the substances on which they feed; while many others have a tube-like mouth, or one like a delicate tongue, spirally rolled up when at rest, and extended when in action. Hence insects have been divided into *masticators* and *suckers*.

In briefly adverting to the former, it may be remarked, that the *mandibles*, or upper jaws, are two strong horny pieces, more or less curved, and often toothed on their inner edge.

Their motion is horizontal. In some creatures they are small and slender; in others they are large. These parts have considerable strength, and their structure is admirably adapted for their intended services. Some are armed with spines and branches for tearing flesh; others hooked for seizing, and at the same time hollow for suction; some like shears, intended for gnawing leaves; and others more resembling grindstones, able to reduce the hardest wood.

To some insects the mandibles supply the place of *saws*, *knives*, *trowels*, *spades*, and *pickaxes*. Thus the jet-ant works always in the interior of trees; and on one side may be found horizontal galleries, which follow the circular direction of the layers of the wood; and on another parallel galleries, separated by extremely thin partitions, having no communication except by a few oval openings.

Within the galleries, separate chambers are formed. Pillars, too, appear originally arched at both ends, and then worked into regular columns. Colonnades sustain the upper stories, and leave a free communication throughout the whole extent. The celebrated Huber, who observed these things, says: "I have seen fragments of from eight to ten inches in length, and of equal height, formed of wood as thin as paper, containing a number of apartments, and presenting the most singular appearance. At the entrance of these apartments, worked out with so much care, are very considerable openings; but in place of chambers and extensive galleries, the layers of wood are hewn in arcades, allowing the ants a free passage in every direction. These may be regarded as the gates, or vestibules, conducting to the several lodges."

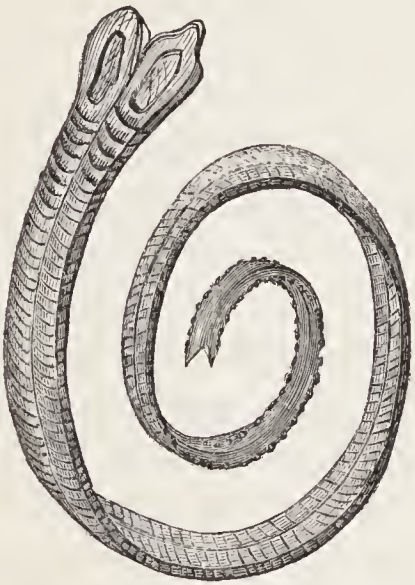
The jaws act as a *pair of scissors* to the rose-cutter bee, which makes a nest of portions of leaves. She cuts

off the pieces most accurately, forming what is like a set of thimbles put one on another, and enclosed in a case; and then she prepares a round piece to shut it, so that being filled with honey, and placed horizontally, not a drop can escape. "Truly," has it been remarked in reference to these creatures, "whether such a result is attained by instinctive or intellectual means, the glory is due to that Intelligence which maketh them and us."

The structure of an insect's mouth, which to be fully understood must be dissected and examined, may be more clear, if, as Mr. Newman remarks, it be compared with our own; supposing, however, the upper and lower jaws to be divided down the middle, the two halves of each to move from side to side, but meeting in front while the lips and tongue remain as they are. Now in this case the upper lip corresponds with the labrum; the lower lip with the labium; the divided upper jaw with the mandibles, the divided lower jaw with the maxillæ, the tongue with the tongue; and when both mouths are closely shut, the parts in each occupy similar places.

Sucking insects are as admirably fitted for their respective functions, as are those of a different class already described. Thus, as the tribes of moths and butterflies eat only the honey which is frequently situated at the bottom of a long tube, they have an organ admirably

fitted for its office. It is a slender, tubular *tongue*, sometimes three inches long, but rolled up when at rest, like the mainspring of a watch. The insect can instantly unrol it, dart it into the bottom of a flower, and draw up, as through a syphon, its delicious nectar.



This remarkable organ is apparently composed of innumerable rings, which must be moved by as many distinct muscles. Though seemingly simple, it is formed, in fact, of three distinct tubes : the two side ones cylindrical and entire, intended, it is thought, for the reception of the air; and the middle one, through which alone the honey is conveyed, is nearly square, formed of two

separate grooves, and projecting from the lateral tubes. These grooves, by means of a most curious apparatus of hooks, like those in the laminæ of a feather, fasten into each other, and can either be united into an air-tight canal, or instantly separated at the pleasure of the insect. In the cut there is a representation of the proboscis of one of these creatures.

The sucker of the brown aphis of the oak is much larger than the body, and, when unemployed, is carried between the legs, close to the belly, extending behind the insect like a tail slightly curved upward. It consists of a transparent tube, terminating in so minute a hole that Reaumur could not discover it with his most powerful microscopes; but he proved its use by pressing out of it a drop of fluid. By means of pressure he could also render more obvious two instruments of a brownish colour contained in the sucker, and which he supposed to act like the piston of a pump, though from their minuteness, this could not be fully established.

The antennæ (this word is the plural of antenna, as larvæ is of larva) arise from the skull between the eyes; and of the various organs of insects, none seem more important, and none are probably more wonderful and diversified in their structure. In no instance are there more than two; having an appropriate series of muscles

and nerves. They vary greatly in form, as appears from the few specimens given in the following cut; sometimes, too, they are short, and in one case,

more than four times the length of the body. They generally consist of a number of tubular joints, each having a separate motion, which enables the insect to give them every flexure necessary for its purposes. They are either wholly or partially covered with down or hair; and in some aquatic beetles they have a part which like the *lid of a box*, shuts them in when unemployed, and protects them from the water.

The principal use of the antennæ is as feelers or

guides, in directing the movements of insects. When some of them, and more particularly the *coleopterous*, or *wing-sheathed*, are about to move from any place of rest, they expand these organs, which have either been laid up in a cavity fitted to receive them, or back upon the body, before they take a single step; probably to ascertain the state of the atmosphere. As the insect begins to move, they, in many cases, do the same, and continue their action, until it returns to a state of repose. In some tribes the vibration is almost constant; in others, when one horn is raised, its fellow is depressed, as if by these means the insects balanced themselves.

Some naturalists have considered them organs of hearing. "A little moth," says Kirby, "was reposing upon my window, and I made a quick, not loud, but distinct noise; the antennæ nearest to me immediately moved towards me. I repeated the noise at least a dozen times, and it was followed every time by the same motion of that organ; till at length the insect being alarmed, became more agitated and violent in its motions. In this instance it could not be touch; since the antennæ were not applied to a surface, but directed towards the quarter from which the sound came, as if to listen."

They seem, too, to be a medium of communication.

When, for instance, the bees have lost their queen, the hive goes on well for about an hour; afterwards, a few of the workers appear much agitated, relinquish their labour and their young, and begin to pace about in a furious manner. Whenever they meet a companion, they cross their antennæ; and the one that seems first to have discovered the national loss, tells the sad news to its neighbour, by giving it a gentle tap with these organs. The latter becomes agitated in its turn, and runs over the cells, crossing and striking at others; and thus in a short time the whole hive is in confusion.

It is also said by Huber, that "Nature has given to ants a language of communication by the contact of their antennæ; and that with these organs they are enabled to render mutual assistance in their labours and in their dangers; discover again their route when they have lost it, and make each other acquainted with their necessities. We see then," he adds, "that insects which live in society are in possession of a language in common with us, although of an inferior degree."

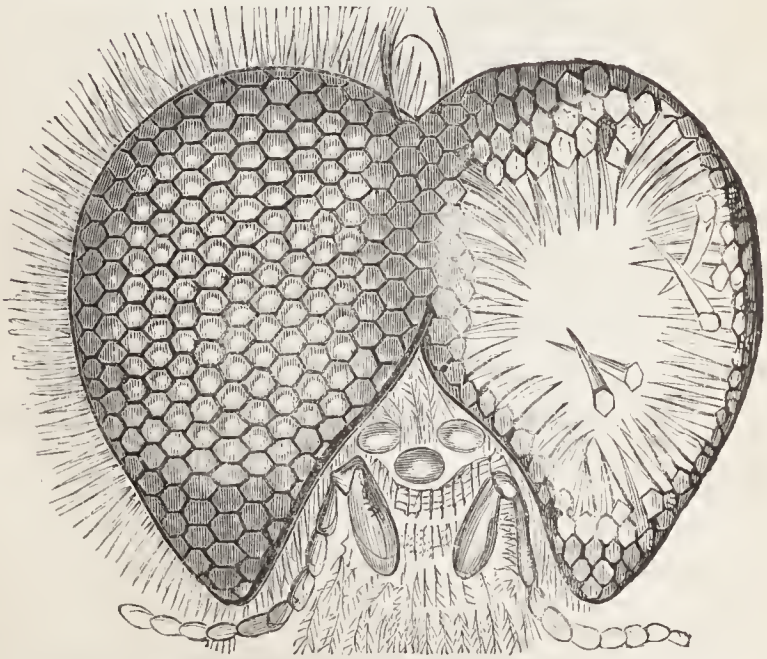
The *eyes* of insects have been well said to include "a world of wonders." Some eyes are called *simple*, and vary in number from two to sixteen. In many they are imbedded as usual in the head; but in a little scarlet mite, they stand upon a small foot-stalk, that the

hairiness of the insect may not obstruct its sight. Other eyes are called *conglomerate*, because they are collected into a body; thus, in the common millepede, there are twenty-eight, placed in seven rows, and forming a triangle, having seven at the bottom, and one at the top. Others are called *compound*, and, when under a microscope, seem to consist of a great number of hexagonal, or six-sided pieces. These lenses are not fitted closely to one another, but each one is situated in a square; their number varies from 20,000 to 50,000 in a single eye. Every one of them receives the image of an object, and appears very nearly to correspond in properties with the crystalline lens of the human eye; so that a butterfly may, without exaggeration, be said to possess 40,000 eyes.

Unlike those of larger animals, the eyes of insects are *not moveable;* and hence, while others have only two points of sight, they have myriads. In addition to the usual organs of vision, they have pellucid spots, called *stemmata*, frequently arranged in a triangle. Swammerdam found that there are nerves which diverge to them, though they are not easily traced.

That the stemmata and the compound eyes are alike the organs of vision, was proved by the experiments of Reaumur. He first smeared the latter over with paint, and the animals, instead of making for their hive, rose

in the air till he lost sight of them. He next did the same with the former, and placing the bees, whose stemmata he had painted, within a few paces of their hive, they flew about on all sides among the neighbouring plants, but never far: he did not observe that these ever rose in the air like the others. He also supposed that the compound eyes and these simple ones have different powers. The former, he concluded, magnified objects to a considerable extent, the latter but little; so that the compound eyes are for surveying things distant, and the others those that are near.



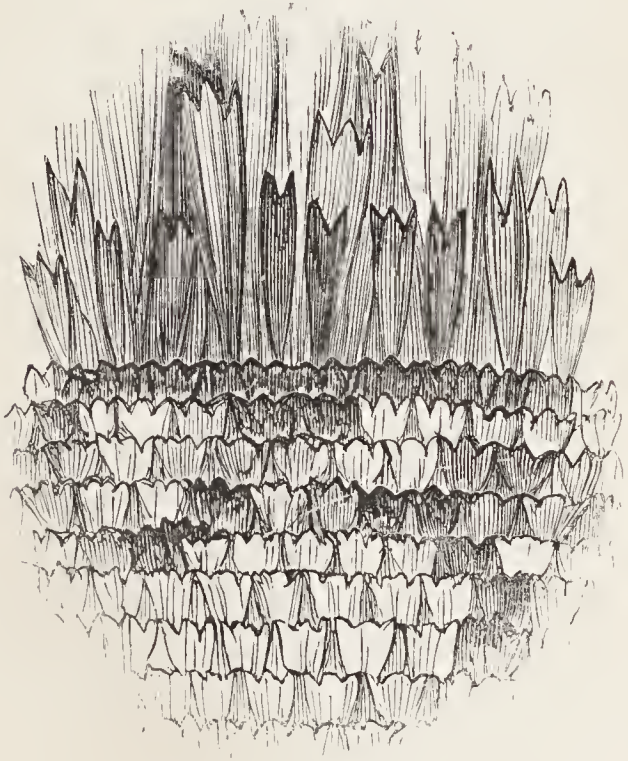
When a facetted eye, like that of a butterfly or a bee,

is closely examined, it will be found to have the appearance of a multiplying glass, the sides or facettes resembling a cut diamond. Puget placed the eye of a flea in such a position as to see objects through it; and very singular was the exhibition. A soldier appeared like an army of pigmies; for while it multiplied it also diminished the object: the arch of a bridge presented a spectacle more magnificent than could be made by human skill, and the flame of a candle seemed the illumination of thousands of lamps.

Leeuwenhoeck looked in the same manner through the eye of a dragon-fly, and viewed the steeple of a church which was 299 feet high, and 750 from the place where he stood. He could plainly see the steeple, though not apparently larger than the point of a fine needle. He also viewed a house in the same manner, and could discern the front, and distinguish the doors and windows, and perceive whether they were open or shut.

Every insect designed for flight, has *wings*, each consisting of two membranes, more or less transparent, applied to each other: the upper one being very strongly attached to the nervures, or veins, and the lower adhering very loosely, so as to be separable from them. The nervures are a kind of hollow tubes which originate in the trunk, and diminish gradually, the marginal ones

excepted, to their termination; and appear to contain air-vessels. The expansion of the wing is supposed to arise from a subtile fluid being introduced into these vessels, that an impulse may be given to every part of this remarkable organ; so that it is supported in its flight, like a sail by its cordage. It is aided also by other means.



The wings of butterflies, sphinges, and moths, are covered with scales, so very minute as to be taken for

extremely fine dust, yet of various forms, and placed in the most perfect order, the edges of the scales in one row, covering the insertions of those in the next, like the scales of a fish, or the tiles of a house, and having a great diversity of beautiful colours. Mosaic work, for personal ornaments, is formed of many small pieces of variously-coloured glass, stuck in a kind of paste, yet so minute as scarcely to be perceived; and with this the scales on the wings of insects have been compared. But here art is infinitely surpassed.

A piece of a peacock-butterfly's wing, a quarter of an inch square, was placed under a microscope, when 70 rows were counted, each containing 90 scales; there were, therefore, 6300 on one side of this small portion of wing. To a square inch there must be the amazing number of 100,736 scales.

But the number of glass pins in a square inch of fine mosaic is only 870, so that it is 115 times coarser than the wing of this butterfly, which is of middle size, and the scales of which are proportional. What, then, must be the comparison with some of the smaller tribes, whose dimensions are only a quarter of an inch? Mosaic work, moreover, is formed of inanimate matter, but the scales, by which they are so far surpassed, are a part of a living creature!

The fore-wings of insects are greatly diversified in texture. Some are composed of a brittle substance, others are distinguished by their tough, leathery nature, and some by their resemblance to elegant net-work.

CHAPTER IV.

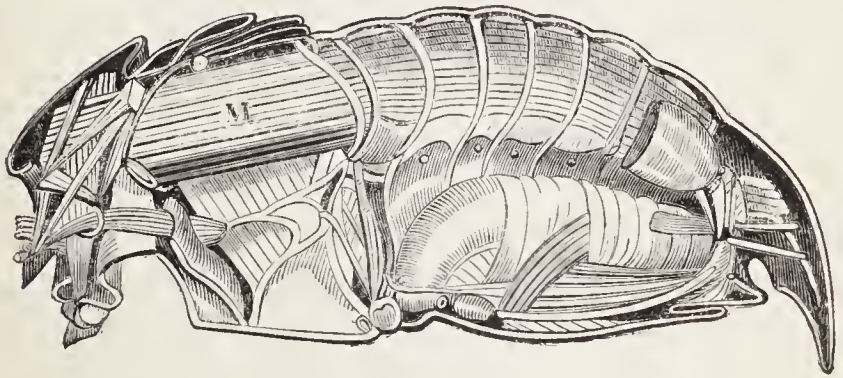
INTERNAL STRUCTURE OF INSECTS—ADMIRABLE ADAPTATION OF CREATURES TO THEIR CIRCUMSTANCES—UNION OF DIVINE WISDOM AND GOODNESS.

As yet, we have only partially attended to the structure of insects: other portions are equally remarkable. Their muscles, for instance, are united to their bony external covering, as in the human frame they are attached to the bones; and are admirably adapted, both in form and situation, to the circumstances of the animal. These organs of motion vary in shape; their ordinary colour is white, but it is said those for flight differ from the rest, by being of a deeper and reddish hue.

Lyonnet counted the muscles of the caterpillar of the Cossus, and found in the head 228; in the body, 1647; and enveloping the intestines, no fewer than 2186: which, after deducting 20 common to the gullet and the head, leaves a total of 4061. In the

human frame only 529 have been counted, so that this little creature has 3532 muscles more than ourselves!

Straus Durckheim has recently paid particular attention to the muscles of the cockchafer. The following is a copy from his representation of them. The largest mass of muscular fibres, marked M, forms the muscles which depress the wings, and are of enormous size and strength.



The muscular power of insects is indeed extraordinary. Some can leap two hundred times their own length; and Bradley asserts that he has seen a stag-beetle carry a wand half a yard long, and half an inch thick, and fly with it several yards. Others can resist pressure in a wonderful degree. One, for instance, an inhabitant of muddy pools, has been occasionally taken up with the water used in paper-making, and, according

to Linnæus, has resisted, *without injury*, the immense pressure given to the surrounding pulp.

"It is fortunate," says Mr. Kirby, "that animals of a larger size, especially noxious ones, have not been endowed with a muscular power proportionate to that of insects. A cockchafer, respect being had to its size, would be six times stronger than a horse; and if the elephant, as Linnæus has observed, were strong in proportion to the stag-beetle, it would be able to pull up rocks by the root, and to level mountains. But the Creator, in these little creatures, has manifested his almighty power, in showing what he could have done, had he so willed; and his goodness in not creating the higher animals endued with power and velocity, upon the same scale with that of insects, which would probably have caused the early desolation of the world that he has made. From this instance we may conjecture, that after the resurrection, our bodies, by a change in the structure and composition of their muscular fibre, may become fitted for motions, and potent agency, of which we have now no conception."

In animals having a spine, the *brain* is situated in the head, and in it all the *nerves* which are the organs of the senses originate. In insects no part is positively ascertained to be the brain; but nerves may be discovered

throughout the body, and traced to large masses or knots, placed at intervals through the whole length of the insect. In the nervous system of insects, there is, however, great variety, and a gradual change takes place in it, when they undergo their transformations; doubtless that it may be adapted to the altered functions of the animal in its new stage of existence.

In creatures with warm blood, sensation travels by means of the nerves and spinal marrow to the brain, where also all its perceptions terminate ; and if the communication be cut off at the neck, the whole trunk becomes paralytic. But if the heads of insects be cut off, the remainder of the body will continue to give proofs of life and sensation longer than the head. Both portions will live ; but the largest will survive the longest, and will move, walk, and occasionally fly, at first almost as actively without the head as when united to it. There is one insect which if cut in two, its halves will live and appear vigorous even for a fortnight afterwards; and what is still more remarkable, the tail part always survives the head two or three days.

It has already appeared that insects have the senses of *sight* and *hearing*, but it is equally manifest that they are endowed with others. Insects have certainly the sense of *smell*. Redi found that no maggots are gene-

rated, except from eggs laid by the parent flies; for when he carefully covered up pieces of meat with silk or paper, sealed down with wax, no maggots were seen. It also appeared that the parent flies attracted by the smell of the covered meat, not unfrequently laid their eggs on the outside of the paper or silk: being thus deceived by the very sense that was given them as a guide.

Other instances might easily be given. To ascertain whether the appearance of the flowers, or the odour of the honey, apprises bees of its presence, Huber placed honey near a hive in a window where the shutters almost closed, still permitted them to pass if they wished. Within a quarter of an hour, four bees and a butterfly had insinuated themelves, and were found feeding thereon.

