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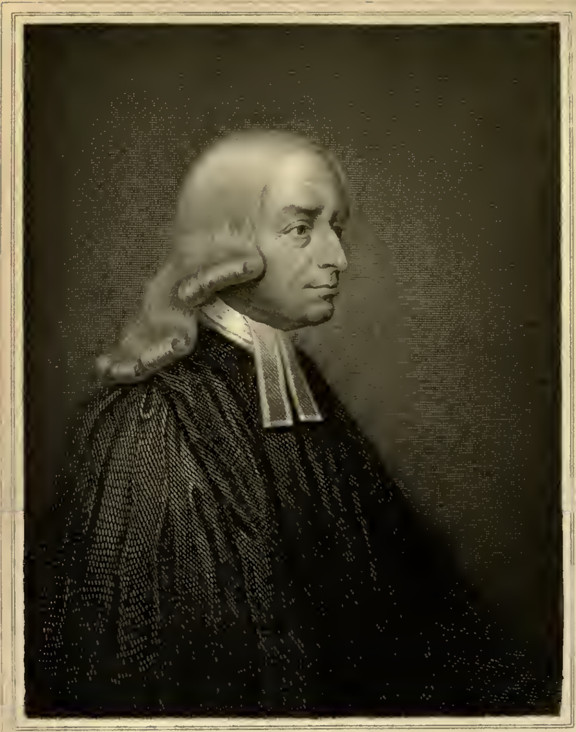

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Revd. John Wesley. A. M.

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A COMPENDIUM

OF

NATURAL PHILOSOPHY;

BEING

A SURVEY OF THE WISDOM OF GOD IN THE CREATION;

BY JOHN WESLEY, A.M.

A NEW EDITION,

REVISED, CORRECTED, AND ADAPTED TO THE PRESENT STATE OF SCIENCE,

BY ROBERT MUDIE;

AUTHOR OF "A GUIDE TO THE OBSERVATION OF NATURE," ETC.

In Three Volumes.

VOL. II.

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PREFACE

TO

THE SECOND VOLUME.

The invertebrated animals, from their countless numbers, their astonishing variety, the singular forms of some, the extreme minuteness of others, the vast strength which they often display in proportion to their size, their wonderful powers of endurance, the singular manner in which manyof them are produced, the curious transformations through which some of them pass though remaining the same identical beings all the time, and the great use in the system of nature of animals so very abundant and so very diversified, form a highly interesting, if not the most highly interesting volume in the whole of the good and glorious book of material creation. Nowhere, indeed, are the wisdom and power of the Creator written in lines more palpable, even to the least observant creature, and not one growing plant, is ever in the slightest degree deficient or at a loss for anything which its natural economy requires, there is never the slightest redundancy in any one. Not an organ, or part of an organ, but which has its use; and not an organ, or part of an organ, which, in the proper sphere of the creature, can be regarded as useless. Farther, every specific organ has exactly the form, and is composed of the material, which is best fitted for its use; but still, in all the countless thousands of different classes and genera which make up the living creation, there is not, when in a healthy state, a single grain or atom of matter more than is absolutely necessary.

Two very great advantages result from the study of this beautiful adaptation which runs throughout the whole of nature; the one of them of a moral nature, tending to improve the character of man, and the other a lesson of practical instruction, highly useful in all the arts of life.

The first is the irresistible proof of the existence and attributes of the Creator, which the study of creation affords; and which, when followed out in the proper spirit, brings the whole of what God has made forward in proof of what he has revealed in the Holy Scriptures. Thus clearly establishing that He who of olden time spake through the medium of prophets and apostles, and of the blessed Founder of the Christian religion, is the same as He who speaks every day and every hour to all our senses and all our feelings, by the instructive voice of universal nature.

This is a most valuable result of an intimate knowledge of the works of God; and it is one upon which it behoves every one who is interested in the welfare of his fellow-creatures, and values his own eternal happiness, to dwell with due, calm, and reverend consideration. Nor is it difficult to see the necessity of this; for the nations which sat in darkness, before the Sun of Righteousness arose with the light of Divine and immortal truth on his wings, could no more refrain from contemplating the wonders of creation, and inquiring concerning their origin and their author, than we who are blessed with the enjoyment of this light, can so refrain, and stand guiltless and without excuse before our Maker, if we neglect or pervert it.

People who knew not the revealed truth, could not have that general knowledge of the nature and the attributes of the ONE GOD, which being above all perception of the senses, and apprehendible only by the mind, and even by that only by Divine assistance, can be had from the revealed word alone. Hence, to such people, every demonstration of god-like working, which forced itself upon them in the contemplation of the works of nature, stood as an insulated fact, powerful in its own evidence, but unconnected with any other. Thus, there arose in the imaginations of their benighted understandings, as many gods as there were remarkable appearances, productions, and occurrences, brought before their observation without any action or instrumentality of man. This is the true origin of those mythologies, which all nations that have made any advances in science and civilization, without the light of the Bible to guide them, have without a single exception framed; and in which the number of the gods has always been in proportion to the degree of knowledge and the advancement in art which the people possessed.

The rudest tribe which has come to our knowledge in modern times, was the natives of the vast and singular land of Australia, before it became a British colony,

"Where angry England sends her outcast sons;"

and even they were not absolutely "without God in the world." They had no distinct conception, indeed, of a Being by whom every one of the changes in nature was brought about, and the memory of the living generation barely reached to a glimmering recollection of the last one which had been laid in the dust; yet, notwithstanding this, they had a dim and shadowy belief that there is in man "a spirit which goeth upward," and that, from cloudy tabernacles in the sky, their ancestors could take note of their deeds.

From this simple beginning—this first feeling of natural religion, so to speak—to the wild mythology of the northern nations, the fantastic one of the Hindus, and the more elaborate systems of the Greeks and Romans, there is an extensive range; but the same principle runs throughout the whole; and strange though at first sight it may seem, one and all of these are testimonies not only to the existence of God, but to the truth of Revelation.

They are voluntary confessions that men of all nations, all ages, and all degrees of civilization, find something in material nature which the properties of matter will not explain; and it is this universal feeling of "the unknown God," to whose altar at Athens such impressive allusion is made by the apostle of the Gentiles, which is the real foundation of all those mythologies. Nor can it escape the attention of the reader that the multiplication of false gods, as the natural knowledge of the people increased, is a proof that, in every addition which was made to knowledge, this feeling of something more than mere nature being necessary always mingled along with it. Thus, the error in their theology always increased in proportion to their knowledge, until every remarkable phenomenon of nature, every kind of scene, every place of importance, and almost every individual man, had a separate presiding and protecting god.

Those gods were of course fashioned after the manner of men, whether they were or were not represented by idols formed of material substance, or otherwise represented to the senses. It will be borne in mind, that in such cases it is not the material representation, whether stock, stone, metal, or anything else, which is the real idol—the false god, which the unenlightened mind goes about to substitute in place of that God of truth, of whom it has no knowledge save the feeling that there is something to be known beyond all that the senses can recognise. That this idol, whether represented by a symbol or not, is necessarily fashioned after the imagination of man, follows from the very nature of the case. This is exactly the subject upon which man, by the exertion of his own unassisted powers, how well and ably soever he may exert them, can obtain no information. Material nature speaks to the outward senses, as material nature only, and as nothing else; and the inward reasoning is nothing more than the comparing of one portion of acquired knowledge with another, and thereby discovering the relations which exist between them; and so advancing step by step, until we come to the most general conclusion that can be arrived at, which conclusion is a true law of material nature, if the senses have been full and faithful in the observation of the individual facts, the comparisons truly made, and the conclusions correctly drawn. In all this, however, let it be as extensive and as philosophical as the nature of the case will admit, and though the result of it is the discovery of a law as general as that of the gravitation of matter, or the construction of an engine as powerful and varied in its application as the steam engine, yet there is not involved in it one single element, however minute, of the true God. "God is a spirit," and to be known as well as to be worshipped aright, he must be "known in spirit," discerned by the internal or immortal principle of man, and not through the medium of the senses. Those senses, wonderfully as their organs are formed, and numerous and beautiful as are their uses, are still capable only of observing matter and its properties and changes; and how high soever we may rear the fabric of knowledge, which is founded on the observation of matter, the mere height to which we can raise it can in no way change its nature, or in the least alter it from material to spiritual.

No truth can be plainer than this; and there is none which it behoves us to bear more constantly in mind; and we may add that, as the structure of material knowledge which we thus rear is wholly our own, it addresses itself with great force and great fascination to our pride, and we stand every day and every hour in jeopardy of being led into error by our fondness for it—a fondness of the strength of which we ourselves arenot always aware.

Therefore, if we are to come to the study of nature, or any portion of nature, so as to profit to the greatest extent by that study, both for time and for eternity, we must come to it with the Bible in our hands; and not content ourselves with the words of it on our lips as a dead letter, but to have the understanding of it in our hearts as a living principle; because there is one element, in the study of nature as the workmanship of Almighty God, which we can find nowhere but in the Bible; and if we have not this element exactly as the Bible in its true interpretation gives us, though we study the works of nature ever so closely, and according to knowledge of mere nature ever so reverently, our conception of the God of nature can be nothing but the conception of an idol, any more than if it were a material idol, and set up in a heathen temple.

That we live in a Christian country, and at a time when the light of Divine truth is very generally diffused over the world, can avail us nothing, if we ourselves are not partakers in the light. On the contrary, we shall, for this very reason, stand condemned, where the heathen who had or have no access to the light of Divine truth will stand acquitted; and therefore, in reference to the right study of nature, as well as to right conduct in every department, calling, and action of life, this important question should be ever present to our minds—"How shall we escape if we neglect the great salvation," which is revealed in the word of God, and sealed by the testimony of the death and resurrection of his only Son Jesus Christ, co-equal and co-eternal?

Into any of our wordly pursuits this knowledge of the true God cannot enter as an element, any more than it can so enter into our contemplation of the productions and phenomena of nature. Indeed, it does not even testify so clearly to revealed truth, after that truth is known and felt, as is done by nature; for the works of nature are the works of God; and the laws according to which natural appearances take place, are immediate laws of God; whereas our worldly pursuits, how necessary or praiseworthy soever they may be, are merely human. Even if we turn our thoughts inward, and study the successive states of our own minds, in their relations to each other, and to the causes out of which they arise, we still have no element of the knowledge of the true God, that can arise out of our contemplation, though we pursue it ever so far and with ever so much truth. There is, no doubt, an immortal spirit in man; but it is a created and finite spirit—an effect which must have had a cause external of, anterior to, and greater than itself, in like manner as the very humblest material substance which exists in creation is palpable to sense.

This last consideration is indeed the one which especially claims our care; because, if we have not the light of the revealed Word to show us the true God, it is always here where we find the false light which shows us the idol; and, as we have already said, we have the evidence of all ages and nations to convince us that, where the knowledge of God is wanting, the proneness to idolatry and the multiplication of idols necessarily increase to the same extent that knowledge increases.

But men are made of the same clay in Christian times, and Christian countries, as they are in the years and regions of the deepest idolatry; and, therefore, though there is no question that the true religion does good to those who seek it not, by the tone and character which it gives to the general mind and manners of all the people; yet it is possible for a man to live in the most Christianized country of the world, and to conform to all the observances of Christianity, so as to have a perfect abhorrence in his words, and even in the deceitfulness of his own heart, of everything in the least approaching to idolatry, and yet to be and to remain, in deed and in truth, as thoroughly an idolater as if his attendances on the ordinances of the true religion were so many rites performed in a heathen temple. Nay, his case is far worse than that of the other, for he is a hypocrite, and his hypocrisy is very often hopeless, because he himself is ignorant of it; and not feeling that he needs any repentance, or any enlightenment, he will never turn him, and come to the light. Indeed this is the grand point of the case in which God alone must be the helper; and it is to show the impossibility of man being able to perform this of his own strength, that our Saviour made the following most important declaration: "No man can come unto me except the Father which hath sent me draw him."

In addition to the natural want which there is of a direct knowledge of the true God, from the study of nature and the common avocations of men, unless the knowledge of the Bible is taken along with them, there is something in our common systems of education which tends to separate the knowledge of God farther from the rest of our knowledge than it is naturally. The classical portion of education which it is deemed necessary, and which it is perhaps necessary, to give to every one, as part of the basis of general education, is inseparable from the mythologies of the classical nations of antiquity, who were, with the exception of the Hindûs and the ancient Egyptians, the most mythological people on the face of the earth. It necessarily follows, from the observed fact of the increase of mythology in proportion to that of knowledge, among every people who are without revelation, that the writings which have come down to us from classic times are valuable in proportion as the people with whom they originated were mythological. We do not say that the value to us is in the mythology; for, excepting in so far as it shows us the notions of the Godhead at which unenlightened men can arrive, by the mere exercise of their senses, and reflection founded upon sensual observation, and thereby more forcibly convinces us that there is no means of getting the right foundations of Divine truth, but by a revelation from God himself, the mythology is in itself a delusion, and therefore a source of error and an evil. But still, as those ancient nations which have given us no mythology, have also given us no philosophy, no history, and in fact no knowledge or means of knowledge, we must take the evil along with the good. In so taking them, however, we must endeavour to deal with them as we are obliged to deal with all the checquered scenes and occurrences of this world. We must endeavour to avail ourselves of the advantages of the good, and at the same time resist, with the utmost vigilance, all contamination of the evil.

This requires a degree of watchfulness which we can seldom hope for in the case of the young; and, we fear, not so often as could be wished for in those who are more advanced in years. On this account there is a sort of separation between religious knowledge and the rest of our knowledge, which not only prevents that assistance which they are calculated mutually to render to each other, but which also ties down our knowledge of nature, and of man in this world, to a species of idolatry; and though the idol is not made with hands, and does not even get a name in language, it has the same existence, and the same pernicious effect upon the mind, as if it stood before our eyes—carved in wood, chiseled in stone, or moulded in metal.