For a still more accurate experiment, he had four boxes made, different in size, shape, and colour, with small card shutters, corresponding to apertures in the covering. Honey being put into them, they were placed at the distance of two hundred yards from the apiary. In half an hour bees were seen trooping thither; they soon discovered the openings through which they might introduce their bodies, and pressing against the valves, reached the honey. Their extreme delicacy of smell is here most obvious; for not only was the honey quite concealed from view, but its very effluvia, from being

purposely covered and disguised, could not be much diffused. On these insects the scent of mineral acids and volatile alkali was also found to act with peculiar power.

Some insects discharge offensive odours, it would seem, to annoy and frighten their enemies. A familiar instance of this appears in the large family of bugs, the fœtor of which is always similar though their food is various. The lady-birds, *Coccinellidæ*, emit a similar, but not so offensive an odour. That of the rove-beetles, *Staphylinidæ*, is very disagreeable; and some bees have a strong smell of garlic. A small green beetle, *Anchomenus prasinus*, is remarkable for its repeated discharges of smoke and noise. But it is not so well known as another, *Brachinus crepitans*, whose discharge resembles a popgun, accompanied with a sort of smoke, of which it is said to have a bladder sufficiently furnished to fire off twenty shots in succession. Its most formidable foe is a beetle, *Calosoma inquisitor*, and as the little bombardier cannot escape his merciless adversary by speed, it stops short, prepared to give battle. Accordingly as the enemy advances, making sure of his prey, he is saluted, when about to seize it, with a discharge, and amidst his surprise, the little creature frequently escapes.

In the exercise of *taste*, insects ramble far and wide. The vegetable kingdom presents to them a vast field for

their banquets; while the larger animals are limited to a comparatively small portion. Apart from the grasses and a few herbs and shrubs, the rest of the plants which cover the face of the earth, are to them either disgusting or absolutely poisonous. But from the gigantic banyan which covers acres with its shade, to the tiny fungus which the eye can scarcely perceive, there is a wide-spread provision of which insects may partake. It is probable that not a single plant exists, even of those which to others are most offensive, that does not yield to some one or other of these creatures a delicious provision.

For them, indeed, a considerable portion of vegetables must have been provided. To mankind and the larger animals, for instance, the common nettle appears of little use, yet it yields food for at least thirty distinct species of insects. Nor is this all. The large herbaceous animals can subsist on no other part of plants than their leaves and seeds, either in a recent or dried state, with sometimes the addition of the tender twigs or bark; but every part supplies proper food for different tribes of the insect race.

Some attack the roots; others the trunk and branches; a third class feed on the leaves; a fourth, with a more delicate appetite, prefer the flowers; and a fifth the fruit or seeds. A further selection even takes place.

REMOVING BEES IN FRANCE.

Of those which feed on the roots, stems, and branches of vegetables, some grubs eat only the bark, others the alburnum, others the resinous or other secretions, a fourth class the pith, and a fifth penetrates into the heart of the solid wood. Of those which prefer the leaves, some taste only the sap which fills their veins; others eat merely the pulpy substance; others only the lower surface of the leaf; while some devour its whole substance. Of the flower-feeders, some eat the petals; others in their perfect state, choose the pollen, and a still larger class the honey secreted in the nectaries.

In the management of bees a great deal depends on supplying them with an abundant pasture. During a large part of the year a rich corn country is to them as a wilderness. They require therefore to be shifted from place to place, according to the circumstances of the season. Thus Celsus advised that after the vernal pastures were consumed, they should be transported to places abounding with autumnal flowers; and hence in ancient times they were annually carried from Achaia to Attica, and from Eubœa and the islands of the Cyclades to Scyrus. The same course is pursued in France.

In our own country the example is also followed. As soon as the bright flowers of summer are on the wane,

the people of the lowlands despatch their hives in cart-loads to the blooming heather of the mountains, where the bees may enjoy an unfailing banquet of sweets. "It is indeed to be regretted," says a modern writer, "that our moorlands, in this respect, are so much more neglected than they ought to be. The very air of the highland hills is often redolent with the rich perfume, while here or there a solitary bee is seen or heard labouring with wearied wing among the inexhaustible stores of nature, and scarcely able to regain its lonely shielding in the distant vale." This is to be regretted as the mountaineers are poor and often want employment. It has been calculated that the pastures of Scotland could maintain as many bees as could produce 4,000,000 pints of honey, and 1,000,000 pounds of wax; and were these quantities tripled for England and Ireland, the produce of the British empire would be 12,000,000 pints of honey, and 3,000,000 pounds of wax annually.

But while we are thus neglectful, the people of Egypt, according to Maillet, imitate in some degree the industry and skill of their forefathers. One of their most admirable contrivances is, their sending their bees annually into distant countries, in order to procure them sustenance there, at a time when they could not find any at home; and then afterwards bringing them back, like

shepherds who should travel with their flocks and make them feed as they go.

It was observed by the ancient inhabitants of Lower Egypt, that all plants blossomed and the fruits of the earth ripened above six weeks earlier in Upper Egypt, than with them. The means they used in consequence, to enable their bees to reap advantage from the more forward state of nature there, are still employed by their descendants.

About the end of October, all such people of Lower Egypt as have hives of bees, embark them on the Nile, and convey them by that river into Upper Egypt, just at the time when the land has been sown, and the flowers begin to bud. The hives thus sent are marked and numbered by their respective owners, and placed pyramidically in boats prepared for that purpose. After remaining some days at the furthest station, and they are supposed to have gathered all the wax and honey they could find in the fields within the space of two or three leagues, they are conveyed in the same boats two or three leagues lower down, and are left as long as is necessary for them to collect the sweets of this spot also. Thus the nearer they come to the place of their usual abode, they find their food forward in proportion. At length, about the beginning of February, after

having travelled through the whole length of Egypt, gathering the rich produce of the banks of the Nile, they arrive at the mouth of that river, towards the ocean, from whence they set out, and from whence they are now returned to their several homes. An exact register is kept of every district from whence the hives were sent in the beginning of the season, of their numbers, of the persons who sent them, and likewise of the mark or number of the boat to which they belonged.

The two feelers, with which the heads of insects are provided, and the four joined to the mouth, appear specially intended for the sense of touch. Kirby contends, moreover, that they have an internal sense. "The picture," he says, "may be painted on the retina of the eye, and the sound may strike on the tympanum of the ear, but neither the one nor the other can be received by the intellect, unless the internal power or faculty of perception be in action, and mediate between them. This is what I mean by the internal sense, which, to use a term of Mr. W. S. Mac Leay's, is osculant between intellect and sense, or forms the transit from one group of powers to the other."

In animals having a spine, the whole of the blood contained in the body is supposed to pass through the heart: the bodies of insects have not this member, but

blood-vessels are attached to large reservoirs, which form a line the whole length of the insect. The blood, if so it may be called, is thin, transparent, and colourless. Its circulation has been, until lately, considered very doubtful. It was, indeed, long known by naturalists that it must take place to prevent the consequences of stagnation; but the proof of it was wanting. At length, however, the discovery has been made; and the circulation is found to be as beautifully perfect, and the pulsations as regular, as in the human system.

To Mr. Bowerbank we are much indebted for his observations on the circulation of the blood in insects. The larva of an ephemera, properly fixed in the microscope, presents, he says, a truly beautiful sight. The blood, abounding in flattened oat-shaped particles, is seen circulating in every part of the body, not in a continuous stream, but at regular points. The action of the valves is singularly interesting.

The head of another larva is, however, much more transparent than that of the ephemera, and affords therefore a still better view of the circulation in this part. Here the blood is seen rushing, like a beautiful intermittent fountain, towards the mouth, and dividing right and left into two jets, a portion of each of which flows within a given boundary past the back of the eye,

whilst the remainder winds its way through other channels, deep in the side of the head, and returns again into the body.

In the antennæ of this insect, too, the circulation is carried forward within well-defined vessels. Each is composed of six joints, up four of which the blood is seen to take its course; and passing round the end of the fourth joint, it returns by a distinct vessel into the head.

In the leg, likewise, the circulating fluid and its vessels, are clearly to be traced; and, as in the antennæ, the particles of the blood are seen to descend on the one side of the leg, and turning the extreme point, to return up the contrary side to the one by which they come down. Mr. Bowerbank, and a friend of his, clearly saw a fluid pass down the side of one of the principal ribs of the wing in a perfect insect, and in this last stage of insect-life, he thinks the circulation is carried forward as well as in the larva, though, perhaps, not with so much vigour as when the animal is young and growing.

The structure of the *alimentary canal* in insects is wonderfully diversified. Not only are differences discoverable as we pass from family to family, and from species to species, but the same individual will often be found to have a digestive canal quite different, accord-

ing as it is examined in its grub or perfect state. All these variations exactly accord with the temporary or constant mode of life of the creatures in whom they appear. "Thus," says Cuvier, "the vivacious larvæ," or grubs, "of the scarabœi and butterflies have intestines ten times as large as the winged and sober insects, if I may use such an expression, to which they give birth."

In two beetles, which have been examined, a remarkable difference has been observed. In the one there is no crop or gizzard, but the stomach is fringed on each side, and there are three pairs of bile-vessels; while in the other, the gullet is dilated into a crop, which includes a gizzard, in which the Divine wisdom is singularly apparent. Though so minute as scarcely to exceed a large pin's head in size, it is said to be provided internally with more than *four hundred pairs of teeth*, which are moved by an immensely greater number of muscles. The object of this extraordinary structure is the comminution, or reducing to powder of the timber which this beetle has to perforate and probably devour. Its stomach has only two pairs of bile-vessels.

Insects have no part like the *wind-pipe* of other creatures, solely appropriated to breathing; but the organs

of respiration, which consist of simple tubes, may be found in every part of the body. These internal organs, by which the air received is distributed, are full of wonders. The structure of the trachea of the cossus, for example, is admirably adapted to its purpose. Had its vessels been composed of membrane, that is, of a web of interwoven fibres, they could not possibly have been kept from closing; but this is guarded against, and the necessary tension or stretching of the tubes provided for, by a corkscrew-like cartilaginous, or *bony thread* intervening. Thus, however small the vessels, or violent the contortions of the insect, they are always sure to remain open.

Moreover, the two tracheæ give birth to 236 tubes; and adding the smaller ones into which they ramify, they have, in fact, 1004 branches. All these are necessary; for not only are they carried along the intestines, penetrating and filling every ganglion or knot, but they are also distributed to the skin and every organ of the body, and accompany the most minute nerves through their whole course.

The little wriggling, worm-like animals, sometimes seen in tubs of rain-water, ascending to the surface, remaining there awhile, and then sinking to the bottom, are the grubs of some species of gnat, which are fur-

nished with a very singular organ. It is tunnel-shaped, and ends in five points, like a star; and by this it is usually suspended at the surface of the water, and preserves its communication with the atmosphere. When the animal is disposed to sink, the points or rays of this part are used to close it, and to cut off this communication. When it is immersed, a globule of air remains attached to the end of the tube, so that it is lighter than the water, and requires some effort to reach the bottom; but when it wishes to rise, it has only to unclose the tube, when it easily ascends to the surface, and remains there for any length of time.

The grub of a chameleon-fly has a breathing organ, resembling, in some degree, as appears in the cut on the next page, the arms of what are called sea-anemonies. The last joint of its body is very long, and ends in an orifice, (to receive the air,) which is surrounded by a circle of diverging rays, consisting of beautifully feathered hairs, or plumes. These are so prepared as to repel the water, in order to suspend the animal by its tail at the surface, and preserve a constant access of air. When it sinks, it turns these hairs in, and shuts the orifice, carrying down with it an air-bubble, that shines like quicksilver; and which it is supposed enables it again to become buoyant when it wants to breathe.

The air-tubes of insects communicate with the air by means of *apertures*, called *spiracles*, which are very various in form, size, and number, and occur at intervals along their sides. Sometimes these spiracles are furnished with movable lips, which the insects can close at pleasure, and thus exclude all injurious substances; at others they are furnished with a fringe of delicate hair, which answers the same purpose; and sometimes they are constantly open, without any kind of pro-

tection, but obviously for the important reason, that none is required.

Such then is a brief view of the structure of the insect tribes. Scarcely any situation is without some peculiar to itself, and hence for varied circumstances they are fully prepared. Thomson seems to have been familiar with their haunts, when he said:—

"Ten thousand forms! ten thousand different tribes!
People the blaze. To sunny waters some,
By fatal instinct fly: when, on the pool,
They sportive wheel; or, sailing down the stream,
Are snatched immediate by the quick-eyed trout,
Or darting salmon. Through the greenwood glade
Some love to stray; there lodged, amused, and fed
In the fresh leaf. Luxurious, others make
The meads their choice, and visit every flower,
And every latent herb: and where to wrap,
In what soft beds, their young, yet undisclosed,
Employs their tender care. Some to the house,
The fold, and dairy, hungry, bend their flight;
Sip at the pail, or taste the curdling cheese:
Oft, inadvertent, from the milky stream
They meet their fate; or, weltering in the bowl,
With powerless wings around them wrapt, expire."

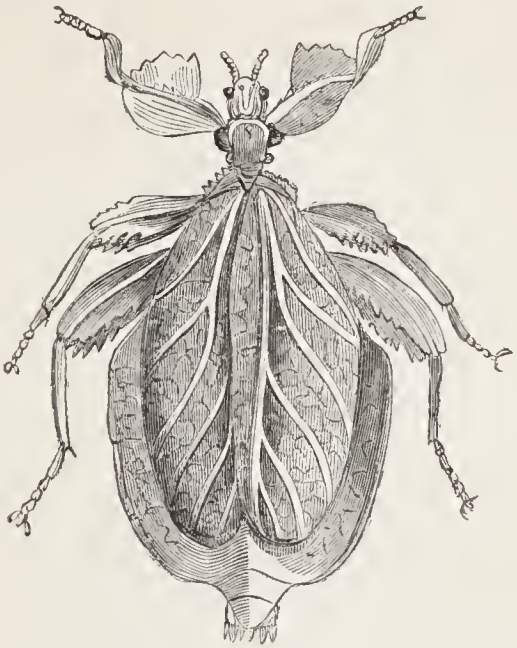
Among the many remarkable provisions made for the security of insects, is one which may here be noticed, their resemblance to the objects near or in which they are, under ordinary circumstances, to be found. "One of our scarcest British weavils," says Kirby, "by its grey

colour, spotted with black, so closely imitates the soil, consisting of white sand, mixed with black earth, on which I have always found it, that its chance of escape, even though it be hunted for by the lyncean eye of an entomologist, is not small."

"Many insects are like pebbles and stones, both rough and polished, and of various colours. Many of the mottled moths, which take their station of diurnal repose on the north side of the trunks of trees, are with difficulty distinguished from the grey and green lichens that cover them. The spectre tribe go still further in this mimicry, representing a small branch with its spray. I have one from Brazil, eight inches long, that unless it was seen to move, could scarcely be conceived to be any thing else; the head, as well as the legs, having their little knags and knobs, so that no imitation can be more accurate."

Many imitate dry leaves so exactly by their opacity, colour, rigidity, and veins, that were no other part of the animal visible, even after a close examination, it would be generally affirmed to be nothing but a dry leaf. It is said, that some of these insects, of different species, from India, Africa, and South America, were so like the sear and yellow leaves of autumn, or the half unfolded, sap-green leaves of spring, that were even thousands clinging

to a bush or tree, the eye of man would pass them without notice. How much is there then in the circum-



stances of insects to urge us to admiration and praise! If an artificial spider, in which "a thousand movements scarce one purpose gain," demands a tribute to the talent that could devise, and the delicate hand that could execute its mechanism, what should we think of that Great Artificer, who, while he has adapted every creature to his condition, has, in the ten millionth part of the bulk of that spider, established organs of vitality and motion incalculably more perfect!

The insect race are the most numerous of the whole

class of organized beings, to whom has been granted the vital principle. All are fitted for their place in creation, their peculiar mode of life, and the purposes they are designed to serve. Nothing is wanting to preserve existence, to afford defence, to secure food, or for motion from place to place. As this adaptation is a proof of Divine *wisdom*,—because the means are most admirably adapted to the end; so it is also a proof of Divine *goodness*—because that end is the welfare of the animal.

The same combination appears also in other parts of the creation of God. It forcibly strikes on the devout mind as it passes from the lowest to the highest grade of animated existence. Yet, when it pauses here, there are superior objects to which it may turn, and which are calculated to excite kindred feelings of far greater strength. The stars, so bright and glorious, as they array the dark curtain of the night, are lost amidst the splendours of the sun, and thus is the brightness of creation eclipsed by the far-surpassing splendour of redemption.

To have a view of wisdom united with love, on which the eyes of the excellent of the earth have been and still are fixed, and on which angelic beings themselves delight to gaze, we must repair to the Saviour's cross.

Here these perfections of the Godhead are pre-eminently conspicuous—here they shine forth with transcendant glory. Paul, as he takes his station on Calvary, exclaims, "Christ crucified is the wisdom of God;" while John is heard saying with equal emphasis, "Herein is love, not that we loved God, but that he loved us, and sent his Son to be the propitiation for our sins."

And what are the obligations which such a display of the Divine attributes enforces? Not assuredly, to make human science the great object of life; but to "count all things but loss, for the excellency of the knowledge of Jesus Christ our Lord." To contemplate Him as the great and only Redeemer—to trust entirely in his mediation—to love Him with supreme affection—and to seek, by holiness and usefulness of life, the glory of his name, is the highest display of human wisdom. The charge is issued—and it comes alike to him who reads and him who writes—"Seek ye *first* the kingdom of God, and his righteousness;" and as it is obeyed, the promise in reference to whatever is desirable and necessary shall be fulfilled: "*All* these things shall be added unto you."

CHAPTER V.

INSTRUMENTS FOR DEPOSITING EGGS—THE APPLES OF SODOM —DIVERSITY IN THE EGGS OF INSECTS.

The provision made by insects for their future young, is very remarkable. Quadrupeds and birds are able to attend to their progeny during the early stages of their existence, but these animals, with few exceptions, do not live to see their descendants ; hence has a gracious Providence granted them a degree of foresight, which compensates for the want of this special care. The movements of the insect mother may therefore excite peculiar interest.

It is here, however, desirable to state, that she is provided with an instrument called an *ovipositor*, by which she may lay her eggs in places where the grub may find food as soon as it is born. This is one of the most remarkable gifts, both as to its structure and operation, which God has bestowed on these little creatures. Sometimes it has one part inside another like the pieces of a telescope ; at others it is cylindrical as they are, but ending in a pair of joints, which seem to act as forceps,

or pincers, including a tube, probably to convey the egg, that the pincers may introduce it ; and, in some instances, the ovipositor is bent like a sabre.

Above is a representation of the augur, as Reaumur calls it, of the cicada—styled improperly by some, the grasshopper: it is composed of a horny substance, and lodged in a sheath, which lies in a groove of the last ring of the belly. A slight pressure brings it forth, when it appears to be of equal thickness throughout, except at the point, where it is somewhat enlarged and angular, and has fine teeth on both sides. The sheath is composed of two horny pieces, slightly curved, and ending in the form of a long spoon, so that the concave, or hollow part, may receive the convex or rounded end of the ovipositor.

When this instrument is examined with a microscope, there appear nine strong teeth on each side, placed very regularly, and becoming finer towards the point, where there are three or four which are very small. Simple as it seems, it is composed of three pieces; two outer, armed with the teeth just mentioned, which Reaumur calls files, and another pointed like a lancet, but not toothed. The former can be moved backwards and forwards, while the latter remains fixed; and the means by which the three pieces are held united, while the files can easily be put in motion, are most exquisitely contrived. Beside the muscles necessary for the movement of the files, the handle of each ends in a curve of the same hard substance as itself, which not only supplies the muscles with a sort of lever, but serves to press, as with a spring, the two files close to the central piece.