We accordingly find that very intelligent men, and even men who profess the most sincere belief in the truths of revelation, often cast about to find something which, in natural operations and phenomena, can be substituted for the creation and providence of the Almighty. We do not allude to such men (and there have been a few such) as have endeavoured to warp and distort the evidence of creation into an argument against the existence of the Creator; because, in the proper feeling of Christians, those men deserve our pity; and the more that they have learned of the mere details of any one department of nature, or of all the departments, the more our pity for them should be deepened. They, poor benighted men, are like the tasteless at a banquet, the deaf at a concert, or the blind in a garden of flowers,—they are among the beauties, the harmonies, and the enchantments of nature, but they feel them not.

There are others, however, who stand in different circumstances, and who, without any ground upon which they can be accused of irreligious intention, are nevertheless guilty of separating the God of creation from the God of the covenant, and thereby reducing the former to the character of a mere idol. Now, in the case of such parties, the danger to the reader is almost always in proportion to the good intention of the writer; because the admixture of truth, and the reverential language used throughout when speaking of God, bring the false god home to the reader as well as the true one; and, if the expression may be permitted, the Holy One himself is in some sort made an idol, in as far as he is the God and maker of the material creation.

It is not easy to avoid this, and perhaps there is no man who can at all times fully avoid it; but on this, as on all other difficult subjects, there are means whereby we may be kept as near to the truth as possible, and brought back to it in cases of departure. The case itself, if the exposition of it which we have given has been understood, will point out what those means are:—the idols of the nations, whether imagined as being set over one part of nature or another, and whether more limited or more extended powers were ascribed to them, were and are always fashioned after the likeness of man. They are delineations of men having powers far more energetic than the common race who dwell upon the earth; but their passions, their motives, and their actions, as described even in those mythologies which are understood to have the least of absurdity in them, are all the same in kind with those of man. Nor can it be otherwise; for, as we have already shown, human nature is the only source from which the materials of them can possibly be obtained; and all that they contain in supplement to the real delineation of human nature, is fiction and folly.

Now, the way to arrive at a proper feeling of the identity of the God of nature and the God of revelation, is to take our views of nature in a manner the least accordant with action as performed by man, which action, in the case of working or producing any result, always means the forming of something out of materials, and by means of instruments, both of which are prepared ready for the work, and which are in addition to the labour of the workmen, and not part of it. When we transfer this notion of man's working into creation, and contemplate the succession of objects or events, it will apply, so as to satisfy a common inquirer, to that part of the series which falls within our ordinary observation. That it should do so is very evident, because it is of the same kind with that observation, both being limited to matter and material organs and actions. We can also imagine the series, viewed in this way, to extend backwards or forwards beyond any assignable limit; that is, any limit which we can name in a number of years or of centuries.

But this indefinite age and duration of the system of material nature does not satisfy the mind, even when that mind is limited to the human view of it, or views it after the manner of men. And it is impossible that this should not be the case; for we cannot contemplate human action without referring to a beginning; and our notion of that beginning always involves three previously existing elements —the materials, the instruments of working, and the knowledge of the use of those instruments and of the nature and fitness of those materials for the production of that which has to be made.

But when we turn our thoughts to the origin of the series or system of nature, preserving this human view of it, we are completely bewildered and at a loss; for we can no more imagine the pre-existence of the materials, the instruments, or the understanding of that which is to be produced, than we can understand that a thing or being can exist before it exists; and thus we are reduced to as palpable an absurdity as it is possible to imagine. But the whole system consists of a succession of changes, appearances, and productions, each of which we can perfectly understand upon this human view of it, when we take it in the individual instance; and not only this, but we can follow the succession of changes or productions through a good many steps, and we can compare one with another, even in the individual instances, or in the successions. All that we want is a beginning; and there is nothing within the whole compass of our experience, as derived from observation by the senses in ourselves personally, or as can be communicated to us in the testimony of others, which can be of the slightest help to us in this matter. Here, therefore, we are left entirely without even the slightest means of knowledge; and whenever this is the case, any reasonings which we may form, and any conclusions at which we may seem to arrive by means of those reasonings, are nothing but idle words, in the framing of which we do injury to ourselves in speech; and if we communicate them to others in speech or in writing, we also abuse and injure them. Therefore, for information as to the basis of any notion which we can form respecting the beginning of the material creation, we must have recourse to the same quarter from which we get our first elements of the knowledge of the true God—namely, to the book of Divine revelation.

As we must apply to this source for the very commencement of our knowledge of creation considered as a system, the view of the God of nature which we carry along with us, must necessarily be that which the Bible gives us of the God of revelation. Therefore, if we have not previously informed ourselves upon thissubject, we are not properly prepared for entering upon the study of the works of creation, and so cannot duly profit by that study! The view which the Bible gives us of God the Creator, is of course given by similitudes, in as far as the essence or abstract nature of that Being is concerned; for, God being infinite, and all our capacities, mental as well as bodily, being finite, and not only having boundaries, but narrow boundaries, it is utterly impossible for us to know anything of the abstract nature of God as an existence; consequently we must limit our inquiries to what is declared in His word, and demonstrated in His works. Then, if we have satisfied ourselves of the evidences of the truth of the Bible, which are perhaps far more clear and simple than those of any other historical facts of equally distant occurrence, we have only to examine and see whether the revelation in the word and the demonstration in the works are according to the nature of one Being; and if they are, the truth of our knowledge of God, in every light in which he can be viewed, stands above all question and all doubt.

Now it is in the beautiful adaptation of every creature in nature, and every part of every creature, to the purpose to which we see the creature naturally apply it, and the perfect connexion of one with the others, so that each is dependant upon all, and all are dependant upon each, which furnishes us with the truly scriptural view of God, as the author and governor of the material creation. This extends to all space—to the remotest star which the most powerful telescope can discover in the clearest winter night, as well as to the substance of our own bodies; and it reaches backward to the creation of everything that has been made, and forward to the period when each, when any number, or when all of them shall cease to exist, without any reference to the length of time which there is between any of those events and the moment of our present thought.

We have deemed it necessary to go at some length into the explanation of this point, for several reasons:—First, the close connexion which a clear understanding of it has with our full and satisfactory enjoyment of this world, and of our hopes of eternal happiness in the world to come. Secondly, because in most books which profess to treat of the productions of nature in a philosophical manner, this point is almost wholly overlooked; and this not merely in the common works which profess to convey only the natural knowledge of their subjects, without any reference to religion; but also in the whole, or at least the greater number, of those which professedly treat of natural theology, which words are merely a technical expression for that knowledge of the Creator which is derivable from the study of his works. In most of those works, not excepting the ones which are written in the most pious spirit and the most pleasing manner, and which are therefore the best adapted for general readers, and the most generally read by the public, the whole line of the argument is substantially human, and the conclusions not that the works of God are infinitely superior in kind to the works of man, but only that they are infinitely superior in degree. This does not differ much in principle from the mythology of the more enlightened of the heathen nations. The workmanship of man is made the standard of comparison; and unless we regard that which is compared as being exactly the same in kind with the standard of comparison, no rational comparison is made, and consequently no useful conclusion can be arrived at. It proves nothing with regard to the true God as revealed in the Bible, that some joint or organ of an animal is superior, be the superiority to what degree it may, to any piece of mechanism which could be contrived and executed by human skill; because the human part of the comparison demands those three pre-existent elements, in the absence of which we have shown that the true notion of creation by a God of infinite and eternal knowledge and power, substantially, and indeed wholly, consists. Thirdly, we have stated this point at some length, because the subjects upon which we have to touch in this volume are so exceedingly numerous, that it will be impossible for us to trace their connexion with that fulness which would be requisite. All that we can do is to mention a few of the leading points, for the purpose of attracting the attention of the reader: and we must leave not only the details but the connexions and comparisons, to be sought for in more extensive works; therefore we have judged it best to furnish the reader with a full view of the manner in which he is to proceed, in order duly to appreciate the wisdom of God as displayed in his works.

Having done this, we shall very briefly notice the second grand use of the study of nature—namely, that which bears upon our instruction as men for this world. This is far more temporary than the former, because the use of it ceases when the mortal life terminates; but while that life lasts, it is more useful to us than any other subject which applies to the whole of our sojourn here below. Nature is the store whence we obtain all the substances which form the materials of our arts, in everything that can either maintain our existence or administer to our comforts, individually or socially. Of those materials many are found in the portion of nature which, in the common acceptation of the words, does not possess either the principle of growth or the principle of life; others are the production of the principle of growth in the different vegetables and vegetable substances which compose so large a portion of our food, our clothing, and all our accommodations; and others again are the products of both growth and life, in the various animal substances which in all the three grand departments of our comfortable subsistence, are scarcely less numerous or less necessary than the vegetable ones. These are about us every day, and necessarily occupy a great portion of our attention; and in order that we may obtain them in the greatest abundance, the best condition, and the easiest manner, it is necessary for us to know, not merely the one from the other, but the nature of each, in so far as that knowledge is attainable. For a numerous and thickly inhabited population, there must be a great deal of artificial or procured culture of plants and rearing of animals; because the very richest spots on the surface of the earth cannot, when in a state of nature, support any more human beings than a few wandering savages, leading miserable lives in the forests, and almost invariably acquainted with no art save that of destroying the wild animals—and one another.

But we stand as much indebted to nature for the knowledge of what we are to do with our materials after we have obtained them, as we do for obtaining a proper supply of the materials themselves. The operations which we perform in our arts differ in mode and in object from the operations which occur in nature around us; but the principles on which they depend are the same in both cases. The properties of matter are the obstacles against which we have to work; and as those properties are varied without end in different kinds of substances, or in different states of the same substance, we require to know what everything which comes under our hands can do, and also what it can bear. Nor must we in this respect delay the acquirement of the knowledge till we come to the particular case in which that knowledge is to be useful to us; for were we to do this, we should be always unprepared for our work, and therefore incapable of doing it. The active part of our practical labour may in general be said to consist in motion, or change of place in some subject and to some extent; and though the ultimate action at which we wish to arrive may not be a simple motion, but a change in the texture, the colour, the shape, or some other of those attributes of a substance which are apparent to our senses, yet motion of some kind or other always enters more or less into even these instances.

Now, our grand school for motion is the animal creation, because it is here that we find the nearest resemblances to that which we ourselves wish to perform; and we find it varied in so many ways, performed by organs of such different size and form, and so perfectly performed without want or waste in any one case, that it is impossible that a practical instance can arise from which we have not an adequate lesson in one part or other of the living creation. We cannot, it is true, imitate the grand principle of life, in its development, its growth, and its faculties of repair and renovation. But still, if we take the individual action of the animal, detached from its connexion, which is the view in which every individual case of our working presents itself, there is so far a similarity between them, as that the one may be our example and instructor, much in the same way as if it were a lesson of our own experience. This is the grand practical advantage which we derive from the philosophical study of the working of nature; and if we do not possess ourselves of this, we are in a state of helpless ignorance, dependent upon our fellow men, and at the mercy of every caprice and every contingency. It is true that the life of no man is long enough, and the mind and body of no man is energetic enough, for obtaining the whole of this knowledge, or even any more than a very limited portion as compared with the whole. But still, though our lives are brief and our capacities limited, it is not the less our duty to apply them wisely and diligently, because whatever may be the duration of the one, or the energy of the other, they are the two elements of all that we can enjoy, and possess, and do in this world. Therefore, if we neglect any one opportunity by which life may be turned to better account, we are guilty of the destruction of so much of our own lives; and thus the thoughtless and the sluggard may be said, without any overstraining of the figure, to commit a partial suicide every day.

Such are some of the leading inducements to a proper study and knowledge of the works of creation, with reference both to the glory of God and the well-being of man; and we shall now proceed to show how the study of the invertebrated animals is to be so managed as to be fruitful of those advantages.

CHAPTER II.

OF THE USES AND NUMBERS OF THE INVERTEBRATED ANIMALS.

In treating of the first of these, we shall enumerate only a few particular instances; and those which are best known, and consequently most familiar to the reader, are the best suited for this purpose. We shall take those instances quite at random; and it may be proper to mention the range which we have in the taking of them. Now, every living creature which can come under our notice either with the naked eye or with the microscope, and which does not suckle its young, and is not a bird, a reptile, or a fish—as those four classes are briefly explained in the first volume of this treatise,—is an invertebrated animal, and as such free to our choice as an instance.

The first consideration of the usefulness, is usefulness for the food of man; and though in this respect the number of invertebrated animals which are employed in substance for the human food be comparatively limited, some of them are neither unimportant nor unwholesome. The numbers which are made use of in different countries vary with the opinions and customs of the inhabitants; and those used in the British islands are comparatively few, and chiefly confined to *molluscous* and *crus-*

taceous animals, the leading characters of which will be explained afterwards ; and those which are made use of as food are principally obtained from the sea. Of mollusca, the oyster, the muscle, and generally speaking all those animals which come under the vulgar and incorrect appellation of "shell fish," are examples. Some of the land mollusca—as for instance the large garden snail—are eaten by a few persons, and described as being very savoury and highly nutritious when properly dressed; but there is a strong general prejudice against the use of such food, and they have besides a very offensive odour when dressed. The senses of smelling and tasting, as explained in a former part of this work, are in many respects connected with each other; but still it does not follow that though a substance is offensive to the smell, it must necessarily be either ungrateful to the palate, or injurious to the health. The *durion*, a fruit which grows in the rich and beautiful islands to the south-east of Asia, and in a small portion of that peninsula which lies to the eastward of the bay of Bengal, has an odour so exceedingly rank and offensive, that no stranger can endure it for a considerable length of time; but after this prejudice arising from the smell has once been fairly got the better of, the durion is relished and prized above every other vegetable production, even of that choice garden of the globe. The flavour is delicious, the nutritive quality approaches the very richest concentrations which can be made of the choicest animal matter, and it is impossible for any one who has not actually experienced it, to describe the delicious cooling influence of this fruit upon those who, born and nurtured in more temperate climates, are broiling under the fervent heat of a vertical sun, in a cloudless sky, or even suffering under the internal heat of a high fever, which is far from rare, especially among the European sojourners in those sunny lands.