Another remarkable instrument appears in an insect, to which Reaumur gave, in consequence, the name of the saw-fly. In some respects it is like, and in others unlike, the cabinet-maker's tenon-saw, which is made of a thin plate of steel, fitted into an iron back. The saw of the insect has a back; but while the former has a narrow groove cut to receive the plate which is fixed, the groove of the latter is in the plate, and receives a ridge from the back which is not fixed, but

allows the saw to slide backwards or forwards, as it is thrown out or drawn in. The tenon-saw is single, but that of the insect is double, being, in fact, two distinct saws; in using which, one is thrown out, and, as it returns, the other is pushed forward; and this motion proceeds till the incision is made, when the saws, receding from each other, conduct the egg between them into its place. In the tenon-saw, the teeth are alternately bent towards the sides, that the cut may allow the blade to move easily; and to answer the purpose in some degree, the teeth of the insect's saw are a little twisted, and on the outer side of each, small teeth are placed, to act as a rasp. When by this extraordinary instrument a groove is made, and an egg placed in the cavity, the greater part of the saw is drawn into its sheath, and a liquid, something like soap lather, is dropped over the egg, to glue it to the spot, or defend it from the juices of the tree. One fly was observed to make six grooves in succession, which occupied her about ten hours and a half.

Another provision is also remarkable. Vegetable excrescences called galls, some of which resemble beautiful berries, and others apples, may be frequently observed on the leaves of the oak; one species of which, the Aleppo gall, is of much importance. All these tumours arise from an egg, almost too small for sight, being

deposited in a substance out of which they grow, by a little four-winged fly.

If its belly be gently pressed, the ovipositor by which this is done issues from a sheath, in appearance like a small curved needle, of a chestnut-brown colour, and of a horny substance, and three times as long as it first appeared. As, too, it is much longer than the body of the insect, and from its horny nature cannot be either lengthened or shortened, it is bent into the same curve as the body, by mechanism similar to that of the tongue of the woodpecker, which, though rather short, can be darted out far beyond the beak, by means of the forked bone at the root of the tongue being thin, and rolled up like the spring of a watch. The base of the ovipositor of the gall-fly is placed near to the anus, runs along the curvature of the back, makes a turn at the breast, and then following the curve of the belly, appears again near where it originates.

Such, then, is the curious instrument by which an egg is introduced, and, in a few hours, it is surrounded with a fleshy chamber, which serves the young for food, as well as shelter and defence. Some of these habitations are of a globular form, a bright red colour, and smooth fleshy consistence, resembling beautiful fruits, for which, indeed, they are eaten in the Levant ; others, beset with spines,

NESTS OF A GALL-FLY.

or clothed with hair, are like seed-vessels. In short, they are of a hundred different forms, as Kirby says, and of all sizes, from that of a pin's head to that of a walnut.

One instance is, however, too remarkable to be left unnoticed. It is furnished in the following memorandum made by a traveller:—"Among the trees in the forest between Ein Jerah and Adjeloon, in the Hauran, was one on which we found what we conceived to be the true Dead Sea apple, described by Strabo. The Arabs told us to bite it, and laughed when they saw our mouths full of dry dust. It is about the size and shape of a small fig, of a dark reddish-purple colour, with rows of small thorns in the upper end; it seemed not to be a fruit, though called so by the Arabs, but was attached artificially to the branches of this and another sort of tree. The inside was full of a snuff-coloured spongy substance, crumbling into dust when touched. Most were perforated with a small hole. This, and the mode of their attachment, and the fact that they contained no seeds, indicate them to be the work of an insect."

It appears to be a gall on a species of oak. Nothing can be more beautiful than its rich, glossy, purplish-red exterior; nothing more bitter than its porous and easily pulverised interior. Each one, however, contains

only a single inhabitant, which escapes in the winged state, having consumed but a very small portion of the centre of the gall. It is a curious fact, occurring also in some of our British galls, that so large a provision should be made for the insect.

Some moths employ a very singular covering; hair stripped from their own bodies. With this material, which they pluck by means of a pincer-like ovipositor, they first form a soft couch on the surface of some leaf; they then place on it successively, layers of eggs, and surround them with a similar coating of down, and when the whole number is deposited, cover the surface with a roof of hairs, which cannot be too much admired. Those used for the interior of the nest are placed without order, but those employed externally, are arranged with as much art and skill as the tiles of a roof, and as effectually keep out the water, one layer resting partly on the other, and all having the same direction; so that the whole resembles a well-brushed piece of shaggy cloth, or fur. When the mother has finished this labour, which often occupies her for four and twenty hours, and sometimes even twice that period, her body, which was before extremely hairy, is almost wholly naked, having stripped herself to supply clothing to her offspring; and when this duty is finished, she expires. One part of

these moths has an extraordinary quantity of hair for this express purpose.

The great water-beetle spins an egg-pouch, which somewhat resembles a turnip when reversed. Its great diameter is three quarters of an inch, and the small half an inch, from which rises a curved horn, about an inch long, and ending in a point. The insect is provided with a pair of spinners, which move from right to left, and up and down, with great quickness, and from these a white and glutinous fluid appears to issue, that forms the pouch, and from which it is constructed in about three hours. The outer tissue is produced by a kind of liquid and glutinous paste, which, when dried, becomes a flexible and water-proof covering; the second, which envelopes the eggs, is a very white sort of light down, that keeps them from injuring each other. The tissue of the horn is silky, porous, and shining, and much like many cocoons, and it is supposed to be calculated to admit the air. At its base there is an opening for the egress of the insect when hatched, which is closed by some threads, (says Kirby,) that the air confined in the pouch may hinder the water from getting in.

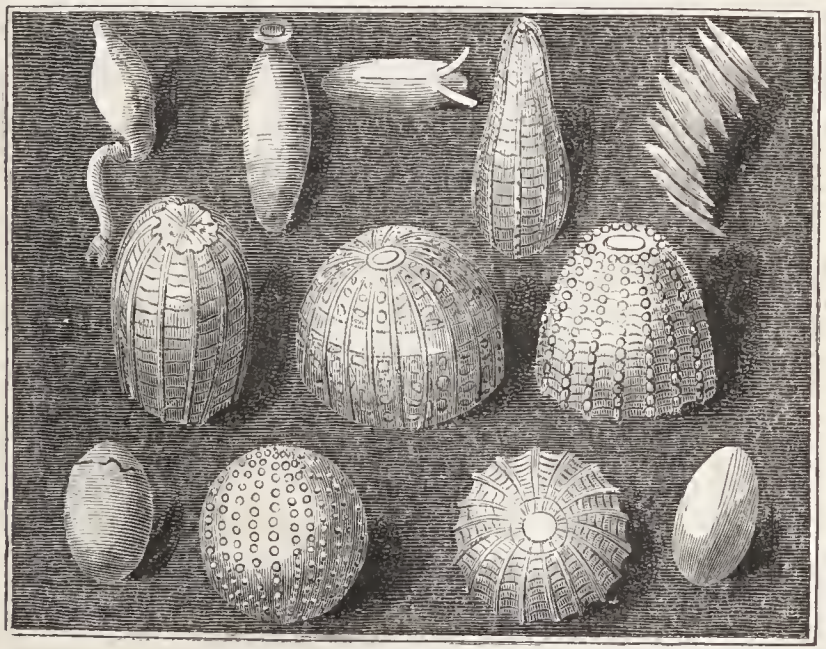
This singular structure does not float at liberty in the water till after the eggs are hatched, the insect always attaching it to some plant. "By means of this anomalous

process for a beetle," says the interesting naturalist just mentioned, "which this insect is instructed by Providence thus to perfect, the precious contents of its little ark are secured from the action of the element which is to be the theatre of its first state of existence, from the voracity of fishes, or the more rapacious larvæ of its own tribe, until the included eggs are hatched, and emerge from their curious cradle."

Another remarkable fact is stated in connexion with a very common wandering spider, called the wolf, and first observed, it is believed, by the celebrated Harvey. In order to hatch her eggs the better, she carries them about in a case, with great solicitude and affection; insomuch that when the skin forming it is, by any accident, broken off from the hinder part of her body, she seeks it with as much diligence and earnestness as a hen would for the chickens she had lost; and when it is found, she fastens it again to its place with marks of much joy. Ferocious in aspect, she manifests an extraordinary change of mien when forcibly deprived of her eggs. It is said she becomes instantly tame, stops to look around her, begins to walk at a slow pace, and search on every side for that she has lost; nor will she even fly when any one threatens to seize her. But should her bag of eggs be restored, she secures it with all haste, and

darts away in a moment; or, if undisturbed, leisurely attaches it again to her body.

By far the greater number of insects lay their eggs singly. Sometimes many are extruded at a time, with great rapidity; at others, minutes, hours, and even days, elapse between the extrusion of each egg. A common moth ejects a large number of very small black eggs, resembling grains of gunpowder, with great speed, and sometimes with the force of a pop-gun; and a crane-fly has been said to project its eggs to a distance of more than ten inches.



There is, as appears in the cut, a great diversity in

the shape of eggs, and sometimes their form seems very strange. Thus the eggs of the common water-scorpion are oblong, and at the upper end are surrounded by a coronet, consisting of seven slender rays of bristles. These, however, are so admirably packed, the unarmed end of each egg fitting closely into the space inclosed by the spines of the one next below it, that no room is lost, and the eggs are secure from all injury.

The eggs of some beautiful flies are oval, and, in certain cases, each of them is attached to a pedicle, or stalk, not thicker than a hair, and seven or eight times as long as the egg. By this pedicle they are planted in groups of ten or twelve, on the surface of the leaves and twigs, from which they project like so many small fungi. When the grub which they include has made its way out, by forcing open the top, they look like little vases, and were once figured as parasitic flowers growing on the leaves of the elder. The provision of the pedicle is most probably designed, in the goodness of God, to place the eggs out of the reach of insects which roam around them. Thus raised on their slender shaft, they are as safe as the twig-suspended nest of the tailor-bird. The foot-stalks of the eggs are formed by the mother-fly attaching a drop of gluten to the branch, and drawing it out to the requisite length before the egg is deposited on its summit.

The eggs of insects are various in colour. In some cases they are white, and in others yellow, orange, blue, green, and of every intermediate shade between red and black. A naturalist was, on one occasion, much surprised at seeing the water at one end of a canal in his garden as red as blood, and on examining it further, he found it discoloured by an incalculable number of minute red eggs.

Some eggs are speckled; others are banded with different colours; and others are brown, with a white zone. Many, after being laid a few days, assume a very different colour, and that of almost all eggs changes when they are near hatching. But this depends more frequently on the colour of the included grub, which appears through the transparent shell of the egg, than on any actual alteration in the egg itself. Sometimes, though rarely, the eggs of insects are covered with down or hair. Those of one little creature are shielded like itself, by a downy web. The eggs of a bug have a sort of net-work, with black veins, in which very short bristles are planted. "I possess," says Mr. Kirby, "a nest of brown eggs, found upon furze, which appear to be covered with very short downy hairs. The top of these is flat, and surrounded by a coronet of short bristles, each surmounted by a small white ball." Some tribes place their eggs in groups,

as do most butterflies, moths, and many beetles. Some species of fly extrude them in a sort of chain or necklace, each egg being connected with those next it by a gummy matter: others lay them in double masses, each mass containing several hundred eggs.

The manner of the cock-roach is not a little remarkable. The female, who occupies nearly a whole week in the business, deposits one or two egg cases as large as half her body: at first they are white and soft, but afterwards they become brown and hard. Each case contains sixteen or eighteen eggs, and when they are hatched, the young cock-roaches make their escape through a cleft at the side, which shuts so closely when they have quitted it, that the aperture can scarcely be detected. Eggs sometimes appear without order in a confused mass; but more frequently they are arranged in different, and often in very beautiful modes. Thus, as the eggs of lackey-moths, which are laid in the autumn, are not hatched until the spring, and the insect does not, like most other moths, place them upon a leaf, with which they might be blown far from their destined food, they are deposited upon the twig of some tree, round which she ranges them in numerous circles. With such admirable art is this done, that observing them on your fruit-trees, you would rather take them for pearls, set

by the skilful hand of a jeweller, than for the eggs of an insect.

Each of these bracelets, as they have been aptly termed, is composed of from two to three hundred pyramidal eggs, with flattened tops, surrounding the twig in a series of from fifteen to seventeen close spiral circles, and having their interstices filled up with a tenacious brown gum, which, while it secures them alike from the wintry blast, and the attack of voracious insects, serves as a foil to the white enamel of the eggs that it encompasses. How such an arrangement can be completed by insects with their tails and hind feet, it is not easy to conceive. In the hope of ascertaining this, Reaumur made several experiments; but the insects, so far from disclosing the secret of their art, laid their eggs at random, and made no attempt to place them symmetrically.

The egg of the gnat is shaped like an olive, or a powder-flask, and by itself would sink in the water, and yet, this insect glues from 250 to 300 in an oblong mass, which is pointed and more elevated at each end, so as to resemble in shape a little boat, which will actually swim safe and unhurt until the grubs are hatched. The lower part on which it always floats is convex, and the upper is concave; and so buoyant is it, that no

agitation of the water, however violent, can sink it. Mr. Kirby says, "To put this to the test, I put half-a-dozen of these boats upon the surface of a tumbler half full of water. I then poured upon them a stream of that element from the mouth of a quart bottle, held a foot above them. Yet, after this treatment, which was so rough as actually to project one of them out of the glass, I found them floating as before on their bottoms, and not a drop of water within their cavity."

The process by which the boat is made is very remarkable; it is exhibited in the engraving. A gnat has six legs: the four fore legs she rests on a floating leaf, or on the side of a bucket, if she is in water contained in such a vessel; and her body is thus held level with the water, except the last ring of her tail, which is a little raised. She then begins to raise her two hind legs, which she crosses in the shape of the letter X, the open part of which, next the tail, serves as a kind of scaffold for the eggs she lays until the boat is nearly formed. Each egg when laid, is covered with a sort of glue; the gnat holds the first-laid egg in the crossed legs until the second is placed by its side, and fastened to it; she then glues to these another egg, making a triangle; and this is the beginning of the boat. Thus she goes on, piling egg on egg, always

THE GNAT'S BOAT OF EGGS.

keeping the boat in proper shape by her useful hind-legs; and as it grows in size, she pushes it from her by degrees, still adding to the unfinished end next her body. When it is of the required size and state, she flies away, and leaves it to its fate, floating on the water.

The period of exclusion from the egg does not depend entirely on temperature; it is affected in some measure by other circumstances. In proportion, however, as the germ it includes is expanded, it becomes visible through the shell when transparent; this is particularly the case with spiders, in which every part is distinctly seen. At length, when all the parts are consolidated, so as to be capable of motion, the animal breaks the pellicle, or thin skin, by the swelling of its body and the movement of its legs, then quits it, and disengages all its parts one after the other. In general, at least, where the shell is harder than that of spiders, insects make their way out by gnawing an opening with their mandibles in the part nearest their head, which, when the shell is very strong, it is often several hours in accomplishing. But in many instances the larva is spared this trouble, one end of the egg being provided with a little lid or trap-door, which it has to force up, and it can then emerge at pleasure. Those of a

species of bug, have, besides a convex lid, a very curious machine, as it should seem, for throwing it off. This is a dark-brown horny substance, and of the shape of a cross-bow, the bow part being attached to the lid or pushing against it, and the handle by means of a membrane, to the upper end of the side of the egg.

The fertility of insects far exceeds that of birds, and is surpassed only by that of fishes. Some produce but a single egg, and others only a small number; but the silk-worm moth produces about 500; the great goat-moth 1000; the tiger-moth 1600; the female wasp at least 30,000. The queen-bee varies considerably in the number of her eggs; in some cases it may amount to 40,000, 50,000, or more. One insect lays 200,000; but all these are surpassed by one of the white ants, which deposits not less than 60 in a minute, which gives 3,600 in an hour, 86,400 in a day, 2,419,200 in a lunar month, and the prodigious number of 31,536,000 in a year. It is probable that she does not always continue laying at this rate, but placing the sum as low as possible, it exceeds that produced by any other known animal in the creation. From insects are thus sometimes produced countless swarms. Numerous accidents, however, to which they are exposed, from the deposition of the egg to their final transformation, reduce their

numbers, and prevent their becoming excessive. Thus, as in other cases, evils are averted by that gracious Providence which includes within its care the least as well as the greatest; the atom as well as the globe, and the insect's egg as well as the angel.

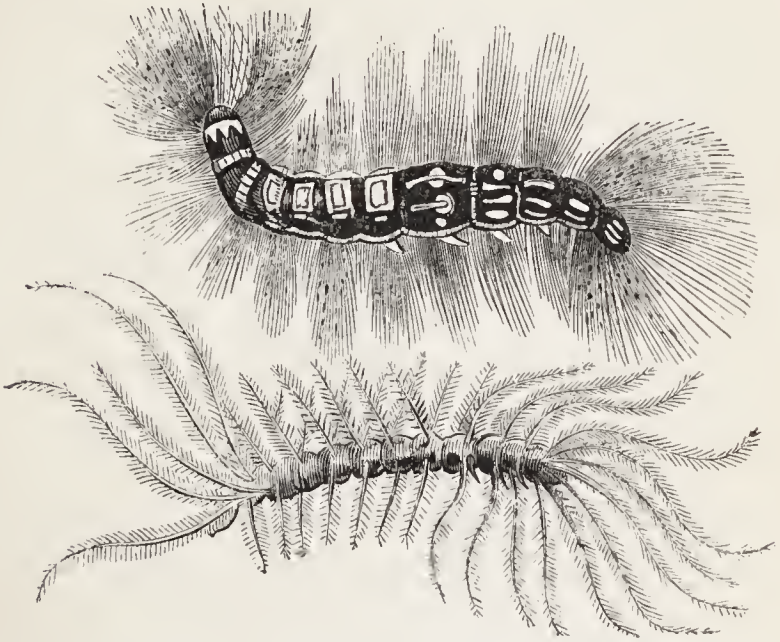
CHAPTER VI.

VARIETY OF CATERPILLARS—SINGULAR MASK AND MOTION OF THE DRAGON-FLY—MOULT OF THE COMMON GRUB.

The insect's egg, when hatched, becomes a caterpillar, with the form of which all are familiar. It is also called a larva, or grub. Many of these creatures are quite naked, but a very considerable number are clothed with hair or bristles, and some have their skins beset with spines, or a mixture of spines and hairs. The hairs of the caterpillar of the great goat-moth are hollow, and set in a ring, raised a little above the skin. Through this ring the hair passes, and appears to be rooted in a very soft substance, which clothes the skin within, and on which the nerves form a tissue, like a small net.

In the hairs of insects there is indeed a most amazing variety. In some they are few, short, scattered, and scarcely to be seen, except through a glass; other species are covered with a down more or less thick. Sometimes they seem to issue from tubercles or pimples,

like streams from the rose of a watering-pot, and partially or wholly conceal the body; and in one case each tubercle has but six hairs, diverging like a star, while the



rest of the body appears naked. Some point to the tail, like the quills of a porcupine; others are directed downwards; some go both ways; and another variation is, that the hairs of half the tubercle are very long, while those of the other half are very short, and even of a different colour. In the larva of one species, the hairs on one part of the back resemble so many brushes, while on the others they are like a common camel-hair pencil.

Several insects are feathered like birds. One has three tubercles in each segment of the body, like so many little blue beads, from each of which proceeds a long black plume; but the most remarkable larva for the shape of its hairs, has them all rough with small points, and moreover, six long tufts, which, when alarmed, it erects, as a porcupine does its quills. Each hair is formed of a series of little conical or sugar-loaf pieces, placed end to end, the point of which is directed towards the origin of each hair, which is terminated at the other extremity by a large and long conical mass, somewhat like the head of a pike.

One of the Saviour's gracious declarations was, "The hairs of your head are all numbered;" but here it is manifest, that those of far inferior creatures engage the attention of the God of creation and providence. And truly with Cowper we may say:—

> "'Tis sweet to muse upon His skill display'd,
> (Infinite skill in all that he has made!)
> To trace, in Nature's most minute design,
> The signature and stamp of power Divine."

Another interesting circumstance connected with caterpillars is their colour. Those that live in darkness in the earth, in wood, and in fruits, are, with few

exceptions, of a uniform whitish colour; but such as are exposed to the light, are usually adorned with a great variety of tints, sometimes the most vivid imaginable. That the white colour of the former is owing to the absence of light has been demonstrated; for some being forced to live under glasses exposed to the light, gradually become brown.