Among the crustacea, which, though generally speaking more highly flavoured, are understood not to be so easy of digestion as the esculent mollusca, may be enumerated the lobster, the crab, the cray-fish, the shrimp, and the prawn—indeed, all those animal productions of the deep which are called "shell fish," and have the members of their bodies jointed or articulated. The numbers in which some of these are obtained, the rapidity of their growth, and the rate at which they increase, are truly astonishing—so much so as to give to the rocky shores of the ocean all the value of pasture lands or corn fields, without rent and without labour.

In this country there are, we believe, no other races of invertebrated animals which are used as human food, in the substance of their bodies; but there are some which are used in foreign countries, among which we may mention the common migratory locust, which is so terrible a scourge in some of the warmer parts of the world, especially those which lie on the margins of the sandy deserts. When the locusts come in the fulness of their array, obscuring the sun and casting a deep twilight shadow upon the earth while they are on their aërial march, they, when they alight on the ground, alight in depth as if they had been showered to the earth like snow on a wintry day; and as the living accumulation rolls and tumbles onward, like a tide-wave on a sea beach, it consumes every green thing, so that for that season the place is a desert. But the people make reprisals by seizing the locusts in countless myriads, and preparing and preserving them by arts which they have learned, so that they are savoury and nutritious food, and in the comparatively bare places to which the ravages of locusts are in general, though not always, confined, they form no very bad substitute for that which is more immediately consumed by the locusts.

There are countless numbers of invertebrated animals, which prey upon the vegetation of most countries; and which, in peculiar states of the weather, commit the most destructive ravages; and as we cannot suppose, consistently with the benevolence of the general plan which runs through the whole system of creation, that any creatures which come habitually where man inhabits come without being in some way capable of returning him a service in proportion to the mischief which they do in some particular way, it were highly desirable that more inquiry were made into the uses to which it may be possible to turn the countless swarms and multitudes of these creatures.

We have some encouragement to the making of further experiments with regard to the use of a greater number of them as human food, in the fact that very many of them are eaten by vertebrated animals of all the four classes; and that the flesh of those species which eat them is not only not upon the whole less wholesome and palatable than that of other animal feeders, but that it is more so in many instances. In the birds and the fishes especially, the feeders upon invertebrated animals are, generally speaking, very superior. We may instance the snipes and woodcocks among birds, and the trout and salmon among fishes; and the latter are so fond of invertebrated animals that anglers capture them by means of artificial or imitation flies.

In the substance of clothing, the number of animals of this grand division which are made use of is comparatively limited; and though a kind of cloth or tissue is formed of the *byssi*, or threads, which are spun by some of the shelled mollusca inhabiting the warmer seas, yet the silkworm stands so pre-eminent as to throw all the others completely into the shade. This animal is improperly called a worm; because it is not a worm, but the *larva* or first stage of life in the young of a species of moth, of which we shall have to take some further notice in a future chapter; but the substance produced by the labours of this little creature is so abundant, so beautiful, so durable, so pliant to the hand of the workman, and so ready to receive the colours of the dyer, that it forms the most beautiful article in the whole of that varied collection which is used for clothing and ornamenting the human body.

There is one other use to man of the invertebrated animals, which it would be unjust to pass over; and that is the colouring matter which they afford. The Tyrian purple, so celebrated in ancient times, as being used for tinting the robes of the most luxurious monarchs, was procured from certain species of shelled mollusca of comparatively small size, occasional specimens of which have been gathered upon the shores of France, and even of Britain; and though other, and less laborious methods of obtaining colours of equal beauty, though perhaps not of equal durability, have been invented in modern times, yet the general estimation in which this purple was held is a lasting memorial of the value of invertebrated animals in the art of obtaining beautiful colours for substances naturally colourless.

The production of the Tyrian purple, as a branch of the arts, is now lost; but we must not thence conclude that the obligations of the moderns to this grand division of animals, in respect of the production of colours, has been at all diminished. It has indeed been transferred to another class; and what the people of antiquity owed to mollusca, we of modern times owe to insects. But we still owe the most brilliant of our dyes to animals of this grand division. At a comparatively early period, it was found that a very beautiful red dye might be procured from a small insect called *kermes*, which inhabits a peculiar species of oak which grows near the shores of the Mediterranean, and in some other parts of the world; and soon after South America had been known to Europeans, it was ascertained that another small insect, bearing some resemblance to the former, and inhabiting a very different species of plant, furnished a dye of far greater brilliance. This is the *cochineal* insect, the substance of which now forms the most valuable dye-stuff used in the arts, because the colour which it strikes is equally beautiful and permanent. It is the scarlet of modern times, which, when properly dyed upon right materials, is understood to be far more brilliant, and not less durable, than the Tyrian purple of the ancients; and mixed with other colouring matters, it is made to impart every shade of colour, in the producing of which red forms an element.

Invertebrated animals are in general of too small a size for forming any of the ordinary household articles. Some shells are, however, of such capacity as to contain a number of gallons; others are used for drinking-cups, others again for blowing-horns, and very many are assiduously collected on account of their beauty.

Other shells, and shelly productions, are made use of for economical or for ornamental purposes, both in the more rude and the more advanced states of society. The fish-hooks, the knives, and various other implements of the ruder people, are formed of what are termed pearl or pearly shells; and there are some instances in which the lustre of a hook, formed of this kind of shell, is a sufficient attraction for the fish without any substance which a fish can eat affixed to it as a bait, much in the same manner as some of the fishes of our seas can be attracted and caught by means of a bit of red cloth fastened to the hook.

In the ornamental arts, the same kind of shells, which generally have a very beautiful iridiscence or play of colours in them, are employed for many purposes. They are properly called "mother-of-pearl," and this mother-of-pearl is made into buttons, paper-knives, knife-handles, and various other little articles; and it is also extensively employed in inlayed wood-work, for the finer and smaller cabinet articles, in which it has a very handsome appearance.

The "pearls," properly so called, which have been so much admired in all ages as articles of jewellery, are not necessarily obtained from those shells which are technically called pearl, or mother-of-pearl shells; but they are obtained from shells of the same kind and structure, and produced only by certain genera of the shelled mollusca,—in all instances, we believe, from bivalve shells, or those in which the shelly envelope which contains the animal, consists of two parts, which are united by a hinge at the one side, and open and shut at the other. Some of these are more nearly allied to our common oyster, and others to our common muscle, and some of them are found in the sea, and others in the fresh water. The pearls which are found in them also vary in beauty in the different species from which they are obtained; but they are all substantially composed of the same kind of matter—namely, of thin layers of salts of lime, alternating with still thinner layers of animal substance, chiefly of gelatine, or the same substance as glue; and it is not unworthy of remark, that many of the gelatinous parts of animals, and even common glue itself, when moderately fine and spread in thin layers, display this iridiscence, or play of colours, as the light falls differently upon them. The finest pearls are found in the seas of tropical countries, and in the shells of animals nearly allied to the oyster tribe; but there are also pearls, of no mean size or appearance, found in the shells of the common horse-muscle, which is a molluscous animal of considerable size and of very offensive odour, and not eatable, which inhabits many of the slow-running rivers of the British islands, in those of them which are at no very great distance from parts of the sea, but not absolutely in the salt or near the brackish water. Those shells are like those of the common esculent muscle which inhabits the sea, of a dark colour externally; but they are of pearly lustre within. They stand in the hollow of the rivers, with the hinge end in the mud, and the upper ends of the shells gaping open, in order to catch those substances upon which they feed. The usual method of catching them is very simple. It is done by means of a long slender stick, which is introduced into the opening formed by the gaping shells; and when the stick is inserted, the animal closes the shells upon it with so much force, that it is easily thrown on the bank, by simply jerking up the stick. A pearl is not found in every muscle, or even in one in a hundred, so that the fishing is far from a profitable one, and is not carried on in any of our rivers as a regular employment at which the person who follows it can find a living; but rather by those who have leisure, as a mere matter of amusement; and the pearls which are found in this way are more matters of curiosity than of real value. We have seen one of the size of a common pea, and not badly formed, although too dingy in the colour to be of very much value, taken from a horse-muscle in the river Conan, in Ross-shire, in the north of Scotland; but we believe that the quantity of pearls obtained in that, or in any other of the British rivers, would not remunerate the very humblest labourer who could be employed in searching for them.

On the pearl banks in the tropical seas the case is different, and there the pearl fishery is carried on as a regular trade, and by no means an unporfitable one. But the labour of those who are more immediately engaged in it is exceedingly severe, and can hardly be considered to accord with our notions of the justifiable employment of human beings. The pearl oysters are dived for in a considerable number of fathoms' depth of water, and the descent of the divers is facilitated by weights attached to their bodies, which they have the means of unhooking when they reach the bottom. At the bottom they fill their baskets with the shells, and upon a signal given by them they are drawn up to the surface; the weights by which their descent is facilitated being drawn up by another operation. We shall, however, have occasion to advert very briefly to this in a future chapter, and so we need not enter more minutely into the details.

Some of the invertebrated animals are remarkable for the beauty of their colours; and there are, perhaps, no other productions of nature, and certainly no contrivances of art, which can be at all compared for richness of colour or brilliancy of metallic lustre with the *elytra*, or wing-covers of some of the beetles. They are accordingly used in embroidery, and they produce a very brilliant effect. The wings of some of the *Lepidopterous* insects—the butterflies and moths—are also exceedingly beautiful both in the tints and in the distribution and contrast of their colours; but these are too tender for being applied to any useful purpose, although they are eagerly sought after as ornaments for the cabinets of the curious.

Some of the invertebrated animals are employed in the healing art; and, as many of them contain very active principles in their substance, it is by no means improbable that a judicious investigation would discover value in this respect in a good many more. We may mention, as instances, the common leech, and the blister-fly. The leech has been so long known and so generally appreciated, that, in former times, it gave name to the surgeon and the surgeon's art; the one being styled a "leech," and the other "leech-craft." In topical contusions, tendencies to inflammation, and other causes of obstruction in the capillaries which unite the extremities of the arteries and veins, and which obstructions and the increased action thence arising, would produce disease of a more serious character, bleeding by leeches is still resorted to, and it is considered both a more safe and a more successful means of relief to the part affected than any use of a surgeon's instrument. The blister-fly again is equally serviceable in relieving the lymphatic system: and is consequently of great service in cases where the system is so weakened as not to be able to take up the refuse, or duly to nourish the cellular tissues, which, from their structure and composition, are more nearly allied to lymph, or at all events to the serum, or colourless part of the blood, than they are to the clot or colour part which contains fibrin, and thus has more resemblance to the muscular portion of the body. Diseases of the colourless parts are often of the most serious character, as is found in consumption of the lungs, in that derangement of the villous coat of the intestines, which is known by the name of dyspepsia, or hypochondriasis, and which renders life itself a burden too grievous to be borne, while the unhappy patient is unable to tell where or how he is disordered; and thus his sufferings, though they stand the most in need of sympathy, very frequently receive little or none. When any disease of this kind has been once thoroughly rooted in the system, no topical application can of course afford relief; but in the beginning, disease may be often subdued, and health restored, by the judicious application of a blister, the active part of which is the substance of the fly in powder, which is applied on the surface of some plaster which will make it adhere to the skin till the powder takes effect. This is done by raising the cuticle, and accumulating a quantity of serous or lymphatic matter under it; and the relief produced the moment that the cuticle, or as it is termed the blister, rises, is often very great. Several species of invertebrated animals have been from time to time proposed to be taken internally as specific remedies for peculiar diseases; but it does not appear that those recommendations have in any one case been grounded on philosophical principles, or the results of proper inquiry; and therefore they belong to the practice of quackery rather than to the art of medicine.

There are some substances still to be mentioned as useful in domestic economy and in the arts, which, though they cannot be said to be actually produced by invertebrated animals, are yet collected and prepared by them. Of these we may mention as instances, honey, wax, and gumlac. The first two are the produce of the labours of the bee, which we shall have to notice in its place; but it is not a little remarkable that honey bees, of some variety or other, are found in almost every quarter of the world, and in wild and wooded districts they often literally fill the hollow trees with their stores and their swarms. The quantity of honey which is thus produced is immense, and that of wax, which composes the cells in which the young bees are reared, and the stores of honey treasured up for food at those seasons when there is none to be found in the fields. The use of the bee in the economy of nature is very great; and we might infer this from its numbers and its general distribution, without taking into consideration the value of that which it produces. Both the honey and the wax are obtained from plants, chiefly, if not entirely, from flowers; and the probability is, that they are originally very nearly the same substance, only the wax undergoes a sort of process of secretion, while the honey, as it is taken from the nectaries or bottoms of the cups of flowers, is conveyed at once to a little bag within the bee, which is a reservoir and not a digestive organ; and thus the honey can be discharged into the cells, or one bee can feed another with the honey quite unaltered. Before the use of sugar became so common as it now is in this country, honey was the principal article used as a sweetener; and it is still the principal substance used for this purpose in those countries where bees in a wild state are numerous; and where sugar, which can be grown only in warm climates, is not obtainable without great expense of carriage. This is remarkably the case in Russia, the swampy parts of which contain few inhabitants, but many flowering shrubs, which blossom at a different season than the common herbaceous plants with which they are intermixed, and therefore the bees find in such countries a full supply for a much greater portion of the year, than they do in countries where there is only one season of bloom in the course of the summer. We have a confirmation of this in our own country, along what may be considered as the boundary of the Highlands and the Lowlands, partially in the North of England, and much more completely along the southern margin of the Grampians in Scotland. At this place, the Highland and Lowland characters alternate with each other along the line—the valley being of the Lowland character, clad with herbaceous vegetation only, and blooming in general before midsummer; while the hill is Highland in its character, clad with heather, and does not come into bloom until the blossoms of the valley are gone. Those places are not the pasture-range of a bee distant from each other, for bees take long flights in quest of food; and therefore, in such situations, bees enjoy a double harvest; and consequently those who keep them for economical purposes derive nearly double the advantage which could be derived in a situation where the whole surface within the bees' range was either of the one character singly, or of the other.

That the honey is very little changed by any operation which the bee performs on it, is proved by the fact that the honey always partakes of the qualities of the plant from which it is obtained. From flowers of herbaceous plants which are rank, scentless, and tasteless, the honey is insipid; whereas, from plants which have a pungent odour, and such an odour is generally accompanied by a considerable pungency of taste, the honey is much more fragrant and racy. Also, if the plants from which the honey is taken have any poisonous quality, the honey itself partakes of that quality. In the celebrated retreat of the ten thousand recorded by Xenophon, the army were severely afflicted in consequence of eating honey in the hills and marshes of Pontus; and it is known that the principal flowering shrubs in that country, *Azalea pontica* and *Rhododendron ponticum*, though plants of great beauty, and abounding so much in honey as to smell strongly of it when in flower, are poisonous. Indeed the whole of the Rhododendron family are suspicious, notwithstanding their beauty and the immense number of their flowers, and consequently travellers always run a risk if they eat wild honey in countries which are clad with these plants; and yet honey is so abundant, and, generally speaking, so accessible in places of this kind, that it is difficult to resist the temptation of it, accompanied as it is by miles of thickly-set flowers, often emitting a rich, but always rather a sickly perfume.

With the Heath family, some of which smell even more strongly of honey than the plants just mentioned, the case is different; and hence, on our own mountains, on those of the south of Europe, and in extensive districts of Southern Africa, where Heath of one species or other is the prevailing shrub, the honey is always as safe as it is delicious. It has not been ascertained what character honey obtained from the Epacris family, which hold the same place as the Heaths do with us, possesses; but it is not known that any of the family is poisonous; and some of them have edible fruit, though very inferior to the berries of many of our Heaths.

In collecting their stores of honey, bees do not rob the blossoms, but rather tend greatly to promote their fertility; and were it not that the bees assist in bringing into contact with each other those parts of the flower whose contact is necessary to its fruitfulness, it is highly probable, nay almost certain, that very many flowers would be barren, not only to the diminution of those plants on which they grow, but to the birds which feed on the surplus seeds of the plants, and of every purpose which the plants answer in nature. Thus we find that in the arrangements of nature, those things which, on a first view of the matter, appear to have comparatively little connexion, are really, as parts of the grand whole, as dependent upon each other as are the several parts of the body of a single animal, or of the structure of a single plant.

It is not understood that the wax of the bees which gather their honey from poisonous plants, partakes of the same deleterious properties as the honey; and this is one reason for concluding that the wax undergoes a sort of elaboration by the bee, while the honey remains in the same state as it is taken from the flower. Wax, as well as honey, is obtained from other parts of plants besides the flowers; and there are several plants which produce, without any animal assistance, a substance very much resembling bees' wax.

Gumlac is produced on the branches of trees by a very small insect; and it is perhaps to be regarded as a vegetable production, though the action of the insect upon the tree is necessary for the production of it. It consists of a very hard gum combined with colouring matter; and the colouring matter may be separated, in which state it is used in dyeing. It forms a durable red, but not a very bright one. It is chiefly obtained from the eastern parts of Asia. The inhabitants of those countries use it extensively as a varnish; and it is applied to the same purpose by European artists.

Such are a few instances of the use to man of the invertebrated animals; and we have next to glance very briefly at their numbers, and distribution over the earth, according to the different climates and seasons of the several regions. As these animals have not the nervous system so fully developed as the vertebrated ones, and as they are without a distinct and specific brain, we may conclude that, in them, the system of sensation, which we have considered as the peculiarly characteristic system of animals, is much less perfect than in the others. This is an important part of their general character, and one which can be turned to no small account in forming a judgment with regard to their relations to climate and season.

The system of sensation being the proper animal one, and the animal being of all material creatures the farthest removed from mere matter in a dead or passive state, it necessarily follows that the more perfect the system of the animal, the greater are its resources, and the better it is able to control or contend with those causes, whatever they may be, which affect matter merely as matter. On the other hand, we may just as naturally take the inverse view, and conclude that in proportion as there is development and perfection in the system of sensation in any animal, or race of animals, that animal, or that race, is more under the control of those causes which act upon matter considered in its simple and passive state. And when we direct our attention to the distribution of vertebrated or invertebrated animals, we find that it is in perfect accordance with this principle, and therefore a complete confirmation of it. In our comparison of place with place, according to position on the globe, or to season, we must leave the sea in a great measure out of the question; because the seasonal changes of the sea are very trifling compared with those of the land; and so also are its variations in different latitudes. The reasons of this permanence in the state of the sea, as compared with that of the land, will be noticed in the third volume of this treatise, when we shall have to cast a passing glance on the world of waters. But it is necessary that even now we should point out this distinction between the climatal and seasonal changes of the sea and those of the land, in order that we may come to a right understanding as to why animals of the same class inhabiting the one of them should be so differently distributed from those inhabiting the other.

That the tropical seas are more full of every kind of life than those of the high latitudes, and that some kinds of life are much more developed in the former than in the latter, is true; but it is equally true that, in respect of invertebrated animals especially, the Polar seas are much more populous than the Polar land. It is also true that the inhabitants of the Polar seas, though they breed annually, as is the case with most animals, especially those of high latitudes; yet, as races, they are perennial in the sea, while they are seasonal on the land, disappearing in the severity of the winter, either by burying themselves in the earth, creeping into other hiding-places, or leaving only in places fitted for their being hatched those eggs which are to people the locality anew, when the sun of the returning summer calls them into life. So remarkable is the difference between the sea and the land in this respect, that we have many of the invertebrated productions of the sea in the finest perfection during the winter months, and quite unaffected by the difference between a mild winter and a severe one; whereas, if the winter is moderately severe, not a single invertebrated animal is to be found on the land.

In tropical countries, where there are also extremes of season produced by the alternation of copious rains and burning droughts, just as the extremes of season in high latitudes are produced by summer heat and winter cold, the former accompanied by showers of rain, and the latter by snow-storms; there is also a seasonal appearance and disappearance of very many of the invertebrated animals. Those animals, however, differ so much from each other, in their form, the nature of their covering, the places which they inhabit, the substances on which they feed, the length of their average lives, and all parts of their economy, that it is impossible to make any general statement which will apply to even all the land ones, in almost any latitude.

There is one remarkable circumstance which runs very generally through the whole grand division, and that is the power which they have, in some state or stage of their lives, of resisting the common causes of destruction. It does not appear that any length of time will destroy the vitality of the eggs, at least many of them, if those eggs are placed in circumstances unfavourable to the development of the germ of life which is in them. Nor can we help feeling perfectly astonished that minute things, of which when fully grown a thousand, or even many thousands taken together, would not equal in volume an ordinary pin's head, should be in their rudimental and of course still smaller state more indestructible than the strongest, the most powerful, and the longest-lived of the mammalia. We come to a certain approach to this endurance at what may be considered the terminating links of all the four classes of vertebrated animals, with the exception perhaps of the class of birds, which, being endowed with greater powers of motion than any of the others, are better fitted for shifting their quarters according as the season requires. Some of the mammalia which hybernate, or pass the winter in a dormant state; some of the reptiles, as for instance the toad; and some of the fishes, as for instance the eel, in certain latitudes, are capable of remaining for a long time without food; and others, such as the frog, can bear very severe cold. It does not appear, however, that any of these can endure a temperature of the whole body lower than that of freezing, for any length of time, and afterwards revive; and we know that eels, in shallow water where there is no mud at the bottom in which they can bury themselves, are very liable to be killed by severe frosts. We are, however, speaking of the power of endurance, not as it exists in the full-grown animal, but as it exists in the germ; because there are many animals, the activity of whose system generates heat sufficient to protect them under constant exposure to an atmosphere which is cold enough to freeze mercury, and into which if even warm water is projected to a considerable height, it will fall rattling to the ground in a shower of ice. The undeveloped germ, which we are to regard as being passive, is the state in which to compare the relative power of endurance in different races of animals; for the germ is as it were the general character of the animal, unaffected by any advantage or disadvantage which it may derive from its development, or the mode and circumstances in which that development is brought about. Now, it is known that the germ of no vertebrated animal can endure either the temperature of boiling water, or that of freezing, for any length of time, and retain its vitality. On the other hand, the germs of very many of the invertebrated animals can endure a temperature much higher than boiling heat, or much lower than freezing cold, without the slightest injury.

This is a very singular difference between the two grand divisions of animals in what may be considered as their most defenceless states; and we shall immediately see how necessary it is to the maintenance of the system of nature; and that the Creator is nowhere more clearly manifested than in those general adaptations which fit them all for their several purposes in the accomplishment of His good purpose—for showing forth His glory, and for administering to the service and comfort of man.

From what we have said of the comparatively inferior development of the system of sensation in the invertebrated animals, and the consequent power which climate and seasons have over them, more than they have over the vertebrated animals, it became necessary that the means of preservation in the race should be strengthened in the same proportion as those powers are weakened in the individual. When a stagnant pool is dried up by the heat of summer, it is probable that the mortality thereby produced is greater than if the whole vertebrated animals of a country were at once destroyed; but no sooner does a shower of rain come, and a certain degree of putrefaction take place in the aquatic plants, than the pool is as thickly peopled with those microscopic inhabitants as ever. So also if a little of the paste of flour, which has been boiled ever so long in the making, be allowed to become sour, and then mixed with water, the mixture, when a microscope of sufficient magnifying power is applied to it, will appear to be composed almost entirely of little eels, very handsomely formed, and moving about with great activity. Allow the same mixture of paste and water to become solid by drought, or by freezing, and let it be again moistened or thawed, and it will be as completely peopled as ever with its microscopic inhabitants.

There is nothing in the mere putrefaction of vegetable matter, in the pool in the one case, or in the souring and moistening of an admixture of the flour of wheat and water in the other, which can, by possibility, produce a single germ of an animal, even though that animal were supposed to be diminished a thousand or a million fold beyond the most minute creature which microscopes of the present construction can bring under our notice. If we admit the possibility of this in one case, we must admit it in every case; because the question is not one of change of size, but of change of matter; and the cause of change of size is common to them all; for there is no question that we can in thought trace back the original germ of even the largest animal to a period at which we can assign it only an atomic bulk, that is, a bulk less than any specific dimensions to which we can give a name in language. In the cases of the larger animals, and also of the plants upon which we can make experiments and observations with the naked eye and in the ordinary course of our working, we find that there are no means by which one distinct species can be changed to another, how nearly soever they may be allied to each other in their structure and habits; and if this be true in every case of nature which we can bring fairly under our examination, it is contrary to every principle of philosophy, and every rule of judgment and of action in common life, to suppose that it does not hold equally with regard to the rest; and that it is physically impossible for us to obtain a plant or an animal of any class, or of any species whatever, whether large or small, except from a fertile germ of the very same species, retaining its principle of vitality, and placed in circumstances favourable to its development.

Now, in the case of the little creatures which we find in the sour paste, the germs must have been boiled, and in one of the forms of the case they must have been frozen, and yet we find that the principle of life in them was not destroyed by either of those means; nor are we warranted to conclude that those exceedingly small germs would be destroyed—that is, deprived of the power of being again awakened with living action—even though exposed for thousands of years to the heat of a furnace, or to cold exceeding any with which we are acquainted.

This is a very wonderful part of the physiology of creation; and it is as instructive as it is wonderful. In proportion as the living creature is more developed in its organization, and more constantly energetic in all its functions, it is the more subject to casualty stands in more constant need of renovation by food, and revival by the influence of the atmosphere; while, on the other hand, as we descend in the scale of development and of action, we find that the creature can endure longer and longer death-like pauses in its state; and when we come to the very simplest condition and the most minute form, we find that absolute destruction is a matter not easily to be effected. This is true in the vegetable world as well as in the animal: for while the life of the stately palm is confined to a single bud on the top; and the pine, which in some countries, raises its spiry form to the height of two or three hundred feet, is dependent on a single terminal bud at the extremity of the ramification of the branches; the hard lichen, which can barely be distinguished from the stone upon which it grows, is alive, and capable of producing the entire plant anew, in almost every part of its substance; and some of those which are still more minute, such as the moulds, that appear but as a stain on the surfaces of substances, absolutely appear to be sown on the viewless air; because, if exposed to the common action of the weather, there is not a substance adapted for supporting those very minute plants which is not very speedily covered with them. There is scarcely a remain of any larger and more developed animal or vegetable, which has not one of these little parasites peculiar to it. It may be, for instance, the bone of an animal, a decaying leaf, or the stem of a sickly plant, each of which, generally speaking, has its appropriate parasite, which helps the decaying matter to return again to another kind of life; and though the particular substance may be shut out from the access of every imaginable thing save the all-pervading atmosphere, no sooner does it arrive at that stage of decay in which it is fit for becoming a soil to the new plant, or a pasture to the new animal, than the plant or the animal is there, to take advantage of it, and prevent it from becoming an unprofitable thing in the wonderful system of the universe. The mould which appears lining the cells which contain the seeds of an apple, of which the integument and the pulp are entire to our inspection, as well as the hard lining of the cell, is a remarkable instance. Nor is it less wonderful, why, at one stage of decay in a cheese, the fissures in the very centre of it should become covered with a peculiar mould; that this should be brought about by artificial means; or that in other stages of decay in the same substance, it should become thickly peopled with colonies of the cheese-mite, of whose progression towards their new settlement no observation of man can find the slightest trace.