Many are of one uniform colour, while others are arrayed in a variety of tints, distributed in various ways. Some are of the colour of the plant on which they feed, and hence they are with difficulty discovered by their enemies. The caterpillar of a nocturnal moth is said to assume the colour of the lichen on which it feeds, being grey when it feeds on a grey one, and yellow when it feeds on a yellow one. What a remarkable instance is this of providential care and protection! Another appears in the case of the caterpillar of the coronet moth, which feeds on the privet: it is so exactly of the colour of the under side of the leaf, to which it usually clings during the day, that a person may even have the leaf in his hand without discovering the caterpillar.

"The caterpillar," says Kirby, "of one of the most beautiful butterflies and moths that inhabit Britain contends with the perfect insect in loveliness; yet, in

general, no judgment can be formed of the beauty of the future fly from the colour of the larva; and the young entomologist must not flatter himself always with the hope, because the caterpillar excites admiration by its colours and their arrangement, that the butterfly or moth it is to produce will do the same; nor ought he to despise and overlook a sombre or plain coloured individual of the former, under the idea that it will produce one equally plain of the latter; for it often happens, that the splendid caterpillar gives a plain butterfly or moth, and *vice versa*."

Two instances may, however, be mentioned of conformity between the colours of the caterpillar and those of the future moth. One is that of the common currant moth, the caterpillar of which is white, ornamented with several black spots, of different size. At the two extremities it is yellowish, with a longitudinal ray of the same colour on each side the head, and the legs are black. These colours are all to be found in the fly; the ground of its ring being white, ornamented with many black spots of different sizes. The other instance is that of a green caterpillar, which gives a green moth.

"The very colours of caterpillars," says Isaac Walton, "are elegant and beautiful. I shall, for a taste of

the rest, describe one of them; which I will, some time, show you feeding on a willow tree; and you shall find him punctually to answer this very description: his lips and mouth somewhat yellow, his eyes black as jet, his forehead purple, his feet and hinder parts green, his tail two-forked and black; the whole body stained with a kind of red spots, which run along the neck and shoulder-blade, not unlike the form of St. Andrew's cross, or the letter X, made thus cross-wise, and a white line drawn down his back to his tail; all which add much beauty to his own body. And it is to me observable, that at a fixed age this caterpillar gives over to eat, and towards winter comes to be covered over with a strange shell or crust, called an aurelia; and so lives a kind of dead life, without eating all the winter. And as others, of several kinds, turn to be several kinds of flies and vermin the spring following, so this caterpillar then turns to a painted butterfly."

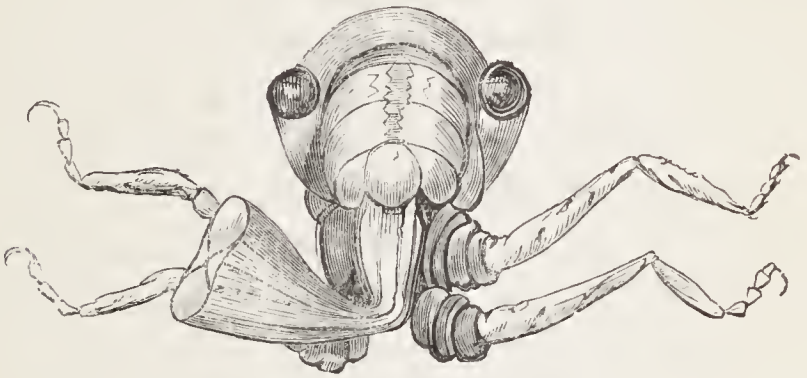
The larva of the dragon-fly has two peculiarities. Although it has six feet, it does not use them so much for walking as for seizing its prey; and its motion is most extraordinary. If one be taken for the sake of experiment, and be put into a large saucer of water, with some of the dead leaves or sticks it had for a covering,

these will soon float towards the tail, and afterwards be driven back by a little stream it throws out, and to do which it is provided with a wonderful apparatus. If it be held head downwards, and some drops of water be let fall on its tail, it instantly sucks them in, when its body becomes larger; but its size is lessened when the water is expelled. If a coloured fluid be let down just over the tail of the insect, it will throw out a stream of it several inches. Now this stream causes its motion, because it is resisted by the still water behind, and a contrary current is then produced by this singular pumping. The caterpillar seems also to breathe partly by this means, and to have small water insects brought within its reach.

It is a singular fact that, some years ago, it was proposed to shoot a stream of water by a steam-engine or forcing-pump, out of the stern of a boat, so that the impulse of the stream on the water in the river might push the boat itself forward; and this is the very method the larva of the dragon-fly adopts.

Another peculiarity in the structure of this species of larva is probably without a parallel in the insect world. In the grubs of most insects the under-lip is small, but in those of the dragon-fly, Messrs. Kirby and Spence observe, "It is by far the largest organ of the

mouth, which, when closed, it entirely conceals; and it not only retains, but actually seizes the animal's prey, by means of a very singular pair of jaws with which it is furnished. Conceive your under lip to be horny instead of fleshy, and to be elongated perpendicularly downwards, so as to wrap over your chin, and extend to



its bottom, that this elongation is there expanded into a triangularly curved plate attached to it by a joint, so as to bend upwards again, and fold over the face as high as the nose, concealing not only the chin and the first mentioned elongation, but the mouth and part of the cheeks: conceive, moreover, that to the end of this last-mentioned plate, are fixed two other convex ones, so broad as to cover the whole nose and temples; that these can open at pleasure transversely like a pair of jaws, so as to expose the nose and mouth; and, that their inner edges

where they meet, are cut into numerous sharp teeth or spines, or armed with one or more sharp claws; you will then have as accurate an idea as my powers of description can give of the strange conformation of the under-lip of this larva, which conceals the mouth and face precisely as I have supposed a similar construction of your lip would do yours. You will, probably, admit that your own visage would present an appearance not very engaging while concealed by such a mask; but it would strike still more awe into the spectators, were they to see you first open the two upper jaw plates, which would project from each temple like the blinders of a horse; and next, having, by means of the joint at your chin, let down the whole apparatus and uncovered your face, employed them in seizing any food that presented itself, and conveying it to your mouth. Yet this procedure is that adopted by the larva of the dragon-fly, provided with this strange organ. While it is at rest, it applies close to and covers the face. When the insects would make use of it, they unfold it like an arm, catch the prey at which they aim with it, and then partly refold it, so as to hold the prey to the mouth in a convenient position, for the operation of the two pair of jaws with which they are provided."

Pedate larvæ, or grubs, have legs of two descriptions:

those that to perfect legs add spurious ones, with or without claws; and those that have only perfect legs. The spurious, or pro-legs, consist of three or four folds, and are commonly, though not always, terminated by a coronet or semi-coronet of very minute crooked claws, or hooks, sometimes amounting to nearly a hundred on one pro-leg, and alternately longer and shorter. They are crooked at both ends, and are attached to the back, by means of a membrane which covers about two-thirds of their length, leaving their two extremities naked. Of these the upper one is sharp, and the lower one is blunt. The part of the pro-legs within the claws, is capable of opening and shutting. When the animal walks, that they may not impede its motion, this part is shut, and the claws are laid flat with their points inwards; but when it wishes to fix itself, this part is opened, becoming of greater diameter than before, and the claws stand erect with their points outwards.

Caterpillars which have no legs, (or jointed organs that have free motion, and can walk or step alternately,) seldom have occasion to take long journeys; and many of them, except when about to enter the pupa state, only want to change their place or posture, and to follow the food, whether animal or vegetable, to which, when included in the egg, they were committed by the parent

insect. How complete is their adaptation to their circumstances, for legs would be of no great use to them, and to some a considerable impediment! Caterpillars are capable of three kinds of motion: they swim, or jump, or walk, as it may be called, though some move by gliding; and others, that fix the head to any point, bring the tail up to it, and so proceed by stepping.

One grub is distinguished by three legs of this kind. De Geer says, that it is found in the water of swampy places and in ditches, is not bigger than a horse-hair, and about a quarter of an inch in length. Its mode of swimming is like that of a serpent, with an undulating motion of the body; and it sometimes walks on the bottom of the water, and upon aquatic plants. Its very extraordinary tentacula resemble, in their length and rigidity, wooden legs. The anterior leg terminates in two feet, armed at the extremity with a coronet of long moveable hooks. These feet, like the tentacula of snails, are retractile within the leg, and even within the body, so that only a little stump, as it were, remains without. The insect moves them both together, as a lame man does his crutches, either backwards or forwards. The two posterior legs are similar, but larger, and entirely separate from each other, not, like that just described,

retractile within the body, but always stiff and extended. These are also armed with hooks.

Were some persons told that a quadruped has been seen in a distant country, whose legs were on its back, the effect produced would remind us of Cowper's words :—

> "Can this be true?" an arch observer cries;
> "Yes," rather moved, "I saw it with these eyes."
> "Sir, I believe it on that ground alone;
> I could not, had I seen it with my own."

And yet, unexceptionable witnesses affirm, that some insects have this extraordinary structure. The grub of a little gall-fly was found, for instance, to have on its back, on the middle of each segment, a retractile fleshy protuberance, that strikingly resembled the spurious legs of some caterpillars. "A little attention," argues Reaumur, "will convince any one, that insects, circumstanced like this one, if they have any legs should bear them on its back. For this grub, inhabiting a spherical cavity, in which it lies rolled up, as it were in a ring, when it wants to move, will be enabled to do so in this hollow sphere, with much more facility, by means of legs on the middle of its back, than if they were in their ordinary situation." So wisely has the providence of God ordered even the circumstances of this little creature!

While an insect is in its caterpillar state, it frequently

casts the skin. A day or two previously to each change it ceases eating altogether, and becomes languid and feeble; its colours fade, and it seeks a retreat where it can undergo this operation in security. Here fixing itself by its legs to the surface on which it rests, or to a slight web spun for the purpose, it turns its body in various ways, swelling and contracting its different segments, for the purpose, it may be supposed, of separating the outer skin. After continuing this action for several hours, with occasional intervals of rest, the moment arrives, when the skin splits; the opening thus made is soon increased by repeated motions, the head protrudes, and at length the little creature withdraws itself entirely from its old skin, which, when cast, remains in appearance so nearly perfect, that it might be taken for the caterpillar itself.

An eminent naturalist gives the following interesting account of the moult of a common grub :—"Nothing in all nature, in my opinion, is a more wonderful sight than the changing of skin in these and other like worms. This matter, therefore, deserves the greatest consideration, and is worthy to be called a specimen of nature's miracles; for it is not the external skin only that these worms cast, like serpents, but the throat, and a part of the stomach. But this is not the whole of these wonders,

for, at the same time, some hundreds of pipes within the body of the worm cast each its delicate and tender skin. Their usual skins are afterwards collected into eighteen thicker, and, as it were, composed ropes, nine on each side of the body, which, when the skin is cast, slip equally, and by degrees, from within the body, through the eighteen holes of the tubes before described; two other branches of the pipes that are smaller, cast a skin likewise."

For some time after this change, the caterpillar continues extremely weak, but when it has taken a few meals, its strength is renovated, and by exposure to the air it assumes a more beautiful appearance than before. Insects mostly live longest in this state, but the period of their continuance varies in different species. The grub of the flesh-fly attains its full growth in six or seven days. That of the bee in twenty days; the grub of the common cock-chafer lives through three months, that of the stag-beetle is said to live six years. But the most remarkable is that of a beautiful beetle, never before found in this country, which made its way out of a deal desk in an office in London, in the beginning of the year 1810, which had been fixed there in the year 1788, or 1789; so that, according to every appearance, it had existed in this desk more than twenty years.

Of comparatively little importance is it, however, whether the life of these creatures be short or protracted; it is far otherwise with ourselves. A limited space on earth is connected with solemn responsibility; that of a longer one is proportionately greater. For how much have the young to answer!—for how much more the aged! Yet but little is our accountability seen and felt; those only act aright who wish a sense of it daily and hourly to increase. The day of death will add to its power, and in the day of judgment it will operate as it never did during the longest earthly pilgrimage.

It behoves us all to keep that awful period constantly before us. The motto of Dr. Doddridge was, "Live while you live," and on it he wrote the epigram so much admired:—

> "Live while you live, the epicure would say,
> And seize the moments of the present day:
> Live while you live, the sacred teacher cries,
> And give to God each moment as it flies.—
> Lord, in my view let both united be,
> I live in pleasure while I live to *thee*."

With the conviction so happily expressed, we shall make the language of the apostle our own: "None of us liveth to himself, and no man dieth to himself. For whether we live, we live unto the Lord; and whether

we die, we die unto the Lord: whether we live therefore, or die, we are the Lord's." Blessed, thrice blessed, are those who can employ this language. If death comes late, they have served their generation according to the will of God; if soon,

"The less of this cold earth, the more of heaven."

CHAPTER VII.

THE CLOTHES-MOTH CATERPILLAR—CATERPILLAR OF THE FIELD-MOTH—CADDIS-WORMS.

THERE would have been much reason to admire the providential care so graciously manifested in reference to insects, had there been no approach to the instinctive sagacity of the parent. But it is far otherwise. While the mothers prepare a secure nest for their eggs, and provide, in many cases, food for their young during the first stage of their existence, a very numerous class may be arranged of the newly-hatched insects, who display astonishing skill in forming for themselves proper habitations. Art, high as it has risen, could not equal the productions of multitudes of these little creatures.

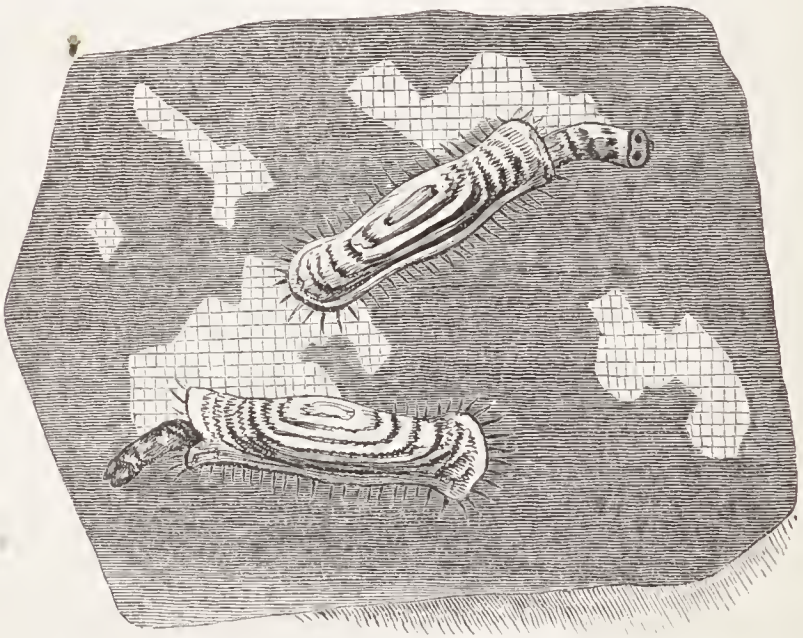
Many insects come into the world naked, but they lose no time in providing themselves with garments. We refer to the caterpillars of the moths, which may sometimes be observed issuing from our wardrobes ; among the contents of which they commit sad depredations.

Advantage to themselves is, however, connected with the mischief done to others, for it is from our furniture and apparel that they derive the materials of their own clothing.

It is worthy of remark, that these, as well as the fashion adopted, vary with the different sorts of caterpillars. But the common shape—that of a small tube, open at both ends—is very convenient. To form it, the grub obtains from different articles to which it repairs, a mixture of hair and silk; and that it may be more soft for its tender body, it is lined with silk alone. Instinct exhibits in this case great judgment, in the selecting of substances which are most appropriate, and equal skill in their combination.

As the garment now manufactured is to last for life, —a strange contrast to the dress of our infancy,—it requires sometimes to be widened and lengthened. These alterations, however, are made at pleasure. A few new hairs or threads are easily added to accomplish the latter purpose, and for securing the former, there is no want of sagacity. On removing the young larva in its first restricted case, from a piece of white to a piece of scarlet or other coloured flannel, the effect will be apparent. To widen the covering, it is split on the two opposite sides, and in the spaces now made, two

pieces of the proper material and size are carefully put in; a mode of procedure which could not be surpassed by a wiser artificer. Nor is this all; for if the tube were split at once through its whole length, the caterpillar would suffer inconvenience, so it actually makes four half-length openings, and ingeniously fills them. The colour of the garment is always that of the stuff from which the material for it was taken, and if the little tailor should traverse clothes of different hues, it will resemble the coat which Jacob made for Joseph in being of many colours.



It may seem singular to have food and dwellings of

the same material, but this is actually the case with these creatures. Nor do they tarry in one place; but, like the sheep and cattle of our fields, they move about from spot to spot, going when the part on which they first settled has been shorn down by their maxillæ, or under jaws, in quest of a fresh pasture. Some appear also very particular, for not liking to walk over long hairs, they cut down whatever comes in their way.

When enjoying repose, these caterpillars are secure, from having fastened the covering so ingeniously made to the cloth where they have been at work, by means of small threads. But when they are about to undergo their change, and to assume the form of a chrysalis, they close up the apertures of their tube with silk.

One creature adorns its covering, as ladies sometimes do their gowns, with furbelows; each one seeming to mark the growth of the caterpillar; for Reaumur thinks that when it has outgrown the first, it adds a second division to its tube, which is lined with silk, and to that a third. More than three flounces are rarely observed; and each one is formed of two semicircles joined together.

The tapestry-moth, not numerous in our houses, is most injurious to the lining of carriages, which are more exposed to the air than the furniture of our apartments.

The caterpillars of this moth do not construct a movable habitation like the common species, but, eating their way in the thickness of the cloth, weave themselves silken galleries, in which they reside, and which they render close and warm by covering them with some of the carded wool.

There is another most destructive insect of a similar species, and ladies have often to deplore the ravages it makes in their valuable furs, whether made up into muffs or tippets. It invades alike the regal ermines and the woollen habiliments of the poor; its proper food, indeed, being hair, though it devours both wool and fur. This species of larva, pressed by hunger, will even eat horse-hair, and make of this singular material a movable house, in which it travels from place to place. These little creatures will shave the hair from a skin as neatly and closely, as if a razor had been employed.

It is worthy of remark, that care and cleanliness are desirable to prevent the ravages of these creatures. The articles of which they are fond should often be examined, and opened to light and air, for these destroyers love darkness and uninterrupted rest. The maternal instinct already noticed, which provides for the welfare of the young, leads to the choice of what we neglect, as

being secure, and to the avoidance of what is often used as unsafe. If, too, articles are completely covered up, they are free from danger, but if a moth can enter but a single crevice, the mischief is done, and the result will be a colony of caterpillars.

Ingenious as the caterpillar of the domestic moth has appeared to be, he is greatly surpassed by his neighbour in the field. This little creature forms its garments of materials obtained from leaves. The oak and the elm are its favourite resort: here it provides a mantle, of a cylindrical form; the end for the head of the insect being round, bent, and hemmed; while the other is formed of three pieces, brought into a point, and easily opened.

The process of making this covering is very remarkable. Between the two membranes of a green leaf is a pulpy substance, called the parenchyma, and this is first removed by the caterpillar. This substance is its proper food, and by its singular movements two objects are gained,—the creature is fed and the leaf is prepared for use.

Reaumur, desirous to observe the result, removed a covering belonging to one of these caterpillars which was thus feeding, and as soon as its loss was discovered, it resumed its meal, and having eaten away enough,

began to make another mantle. It now cut two pieces of the same size and shape, from the membranes of the leaf, with great quickness and amazing skill; and then sewed them together, having first, by various movements of its body, adapted them to its form. The tube was now rendered perfectly smooth, and the whole was carefully lined with silk, those parts being made thicker which had more friction. The loss occasioned by Reaumur, was repaired in twelve hours.

To detach a mantle when made from the leaf, requires strength: the caterpillar therefore crawls partly out of it, pushes its head forward, fastens its fore-legs on the leaf, and laying hold of the inside of the covering with its hind-legs, removes it, and at length fastens it with silken threads, wherever it chooses a new pasture.

Other little creatures are now entitled to our attention. If, desirous of examining them, you placed yourself beside a clear and shallow pool of water, you would observe at the bottom little oblong moving masses, like pieces of straw, wood, or even stone. These are the larvæ, well known to fishermen by the name of *caddis-worms*, and which, when taken out of the water, are found to inhabit cases very singularly formed. Of the larva itself, nothing can be seen but the head and legs, by means of which it moves itself in the water, and

drags with it the case in which the rest of the body is enclosed, and into which it wholly retires on any alarm.

One forms a pretty case of leaves glued together lengthways, but leaving an opening sufficiently large for the inhabitant to put out his head and shoulders, when it wishes to look about for food. Another uses pieces of reed, grass, straw, wood, &c., cut into convenient lengths, carefully joining and cementing each piece to its fellow as the work proceeds; and he frequently finishes the whole by adding a broad piece, longer than the rest, to shade his door-way over head, so that he may not be seen from above. Another weaves together a group of the leaves of aquatic plants into a roundish ball, and in the middle of this forms a

cell. Others form houses, which may be called *alive*, making them of the shells of snails and muscles, even while inhabited;—"a covering," as Kirby says, "as singular as if a savage, instead of clothing himself with squirrel skins, should sew together into a coat the animals themselves."

Most admirable is the provision to protect these abodes from being either too light or too heavy. Not being able to swim, but only to walk at the bottom of the water, by means of the six legs attached to the fore part of its body, and the insect itself being heavier than water, it is of great importance that its house should neither incommode it in walking by its buoyancy or weight, and that it should be so equally ballasted in every part as to be very readily moveable. Hence caddis-worms always choose the most suitable substances; and *if the cell be too heavy, they add* to it a bit of leaf or straw; or, if too light, a shell or piece of gravel.

If, in other cases, there is a resemblance to the operations of art, here there is an appearance of science. It will be well to attend a little to this fact. When a solid body is plunged in any liquid, it must displace a quantity of it exactly equal to its own bulk. Only, let the bulk of the liquid so displaced be measured, which

may easily be done, and we know exactly the bulk of the body.

This fact was discovered by Archimedes, one of the greatest mathematicians of ancient times. Hiero, king of Syracuse, his friend and patron, had given a certain quantity of gold to an artist to make him a crown, and suspecting from its lightness that some silver had been used, he desired Archimedes to examine the matter. While intent on it, it is said, he happened to observe, in bathing, the water which ran over the sides of the bath; finding, too, it was equal to the bulk of his body, and that by trying how much water a certain weight of silver displaced, how much a certain weight of gold, and how much a certain mixture of the two, he rushed out exclaiming, "I have found it! I have found it!" When, too, a body is so plunged, it will remain in whatever place of the fluid it is put in, if the bulk of the body weighs as much as the same bulk of the fluid. For in this case it will be the same thing as if the fluid were not displaced; and as an equal quantity of the fluid would have remained at rest there, being equally pressed on all sides, so will the solid body: it will be pressed from below with the same weight of fluid as from above.

If the body be heavier than the fluid, this balance

will be destroyed, and the weight of the fluid pressing from above will be greater than that pressing from below, and consequently the solid body will sink to the bottom. So if it be lighter than an equal bulk of the fluid, it will rise through the fluid to the surface.

It follows from these principles, that if a body be weighed in the air, and then in any liquid, it will seem to lose as much as an equal bulk of the liquid weighs. Not that it really loses weight, but that it is pressed upwards by a force equal to the weight of the liquid the place of which it fills. If, for instance, a piece of lead weighed an ounce before being plunged into water, if then it be hung by a thread from its own scale, and plunged so that the water in a full jar covers it, a quantity of water equal to the bulk of the lead will run over the sides of the jar, and a number of grains, equal to the weight of this quantity of water, must be taken out of the opposite scale to restore the balance. The reason is, the lead is now pressed downwards in the water with a force not equal to its own weight, but to the difference between its own weight and that of an equal bulk of the water.

In this manner are determined the relative weights of all bodies, or the proportion which they bear to each other in weight, which is called their *specific gravity;*

that is, their weight in *kind*, and sometimes their weight compared with that of other bodies. The ordinary difficulties of doing this have been surmounted by what is called the Hydrostatic Balance, which affords a perfectly easy and most accurate method of comparing all substances, solid and fluid. We have only to weigh any substance first in air, and then in water; the difference of the weights is the weight of a bulk of water equal to the bulk of the substance; and by comparing any other substance with water, in like manner, its specific gravity is ascertained as compared with that of the first substance.

A knowledge of these principles and of others connected with them, is of great importance. Of this, proof will be afforded by one fact. After the diving-bell was invented, it was considered desirable to devise some means of remaining for any length of time under water, and rising at pleasure without assistance. "Some years ago," says Herschel, "an ingenious individual formed a project, by which this end was to be accomplished. It consisted in sinking the hull of a ship made quite water-tight, with the decks and sides strongly supported by shores, and the only entry secured by a stout trap-door, in such a manner, that, by disengaging from within the weights employed to sink it, it might rise of

itself to the surface. To render the trial more satisfactory, and the result more striking, the projector himself made the first essay. It was agreed that he should sink in twenty fathoms water, and rise again without assistance at the expiration of twenty-four hours.

"Accordingly, making all secure, fastening down his trap-door, and provided with all necessaries, as well as with the means of making signals to indicate his situation, this unhappy victim of his own mistaken ingenuity entered, and was sunk. No signal was made, and the time appointed elapsed. A concourse of people had assembled to witness his rising, but in vain; for the vessel was never seen more. The pressure of the water at so great a depth had no doubt been completely under-estimated, and the sides of the vessel being at once crushed in, the unfortunate projector perished before he could even make the signal concerted to indicate his distress." Such an accident never happened to a caddis-worm; the dwelling it forms is admirably adapted in all respects to its circumstances.

It is worthy of remark, that though there is a celebrated cement, called pozzolana, which is prepared of volcanic earth, or lava, yet the cement employed in these remarkable structures is absolutely superior to it in standing water, in which it is indissoluble. Nor is

it to be supposed, that the worm loads its case with such singular materials without a valid reason. The one which forms its abode of snail and mussel-shells, for example, is but little adapted for swimming; and its long body, apparently encumbered with six legs, is specifically heavier than water, the element in which it has to seek its food. As a compensation, therefore, the beneficent Creator seems to have endowed it with an instinctive faculty, which enables it to know what substances are lighter than water: these it attaches to its coat, in order to counterpoise its own excess of gravity, and enable it to swim to the surface, in the centre, or at the bottom of the element in which it has to feed. This seems to account, indeed, for the variety and singularity observable in the coats of those insects.

Several of these grubs construct a remarkable apparatus for protecting the pupa, during its state of inactivity and helplessness. So long as it remains in the grub state, it can withdraw itself within its case of shells, stones, or reed-stems; but as soon as it feels its change approaching, it contrives additional security. It weaves, for this purpose, at the entrance of its gallery, a grating of its singular silk, which hardens in water, and remains indissoluble. The strong threads are made to cross each other, forming a small, thickish circular plate of

brown silk, which becomes as hard as gum, fitting exactly in the opening, and placed a little within the margin. One of these gratings, described by De Geer, was pierced all over with holes, dispersed in concentric circles, separated by ridges running from the centre to the circumference, though not quite so regularly as the spokes of a wheel. Other ridges again are made to traverse the concentric rays, following the course of the circles of holes, in such a manner as to form compartments, each having a hole in its centre. Reaumur found that these holes were for the purpose of breathing, by admitting a current of fresh water, effected, no doubt, by the spiracles of the pupa; and he actually saw the grate-work in alternate motion, from convex to concave, as the water passed out and in.

CHAPTER VIII.

SOCIAL CATERPILLARS—THEIR PROCESSIONS AND ABODES.

All caterpillars are not solitary, like those already described; for others pass a portion or the whole of life in a social manner. The moth lays its eggs in the same spot, and as they are hatched about the same time, her progeny frequently continue together. Of such facts Wordsworth thought when he said—

> "Nor wanting here to entertain the thought,
> Creatures that in communities exist,
> Less, as might seem, for general guardianship,
> Or through dependence upon mutual aid,
> Than by participation of delight,
> And a strict love of fellowship combined."

An example of such societies appears in the history of the gold-tailed-moth. As soon as one of the young caterpillars comes from the egg, it begins to feed; another quickly joins it, placing itself by its side; and thus they proceed till a row of them is formed across the

leaf. A second is then begun; and after this is completed, a third: and so they go on till all the upper surface of the leaf is covered; but as a single leaf will not contain the whole family, the remainder take their station on the adjoining ones. As soon as they have satisfied the cravings of hunger, they begin to think of erecting a common habitation, which at first is only a vaulted web, to cover the web they inhabit; but which, by their united labours, in due time grows into a magnificent tent of silk, containing various apartments, sufficient to defend them all from the attack of enemies and the inclemency of the seasons.

As these caterpillars, like eastern monarchs, are too delicate to put their feet upon the rough bark of the tree upon which they feed, they lay a silken carpet over every road and pathway leading to their palace; which extends as far as they have occasion to go for food. To this habitation they repair when the sun is too hot, and during heavy rains; they likewise pass part of the night in it; and, indeed, some may generally be found at home. On any sudden alarm they retreat to it for safety, and also when they cast their skins; in the winter they are wholly confined to it, coming forth again in the spring; but in May or June they entirely desert it, and, losing all their love for society, live in solitude

till they become pupæ, which takes place in about a month.

Another remarkable species of caterpillar, well known in France, finds a dwelling on the oak. Here hundreds of them often live together, their nests varying in size and curiously made, resembling the large knots of the tree. Twilight and darkness are their times of activity in pursuing food. At the head of the regiment is a chief, by

whose movements the procession is regulated. When he stops all stop, and proceed when he proceeds: three or four of his immediate followers succeed in the

same line, the head of the second touching the tail of the first. Then come an equal series of pairs, next of threes, and so on, as far as fifteen, or twenty. The whole procession moves regularly on with an even pace, each file treading in the steps of the one that precedes it. If the latter, arriving at a particular point, pursues a different course, all march to that point before they turn. Probably, they are guided by some scent given to the tracks of those who pass over them.

Sometimes the order of procession is different; the leader who moves singly is followed by two; these are succeeded by three, then come four, and so on. When the leader—who in nothing differs from the rest, and is probably the caterpillar nearest to the entrance of the nest, followed as has been described—has proceeded to about the distance of two feet, he makes a halt, during which those which remain come forth, and take their places; the company form into files, the march is resumed, and all follow as regularly as if they kept time to music. These larvæ may occasionally be seen at mid-day out of their nests, packed close one to another, without making any movement, so that though they occupy an ample space, it is not easy to discover them. At other times, instead of being laid side by side, they are heaped one upon another, as if they were interwoven together. Thus,

LEAF-ROLLING CATERPILLARS.

also, they are disposed in their nests. Sometimes the families divide into two bands, which never afterwards unite.

Some caterpillars form and inhabit a cylindrical or conical roll, in which, at the smaller end, an opening is left for the egress of the insect when necessary. The one first mentioned is formed as follows. The little artisan first fixes a series of silken cables from one side of the leaf to the other, and when she has forced the sides to approach, by pulling at these cables with her feet, she unites them with shorter threads of silk. Should one of the larger nerves of the leaf be too strong, she gnaws it half through here and there.

A conical, or horn-shaped roll, like the papers into which grocers put sugar, and as well constructed too, is not formed of a whole leaf, but of a long triangular portion cut out of the edge. Other movements are therefore necessary. Taking her station on the leaf, she cuts out with her jaws the piece of which it is to be composed, but she does not entirely detach it, as it would then want a base; but she separates that part of it only which is to form the contour of the horn. This is a triangular piece, which she rolls as she cuts. When the body of the horn is completed, it is necessary to elevate it, as it is intended to have a nearly upright

position on the leaf. This is done in the most appropriate manner; she fastens threads towards its point, and raises it by her own weight.

Many of the social caterpillars roll the leaves of the oak, in order to form from them their abodes. Some are rolled half way down to the stalk, others from side to side, and not a few are made by bringing the edges of the leaf together in the middle. All this is done as cleverly at least, as if human fingers were employed.

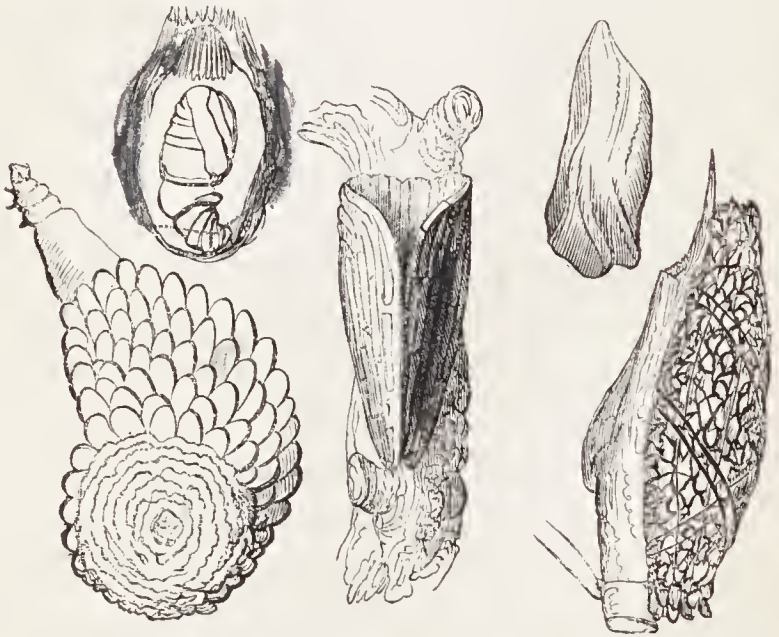
The caterpillar, availing itself of any curve in a leaf, skilfully increases it by moving its head backwards and forwards in the same direction, and by means of little silken threads. On examining one of these, it appears to be formed of two sets, crossing each other. It has been observed, that on the making of each new thread the edges of the leaf were gradually brought nearer, and when the last spun thread became tight, the preceding one appeared loose, and floated in the air. When the leaf is rolled up, the ends are carefully fastened together, and thus a habitation and food are secured for the caterpillar until it is about to change, when the leaf is lined with silk. Many other processes of these creatures are equally curious.

CHAPTER IX.

FORMATION OF COCOONS—THE SPINNING OF CATERPILLARS PERFECT AT ONCE—CONTRAST IN OUR MANUFACTURES.

Caterpillars preceded men in the art of spinning, which, with the sister art of weaving, ranks next in importance to agriculture. These have, however, been found among almost all the nations of the old and new continents, and even among those but little removed from barbarism. They are reasonably supposed to have been invented at a very early period of the world's history. Minerva is represented with a distaff, in some of the ancient statues, to intimate that she taught men the art of spinning: the same honour is given by the Egyptians to Isis; by the Mohammedans, to a son of Japhet; by the Chinese, to the consort of their emperor Yao; and by the Peruvians, to Mamavella, wife to Manco-lapac, their first sovereign. These traditions show that this invaluable art was discovered at an extremely remote period, being prior to that of all authentic records.

It evidently existed in Egypt in Joseph's time, 1700 years before the Christian era, as it is recorded that Pharaoh "arrayed him in vestures of fine linen." Two centuries later the Hebrews carried it, with other arts, on their departure from that ancient seat of civilisation; for when Moses constructed the tabernacle in the wilderness, "the women that were wise-hearted did spin with their hands, and brought that which they had spun, both of blue, and of purple, and of scarlet, and of fine linen." They also spun "goat's-hair."



Cocoons, as in the cut, are formed by many caterpillars, as the place of abode for the chrysalis. Some content

themselves with spinning one of so flimsy a construction as to resemble net-work, allowing the chrysalis to be easily seen, and apparently formed as a support rather than a defence to its inhabitant. Another is described as somewhat resembling an air-balloon, the meshes of which are large and perfectly square. The chrysalis hangs in the centre, fixed by a few slight threads, which diverge from it to all parts of the cocoon.

Others form their cocoons of a somewhat more compact texture, yet still insufficient completely to hide the chrysalis. Most of them, however, endeavour to supply the deficiency by drawing the adjacent foliage close together with silken strings, in the middle of which they occasionally meet, and form their cocoons in company.

The size, colour, figure, and texture of silken cocoons are very various. Their size is, indeed, usually proportioned to the larva or pupa within, but it is not always so. Some large caterpillars, says Kirby, spin cocoons so small, that the observer can hardly conceive how they can be contained in so narrow a compass; while others lodge themselves in apartments which seem to be more spacious than necessary. Some hammock-like cocoons would contain several of their pupæ. One is mentioned, which is ten times the size of the little

creature living in the centre. Hobhouse, in his Travels, describes one of extraordinary size: "Depending," says he, "from the boughs of the pines, near the Attic mountain Parnes, and stretching across from tree to tree, so as to obstruct our passage, were the pods, thrice as big as a turkey's egg, and the thick webs of a chrysalis, whose moth must be far larger than any of those in our own country." What was thus supposed to be a cocoon, might, however, be a nidus, in which there were many insects together.

Some caterpillars, in order to strengthen their cocoons, moisten them with a gummy matter after they are completed; and others use a yellow, paste-like substance, which they apply by continued motions of the head, to the under surface; when dry it becomes a powder, which renders the cocoon opaque. In one case a powdery bloom of a bluish colour has been observed.

A caterpillar, which is almost one of the largest we have, and often nearly four inches long, makes a cocoon of a cylindrical form, with the ends rounded, and the outer surface appears nearly smooth, so that it has an egg-like appearance. On touching it, however, it is found to be set with stiffish hairs. In order to make its cocoon of this figure, the caterpillar has its body

WEBS OF A CHRYSALIS.

continually bent in different positions, while employed in its formation; each end of the body being kept in the shape which is thus given to the two ends of the cocoon.

The manner in which the layer of silk which serves for the ground-work of the cocoon is spun, differs not materially from that of other caterpillars; but when the net-work is somewhat advanced, it is observed to have an external covering of hair, which stands erect to a considerable height. These hairs have been stripped from those parts of the body of the enclosed caterpillar, which are placed against the sides of the cocoon, the caterpillar being observed at such times to put itself against the inner surface of the net-work, whereby the hairs are protruded through the meshes of the net. To prevent a prickly unevenness, which would irritate the soft chrysalis when newly disclosed, the insect forces the ends of the hairs closely against the inner surface of the cocoon, and fastens them in that position with silken threads. The outer parts of the hairs are thus made to lie flat on the surface of the cocoon, which is then rendered stronger by further layers of silk. When completed, its consistence is very hard; the outer surface is made smooth, and the inner lined with a tapestry of shining silk.

Some small hairy caterpillars form cocoons found upon walls or on flat bits of stone, and in making them, the insect pulls off its hairs, and plants them in *an upright position* round its body, side by side, like the pales of a palisade, in an oval ring, in the middle of which it takes its station, and within this inclosure it spins a slender web. This tissue supports the hairs, which are made to bend over it at the top by silken threads, so as to form a kind of roof.

Different materials are used in other instances. One caterpillar descends into the earth about the middle of July, where it forms an egg-shaped cocoon of *bits of earth*, fastened together by silken threads, from which the moth appears in the following April. Reaumur dug up one of this description when nearly completed, and broke off about one-third of its extent at one end, the structure being of considerable thickness. The insect immediately commenced its reparation, which it completed in four hours, by means of bits of earth placed within its reach. It commenced by protruding nearly the whole of its body out of the breach, and seizing a piece of earth with its strong jaws, which it bore into its damaged cocoon. This employment it continued for some time, selecting with much care the bits of earth most fit for its use, yet rarely affixing any of these

grains to the walls of its cell, unless it met with one which happened *exactly to fit* any part of the breach.

It now, however, commenced spinning a slight band of silken net-work round the aperture, and to it attached bits of earth by means of silken cords which it spun for that purpose during its labour; and thus by degrees the size of the damaged part was contracted. When the aperture was nearly closed, the caterpillar, in order to shut it up entirely, was observed to spin arched lines of silk from one side to the other of the aperture, crossing each other at different angles, like a coarse kind of net-work, into which it fastened grains of earth, so as to render its outer surface similar to the sound part. It was not however satisfied until it had also strengthened the inside with smaller grains of earth, so that when Reaumur opened the cocoon again with a pen-knife, the new part was formed equally thick and compact with the other part which had not been damaged. The internal movements of these caterpillars cannot be observed, as they do not begin their silken tapestry until they have completely closed the outer walls.