In this, there is much matter of delightful contemplation for the intelligent mind; because here there is evidence, that there is in the material creation itself, and independently of immaterial and immortal being, something more than mere matter, as palpable to our senses; and as we cannot even imagine the matter to be self-existent, so no more can we imagine this addition to matter to be self-existent, or to be brought about by matter itself. There is, therefore, the clearest evidence of a creation of life, as well as of the substance which, during its continuance, the individual life keeps under its dominion. The forms and modes of this life, whether we consider it as the life of growth only in the vegetable, or as the life of growth and sensation in the animal, are varied without end. But in all these variations there is a constancy in the species, so that the one can no more pass into and become the other, than men can "gather grapes of thorns, or figs of thistles." There is a certain play, or yielding in the whole system, by means of which the various parts, within certain limits, accommodate each other; and thus, under a certain range of varying circumstances, the whole can work together. But in every case there is a barrier beyond which they cannot pass; and when, in the case of either plant or animal, this barrier is once arrived at, the species can exist no longer; and, therefore, it yields to the general law which the Almighty has given to the whole, and so ceases to be. The earth, which is the general grave of material life as it is the general womb and the general nurse, furnishes us with many evidences of this truth, by showing us the remains of races buried deep in the accumulation of rubbish, or deeper still in the substance of rock, of which the living and the growing world, as at present palpable to our senses, does not furnish a single specimen. We, in these northern countries, find in the great charnel-house of the earth the remains of plants and of animals, analogous in their general nature, but varying in the particular so as to adapt them to the difference of climate, to those which are now to be met with only in tropical climes; and when we go to more solid formations, to which an older date must be assigned, we find remains of singular form and character, of which there is not now a single type to be met with in the living state: animals of large dimensions, which had been furnished with wings, far exceeding in dimensions and in power the wings of eagles, furnished with implements at the extremities or on the joints of those wings, with claws like the claws of lions, and armed with jaws more produced and more formidable than the jaws of crocodiles. But, while we meet with those memorials of extinct races among vertebrated animals, there is no such variation between the invertebrated animals which appear to be lost, and those which still exist. It is true that, in many situations, we find the shells of invertebrated animals forming constituent parts of mountain rocks, thousands of feet above the present level of the sea; and, from the clearest analogies which we can trace, those shells must have belonged to animals which not only inhabited the sea, but were tenants of the deep; but even in these, there is such a correspondence with living species, as shows that the invertebrated animals are not subject to such changes, or so much dependent upon the temporary state of our globe, as those which have internal bones and warm blood.

It is impossible for us, limited as our powers of observation are, to scrutinise so minutely into the system of creation as to see the uses of the whole, or even of one division of the invertebrated tribes. But we are warranted in concluding generally, that as are the numbers so is the use; and consequently, as these are, beyond all arithmetic, the most numerous of animated beings, they must be in the general system of nature the most useful.

We find a farther proof of this, in the more general accordance which they have with the seasonal changes of nature than the vertebrated classes. Within the tropics, and in situations where a constant supply of humidity gives continual growth to vegetation, we find those animals quite perennial; and a caterpillar, of some one species of butterfly or moth, always ready to consume every superabundant leaf or other vegetable production, so that the quantity brought forward to maturity may not exceed the means which there are of so bringing them. In those regions of the same climes which are subject to seasonal burnings of drought, we find a very different action of the invertebrated animals, but an action not less fitted for the general preservation, perfection, and beauty of the system of nature. Where there are the most extreme alternations of seasonal rain, and seasonal drought, there is of necessity the most rapid growth of vegetables in the rainy season, and the greatest dearth and destruction when the weather is dry. Such a state of things requires a different species and condition of invertebrated animals for consuming the refuse, than is required to consume the surplus leaf. Accordingly we find, that, in such places, the different species of insects known by the name of white ants are provided in multitudes which no arithmetic can express; and that these do not attack and prey upon leaves or flowers, or living vegetation of any kind, but the boles and branches, the solid timber of trees, after the growth has ceased; and, unless it were removed, the rotten trunk would encumber the earth as an unseemly thing. This takes place in all tropical and warm countries, which have the seasons marked by rain and drought, in the manner which we have mentioned; and, as we shall afterwards have occasion briefly to notice, the numbers, the economy, and the activity of those little creatures, are beyond anything which, from our experience in temperate climates, we could be led to suppose. Many of them are things of darkness, in all probability without any organs of sight, of which, in digging into the solid timber of trees, they have no need; and thus, when they pass from one tree to another, they do so under a covert-way, which they prepare for themselves as they advance. In this manner they not only reduce to powder all the dead trunks and branches which occur in the tropical forests; but, true to their instinct, they attack the posts of houses and palings, and, in short, every species of dead and dry vegetable matter, and turn them into dust with a rapidity which, if it were not experienced, would not be credited. In the British colonies of Australia, a country in which there is a remarkable contrast of drought and rain, it often happens that, in brief space, all the pillars of a wooden portico, or all the posts of a wooden fence, are found crumbled to dust, with the exception of a little pellicle inside the paint with which they are covered, while not a symptom of decay appears on the outside, and not a trace can be found of the coming or the working of the destroyers.

This process of the consumption of solid vegetable matter by small invertebrated animals is peculiar to the warm countries; and when we consider it, we cannot but perceive that it is a beautiful provision of nature. It is a law, which runs universally through the whole series of growing and living nature, that no one race, either of plants or of animals, can be supported on its own ruins. There are, no doubt, instances of cannibalism, but these are violations of the law of nature, and not observances of it; and it is remarkable that, among animals, those which are most prone to eat their own young in the early stages of their existence, are the miscellaneous feeders, and not the regular animals of prey, whose habit it is to kill whatever they eat. There is no one race which could feed upon itself, so as thereby to be maintained; and this proves the unity of creation, by showing how much one must be dependent upon another. But in those fervid climes where, during the rainy season, there is so excellent a production of vegetable matter, and during the dry season such a decay and death of the same, if there were no means of changing the condition of the matter which is left by the decay, the surface of the earth would be so loaded with the dead matter of that kind of vegetation for which it is best adapted, that, in the course of a very short time, it would become unfit for continuing the production. The myriads of invertebrated animals which consume the dead and dying timber of the tropical forests are appointed by Heaven to prevent this catastrophe; and they produce such a change on the substance of the timber, as renders it a fit manure for a succession of the very same species. By this beautiful adaptation, the system is continued in a working state; and year after year, and age after age, we find in every situation in such countries the tree and the plant, for which the physical circumstances of the country are best adapted; and thus those countless invertebrated animals which, to the unreflecting observer, appear to be destroyers, and destroyers only, are really the preservers, of the system of life and of growth.

As we leave the regions of the equator, and come into those in which there are seasonal changes of the year, independently altogether of rain and drought, we find a different condition of the invertebrated animals, more especially of those races of them which appear to be in a peculiar manner set over the vegetable world, to regulate the exuberance of its growth, so that the whole may be made conducive to the greatest advantage and beauty. Nor must we consider it as an imperfection of the system of nature, that there is a consumer appointed to everything which nature produces; for it is in this that the unity and beauty of the system consist. Of every species, whether animal or vegetable, there is a means of production far beyond what that species requires in the due balance of all the productions of nature. There are, for instance, some fishes which, if they were to go on multiplying to the full extent of their power, without any means of destruction, for a very limited number of years, not more than half a century, would suffice to turn into their own substance, not only the whole of the matter which is contained in the earth, but the whole matter of our system—sun, planets, and all. In like manner, there are many of the invertebrated animals, and those even of small size, which are produced in such numbers and so rapidly, that if there were no check to the production, they would get the mastery of all the rest of nature, and in a short time consume everything else; nor would it be long after this till they themselves also would perish, for, as we have already said, and as any one who chooses to consider the subject may find, there is no race of beings which can of itself maintain itself.

It is this dependence of all the children of nature upon each other, which is the most valuable lesson that the system gives us; and it is not confined to those which are in the same locality, or, as we would say, in juxtaposition with each other, as feeder and food; for there is a reciprocity between different climates and different latitudes, and also between the land and the waters, by means of which the one is mutually beneficial to the other, just as the pasturing of sheep brings a kindly grass upon the common, and the grass so brought nourishes and fattens the sheep in return.

When we come into the temperate zones, we find that the watchfulness of the invertebrated animals over vegetation is of a different kind from what it is in the regions of the equator. In those latitudes there is a leafless winter, during which vegetation is inactive; and, alternating with this, there is a summer of long days, during which it is comparatively vigorous. In such situations, however, it is the annual growth of the tree, and not the permanent part of it, which requires to be kept down; and a principal part of this annual production is the deciduous leaf. Therefore, in such latitudes, the caterpillar which consumes the leaf is the principal invertebrated animal which is set over the tree. And we find in such climates a very remarkable manner in which those caterpillars work according to the changes of the weather. In the early part of the season, if dry and withering winds from the east blight the leaves, and bring on in their juices the same sort of chemical action which takes place when, in due season, the leaf has performed its office, and is preparing to heal off, in order to leave to the storm only that part of the tree which is clad in armour against the violence of the storm —if this happens, then we find that the eggs of the caterpillars are quickened in myriads, and those leaves which would act as poisons to their parent trees, by bringing winter upon them before summer had commenced, are very speedily consumed, and the strength of the tree is not exhausted in vain efforts to continue that, which from the injury it has received, would be of no value. If this takes place at a sufficiently early period of the season, the tree buds again, and its progress, though checked, goes on as usual. If, on the other hand, it is late, the tree relapses into a state of repose, from which it afterwards awakens with increased vigour; and in this way what we are accustomed to call the blight of one year is not only the harbinger, but in some measure the cause, of a more exuberant growth and production during the next. It is difficult for us, with our limited powers, to observe the facts in those cases, and when we have observed them it is still more difficult for us to generalise them with wisdom and truth; but if we could accomplish these, there is no question that we should be able to see the goodness of God even in those occurrences which we call natural events; and that blight and mildew, locust and canker-worm, all work for good in the general system of nature.

When we carry our observations to a greater distance from the equator, and approach the regions of the poles, we find that there is another difference in the character of those invertebrated animals which appear with the seasons. There the trees again become perennial in their leaf, and therefore the destruction of them requires to be in the timber; but this destruction is not brought about by animals, even of the invertebrated classes, as it is in the regions of the equator. It is, in so far as it extends, chiefly the result of parasitical plants—fungi, moulds, mosses, and others, the operation of which is much slower than that of the animal destroyers in the burning regions of the tropical sun.

And here we cannot help pausing to admire a very remarkable instance of the provident goodness of the Almighty, in ordering the general system of nature so as to provide for the wants and administer to the comforts of man, even in those remote ends of the earth. In the equatorial regions there are not many fires, and consequently the fuel which feeds such fires is not necessary excepting in the arts; and the seasonal production of vegetable matter is so great that it is quite sufficient for these purposes. In colder climates, however, fires are necessary not only in the arts, but for rendering the habitations of men comfortable in the inclement season, which, in the average of such climates, may be regarded as extending over half the year. The system of nature, in the tropical countries, turns the vegetable produce into dust through the instrumentality of those small but numerous invertebrated animals to which we have alluded, and sometimes by means of what are called accidental fires. These latter take place during the season of drought, by the friction of the stems against each other; and some of the tropical plants—the bamboos for instance, which are plants of very rapid growth—have their epidermis or outer rind containing a considerable quantity of silica or the earth of flint, as if it were for this very purpose. But in the cold climates, vegetable matter does not perish by such means. On the other hand, it is treasured up as a store of fuel. A tract of land has borne one species of timber, oak for instance, until it can bear that species no longer, because of the decayed matter of oaks which is mingled with the soil. Some have alleged that a species of matter is given out by the living plant, which unfits the soil for the production of the same species; but this is a mere hypothesis for which there does not appear to be the slightest foundation either in nature or in reason; and thus the only rational conclusion is that the dead substance of the plant, mingling with the soil upon which it grows, becomes in time so abundant as, upon the principle that no species can feed itself, renders the soil unfit for nourishing the same species any longer. When this degree of saturation of the soil is arrived at, no more of the seeds or fruits which are shed by the living plants can germinate; and thus the duration of the race is limited to the generation which is then standing in the ground. According to the general law of all terrestrial things, this race must come to an end; and when growth is over, the bare trunks stand, bleached by the weather, for a longer or shorter time according to the character of the climate, but always longer in proportion as the climate is colder. They give way at last; and any one who has observed in what way a post rots, can be at no loss to see at what place they must decay. The decay of the post is neither in the portion which is wholly in the earth, nor in that which is wholly in the air. It is at the line where these meet, that is, immediately above the surface of the ground: the reason of this is, that the portion there is exposed to the greatest action of water and of air and heat jointly; and those are the general means of decomposition. Upon this principle the dead trees are cut off near the surface of the ground, with as much certainty as if they were cut with a saw, or girdled with an axe; and when this process has been carried on to a certain extent, this part is no longer able to support the stem against the action of the winds, and thus the whole stem falls prostrate to the earth.

After the trunks of the trees are thus laid prostrate, the first production which appears upon them is that which characterises the decay of vegetation in all climates having a cold winter—a crop of fungi or mushrooms of some kind or other, and there is generally a particular kind which comes upon every species of tree in this state; it springs up just where the fallen trunk is in contact with the earth. This crop is of as brief duration as the rest of the family to which it belongs; and when it decays, from its spongy nature it passes into a sort of paste, which renders the place between the fallen trunk and the ground completely water-tight. This furnishes a sort of dam, which the rain speedily fills with water, and the production of the common bog-moss, whence the sporæa or seeds of which come one knows not, is very speedily the consequence. Once begun, this is a new receptacle for moisture; and in a very short time the trunk of the tree is buried under a covering of green moss. This moss continues growing at the top, and dying at the bottom, until it reaches such an elevation as that the slope from the sides carries off the water; and then it consolidates and becomes an appropriate soil for a different species of timber, which lasts for its appointed time, and then yields as the former did, and the process is renewed.