Another caterpillar is still more ingenious. The substance of its cocoon is chiefly earth, but instead of the outside being rough and uneven, it is smooth and finely polished, and instead of being formed beneath the

ground, it is built on leaves. Reaumur found some of these insects on the oak and apple, and some of them formed their cocoons during the night, without his having observed the process. He noticed, however, that their earthen walls were moistened, although the earth at the bottom of his breeding-cage was quite dry. It was evident, therefore, that the caterpillars had moistened the earth, but he could not imagine how an insect, which in constructing its cocoon, is, for the most part, inclosed within, could give the exterior so smooth and polished a surface.

Having observed, however, one morning, that his only remaining caterpillar was preparing to form its cocoon, by attaching a few silken threads as a base upon a leaf, and returning in less than an hour, he found it had, during his short absence, completed three quarters of its abode. Its mode of construction he discovered to be somewhat similar to that employed by cottagers in building mud walls; the chopped straw which is employed to bind the mud together being like the meshes of a loose silken web of an oval shape. When the habitation is nearly completed, the insect collects a quantity of earth within the net exactly sufficient for its future purposes.

In this abode it shuts itself up by entirely closing the aperture, and commences the building of its mud walls

by moistening one of the bits of earth with a liquid which it emits from the mouth, and when this is well done, it forces the paste through the meshes of its net, when it immediately assumes a smooth appearance. Reaumur observed that it repeatedly pushed its head with considerable power against the inner surface of the cocoon, so as to force the more moistened earth to run through the meshes of its net. Thus it has both an external and internal covering of mud. When the operation was completed, Reaumur opened the cocoon, and took it away from the caterpillar, which, however, made a second during the night; it was, however, but slightly cased with mud, the insect not having sufficient fluid left with which to moisten the grains of earth.

The caterpillars of numerous other species of moths form their cocoons of *chips of wood and bark*, bound together with silk, but these are generally arranged without much regularity. One of the hardest thus made is that of the puss-moth caterpillar. It is composed of very minute *gnawed bits of bark*, strongly cemented together with a gummy secretion mixed with silk.

Reaumur found on the oak an ingenious little creature which constructs its cocoon with an immense number of small *chips of a rectangular* form, which it gnaws from the bark of that tree, and fastens together like *the*

boards of a room-floor, end to end. One of them was brought to him on a twig, and on each side of its body there was observed a thin appendage a little longer than the insect, attached to the twig, of a long triangular form, They projected at an angle from each side of the twig, and somewhat resembled in miniature, the feathers fastened to the end of an arrow. A representation of it may be found in the cut, page 126. The space between the two wings was also of a triangular shape, and this forms the basement of the insect's cocoon, the chips of which the wings were formed having been gnawed from it.

This commencement of the insect's operations by forming two flat and triangular walls, is not a little remarkable. Reaumur wondered, at this stage of the work, what form the cocoon would ultimately take, thinking that other appendages would be affixed to these at different angles, so as to form a kind of perpendicular roof; but the insect designed these two wings alone to form a case perfectly closed, and these two were fully sufficient for the purpose.

Its object was now perceived to be, to bring the outer edges of these two wings together, just as we shut a pair of folding or cupboard doors, when they are opened and pushed backwards. Most striking, therefore, are the skill and precision with which the insect

must form the two wings, for unless they are made of a proper size while apart, they could not possibly be brought together, nor could the edges be made to fit closely to each other. While the carpenter has his compasses, rules, and planes, the insect has no such instruments ; yet it can work correctly without them. When its two walls or wings are of a proper size, the caterpillar, which always keeps between them, attaches threads to the outer edge of one of them at the lower part, which it then applies to the opposite outer edge of the other ; these threads are then pulled until the edges are brought into contact, when it fastens them with short silken threads. In this way it proceeds upwards, until the two edges are very cleverly brought together.

Here, however, another difficulty occurs. A concave but not a deep space, has been formed within these walls on the back of the twig ; but when they are thus brought together they are flat, and form an acute angle, not only in front, but at each side, which would, of course, be very inconvenient to a cylindrical chrysalis within. But for the removal of the difficulty the little tenant is prepared, and by repeatedly pushing against the walls with its head, causes them to take a convex figure. The opening at the upper end of its dwelling

is also closed afterwards in the same manner; and when the whole is completed, the seams cannot be perceived. The inside is then lined with a fine coating of silk, and the insect undergoes its transformation in security, being well protected by the great resemblance of the cocoon to the bark on which it is fixed, and of which, in fact, it is composed.

Insects, in climbing, use either ladders or a single rope. If, for instance, the caterpillar of the common cabbage butterfly be observed climbing on a window, it will be found, on the glass being minutely examined, that the creature, like a snail, leaves behind it a visible track. A microscope will show that this is a ladder, formed of little silken threads, to enable the caterpillar to ascend a surface which it could not otherwise traverse. The spinner yields at first a gummy fluid, which hardens in the air, and admirably answers the intended purpose.

Many caterpillars that feed on trees, have to descend from branch to branch, and sometimes to the ground. Now, could they move easily over the bark, what a journey would they have to take, if this were their only course. They are, therefore, prepared by the great Creator, for one which is much easier. They are able to spin a line of any length, and thus to move

SILKEN LADDERS OF CATERPILLARS.

about at pleasure. If the branches of a tree be suddenly shaken in summer, the geometers, as they are called, from appearing to measure the surface they pass over, may be seen descending by their silken strings, and hanging suspended in the air.

If one of these be placed on the hand, it will be observed to draw a thread as it proceeds; the head is extended as far as the insect can stretch it; then fastening the thread there, and bringing up the rest of the body, it takes another step, but never moving without this clue. Thus it has the means of dropping itself safely from the top of the highest trees, and of ascending again by the same rope.

It is worthy of remark, that as the silky matter is fluid when first formed, there appears some danger of the caterpillar falling to the earth. To guard against this, it descends gradually, dropping but little at a time, pausing just as may be desirable, and at last securely reaching the ground. For all this there must be full provision in the structure of the caterpillar, and the fluid must be prepared at once to bear its weight.

In climbing, it seizes the thread with its jaws, as high as it can reach it, and then raising the part of its back which corresponds with its six perfect legs, till these become higher than the head, it catches the

thread with one of the last pair; from this the other receives it, and so a step is gained, to be followed by others in the same way.

The spinning of the caterpillar, it may be observed, is *at once perfect*, and in this its operations greatly differ from those of men. The use of cotton clothing spread very slowly, except when urged onwards by Mohammedan conquest and colonisation. The manufacture was general in India, and had attained great excellence in the fifth century before Christ, yet eighteen centuries more elapsed before it was introduced into Italy, or Constantinople, or even secured a footing in China. In Italy, Germany, and Flanders, it had a lingering and ignoble existence. To suppose that the same manufacture ever existed in any other part of Europe which now exists in England would be a great mistake.

For a long period no material improvement took place in any country, in the implements by which cotton was spun and woven. The implements used in all parts of the earth from the earliest times were the distaff and spindle. The only advance made in this department was in relinquishing the distaff for the one-thread spinning-wheel, which has long been used in India for the coarse qualities of thread, and which has also obtained in China and in all European countries.

But what a change has latterly taken place! Little more than sixty years since, even thread used in the manufacture of cotton, wool, worsted, and flax, throughout the world, was spun singly by the fingers of the spinner; but now, several thousand spindles may be seen in a single room, moving with amazing rapidity, without a single hand to guide or urge them forwards, drawing out, twisting, and winding up as many thousand threads, with exactness and power the most astonishing. Still, what human skill can equal the threads of insects? The mechanism by which they are produced is stamped with Divine perfection, compared with which the finest specimens of art are coarse and clumsy.

CHAPTER X.

THE SILK-WORM—SILK SPINNING SPIDER—THE PINNA—ACCOUNT OF THE SILK MANUFACTURE.

"The same wisdom," says Bonnet, "which has constructed and arranged, with so much art, the various organs of animals, and has made them concur towards one determined end, has also provided that the different operations, which are the natural results of the economy of the animal, should concur towards the same end. The creature is directed towards his object by an invisible hand, he executes with precision, and by one effort, those works which we so much admire; he appears to act as if he reasoned, to return to his labour at the proper time, to change his scheme in case of need. But in all this, he only obeys the secret influence that drives him on. He is but an instrument which cannot judge of each action, but is trained up by that adorable Intelligence which has traced out for every insect its proper labours, as he has traced the orbit of every planet.

When, therefore, I see an insect working at the construction of a nest, or a cocoon, I am impressed with reverence, because it seems to me that I am looking at a spectacle where the Supreme Artist is hid behind the curtain."

The feelings of this eminent naturalist may properly be ours, as we proceed to consider some creatures which have not yet been noticed. Thus silk is spun by a caterpillar, which feeds on the leaves of the mulberry tree; it is called the silk-worm; it comes from eggs laid by a kind of greyish moth in the autumn of the preceding year. They are about as large as a grain of mustard-seed, at first of a yellow colour, but afterwards of a bluish hue.

In May the eggs are hatched, and produce small black caterpillars, less than the tenth of an inch in length; these daily increase in size, and gradually alter their colour until they become nearly white. In about eight days the head grows larger, and the creature is seized with its first sickness, when its size increases; and in the course of a month, its weight is multiplied many thousand-fold. It then throws off its whole covering, not only that of the body but of the feet, of the entire skull, and even of the mandibles, or jaws, which process may be seen by the unassisted eye, but of course more

clearly through a magnifying-glass. It is again attacked by sickness, after which it moults again; and when this has been repeated for the fourth time, the caterpillar is about one and a half or two inches long. It devours its food most voraciously, and during ten days, increases rapidly in size. Its whole form is now remarkable.

Goldsmiths or gold wire-drawers have iron plates, pierced with holes of different sizes, and they draw gold and silver wire first through the larger and then through the smaller, according as it is required to be fine. Now the silk-worm has under her mouth just such an instrument, having a pair of holes, which are united in one on the outside. This is connected with the part that provides the silk, and which is formed of two long floating twisted tubes, growing slender towards the head of the insect, where they unite to form the spinneret which renders the silk. The length of these vessels depends on the quantity of silk wanted by the insect; those of the silk-worm are about ten inches long, while those of the larva of the goat-moth are little more than three inches.

The silk-worm fixes the first drop of gum that issues from these vessels, through the holes just mentioned, where she pleases, and then draws back her head, or lets herself fall, while the gum, continuing to flow, is drawn out and lengthened. On being exposed to the air, it

THE SILKWORM AND ITS CHANGES.

immediately becomes dry, and acquires consistence and strength. And most wonderful is it that she is never deceived in adjusting these openings, or in calculating the proper thickness of the thread, but always makes its strength proportionable to the weight of her body. The thread varies considerably in colour and texture, and sometimes resembles cotton or wool. In spiders it is much more soft and tender than that of other spinning insects.

The outer part of the cocoon or ball it spins is formed of a rough silk-like substance, called floss ; inside this is a thread more even and distinct, and then the apartment of the chrysalis, or aurelia, which lodges here, seems lined with a substance of the hardness of paper, but much stronger ; while the third, which composes the cocoon, is not rolled regularly round, but lies very unevenly upon it, and winds off first from one side and then from the other.

In this country, the caterpillar takes fifty-six days to arrive at perfection, during which time it always sheds its skin as many as four and occasionally five times ; the cause of this additional change is not known. After every change the caterpillar is lighter in colour, and has a larger head than previous to the change ; it spins during five or six days, making about sixty-two days.

In warmer climates it arrives at its full growth in forty-seven days, and has finished spinning in five more.

When the caterpillar is about to change its skin, it ceases to eat, holds its head up, and appears ill and sulky ; the new head is plainly to be discovered through the transparent skin, behind the old one, and rather of the shape of a triangle. After remaining in this state two or three days, the skin opens behind the head, which cracks lengthwise, and is cast with the skin ; the caterpillar then twists itself from side to side, and writhes about, while the skin gradually slips from its body, and comes off at the tail.

One author thus writes :—"There is scarcely any thing among the various wonders which the animal creation affords, more admirable than the variety of changes which the silk-worm undergoes ; but the curious texture of that silken covering with which it surrounds itself, when it arrives at the perfection of its animal life, vastly surpasses what is made by other animals of this class. All the caterpillar kind do indeed undergo changes like those of the silk-worm, and the beauty of them in their butterfly state greatly exceeds it ; but the covering which they put on before this change into a fly is poor and mean, when compared to that golden tissue, in which the silk-worm wraps itself. They,

indeed, come forth in a variety of colours, their wings be-dropped with gold and scarlet, yet are they but the beings of a summer's day; both their life and beauty quickly vanish, and they leave no remembrance after them; but the silk-worm leaves behind it such beautiful, such beneficial monuments, as at once record both the wisdom of their Creator, and his bounty to man."

In this case the words of Cowper are also verified:—

"The beams of April, ere it goes,
A worm, scarce visible, disclose;
All winter long content to dwell
The tenant of his native shell.
The same prolific season gives
The sustenance by which he lives,
The mulberry leaf, a simple store,
That serves him—till he needs no more!
For, his dimensions once complete,
Thenceforth none ever sees im eat;
Though till his growing time be past,
Scarce ever is he seen to fast.
That hour arrived his work begins;
He spins and weaves, and weaves and spins;
Till circle upon circle, wound
Careless around him and around,
Conceals him with a veil, though slight,
Impervious to the keenest sight.
Thus self-enclosed as in a cask,
At length he finishes his task;
And, though a worm when he was lost,
Or caterpillar at the most,
When next we see him, wings he wears,
And in papilio pomp appears;

Becomes oviparous; supplies
With future worms and future flies
The next-ensuing year—and dies!
Well were it for the world, if all
Who creep about this earthly ball,
Though shorter-lived than most he be,
Were useful in their kind as he."

The silk-worm, though the most celebrated and successful, is not the only manufacturer of silk among inferior creatures. There are spiders whose produce is said to be equally beautiful, strong, and glossy. The spider spins minute fibres from small papillæ, or nipples, placed on the hinder part of its body, and from these it forms or moulds a viscous liquor, which, after being drawn through them, dries on exposure to the air, and becomes silk. M. Reaumur found that each of these nipples consists of many smaller ones, which can only be discerned by their effects. M. Bon was able to count fifteen or twenty fibres in a single thread, while Reaumur relates, that he has discovered through a microscope, seventy or eighty, and found there were a far greater number than he could reckon, so that he believed himself to be far within the limit of truth when he supposed that one slender filament of a spider's web is made up of 5000 fibres. The thread which forms the web to entrap the prey is very fragile; but those which are wound very loosely round the eggs, in a

shape like that of the silkworm's cocoon, after it has been prepared and loosened for the distaff, are much stronger. M. Bon collected many of these bags, from which a new kind of silk was made, inferior, it is said, in no respect to that of the silkworm. It took readily all kinds of dyes; stockings and gloves were also made from it; and some of these he presented to the Royal Society of London and the Royal Academy of Paris.

With these creatures, too, must be associated one living beneath the surface of the sea, and of a very humble rank, yet, in various points of view, of great interest. The pinna, one of the Mollusca tribes, with two shells, is generally found at a small distance from the shore of the Mediterranean, Indian, American, Atlantic, and European oceans, as well as in the Adriatic and Red seas, and seldom on bold and rocky coasts, exposed to the furious assaults of the tide. It has been elegantly termed "the silkworm of the sea," from its spinning a fine silky beard, by which it firmly moors itself to the sand, gravel, roots of marine plants, or, in fact, any other matter within its reach.

The animal is provided with a kind of tubular instrument, having a gland which secretes a glutinous substance; and by means of slight pressure, a drop of it falls on the spot to which the byssus, as the beard is

called, is to be attached. Its singular organ, however, which in shape resembles a tongue, and therefore frequently bears that name, answers different purposes; for whenever the creature wishes to change its place, it serves to drag the body forward, and may therefore be called a leg, for being fixed to some solid body, and then, contracted in its length, the animal is necessarily drawn to the spot where it has fixed itself, and, repeating the movement, arrives ultimately at its destination.

But its principal use is in spinning the threads of the byssus: for it becomes cylindrical at the base or root, and has a canal running through its entire length, as a passage for the substance of which they are made, and also for moulding them into the proper form. Accordingly, when the first drop is placed on the chosen spot, this organ is retracted; thus a silken filament is drawn out, and the operation being continued some thousands of times, a beautiful tuft of silky fibres is produced. The natural colour is a rich golden-brown, which readily receives any tint.

Paley, when describing the operations of the silkworm, justly compares them to the process of wire-drawing,—in which the substance required is produced by its being drawn through a plate of steel containing

FISHING FOR PINNÆ.

holes which have been made that it may be reduced to the proper shape and size—and in a similar way the pinna acts. One difference only appears. The wire is the metal unaltered, except in figure: whereas, in the forming of the thread, the nature as well as the form of the substance is somewhat changed; for while in the animal—whether it be indeed an insect or a mollusk,—it is merely a soft and clammy glue, yet it acquires firmness and tenacity on its exposure to the air.

On the coasts of Sardinia and Corsica the pinnæ are in great request for the sake of the byssus; and are fished up with a curious instrument. It consists of two semicircular bars of iron fastened together at each end, but three inches distant from each other at the centre; having at one end a hollow handle in which a pole is fixed, and at the other a ring, to which a cord is fastened. On a pinna being discovered, the iron is let down slowly over the shell, which is then twisted round and drawn out. Notwithstanding the extreme delicacy of the individual threads, they form frequently so compact a tuft that considerable strength is required to separate the shells from the rocks to which they adhere.

When a sufficient number have been caught, the silk is cut off, and after being twice soaked in tepid water, and once in soap and water, it is spread out to dry in

some cool and shady place. It is again softly rubbed, and separated with the hand, while it is yet moist, and then spread out again. When quite deprived of moisture, it is drawn through a comb with the teeth wide apart, and afterwards through a similar instrument, with finer and closer teeth. The silk intended for finer works, is afterwards drawn through closer iron combs or cards. It is spun, two or three of the threads being mixed with one of real silk; the web being of a beautiful yellow brown, resembling, when steeped in lemon juice and afterwards pressed with a warm iron, the burnished golden hue on the backs of some splendid flies and beetles.

The threads of the pinna were wrought into gloves, and other articles of dress, in very early times, and a robe presented by one of the Roman emperors to the satraps of Armenia, was probably made of this material. Several beautiful things are also made of them at Palermo. The delicacy of the thread, however, is such, that a pair of stockings, made of it, may be contained in a snuff-box of ordinary size. Some stockings of this silk were presented, in 1754, to Pope Benedict XIV., and, though so very fine, protected the legs alike from cold and heat. In gouty and rheumatic cases, stockings and gloves of this material are still

deemed useful; but it is not to be seen in England, except in the cabinets of the curious.

In reference to the productions of these creatures, it was well said by the Earl of Shaftesbury,—"How shining, strong, and lasting, are the subtile threads spun from their artful mouths! Who, beside the All-wise, has taught them to compose the beautiful soft shells, in which, recluse and buried, yet still alive, they form those beautiful threads, when not destroyed by men, who clothe and adorn themselves with the labour of these sweet creatures, and are proud of wearing such inglorious spoils?"

To return to the silk-worm: it may be remarked that its produce has been a valuable article of commerce, and a favourite one for dress from time immemorial. The period at which it was first used by man cannot be traced. The credit of drawing the slender filament from these little silken balls, from which such various and beautiful fabrics may be formed, is claimed by the Chinese. Their records are said to speak of the use of silk as of very early date. They represent the empresses as surrounded by their women, engaged in hatching and rearing the little manufacturers, and in weaving their valuable produce. They give the honour of doing this first to one who was named, See-ling-shee.

Silk was introduced into Europe, A. D. 550, by two monks, who brought the eggs of the silk-worm, in hollow canes, to Constantinople, and there succeeded in rearing the larvæ and obtaining their produce. In England it was very slowly introduced. Soon after the Conquest, however, it was used; and in 1521, when Alexander III. of Scotland, married Margaret, the daughter of Henry III., a thousand English knights appeared in garments of silk, which were thrown aside next day for others equally gorgeous and splendid.