In many of the peat-bogs of the northern parts of the world, there are the records of several successive forests, each almost exclusively composed of trees of the same kind, but all different from each other; and connected with each of those monumental forests, there is often ten or twenty feet of consolidated moss and other vegetable matter, with very little admixture of earthy substances. If this moss contains oaks as one of the layers, the colour is nearly as black as coal when exposed to the air, and if the mass is thick, the consistency arising from the pressure is often very considerable after the substance is exposed to the air, and the water by that means evaporated. Sometimes these accumulations tell other histories besides their own ; for there are found in them the bones of animals, and especially the horns of deer, which, from their large size, evidently have belonged to species that are not now found alive in the same places ; and not unfrequently the ruins of houses, together with weapons, and domestic utensils and ornaments, are found preserved in the same sepulchres ; for in those accumulations of vegetable matter, soaked with water in a comparatively cold climate, there is a wonderful antiseptic power, which preserves from corruption every thing that they contain at a sufficient depth for being beyond the action of atmospheric influence. In the mean time, however, we are not concerned with the story of animal or of human life, which those deposites may have to tell, but simply with their accumulation in regions where they are especially wanted for the benefit of mankind.

It is, however, not unworthy of remark, that the layers of fallen trees which, lying *stratum super stratum,* mark the progress of accumulation in those bogs, very often lie all in the same direction, and this direction in the British islands answers to the seat of the prevailing winds at the present time,—that is to say, the tops of the trees lying north-east, and the root-ends south-west, indicating that they have yielded to a wind blowing from the latter quarter.

The further we proceed into the colder regions of the world, the more numerous do we find those accumulations of vegetable matter; and though their growth is perhaps not so rapid as that of the vegetation of warmer countries, their duration is far more secure. In this way there is often laid up, in the course of thirty or forty years, a store of fuel, indiscriminately called peat or turf, sufficient to last the inhabitants of the district for a much longer period than the whole extent of surface which it occupies would last, if covered with the most stately trees that will grow in the same parts of the world. Those bogs are often from fifty to a hundred feet thick of vegetable matter, unmixed with any foreign substance, and available for the necessities of the people; and as those volatile ingredients which, in wood, or any other recent vegetable matter, so rapidly ascend and go to waste, are in a great measure gone from those accumulations, and carbon, which is the most effective of all fuel, is the principal substance that remains, a much more powerful and continued heat is produced by these materials than would be produced from the same volume or weight of any timber whatever.

There is another consideration which applies especially to the northern parts of those countries which abut upon the Atlantic Ocean. The current of the waters in that ocean is peculiar; and the rivers of America, especially, bring down, during the spring floods, an immense quantity of timber. This timber is cast in immense floats upon the shores of the northern islands, where not a tree grows; and thus in its recent state it serves all the necessities of the people. But there are evidences that convulsions of the earth, whether of a more local or of a more general nature, whelm those vegetable accumulations, whether grown on the spot, or brought from a distance by natural causes, under the pressure of many fathoms of earthy substances; and this pressure, with or without the assistance of heat from below (for the point is not determined or determinable), converts the vegetable accumulation into coal, such as is dug from the mines of various parts of this country, and which, in point of strength and durability as fuel, is superior to every other substance. Thus we see that the absence of invertebrated animals which would consume woody matter, is a very great advantage to man in the cold climates; and it is to this circumstance, more than to any other of a physical nature, that Britain owes that superiority for carrying on the useful arts which it possesses above every other country that could be named.

But still, in the high latitudes, there is no want of the smaller tribes of invertebrated animals at that season of the year which requires their presence: there, however, they are gone while vegetation is in the dormant state; and the same sun which expands the seasonal bud, hatches the egg of the caterpillar. As long as the temperature is moderate, a very large proportion of those creatures deposits their eggs on vegetables, glueing them to the buds and branches of trees, or inserting them in holes of the bark, which the parents are furnished with instruments for making; and some deposit them in the earth, where they live for more than one year below the surface, feeding upon the roots of plants, and sometimes, in peculiar states of the weather, the young come upward, and cut the roots of the grass within an inch or two of the surface, so that over a whole meadow it may be rolled up like a carpet, and is of course destroyed for all future purposes of vegetation, while on other occasions they attack, in a similar manner, the roots of the corn, and completely destroy the crop. There are, however, many species which trust to the waters for the continuation of their race; because, as we have already hinted, the waters preserve a greater uniformity of temperature than the land does; and where the surface of the water is covered with ice, the unfrozen water below never descends to the temperature of freezing, and is generally, if not invariably, very much higher. The coating of ice upon the water preserves the heat of the unfrozen water below, much in the same manner as the snowy mantle which is thrown over the Polar lands preserves the heat of these. Both are bad conductors of heat, and both affect the surface only; and thus by their means a certain portion of the heat of the summer is preserved in the land and in the waters during the winter, so that the cold itself is, to a considerable extent, the prevention of that destruction which it would produce, if it had uninterrupted access to those animals and vegetables which are shielded from its influence by the snow and the ice.

The number of germs which is preserved in this manner, in the very cold latitudes, is beyond what any one would suppose; and the number of living creatures, especially winged insects, which are produced in the summer, is great. In Lapland, in Canada, and in other countries of extreme cold, the inhabitants of temperate climates can hardly have any conception of the number of flies, many of them armed with stings, which literally encumber the summer air, and render the margins of the waters, and the shade of the trees which grow by those waters, perfectly intolerable to human beings. Many parts of Canada, for instance, are for nearly half the year completely bound up in fetters of ice, and exposed to the ardour of a heat almost equal to that of the tropics during the summer; and while one is panting under this heat in the open parts of the country, if one attempts to take refuge under the shade of a tree, by some swampy pool, a cloud of flies descends which is absolutely unbearable; clearly showing how powerfully the waters in those countries tend to the preservation of the germs of invertebrated animals, and with what energy, and in what numbers, the summer sun brings them to maturity.

Nor must it be supposed that this immense production of small animals which takes place in the high latitudes, during the summer season, is without its use in the general economy of nature, or that these children of a day or an hour, (for the lives of many of them in their perfect state do not extend much beyond the more brief of those periods,) are made for themselves alone. We have mentioned again and again, and the tale cannot be too often repeated, that all the living and growing productions of nature are mutually dependent upon each other; and that, if there is at any place, or in any season, an exuberant production of any one description of creatures, there will be provided, in the same place, and at the same season, a corresponding number of creatures which shall profit by this exuberance. Now, the very same sun which carries long day and intense heat into those high latitudes, parches up the northern parts of the equatorial regions, so that vegetation pauses, and the small animals which live upon young vegetation are gone for the season. When this takes place, the feathered tribes, whose wings are fitted to carry them in a short time over a large portion of the earth's circumference, speed onward to the high latitudes in countless numbers; and in consequence of the long day, and the vast number of little creatures which they meet with in such situations, find there much more abundant food than they can procure even in the regions of the equator, where the day is never much more than twelve hours in length, and the twilight, which is the favourite feeding-time for many of the birds, is of very brief duration. Those lovely wanderers pause at different places by the way, according to their own natures and the substances upon which they feed; as for instance, the nightingale does not in our islands reach the north of England, though on the continent of Europe it attains a higher latitude: but there are many birds which resort to the extreme north and nestle and rear their broods there, under circumstances more favourable than they could obtain even at the equator itself. The food of those birds, whether we regard them as aquatic, or as confined to the land, is generally, indeed we may say invariably, invertebrated animals of one race or another: and thus, we may confidently assert, that the invertebrated animals are the chief support of those races. In the case of birds which feed on vegetable substances, it is different; for though they are driven southward during the inclement season, none of them reach nearly to the regions of the equator: and they do not quit their northern haunts until the severity of the season compels them to seek a more genial climate, long after the seasonal supply of invertebrated animals has disappeared.

The circumstances which we have mentioned in this chapter will, if properly understood, show the principal use of at least some sorts of the invertebrated animals in the general system and economy of nature; and this general view of the subject will prepare the reader who wishes for information, for entering upon the details with the certainty of that knowledge which the careful study of nature is calculated to impart; and this is the proper mode in which the productions of nature ought to be studied, because it is the one which is redolent of instruction.

CHAPTER III.

ON THE DIVISIONS AND CLASSIFICATION OF INVERTEBRATED ANIMALS.

As the circumstance upon which the name of those animals is founded is not positive, but negative—not something which they have, but something which they want, it cannot be made the basis of any arrangement; and thus the only use of it is to distinguish them from those animals which have a skull and vertebral column, enclosing a brain and its continuation in a spinal marrow, and which skull and column are the foundations upon which the whole organic structure of the animal is, as it were, reared. In the invertebrated animals there is of course no skull, no spinal column, no brain properly so called, and no internal skeleton or frame-work of bones, upon which the soft parts, in which the living action is more immediately displayed, are supported. The support of the acting parts of all invertebrated animals is the envelope in which their bodies are contained. Sometimes this is a mere skin, of greater or less consistency according to the species; sometimes it is a crust, partaking of the nature of horn, or being chiefly composed of gelatine; at other times it is a firm crust, partaking in part of the nature of bone, or containing phosphate of lime, which is the earth of bones in all vertebrated animals; but, in the invertebrated, the crust always contains a certain admixture of another substance which approaches more nearly to the composition of those limestone and marble rocks which are so abundant in the earth, and so useful and ornamental in the arts; and there are still others in which the external envelope is composed, in the earthy part, wholly of this limestone or marble, which is technically known by the name of carbonate of lime, and this carbonate of lime is mixed up with a greater or smaller portion of animal matter, chiefly gelatine or glue, according to the species. When the covering is soft, or contains little or no earthy substance, it gets no particular name except from its form and consistency; and then the description of its varieties forms part of that of the animals which possess it. When it consists of earthy matter, in whole or in the greater part phosphate of lime, it is called a crust; of which we have examples in the lobster, the crab, and the shrimp. When carbonate of lime enters into its composition, it is called shell, if the individual animal contains a portion of it, formed and possessed by itself, and independent of any other animal of the same species. If the earthy matter of the shell is combined with a considerable quantity of animal gelatine, the shell is called a pearl shell, or mother-of-pearl shell, because such shells have the peculiar lustre of those pearls which, when pure and perfect, are so much esteemed in jewellery ; but the native shell has often a far more splendid display of colours than the pearl, as the pearls themselves are the produce of disease in shells which have not much colour; and, indeed, the more nearly white the mother shell is, the pearl is the more esteemed. This pearly lustre is produced by the structure of the pearl shell, which consists of very thin layers of gelatine and carbonate of lime alternating with each other. The beautiful play of colours which those shells often exhibit, appears to come from the interior of the shell ; but it is probable that this appearance is a deception, and that it is the form of the surface only which breaks the light into its various tints, and thereby produces the play of colours. This is rendered highly probable, if not completely demonstrated, by the fact that fine clay, or any other substance of the same nature, which is strongly impressed by a pearl shell, will show, dimmed only by its own particular colour, the same play of colours as the shell itself.

Shells which consist chiefly of carbonate of lime do not in general possess this pearly lustre, and they are much harder and more inflexible than the others. Generally speaking, they are also far more glossy and polished on the surface ; and on this account they are called porcelain shells, from the resemblance which their gloss has to that of china-ware.

Almost all land shells, and also fresh-water shells, are of the pearly structure ; and so are also those sea-shells which are termed *littoral*—that is, those which are found in the living state on the shores or banks of the sea. Many of these inhabit the tidal part of the shores; and in the season of reproduction the rocks are often covered over by the young, to a greater height than the still water of the flood tide ever reaches, but never higher than the spray dashes when the wind is on the waves and the surface is agitated. Others, however, inhabit at the depth of a good many fathoms: but it is probable that few or none of them are lower down than can be reached by the soundings of an ordinary line.

Porcelain shells, on the other hand, are very rarely, if at all, found on the land, or in the fresh waters; and even at sea they are not, generally speaking, littoral, or found in the tide-way, or on the banks at moderate depth. They are *pelagic*, or far-sea, or deep-sea shells, and there are but few of them which we have the means of examining in the living state. Multitudes are, however, cast upon the shores, more especially in tropical countries, where there is a current of the ocean waters rolling toward the shore; and of these many are of great beauty, and highly prized as ornaments.

When the shell, or production of earthy matter, forms the habitation not of one animal, but of many, it takes in great part the form of a vegetable substance, though it is truly an animal production, containing more or less of the salts of lime, according to circumstances. If hard and firm, and of considerable thickness in the individual parts, it is popularly called a coral, and some of those corals are of fine colour, admit of a high polish, and are much esteemed for ornamental purposes. If the individual portions are less compact, and detached, and branching, it is called a coralline; and some of those corallines have so much the appearance of vegetable productions, that they have occasionally been considered and described as plants. Some of those corals are, in the warm seas, produced with amazing rapidity, so that they are brought up from an unfathomable depth to near the surface in the course of a very few years. They are remarkably compact and hard; and there have been instances of a spike of coral piercing completely through the bottom of a ship, thus stopping the leak which itself had made, and so preserving the ship until it reached the shore. An instance of this kind occurred to the enterprising and illustrious Captain Cook while exploring the seas to the eastward of New Holland—seas which, from the middle latitude of New Holland, and round the northeastern extremity, are remarkable for this sort of production. Those coral rocks, reefs, and islands, which are sometimes of great extent, though never elevated above the surface of the water, except by other causes, are all the productions of invertebrated animals, and animals of the very lowest or least developed division, which do not possess any visible organs of motion or of sensation, and which individually are so very minute, that the naked eye can hardly discern them.