Silk is now produced abundantly in Europe, as in Murcia, in Spain, and the South of France, but principally in Italy; in Hungary it is cultivated, but with little success. In England all attempts have hitherto failed, probably from the want of sufficient warmth, and from the superior value of labour.

In France, Germany, Turkey, Italy, and the continent of Asia, it is an article of great commercial importance. In our country it is a very valuable manufacture. It was said in the days of Oliver Cromwell: "The Englishman buys silk of the stranger for twenty marks, and sells him the same again for one hundred pounds." But now, we buy three millions and a half pounds of raw silk from the stranger, employ half a million of our own people, with the aid of machinery, in

SILK MANUFACTURE IN CHINA.

its manufacture, and sell it to them and the stranger, at a price as low as that of calico half a century ago!

The history of the silk manufacture in this country is highly interesting. In 1685, the revocation of the edict of Nantes compelled many merchants, manufacturers, and artificers, to fly from France; and about 70,000 made their way to England and Ireland, with as much property as they were able to remove. "The first effort of our French refugees," says De Foe, "was our thin black crapes, a manufacture purely their own. I refer to the memory of people conversant with trade, how universally it pleased our people; so that the least quantity of wool that ever was heard of in a garment supplying the room of a suit of cloth, it became a general habit, and the ladies of the best quality began to appear in a gown and petticoat under twenty-five shillings, till the meanness of the price giving every servant an opportunity of being as fine as her mistress, it grew a little obsolete among the women. Then the men fell into it. It served gentlemen for waistcoats, all men for linings, and, for a time, the clergy for gowns."

A large number of persons who had been engaged in the fabrication of silks resorted to Spitalfields, and contributed much by their knowledge and skill to the improvement of the manufacture in England. The silk

called alamodes and lustrings were introduced by them; and to them we are also indebted for our manufactures in brocades, satins, black and coloured mantuas, black paduasoys, ducapes, watered tabbies, and black velvets, all of which fabrics had been previously imported.

At Derby, other efforts were made in this branch of manufacture. They were commenced by a person named Crotchet, who erected a silk-mill there in 1702. His prospects were favourable till the scheme he had formed was put into practice: but then disappointment ensued. The fact is, that three engines were found necessary for the whole process; he had but one, and became, in consequence, insolvent. A family of the name of Lombe was afterwards, however, very successful.

The Italians had become, at this time, so much superior to the English in the art of throwing silk, that it was impossible for the latter to bring the article into the market on equal terms. It was also customary for the English merchants engaged in the Italian trade, to send their sons and apprentices to Leghorn, Turin, Ancona, and other parts of Italy, to complete their mercantile education, by acquainting themselves on the spot with their peculiar line of business.

Professedly in compliance with this custom, but with another as an ulterior object, Mr. John Lombe, a young

man of considerable spirit, a good draughtsman and an excellent mechanic, proceeded to Leghorn in the year 1715. As he knew that admission into the silk manufactories was prohibited, he hoped to learn how they were conducted by corrupting the servants, and in this he succeeded. Frequently gaining access in private, he gradually became acquainted with the various parts of the Italian machinery, committing to paper whatever he had acquired before he slept, though the punishment prescribed by the laws of the people, "for those who discovered or attempted to discover any thing relating to this art, was death, with the forfeiture of all their goods, and to be afterwards painted on the outside of the prison-walls, hanging to the gallows by one foot, with an inscription denoting the name and crime of the person; there to be continued for a perpetual mark of infamy." It was not however until Lombe, unmoved by fear, had acquired a knowledge of the whole process, that his plot was detected, when he fled with the utmost precipitation on board a ship, taking with him two natives, who had favoured his interest and his life at the risk of their own.

On his return he appears to have been actively engaged in forwarding the works undertaken by himself and his brother Sir Thomas at Derby, which had been

chosen from its being likely to supply them with artisans as well as water. He in consequence reduced the prices so far below those of the Italians as to enable him to monopolise the trade; yet, according to Hutton, in the history of his native town, the overflowings of the profit were so very considerable as to enable him to pay for the grand machinery he erected as it went on.

But his prosperity was at length interrupted. An artful woman arrived from Italy in the character of a friend; she associated with the parties concerned, and assisted in the silk-manufacture. But she attempted to gain over both the Italians, and succeeded with one. By these two persons, it has been supposed, and perhaps justly, that poison was administered to John Lombe, who lingered for two or three years in anguish, and died at the early age of twenty-nine. The Italian fled to his own country, and the woman was interrogated, to the increase of suspicion, but not to the full discovery of the probable crime.

The machinery, erected at so great a cost, was secured by patent to Sir Thomas Lombe. According to his statement, it had 97,746 wheels, movements, and individual parts, which worked day and night, all receiving their motion from one large water-wheel, being governed by one regulator, and employing three hundred persons

to attend and supply it with work. On his applying to parliament for a further term for the sole making and using his engines, or some other adequate recompense, it was thought best to give him a grant of £14,000, on condition that the invention should be thrown open to the trade, and that there should be a model of the machine for public inspection in the Tower of London.

In the course of time, similar mills began to be erected in different parts of the country: but in consequence of the difficulties in procuring Italian raw silk of the proper size—the exportation of which from Italy was prohibited—and also because the mills happened afterwards to find employment for other purposes, the quantity produced in this country, for many years, bore no proportion to the imports from Italy. Since that time, however, the manufacture has revived and improved, and is now carried on to a very considerable extent, not only in Derby, but in other parts of the country.

The interest of this digression will prove, it is presumed, a sufficient excuse for its being made; and to another fact in the history of insects, it is necessary now to advert. It appears indispensable for them, generally, to feed copiously during their larva state, in order to provide a store of nutriment for their subsequent changes; since most of them eat little, and many

nothing, after being transformed into pupæ and perfect insects.

The mandibles of caterpillars, which do not act perpendicularly, like the jaws of quadrupeds, but horizontally, are, for the most part, very sharp and strong, being of a hard, horny substance, and moved by powerful muscles. Ordinarily they are slightly bent, in the form of a reaping-hook, having the concavity indented with the tooth-shaped projections, formed out of the substance of the jaw, and not socketed, as the teeth of quadrupeds. These are made to meet like the blades of a pair of pincers : and in some cases they both chop and grind the food. Beside these, there is a pair of jaws placed on each side of the middle portion of the under lip ; and from their being of a softer substance, they seem to be more for the purpose of retaining the food than for mastication.

In the process of transformation, a corresponding change takes place in the internal structure of the organs of digestion ; and the formidable apparatus for masticating just described, is well adapted to supply the capacious stomachs of caterpillars. An insect in this state will actually devour, in a month, sixty thousand times its own weight of leaves ; while the moth, or the butterfly, into which it is afterwards changed, may not

sip a thousandth part of its weight of honey, during its whole existence. In the caterpillar, there is a most capacious stomach, which indeed fills a large portion of its body; but in the butterfly, the stomach is diminished to a thread. Heroldt traced these changes as they successively occur, from the caterpillar to the butterfly. In the caterpillar he found the gullet, the honey-stomach, the true stomach, and the intestines capacious; but two days after its first change, all these were visibly diminished, as well as the silk reservoirs, which, in a chrysalis eight days old, wholly disappeared, while the base of the gullet was dilated into a crop, and the stomach was still more contracted into a spindle form. When near its change into the perfect insect, the gullet is still more drawn out, while the crop, still small, is now on one side of the gullet; and, in the butterfly, is enlarged into a honey-stomach. Thus provided with such masticating powers and capacious stomachs, the larvæ, all of whom are employed in eating for at least ten or twelve hours in the day, and a great number during the night, commit extensive ravages on the substances which yield them food. Of their destructiveness an example may now be given.

In the month of June, 1827, there was scarcely a leaf to be seen on the oak trees which form the greater

portion of Almour Wood, in Kent: and this extensive destruction had been effected by one species of the small, solitary *leaf-rollers*, a sort which seldom consumes more than four or five leaves, if so much, during its existence. The number of these caterpillars must then have been almost beyond conception, and that of the moth the previous year, must also have been very great; for the mother moth only lays from fifty to a hundred eggs, which are glued to an oak-branch, and remain during the winter.

Thus the goodness of the Creator is often manifest in keeping caterpillars within due bounds: for, otherwise, those of one moth alone, the gamma moth as it is called, from having upon it the Greek letter γ, to say nothing of other British species, would soon destroy a great part of our vegetation.

CHAPTER XI.

PREPARATIONS OF THE CATERPILLAR FOR ITS CHANGE—ITS RELEASE—THE CHRYSALIS.

When the grand duke of Tuscany visited Holland, in 1688, he is said to have been much gratified when Swammerdam showed him how the future butterfly lies neatly folded up in the caterpillar, like the flower in the unexpanded bud. So struck was he indeed, with this, and other wonders of the insect world, that he made the great naturalist a princely offer to reside at his court. Some of these, not yet noticed, we proceed to consider.

When the insect has lived its appointed time in the caterpillar state, it prepares for a remarkable change. Many creatures retire to any hole on the surface of the ground, and cover themselves with dead leaves or moss; while others repair to the niches in walls, the chinks of trees, or any similar hiding-places; or else make a cavern in the earth. Not a few take long and arduous journies for this purpose; and aquatic larvæ leave the water and betake themselves to the shore. Some have all

they want when they have gained a retreat; others adopt various manœuvres for their defence.

Some caterpillars, for instance, suspend themselves perpendicularly by the tail, and yet this is no trifling task; for the chrysalis is incased within the skin of the caterpillar, and is without feet or other external organs. Let us see, then, how its object is accomplished. When the insect has chosen the substance to which it is to be attached, as some part of a leaf or stem, it spins on it many loosely interwoven silken threads; it afterwards bends its body so as to place its last pair of pro-legs among these threads; and then, by a slight effort, the little hooks which surround them become so much entangled as easily to support the weight of the caterpillar. It now suffers the anterior part of the body to fall; and thus it hangs, with its head downwards, often for twenty-four hours, at intervals contracting and dilating itself.

At length, as the skin splits near the head, a part of the chrysalis appears; and as this portion moves like a wedge, the split rapidly extends towards the tail; while, by various movements of the caterpillar, its skin is pushed at last in folds near the tail, like a stocking which is rolled on the ancle before it is withdrawn from the foot. Now comes another important operation; for,

as the chrysalis is much shorter than the caterpillar, it is as yet at some distance from the silken threads on which it is to be fastened, and is supported merely by the unsplit portion of the caterpillar-skin. Shall it, then, having no arms or legs, detach itself and be suspended in the air, while it climbs up to take its place?

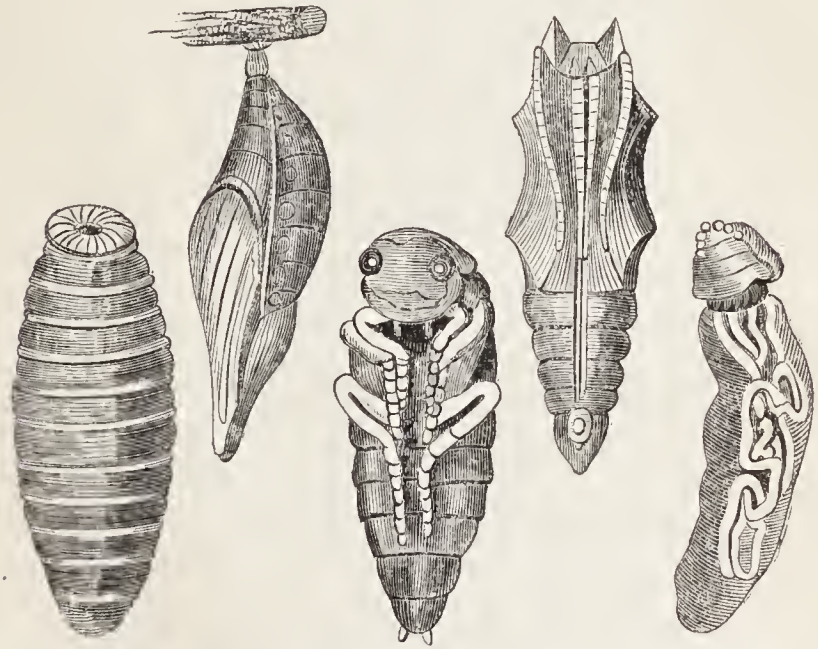
The fact is, that the creature is fully provided for its circumstances. The chrysalis seizes, by means of two segments of its abdomen, on a portion of the caterpillar-skin, holding it as with a pair of pincers, and, bending its body, entirely frees its tail; it then makes a ladder of the cast-off skin, and by different segments it seizes a higher and a higher portion, until, at last, it reaches the summit, where, by the hooks of its tail, it fastens itself to the silk. "Assuredly," says Reaumur, "it must have been taught to perform its task by a great Master!"

In other cases, the larva not only fixes its legs among silken threads, but forms a girth, often composed of fifty or sixty threads, and fastened on each side of the body, to the surface under which it is placed. The process varies with different insects. The caterpillar of the beautiful swallow-tail butterfly, and others of the same family, adopt a curious but natural mode. The insect forms the loop which is to serve for its girth, and

then creeps under it. As, however, it has to keep itself from being entangled in the fifty or sixty fine threads of which the girth is composed, so that it may place its body under them, it employs the first two pairs of legs as a woman does her hands in winding a skein of cotton, to keep all its threads unentangled and properly stretched; and it often has great difficulty in preserving them from slipping off. When a sufficient number of threads is completed, the insect bends its head between its legs, and places itself under the collected loop, which it easily pushes to the middle of the body.

In about thirty hours after these operations are finished, the skin splits, and the chrysalis pushes its covering in folds to the tail, by various motions. These curious modes of suspension may be easily observed. It is only to collect, and feed until their change, the black spinous caterpillars of the common peacock butterfly, so commonly found upon nettles, or those which swarm in cabbages or brocoli in every garden. To hit the precise moment for observation, however, a considerable number of the larvæ of each kind should be fed, some of which, if watched narrowly when they have reached their full growth, will scarcely fail to show, in the former, a specimen of *vertical*, and in the

latter, an instance of *horizontal* suspension. These are the principal positions taken by caterpillars, but some are inclined at various angles, and others are attached with less art, appearing only to be fastened by some part of the body to the substance they choose.



The forms of chrysalises or pupæ, as appears from the cut, are peculiar. If, for instance, that of the lappet-moth be disengaged from the cocoon, it has much the appearance of an Egyptian mummy. The feet are crossed over the breast and folded closely down; and the wings are compressed into a very small compass. This appears the more remarkable, as the wings of the

moth are large and conspicuous, and so like the withered leaves of an oak, both in form and colour, that the insect would readily deceive a careless observer. By opening one of these pupæ, Reaumur discovered that various sheaths were appropriated to the feet, the antennæ, and the wings.

There is much less variety in the colour of pupæ than in that of larvæ. Some are white or whitish; others are brown of various shades, often verging on black or red; but many are gaily decorated. Some are of a greenish-yellow, marked with spots of black; others are of a uniform green; others reddish; and others again red, with black spots. A still greater number shine as though gilded with burnished gold, either applied in partial streaks, or covering the entire surface. It was from this gilded appearance in some pupæ that the terms chrysalis and aurelia, derived from the Greek and Latin names for gold, were applied to all. The alchemists mistook this for real gold; and referred to it in proof of the transmutation of metals.

But Reaumur has satisfactorily shown that, in this case, the proverb is applicable, "All is not gold that glitters." He found that the gay appearance is owing to the shining membrane immediately below the outer skin; this being of a transparent yellow, gives

INSECT TRANSFORMATIONS.

a golden tinge to the former; in the same way that tin foil, when covered with a yellowish varnish, assumes the metallic appearance of gilt leather. It is essential for the production of this effect, that the inner membrane be moist; and hence may be explained the disappearance of the gilding as soon as the butterfly is ready to escape from the pupa. The shades of colours in these gilded chrysalises is various. Some are of a rich yellow, like pure gold, others are much paler; some are nearly as white as silver, and one is red, with silver spots. But this condition precedes another change.

The transition made by insects from one state to another, may well remind us of the changes through which we must individually pass. "It is appointed unto all men once to die," and among the consequences of death is the resurrection. Of this we have a striking example in the insect world. We have seen these creatures begin their existence in the form of caterpillars; and in this humble state of being they continue for a time. At length they appear to die, first constructing for themselves a kind of shell or tomb, in which they may be said, with strict propriety, to be afterwards buried. No trace of life is now apparent, yet as the term of burial hastens to its close, the tomb opens, and a winged creature comes forth, with a nobler form, often

arrayed in great beauty and splendour, endowed with new and exalted powers, and fitted for a higher state of existence.

Such a transition might at once satisfy the mind, if it entertained a doubt concerning the power of God, or his sufficiency to raise the body of man from the cold sleep of death. Against the resurrection itself there is indeed no presumption, and in favour of it, on the contrary, there is a strong one from analogy. In addition to the case already cited, there is another in the process of vegetation. The little germen which the seed contains, is fed by the death and corruption of the rest, that it may spring forth into new life.

Still, though we may now listen to the voice of analogy, no trace of the doctrine of the resurrection can be found in all the researches of philosophy. When Paul declared it to the wise men of Athens, he was treated with contempt. And yet how sublime and consolatory is the truth which they knew not and despised! Man, guided only by the light of nature, looks forward with many melancholy forebodings to the grave. All who have gone before him, except Enoch and Elijah, appear to have entered the dark and narrow house. His own steps tend to the same dreary abode. It meets his view as a massy prison shrouded in gloom. And philosophy can tell

PAUL PREACHING AT ATHENS.

him of no exemption from its bondage—no means of escape. "Here," it exclaims, "is the end of man—all he possessed is mortal;—here he mingles for ever with the dust of the earth!" Afflictive indeed is the intimation; it leaves the soul a prey to despair. But how may it rejoice when, in the exercise of faith, it hearkens to the Son of God exclaiming: "I am the resurrection and the life; he that believeth on me, though he were dead yet shall he live, and he that liveth and believeth on me shall never die."

The body which is sown in corruption, shall be raised in incorruption; its strength as well as its other attributes, like those of the mind, will be prepared to advance towards a higher perfection, while its former state of humiliation will be followed by one of honour and beauty. Paul tells us that Christ, whose "face," on the mount of transfiguration, did "shine as the sun, and whose raiment became white and glistening;" and who appeared in such splendour in vision to the beloved disciple that he said, "When I saw him, I fell at his feet as dead," will fashion it like to his own glorious body." Oh what a transformation must that be which this poor, frail, perishable frame will experience, when this declaration shall be completely fulfilled!

Here, however, the reference to it is peculiar. As an

event, the resurrection of the dead will be universal, and we shall be the subjects of it, whether it be anticipated with hope or dread; for "all that are in their graves shall hear the voice of the Son of God, and shall come forth." But to some, the change will yield no privilege. For what is it for a criminal to be led out of prison to be tried, condemned, and borne to the place of execution? And what is it for the body to be revived, but not renovated—inheriting the principles of all the evils entailed by sin, and rendered immortal only for the endurance of misery! Surely the grave is better than perdition, and the slumber of the tomb than the torture of "the worm that never dies!"

On us therefore it devolves so to live as if "by any means, we may attain unto the resurrection of the dead." "To awake to everlasting life," will be an infinite reward for any effort, any sorrow, any sacrifice. Gracious Redeemer, undertake our cause! May we receive thy word, rely on thine atonement, and be conformed to thine image; and then we shall exult, and adore thy grace, on the morning of the resurrection!

CHAPTER XII.

EXTRAORDINARY CHANGES—THE BUTTERFLY MAY BE TRACED IN THE CHRYSALIS — ESCAPE OF VARIOUS INSECTS— PERFECT STATE OF THE RIGHTEOUS.

To adopt the language of an eminent writer, "Were a naturalist to announce to the world the discovery of an animal which for the first five years of its life existed in the form of a serpent, which then penetrating into the earth, and wearing a shroud of pure silk of the finest texture, contracted itself within this covering into a body without external mouth or limbs, and resembling more than any thing else an Egyptian mummy, and which, lastly, after remaining in this state, without food and without motion, for three years longer, should, at the end of that period, burst its silken cerements, struggle through its earthy covering, and start into day a winged bird;—what, think you, would be the sensation excited by this strange piece of intelligence? After the first doubts of its truth were dispelled, what

astonishment, would succeed! amongst the learned what surmises! what investigations! among the vulgar, what eager curiosity! what amazement!"