This is a portion of nature's working, which is equally wonderful and instructive. It shows us that, according to our ordinary modes of estimating, "the race is not to the swift, neither is the battle to the strong;" for while we meet with a few bones of ancient mammalia, more rarely those of birds, and more frequently fishes, and especially shells, we find them scattered among other substances, evidently showing that they had been altogether passive in the production of those formations of which they are part. But there is scarcely on the face of the earth a country, unless that country bears evident marks of having been forced from the bowels of the earth by volcanic action—that is, by the action of subterraneous fire, in which those little creatures have not recorded a monument incalculably more extensive and lasting than any which the skill and the power of man, aided by reason, and those tools and engines which reason has enabled him to contrive, could by possibility erect.

This is equally demonstrative of the power of God as displayed in the works of creation, and humbling to the vanity of man; and we can, perhaps, nowhere find a more striking instance of the contrast between man's working and God's making, than when we compare the monuments erected by the mightiest monarchs and the most skilful artists of the human race, with those constructed by the most minute and humble of the creatures which God has made, and which work simply and implicitly according to the law which He has given to their nature, and without any thought or reasoning on their part. True to the words of the prophet, "Babylon is heaps," barely distinguishable from the accumulations of rubbish formed by that river of which Babylon once was the ornament; Thebes and Tadmor are mouldering ruins; the glory of Athens is gone; and while the ancient edifices of Rome are crumbling by the action of time, the *malaria*, which, like the pestilence, "walketh in darkness," is invading the remaining part of the city, with more certain destruction and death than the Romans in the very zenith of their power inflicted upon the people of those countries which were over-run and subjugated by their armies. But though the design of the architect and the skill of the sculptor are fast passing into oblivion, those mutilated remains, in which the labours either of the one or of the other can hardly now be traced, are as monumental as ever of an earlier and a better worker—of the invertebrated animal, which originally produced the marble that the human artist borrowed for a time, to be at last returned to the general collection of dead matter, by the wantonness of barbaric hands, or the more slow, but more certain, decomposition of all-devouring time.

This circumstance alone shows us how much the system of things as it now exists, is dependent upon even the humbler classes of the invertebrated animals, and that, as these are in their organisation and sensation the least removed from mere matter of all living creatures, they are, in some sort, the conservators of the rock, the preparers of new lands, against the time when the lands now inhabited shall have run their course, and shall have been unfit for any of the purposes of growth and of life. We have already mentioned the remarkable indestructibility of the principle of life in those creatures, and how independent they, when in the state of germs, are of all those contingencies which are fatal to animals of larger growth and more complete development; and it is impossible not to see that this power of endurance which they possess, is in perfect accordance, and in strict agreement, with this office, which is assigned to them, of renewing the land so as to make it fit for other races, both vegetable and animal. In this manner they appear to form the chain of connexion between those different states of our globe, which are separated from each other by mighty convulsions, and thus they are perpetual witnesses to the original creation, and continued providence, of the great Author of our globe.

We must, however, leave these general speculations, highly interesting as they are, and take a rapid view of the different kinds of invertebrated animals, before proceeding to a few detailed accounts of some of the most interesting species.

Invertebrated animals are conveniently, and naturally, arranged into three grand divisions. In each of those divisions there are great differences of form, as a vast number of genera and species; but still there is a peculiar character, as applicable to the general organisation, which runs through the whole of each of the grand divisions, and serves to distinguish it from the others.

It is, however, not unworthy of remark, that in the animal kingdom, in the first and most remarkable division, that of vertebrated and invertebrated animals, there is a very remarkable resemblance to what we meet with among the vegetable tribes. The vertebrated animals resemble those plants which are called *exogenous*, or which grow from or at the outside, and increase in diameter at the same time that they increase in length, to which division the most beautiful and the most valuable vegetables of our latitudes belong. These are as it were articulated upon the centre; and in the case of the perennial ones, which last for years and for ages, the addition is made by annual layers around this centre, applied to the substance formerly produced. Between them and the vertebrated animals there is a remarkable correspondence; because, so long as those animals grow in bulk, it is by the application of new matter to the external part, to that which was previously produced. In this respect there is a wonderful correspondence between the wood of a tree and the bones of a vertebrated animal. The chief purpose which both serve, is that of support to the parts which are more immediately active; while the wood, after it is consolidated and has become what is technically called "hearty wood," takes no part in the action of the tree, but merely serves as a support to those parts, external of it, by which the action is carried on. So in a vertebrated animal the bones are altogether passive, and have in themselves no tendency to move, or to perform any function whatever in the economy of the animal. They are merely the supports of the active parts; and though the *periosteum*, or membrane by which they are enveloped, is very sentient, there is no sensation whatever in the bone itself; for the bone is a mere aggregate of salts of lime, united and kept in their places by animal gelatine or glue, and neither the one nor the other of those substances is possessed of any kind of sensibility. So also, in the exogenous plant, there is an accumulation of solid matter, which may perhaps be considered as the bone of the tree. This matter does not consist of lime, or any of the earths, but principally of charcoal, or carbon; and the composition of these, their most solid parts, constitutes one of the grand distinctions between exogenous vegetables and vertebrated animals. There is, however, this remarkable coincidence between them, that, in the progress of natural decay, the animal dies first in the bones, and the plant first in the wood. In the decrepitude of animals, human beings for instance, when the apparent stature of the body, and the dimensions of all the members, appear to diminish, there is a death in the bones; and as it is the nature of the animal structure to remove all dead matter out of the system, the dead portion of the bones is taken up by the action of the absorbent vessels, and thrown into the general mass of the circulating fluid as it returns from all parts of the body to the heart. Sometimes the taking up of this bony matter, which has ceased to be useful for the purposes of life, is so great, that the circulating vessels are unable to throw it out of the system, and it is deposited on the substance of the heart or the blood-vessels; which are, in consequence of it, in great part converted into bone. This conversion is called ossification; and there have been instances in which a human being has been able to bear up under it, until the greater part of the arteries, those of the lower part of the body especially, have been converted into bony tubes, and, in other instances, the heart; and the parts of the great arteries immediately adjoining it have, after death, been found to be converted into the same substance. In this dreadful state of the system, life is preserved for a much longer period than any one would believe, by the use of powerful stimulants, such as the strongest ardent spirits; and many instances have occurred in which persons in this situation, who had been kept alive by drinking undiluted brandy, have died in the course of a few hours when they had no means of getting the accustomed supply of that liquor.

The plant does not decay and die exactly in this manner, for it does not appear that there is in plants any means by which they can throw out of their system any substance which has ceased to be useful for the purposes of vegetation; but in trees, which are the longest-lived of the vegetable race, the wood, after it has ceased to take part in the active operations of the trees, and has passed into a state of inactivity, after a period of time, longer or shorter according to the nature of the tree and the soil in which it grows, begins to decay; and we find that old trees become hollow, from the decay of their internal or oldest wood, long before the power of vegetation in the external or active part of them ceases; and that vegetable life still lingers in a part of the surface after the greater portion of the substance of the tree has been reduced to dust, in the natural progress of decay, and without the action of any animal or external agent, except simply the influence of the atmospheric air.

Endogenous plants have a similar resemblance to invertebrated animals. Such plants have their support in the external crust, and they grow at and from the centre. In consequence of this mode of growth, those which have the longest duration increase in length, but not in diameter; and very many of them have the vegetable life confined to a single bud, the action of which will sometimes carry the tree to a very great height, as is beautifully exemplified in many of the palms which form such splendid ornaments of the tropical forests.

Nor is it unworthy of remark, that the power of life—that is, its capability of resisting destruction—is much greater in those plants, than it is in the exogenous ones. Also, when endogenous plants are of sufficient size to be classed as trees, the solid matter which is formed in their stems, is much more firm and durable than that of the best trees of the common character. It is true that the timber of such trees is not so serviceable for the carpenter and the cabinet-maker, especially the latter of these workmen ; for it generally consists of a bundle of exceedingly hard fibres, with spongy cellular matter between, which at once separates the strong fibres from each other and unites the whole of them together. Sometimes the cellular portion of the stems of such plants contains a considerable quantity of farinaceous or starchy matter, which the inhabitants of the countries where they grow have the art of extracting and turning into flour. The sago-palm, which grows chiefly in the south-east of Asia, and the adjoining islands, may be given as an instance of this kind; and sago flour is produced in such abundance, that it is an article in the general commerce even of Europe, and much esteemed as affording a very light and easily digestible food for those who are afflicted with disease. But whatever may be the nature of the softer matter of such plants, the woody fibre, in what form soever it may be produced, always partakes of the enduring character of the plant itself. The fibres produced by various palms are known in commerce by the name of *coire*, and when spun into ropes, or made into mats or cloth, they are strong and durable beyond all that could be imagined by those who are acquainted with the same manufactures as made only of flax or of hemp. A coire cable will hold a ship with more certainty than two hempen cables of the same size ; and it has this additional advantage, that it is very elastic, and thus, when a sudden gust strikes the vessel, and a severe strain is given, the strain is exhausted by the elasticity of the coire cable, so that, if there is much cable out, it does not reach the anchor; which thus does not drag or come home, as is too often the case when a vessel rides at anchor with a hempen cord.

We shall have to revert briefly to matters of this kind, when we come to examine the adaptation of the several races of the vegetable kingdom to those parts of the world of which they are natives; but we cannot help casting, in the mean time, a hasty glance at the provision which is made for the safety of man in the substance of which we have been speaking. The seas among the Eastern islands, where coire is produced in the greatest abundance, are, at certain seasons of the year, the most turbulent and dangerous to be navigated of any that are known. At the turnings of the monsoons—that is, when the general current of the atmosphere changes from blowing south to blowing north, or the reverse, both of which changes take place every year—all the winds of heaven are let loose upon those seas; and the strength of the wind is so great, and the changes from one point often to the very opposite one are often so rapid, that no craft formed and rigged like our vessels, which are adapted to the average states of the atmosphere, could live for even one hour under their violence. The place, however, is a place of islands; and passages of the narrow seas are indispensable to the comforts of the inhabitants, even at those turbulent seasons; and, as if on purpose to provide for those exigencies, all the materials of which their light barks are composed are of this yielding and remarkably tough and enduring nature. Nor is this a solitary instance; for on all places of the earth's surface, how much soever they may differ in their characters, we find that each supplies man with the means which are best adapted for making him comfortable in that particular locality, if he will only inform himself of the proper method of using those means. Thus the goodness of God encompasseth the whole earth, and man is alike under His providence in every climate and in every latitude.

There is another remarkable coincidence between the humbler classes of plants and those of animals, which it would be improper to pass over. They are always the first to come and the last to depart. If land is elevated from under the sea, or a new surface of rock is in any way exposed, the moulds, the mosses, and the lichens form the first crop which nature sows upon it, and the first living inhabitants are small insects. These make a beginning, however; and, though the time is longer or shorter, according to the situation of the place on the globe, and to other circumstances, yet there is always in the end a soil produced capable of supporting a larger and better vegetation; and as soon as plants which produce seeds come to maturity, birds become visiters; and ultimately some of them become residents, by which means in process of time the barren surface is converted into a land of plenty. We shall, however, be better able to follow out this very pleasing part of the subject, after we have obtained a further acquaintance with the vegetable tribes, and the relations which there are between them and the animals. Therefore, we shall now briefly notice the characters of the grand divisions of invertebrated living creatures, preparatory to a few explanations of some of the more extraordinary parts of their economy.

There are three grand divisions of invertebrated animals, to which the names of molluscous animals (*mollusca*), articulated animals (*articulata*), and radiated animals (*radiata*), are given; and though the distinctions between these are not so marked, as those between each and all of them and the vertebrated animals, yet they are sufficiently marked for being of great use in the study of animals—a study in which we must "divide," before we can reasonably expect to "conquer."

Mollusca, as the name implies, are soft animals—that is, they have the skin which immediately envelops their bodies flexible, and often capable of greatly altering the shape of the animals. They never have any internal bones, so that their muscles are inserted in the skin only. In many species, however, there is in the skin of those animals a wonderful power of producing shelly matter; which is sometimes embedded under a cloak or mantle of thick skin. Sometimes, again, it is merely attached at a single point, or by the tendons of muscles, with which the animal is furnished for the purpose of moving the shell, or of opening and shutting the valves or pieces of it, if there are more than one. In all cases, however, this shelly matter is external of the real skin of the animal, though it is very often covered with an epidermis, or scarf-skin.

In animals of this type, there is no distinct and perfect brain; but there is a nervous substance; and there is no instance of the absence of such a substance in anything possessing animal life. But while, in vertebrated animals, the nervous mass is the foundation, to which all the other parts are subservient, in the class under consideration the nervous mass appears to be secondary; and consequently the system of sensation is inferior to that of growth and nourishment. Accordingly, the principal nervous mass, or ganglion, is placed on the gullet or passage by which the food is conveyed to the stomach; and the rest of the nervous substance accompanies the viscera. It consists of several ganglia or separate masses, connected by nervous filaments; and though none of the other masses or ganglia are equal in size to that which is situated on the gullet, and which on that account is sometimes called the brain, yet they are much larger in proportion to this primary ganglion, than any of the ganglia which occur in vertebrated animals are in proportion to the brain of these.

In accordance with the inferiority of the nervous structure, sensation and motion are very limited in all the mollusca. The only senses of which they have distinct organs are those of taste and of sight, and the latter is wanting in very many of them, indeed in the greater number. None of them possess any distinct organs of motion in the least analogous to those of the vertebrated animals; and though many of them are provided with an apparatus which is termed a foot, that foot is merely a sucker or disc on the under part of the body, by means of which they can adhere to substances, or perform their slow and crawling motions. One family of them only have organs of hearing; and the whole subject of their sensation is an exceedingly obscure one; more especially as we are but ill able to separate the general notion of sensation from a particular organ in which that sensation is displayed. This is no doubt an error; but it is an error of which there is much difficulty in getting rid. The reason is, that we, in all our speculations concerning living creatures, take ourselves along with us as the types, or patterns, whereby we judge of other creatures. We do this without being conscious of it; and the consequence is, that when we find an animal not provided with organs bearing some resemblance to our organs, we are apt to conclude that that animal is possessed of no sensation at all analogous to the particular sense which we associate with the organ, and supposed to be possessed by it only.