Another naturalist has remarked with equal propriety, "This history is so amazing in all its circumstances, that it might very well pass for a romance, were it not built on the most firm foundation of truth;" and Goethe says of these changes, "I would call these transmutations wonderful, if the wonderful in nature were not that which occurs every moment."

It may be here observed, that we are able to perceive in the outer covering of the chrysalis, all the external organs of the fly. Swammerdam also very plainly demonstrated that even before the period when the caterpillar is ready for its change, all the parts of the butterfly may be discovered within its body; satisfactorily proving that the chrysalis is no more "than a beautiful and orderly representation of such limbs of the caterpillar as have grown under its skin; for though the limbs may be seen under the insect's skin, at the time it crawls and eats in the form of a caterpillar, nevertheless, it is in this state, on account of their extreme tenderness and delicacy, a very difficult matter to have a satisfactory view of them. They are, in a manner, as fluid as water, and they lie folded up in

many very tender membranes, interwoven with pulmonary tubes. The best time to obtain a view of them is when the caterpillar is just about throwing off its skin, and exhibiting to open view the operations of nature, which it hitherto concealed."

The outer skin of a chrysalis is of a hard and rigid substance, although on its first exclusion from the skin of the caterpillar, it is not enclosed in this hard covering. "At the moment of this change," observe Messrs. Kirby and Spence, "the envelope is nearly soft and membranous. But the pupæ are covered with a viscous fluid, which appears to ooze out chiefly from under the wings, and which very soon drying, forms the exterior hard shell. At first the antennæ, wings, and legs can be each separated from the body, and it is only after these parts have been glued together by the fluid just mentioned, which takes place in less than twenty-four hours, that they are immoveably attached to the body of the pupa, as we usually see them."

The time may often be known when the chrysalis has reached its maturity, and is ready to make its escape. The colour now frequently undergoes a change : the silver or golden tint vanishes, and those which are transparent, commonly allow the forms and colours of the insects within, as well as the motions of their

limbs, to be clearly perceived. In some instances, the eyes become more brilliant. Other changes may also be observed.

The period required by chrysalises to arrive at maturity, varies with circumstances. It is found that if the creature is exposed to a high temperature, it sooner reaches the perfect state, even though larger in bulk, than others exposed to a low one. The chrysalis of a large moth, which has ceased to be a caterpillar in the early part of summer, will often disclose the perfect insect in twelve or fourteen days; while that of an ichneumon, not one-hundredth part of its size, that did not become a chrysalis till late in autumn, will not appear as a fly for seven or eight months. The same insect, too, according as it becomes a chrysalis at an earlier or a later period of the year, will at one time live but a few weeks, and at another several months in that state.

The mode in which insects escape, differs in different orders. In some cases the struggles of the moth or butterfly within, first make a slit lengthwise, down the middle of the thorax, where there is usually a suture for the purpose; this rapidly extends along the head, and down the parts which form the breast, and the insect thus gradually withdraws itself from its case. It has

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to disengage itself, however, not only from the outer skin, but from a series of inner cases, which separately inclose the antennæ, proboscis, and other parts; and similar cases inclose the parts of the perfect insect, in chrysalises of all other orders. Sometimes this is a work of difficulty, but commonly it is effected with ease.

In other instances, the outer case is commonly more rigid, and without the sutures which appear in the former; but at the end under which the head of the fly lies, and from which it always issues, there is commonly a sort of lid, joined by a very indistinct suture to the rest, which can be pushed off, leaving a sufficient opening for the escape of the insect. Sometimes this lid is formed of two semicircular pieces, which can be separately removed. Many species seem able to force off the lid, by merely pushing against it with their heads, but others, like the common flesh-fly, have a remarkable apparatus for this express purpose, which disappears soon after the insect is disclosed. They have the power of introducing air under the middle of the part to which the antennæ are fixed, and of inflating it to the size of the head, and by the action of this part against the end of the case, the lid is soon displaced. This extraordinary lever has great power, and when it is no longer wanted, it appears to be laid

aside, for the head of the fly soon becomes all alike hard.

Insects which lie deep in the earth, or are shut up in the heart of trees on which the caterpillars have fed, wait till their organs have sufficient strength, and their wing-cases are hardened enough to protect their little pinions, as they force their way through the earth or the wood. One beetle is a full month after quitting its case before it reaches the surface of the ground. As however, there are instances in which no delay would secure the delicate wings from injury, many insects have the precaution, a few days before their exclusion, to force themselves up to the surface of the earth, or to the entrance of their holes in the trees.

The insects, in such instances, are complete as soon as they are withdrawn from their retreat; but a very large number have to pierce the cocoons of leaves, silk, and even wood, in which they are incased. How then shall this be done by creatures having no jaws, but only a soft proboscis? Well has it been remarked: "These difficulties have been foreseen by INFINITE WISDOM, and provided against by INFINITE POWER!" Either some peculiarity appears in the structure of the cocoon, or the insect is able to perform some singular process.

One caterpillar becomes a chrysalis in the interior of a grain of wheat, but the opening it makes for its entrance is not bigger than a pin's point, and through it, therefore, the moth cannot force its way. But the caterpillar, before it becomes a chrysalis, gnaws out a little circular piece at that end of the grain where the head of the future moth will lie, taking care not to detach it entirely. Thus the moth has only to push against the little door, when it falls, and opens at once a free passage.

Commonly it is the moth that breaks the cocoon, but some chrysalises do so, and therefore, they have sharp points on the head for this purpose. The process of one insect is thus described by Professor Peck : " In the silk-moth, and all others which I have had opportunity to observe, the chrysalis bursts *in* the cocoon, and the fluid which surrounded the new insect in it, escaping at the same time, so weakens or dissolves the fibre and texture of the silk, that the moth is able to extricate itself, leaving the chrysalis behind it ; but this is not the manner in the locust-moth. After remaining till all its parts are fully grown, and it is ready to quit its prison, a certain quantity of exercise is necessary to break the ligaments which attach the moth to the shell of the chrysalis, and to loosen the folds of the abdomen.

In taking this exercise, it can only move the abdomen in various directions; as one side of the rings is moved forward, the hooks in the lines above mentioned take hold of the silk, and prevent their sliding back; the next flexure brings forward the opposite side of the rings, which are prevented by the points on that side from slipping back in the same manner, and the chrysalis is forced out of the slightly-woven extremity of the cocoon, and through the silk-lined cavity, till it is protruded for about one third of its length out of the opening in the bark, and into the air."

But the insect, even when extricated from the prison in which it has been confined, has not yet attained its full perfection, being at first weak and feeble; the wings, too, are of a very small size, compared with that they acquire when fully expanded, appearing at first like pieces of wet paper, soft, and full of wrinkles, cavities, and swellings. So rapidly, however, do they expand, that as Swammerdam says, "The naked eye cannot trace their unfolding, from reaching scarcely half the length of the body, until they acquire, O miracle of miracles! in the short space of about half a quarter of an hour, their full extent and bigness."

The change with regard to a very interesting and beautiful butterfly is thus described by another eminent

naturalist; "The pupa of this being brought to me by a friend, I had the pleasure to see it leave its puparium. With great care I placed it on my arm, whence it kept pacing about for the space of more than an hour; when all its parts appearing consolidated and developed, and the animal perfect in beauty, I secured it, though not without great reluctance, for my cabinet, it being the only living specimen of this fine fly I had ever seen. To observe how gradual, and yet how rapid, was the development of the parts and organs, and particularly of the wings, and the perfect coming forth of the colours and spots, as the sun gave vigour to it, was an interesting spectacle. At first it was unable to elevate or even move its wings, but their numerous corrugations and folds gradually yielded, till they had gained their greatest extent, and the film between all the nervures became tense. The ocelli, and spots and bars, which appeared at first as but germs or rudiments of what they were to be, grew with the growing wing, and shone forth at its complete expansion in full magnitude and beauty."

Other changes take place. The two filaments of the proboscis, which were stretched at full length along the breast, are now curled into a beautiful spiral tube under the head; and the antennæ which were laid by the side

of the legs beneath the body, are stretched into the air, from the crown of the head on which they are fixed.

The manner in which the surprising change in the size of the butterfly's wings is so suddenly effected, from its small corrugated form until it is fully developed, is owing to the action either of air or an aqueous fluid, or sometimes both, in the tubular nervures of the wings. On looking at these beautiful instruments of flight, we only perceive a covering of richly-covered down, yet on brushing this off, and minutely examining the substance of the wing, it is found to consist of two layers of very thin membranes, between which various veins, or nervures, as they have been termed, are found disposed in a longitudinal direction. Thus, when the insect impels into the minutest ramifications of these nervures of its moist and corrugated wings, sufficient fluid to distend the tubes, it follows that the membrane between the tubes or nervures becomes at the same time extended to its proper size, when it very quickly dries by the action of the atmosphere.

The experiments of Swammerdam and Reaumur have shown that an aeriform as well as an aqueous fluid is sometimes injected into the tubes, and hence it is that the insect, when nearly disclosed, agitates its unfolded wings for the purpose of putting these fluids in motion.

Indeed, according to Swammerdam, a violent agitation is produced in the fluids of the butterfly, so that they are driven from the internal vessels into the tubes of the wings, which are likewise supplied with air from the trachea. The manner in which the wings are wrinkled when closed is admirably adapted for the easy extension of the connecting membrane, for though the wing seems at first much thicker than it is afterwards, yet the appearance is not real, being only produced by the two layers of membranes not being applied to each other, so that there is a space between them; and also by the surface of each membrane being entirely covered with wrinkles, so very minute as to be almost invisible to the naked eye.

According to Swammerdam, "The blood in the bee, when the wing is cut, appears by reason of the extreme smallness of the blood vessels, under the form of little pellucid globules, which insensibly, and by degrees, increase into considerable little drops. The wings of the bee have likewise many pulmonary tubes; which when the chrysalis is casting its last skin have also together with all the other parts, once more to throw off their exuviæ or coverings. After this, when these tubes are again distended by the freshly impelled air, and the air vessels which have previously been contracted, are inflated and

distended with the same air, it follows that the whole wing afterwards expands itself, and becomes thrice, nay four times longer than it was before. This expansion of the wings then, depends both on the expulsion of the air and of the blood, for at the same time when the air is impelled into the wings, a considerable quantity of blood is likewise driven into the vessels of the wings."

"The female bees," he adds, "do not, as the common bees and the male, come forth with their wings folded up, but expanded, and displayed, and in a state ready for flight. On this account, the all-wise Author of nature has provided for them a more spacious mansion, in which they may expand their wings conveniently and properly, so that after they have burst from their cells, they may be prepared for swarming immediately, if there be a necessity for it, or if the young queen may be in a condition to drive out her royal mother, and take her place if there be occasion."

It is a curious question in what manner the downy scales of the wings of some insects are at this time disposed, and whether they increase in size; since it is to these scales which are so densely planted both upon the upper and the under surface of the wings, and not to the substance of the wing itself, that the butterfly owes all its gorgeous colours. De Geer thinks they should be con-

sidered as *feathers*, from being attached to the wings by minute quills; but Reaumur regards them as *scales*, from being composed of small membranous plates, having nothing in common with feathers. Leeuwenhoeck observed more than 400,000 of these scales on the wings of the silk-worm moth. There appears, too, to be a *double layer* of scales on both sides of the wings, the under layer generally consisting of *white* ones.

Sometimes the release of the perfect insect is chiefly owing to its own exertions. As the texture of the cocoon of the silk-worm is uniform throughout, and its layers are of equal thickness at both ends, the moth escapes by cutting or breaking the threads at the end opposite to its head; and thus destroying the continuity of the silk. How this escape is effected has not been satisfactorily determined. Reaumur infers that as the eyes are the only hard organs of the head, their numerous minute facettes serve the purpose of a fine file, and divide the threads; though insects make their escape by means of a fluid. Thus when one creature is prepared to do so, it discharges from the mouth a large quantity of liquid, with which the upper end of the case is so perfectly softened, as to enable it speedily to make its way out; an operation which is said to be always performed in the night. It is most probable however that the silk-

worm first moistens and then breaks the threads of its cocoon, while a mere push against the moistened end is perhaps sufficient, when the fabric is of a slighter texture.

The puss-moth has to pierce its wood-thickened case, and to this the eyes are certainly unequal: nor could any common fluid assist their operation, but what this cannot do, an acid can effect, and with a bag of it the moth is actually furnished. She pours out its contents as soon as she has forced her head through the skin of the chrysalis, and upon the opposite end of the cocoon; the acid then instantly acts on the gum, loosens the grains of wood, and consequently, a very gentle effort pushes down what was before a strong barrier. It is equally remarkable that a vessel, to contain so potent an acid, ought to be of glass, while the moth has only a membranous bag; yet this is of so admirable a fabric as not to be acted on by it! This is indeed a most astonishing provision, which is eminently calculated to call forth feelings of adoration towards Him, who knowing the wants of his creatures, affords to all an adequate supply.

When the ant-lion is about to change into a pupa, it constructs a cocoon of sand, which it lines with a beautiful tapestry of silk, the whole being less than half an inch in diameter; the pupa itself, when rolled up, filling only a space of about half this size. When it

has remained in the cocoon about three weeks, it breaks through the covering and comes forth, making use of its mandibles to gnaw the cocoon. Having arrived at the outside, it requires only to expand its wings and its body to complete its transformation ; but this process is very amazing ; for though the creature is not more than half an inch in length, it almost instantly stretches out to an inch and a quarter, while its wings, which did not exceed the sixth of an inch, expand to nearly three inches. In another instance, the cocoon is not bigger than a small pea, while the body of the fly is nearly half an inch in length, and covers, when its wings and antennæ are expanded, a surface of an inch square.

It has already been stated that some larvæ inclose themselves in cases of different materials, open at each end ; and that in becoming pupæ they secure these apertures with a grating of silk. When their change has actually taken place, they continue without motion, at the bottom of the water. The mode in which they make their way to the surface, when prepared for their flight in the air, is worthy of observation. While in its case, the insect can move its four front legs and antennæ ; and it is provided with *temporary* jaws. With these it makes an opening in one of its silken doors, forces its way out at that end, and then, by moving its

legs, it swims to the surface, and here its skin splits, and discloses the perfect insect. That these jaws are intended for this express purpose, and for no other, appears from the fact, that they are cast off with the rest of the pupa-case. The mature insect, if stopped in its flight through the air, will show that it has no vestige of them.

Some aquatic pupæ, not inclosed in cases, are of greater specific gravity than the water, at the bottom of which they reside, until a few hours before the insect arrives at maturity. They can, however, by moving the tail backwards and forwards, slowly raise themselves to the top; for the exclusion of the perfect insect, however, they must remain quietly suspended there, and the thorax, in which the opening for its escape is to be made, should be at least level with the surface. All that is thus required, therefore, takes place. And here a most singular provision is apparent. The middle of the back of the thorax—apparently from being covered with some oily secretion, can repel the water. As soon, therefore, as the insect reaches the top, the water retreats from it on all sides, leaving an oval and dry space upon it, and the mere attraction of the air to the dry part is sufficient, according to Mr. Kirby's experiments, to retain the creature at the surface.

But, to mention only another instance, this will appear, like those preceding it, to have been matter of providential and gracious arrangement. In the pupa state, the gnat usually remains suspended, with one end of its body turned downwards; but when the period for its change has arrived, it stretches it out upon the surface, above which its thorax is raised. Scarcely has it been a moment in this position, than by swelling, it causes the thorax to split between the two breathing horns, and through this opening the anterior part of the gnat then issues; as soon as the head and

trunk are disengaged, it proceeds with its labour and raises itself, so as to appear like a mast in a boat.

As its work advances, the mast is more and more elevated and lengthened, till it becomes nearly perpendicular, just as that of a boat is gradually raised towards a vertical position. No one of its legs or wings is of any use in maintaining it in these circumstances. The latter are too soft, and, as it were, folded; and the former are stretched out along the abdomen; the segments of this last part are therefore the only agents.

The observer who sees how the little boat gradually sinks, and how its margin approaches the water, forgets the mischievous insect it contains, which at another time he would crush without remorse, and becomes interested in its fate, especially should the wind agitate the water. A very little is sufficient to drive the voyager about rapidly, since it catches the wind in some degree, like a sail. Should it be upset, it must, as is the case with numbers, inevitably perish. But having fixed itself thus perpendicularly, the gnat draws first its two anterior legs out of their case, and moves them forwards, and next the two intermediate ones; then, inclining itself towards the water, it rests its legs upon it, for water is sufficiently hard and solid to support them, though surcharged with the weight of the insect's body. As soon as it is thus on the water, it is in safety; its wings unfold themselves and are dried, and it flies away. All this is the work of an instant.

The history of insects thus exhibits many striking peculiarities. One individual indeed unites in itself three species, whose modes of existence are often as different as those of the most distantly-related animals of other tribes. The same insect, it has been said, often lives successively in three or four worlds. During one period it inhabits the water; during another the earth; and during a third, the air; having in each of its abodes a new form, and being fitted for each state by new organs. And for this, as Bonnet has suggested, as he points us for an illustration to the cocoon of the silkworm, there is an important reason. Of what advantages should we have been destitute, if the moth of that insect had appeared only as a moth, without being previously a caterpillar! But in common with multitudes of creatures, it is first a caterpillar, it afterwards becomes a chrysalis, and in its maturity it flits about as a moth. The same Divine wisdom, however, appears in them all.

And now, having traced the insect through the various stages of its existence, and observed it pass from the egg to the perfect state, the history of these interesting creatures may here be closed. Much more remains to be told, but what has already been communicated is worthy of remembrance. The continued

observations of after years will also increase the stores of knowledge which are now possessed, and exemplify still further the Divine attributes which have been already so strikingly manifest.

Nor should it be forgotten, that there is a perfect state to which the righteous are hastening. The gospel reveals to them a truly blessed condition. "I beheld," says John, "and lo, a great multitude, which no man could number, of all nations, and kindreds, and people and tongues, stood before the throne and before the Lamb, clothed with white robes, and palms in their hands; and cried with a loud voice, saying, Salvation to our God which sitteth upon the throne, and unto the Lamb," Rev. vii. 9, 10. How glorious, then, is that state! Sanctified wholly, and rejoicing in their triumph over all their adversaries, the redeemed of every country and of every age, unite as with one heart and voice in celebrating the riches of redeeming mercy, to which they owe their deliverance from eternal woe, and their exaltation to "the fulness of joy."

Next in importance to the full enjoyment of this blessedness, is "a good hope through grace." With this nothing is to be compared on this side heaven. But we cannot obtain it of ourselves; no power that we possess can secure it; no fellow-man can confer it;

it is a gracious gift of the Holy Spirit of God. In some respects it resembles faith, for it rests on the same foundation, and is exercised on the same objects; but in others it differs, for while faith credits the promise, hope looks forward to its fulfilment. The language of faith is, "*All* that have washed their robes and made them white in the blood of the Lamb, shall stand before the throne;" but hope adds, "*I* am on my way to their blissful society;" the one beholds, with unscaled eyes, "the inheritance, incorruptible, undefiled, and that fadeth not away;" the other rejoices in the ardent expectation of its glory and happiness.

A hope thus operating, is a purifying principle; it brings the soul near to heavenly things, and peculiarly within their holy influence. "Every man," says the apostle John, "that hath this hope in him, purifieth himself even as he"—that is, God—"is pure." Hence an aiming at holiness, a labouring for it, and a longing after its highest degree and measure. Well may it be styled "a blessed hope," and be described as "an anchor of the soul both sure and stedfast, which entereth into that within the veil, whither the forerunner is for us entered, even Jesus, made an high priest for ever, after the order of Melchisedec," Heb. vi. 19, 20. "Whatsoever things were written aforetime were written

for our learning, that we through patience and comfort of the scriptures might have hope," Rom. xv. 4. In the exercise of prayer then, let this volume be concluded: "O Thou who art the God of hope, fill us with all joy and peace in believing, that we may abound in hope through the power of the Holy Spirit!"

THE END.

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