This, though a very natural, is a very unfortunate mode of viewing the subject, and, therefore, we ought to guard against it, by endeavouring to obtain a more enlarged and general view of sensation as a function of life in the abstract, without any particular reference to the form of organisation which belongs to that life. Even in ourselves we find a wonderful deal of sympathy between the different senses which have organs, so that when we are deprived of one, another comes in time to act very wonderfully as the substitute for it; and there are also certain agencies which, operating upon one of the senses, have a remarkable effect upon some of the others. As an instance of this, we may mention those grating sounds, such as the sharpening of a saw or scythe, or the crushing of a cinder under the foot, which "set the teeth on edge," or occasion a most unpleasant feeling in a part of the body which is, generally speaking, not one of the most sensitive, in that way.

From these circumstances, and from many others which will readily present themselves to the mind of an intelligent reader, it should seem that it would be the wisest plan to consider sensation as a general function of animal life, inseparable from its existence, and that the particular senses which are allocated to organs, and which vary in their number in different kinds of beings, are merely modifications, by means of which the particular animal is adapted to its particular purpose in the economy of nature.

Viewing the subject in this general light—and it is the only one which is truly philosophical—we must not deny that there may be a general sensation which, in as far as the animal requires it, answers each and all of these purposes, which in the more developed, or, as we say, perfect animals, are more immediately vested in specific organs.

The snails and slugs which infest our gardens are among the molluscous animals with which we are best acquainted; and though some of them possess organs which we are inclined to consider as eyes, it is certain that those eyes are of small use to them in any part of their economy. But still these animals, according to their several natures, are just as well fitted for finding their food, as animals of the keenest eye or the quickest ear. They are mostly night-feeders, and all of them shrink from the direct beams of the sun, by withdrawing into their shells, by crawling into holes, or by both; but still the snail and the slug, in their nocturnal and slowly conducted excursions, find no more difficulty in discovering in its finest condition that plant or fruit which is their favourite food, than the lion and the eagle do in finding their prey, if, indeed, they find as much.

What the sense is by which they are guided, we have no means of knowing; because it does not appear to be at all analogous to any of those particular senses to which we give names, and refer to particular organs.

This is a very important part of the subject, and one which renders the study of the invertebrated animals especially necessary for the completing of anything like a correct knowledge of life and living action; unless, indeed, we pay some attention to those animals, and mark how they perform their parts in nature, by means of structures so different from our own, we never can have anything like an adequate notion of the beauty of creation, or of the wisdom of the Creator. Without this comprehensive range of thought, we can hardly avoid looking upon the working of creation, as if it were a working after the manner of men; and it is highly probable, that it is the want of some such general knowledge as this, which has led even the best and most popular of our writers on the wisdom of God as displayed in creation, to hold up that wisdom as superior in degree only to the wisdom of man; and thus, without intending it, to humanise our notions of the Almighty. Nothing can tend more than this does to humble our pride; but this humbling is of that beneficial kind which, when duly persevered in, never fails in exalting us to the highest rank in wisdom to which human beings can be exalted.

There is yet another general view of molluscous animals, which is highly useful in guiding us to true wisdom, and enabling us to see, in as far as our limited inward light can see, the mode in which the different parts of nature work. It is in the system of sensation as connected with separate senses allocated to different organs, and in progressive motion in change of place, that we find the mollusca deficient. Many of them—such, for instance, as the oyster—are soldered to the rock ; and others anchor themselves by byssi, or threads, of their own spinning ; so that during the whole term of their lives, they do not travel an inch, or even the tenth part of that short distance ; and, in some of these, there is scarcely anything which even rational conjecture can fix upon as being an organ of sense.

When, however, we come to examine the system of growth, nourishment, and reproduction in those animals, we find no such deficiency as that which appears in their system of sensation. Their organs of digestion and of secretion are not quite so complicated as those of the vertebrated animals ; but still they are more perfect than in several others of the invertebrated races.

In the arrangement of these different organs, they are by no means so uniform as the vertebrated animals ; but still all of them may be said to be *symmetrical*, that is, capable of division upon a mesial plane, so as that the one half may be an exact counterpart of the other, only turned the opposite way, or the one to the right hand, and the other to the left. As some of the mollusca inhabit the land, and others the water, some are furnished with a peculiar sort of lungs for the breathing of free air ; and others with gills, by which they can breathe air through the medium of water. Of the aquatic ones, some are swimmers, though, generally speaking, their motions are slow ; but of the land mollusca, there are none that have any power of flight, or even any regular organs for anything like a walking motion. The snails and the slugs are the land mollusca with which we, in these countries, are the most familiar ; and they are often used as the emblems of sluggish motion, while, in many of the other races which inhabit the water, there is, as we have already hinted, scarcely any other motion than the opening and shutting of the valves of a shell.

All the mollusca have a double circulation; that is, they have a circulation to the lungs or the gills, as well as a systematic one for nourishing the different parts of the body; and the pulmonic part of the circulation is carried on by means of a fleshy or muscular ventricle; which is not, as it is in fishes, situated between the systematic veins and the pulmonic arteries, but between the pulmonic veins and the systematic arteries. This is in them, therefore, a systematic ventricle; and there is only one family which have a pulmonic ventricle in addition. The systematic ventricle is, in some of the species, divided into two parts; and in others, only the auricle is so divided. In those species which have more than one ventricle, the whole is not in every case placed in one single organ, as it is in the vertebrated animals, but in several detached parts, which have the appearance of a plurality of hearts. Nor is it unworthy of remark, that this plurality or separation of the parts, in the primary organs of circulation in these animals, is in strict accordance with the division of the primary parts of the nervous mass into those ganglia to which we have already alluded. We know too little of the relations that subsist between the different systems of which the animal structure is made up, to be able to say what purpose is effected by this division of both the nervous and the circulating systems, and the distribution of both through the structure of the animal; but, as they accompany each other or occur in the same species, there must be some connexion between them, in virtue of which they both conduce to some one purpose in the economy of the animal. There can be no question that, in this detachment of the heart, and of what may be considered as the brain, over the different parts of the animal, there is an approximation to the character of those classes which have complete life diffused through the different parts of their bodies, and which can, in consequence of this, convert themselves into as many perfect animals as the parts into which they are divided. In all those races of the invertebrated animals which may be considered as intermediate between the vertebrated animals and the radiata, as these, to all appearance, grow from or around a centre, which cannot be considered either as a nervous mass, as it is in vertebrated animals—or as a system of nutrition, as it is in the mollusca—there is an approximation, in some respect or other, to this final or last developed race of animals; while, in other parts of the structure, a resemblance to the more fully developed animals is preserved. The precise point at which the one type is lost, and the other taken up, is, however, a very nice matter; and it cannot, in the present state of our knowledge, be made the subject of popular inquiry, or even very satisfactorily explained by all the aids of the most refined and careful science.

The blood of the mollusca is always of a white or bluish colour, containing much less fibrine than the blood of vertebrated animals; and there is reason to believe that in them the systems of circulation and absorption are so far united, as that the veins, besides bringing back the blood from the different parts of the body, bring back the other refuse, without the aid of any lymphatic vessels.

In animals of this division, the muscles have their insertion in various parts of the skin, and they consist of tissues more or less numerous and complicated, according to the nature of the species. As there are no bones, there are of course no motions of joints; but the action of the animal consists in alternate contractions and elongations. On land, these contractions are capable of producing only very slow motions, and the animal must hold on with one part of its body while it advances the other. This species of motion is quite incompatible with anything except crawling; because in the performing of it, a portion of the animal must be always at rest—the hind part while the fore part is projected forwards, and the fore part while the hind is drawn after it. Some of them perform this motion with greater rapidity, and others with less; but it will readily be understood that, in all cases, it is only a half motion; and that, thus, the crawling animal never can acquire a momentum as is done by animals which have continual motion, into which rest hardly enters as an element. But though such animals never can acquire a momentum, or power of continual motion derived from the motion they have already performed, they are exempted from that fatigue and exhaustion of the system, to which all animals capable of performing rapid motions are necessarily exposed. Their muscles being internal, can all act to the greatest advantage; and the rest which the one part of the body receives while the other is moving, contributes still further to the same effect. In consequence of this, we might suppose a snail or slug to crawl for a whole year, or a dozen of years, without ever getting warm; whereas one of the swift animals is often exhausted and panting after less than an hour of flight or chase.

In the water the motions of molluscous animals are performed with greater ease, because there, they, the naked ones especially, differ very little in specific gravity from the fluid in which they reside; and thus they may be said not to be burdened with any weight. Their whole muscular action is thus left free to be exerted in propelling them forward; but even here they labour under disadvantage as compared with vertebrated, or even articulated animals. They, from the nature of their structure, can have no organ which can in any way act like an oar, because they have no solid or inflexible part, which can be made a lever, capable of giving a definite stroke by turning on a fulcrum. Thus, their swimming is only a sort of crawling through the water; and those which are loaded with heavy shells, the weight of which is always greater than that of an equal bulk of water, are seldom able to make their way through the free water, any more than a wingless animal can make its way through the free air; and they are in consequence compelled to crawl along the bottom, or the rocks, by means of the foot or sucker, in the same manner as animals of the same grand division crawl along the land.

There is in this, one circumstance which is very worthy of remark, as pointing out the very extraordinary nicety with which animals are adapted to the elements in which they live. There are shelled mollusca on the land as well as in the water; but while some of the aquatic ones have shells weighing many pounds, and most of them of great weight and strength as compared with the size of their bodies, all the land ones have them of thin tender structure, and consequently of light weight. A double purpose is answered by this beautiful adaptation: the aquatic ones do not feel the burden of that part of their shell which is equal in weight to the same bulk of water; and this additional substance of shell, which they are enabled to carry without any additional effort, helps to resist the greater pressure to which they are exposed by the weight of water which is over them. We know not what pressure may be on those shelled mollusca which inhabit the deepest places of the sea, but they are understood to be the very last inhabitants of the deep, as the fragments of their shells are the last memorials of life which the deep sea-lead brings up from those soundings which are most likely beyond the sphere of life of any kind. But about five hundred fathoms is not an over-estimate of the depth at which some of the pelagic mollusca which have porcelain shells may be presumed to reside; and this gives a pressure of about a hundred atmospheres, or not much less than fifteen hundred pounds, on the square inch; whereas the pressure on an inch of a land shell is only the hundredth part of that. It is worthy of remark, too, that this strength of the shell is, generally speaking, very finely adapted to the average pressure under which it lives. We must not object to the use of the word "lives" as applied to a shell, because so long as the shell is in connexion with a living animal, it is itself alive just as much as though it was endowed with sensation, only it is a different kind of life. We see the adaptation of the strength of the shell to the depth in those mollusca which are used as food. The muscle, which is found on banks in the shallows only, and never in deep water, has a thin aud tender shell; whereas the oyster, which is always found at a greater depth, has invariably a thicker and stronger one. Yet the oyster itself, though an inhabitant of banks lying deeper than those inhabited by the muscle, is still a bank animal, and not a pelagic one; and thus, though its shell is much stronger than that of the muscle, it is not at all comparable with those shells which are found only in very deep water; and which, if they inhabit there generally, belong, for the most part, if not exclusively, to animals which have much greater powers of locomotion than either the muscle or the oyster.

In addition to the cloaks and shells which we have already mentioned as being divisible into several groups, some in which the cloak is not provided with any hard or shelly matter, some in which the hard matter is internal of the cloak, and some again in which it is external, or forms a shell either of the pearly or porcelain character, there is an endless number of gradations. Sometimes the hard matter is wholly animal, according to our common notions of animal substance; and in these cases it has very much the consistency of horn; and the tender shells contain in their substance a much greater proportion of this horny matter than the firm and durable shells. Then, when we come to those which inhabit the deepest waters, we have the shell composed almost entirely of salts of lime; and more hard and inflexible than any of the bones of vertebrated animals, with the exception perhaps of the enamel in the teeth of some of the mammalia, in which—in the hippopotamus for instance—it is so hard as to strike fire with steel, that is, to burn small portions of the steel, when the two are brought into contact rapidly and violently. In proportion as the shell or other solid part of molluscous animals contains less salt of lime and more animal matter, it is more distinctly invested by a scarf skin, or cuticle; and in proportion as this is the case, the animal and the shell are more completely connected with each other. The inhabitant of a soft pearl shell rarely has the power of even partially coming out of that shell, but the inhabitants of the porcelain shells almost always have this power; and many of them can crawl along, carrying the shell only attached to the cloak or mantle—the part from which it is produced.

In fact, the more that this part of the structure departs from the true animal character, and approaches the nature of stone, the less does this part appear to be identified with the life. This holds true in those parts of vertebrated animals which consist of horny matter or matter composed in part of salts of lime; and it is not a little remarkable that, different as the structures and habits of vertebrated and molluscous animals are, those less sensitive parts of them should be composed of very nearly the same materials. If we take a bone and a shell, and expose each for a sufficient length of time to the action of an acid sufficiently powerful for dissolving the salts of lime, there will remain in both cases a cartilaginous substance, preserving, in a great measure, the form of the entire bone or shell, but flexible; and this cartilaginous substance is always less and less consistent, or firm in its structure, in proportion as the bone or shell contains more of the salts of lime. On the other hand, if we take the bone or shell, and expose it for a sufficient length of time to the heat of a fire sufficient for burning the animal matter, but not so intense as to melt or otherwise decompose the earthy salts, then we obtain the earthy matter alone, without any admixture of the animal. If the matter thus obtained is chiefly carbonate of lime, the action of the heat will drive off the carbonic acid as well as consume the earthy matter, and the residue will be common quicklime, and will slake upon being put into water, in the same manner as limestone does when burned in the kiln. The matter and the form of those substances are, however, so exceedingly diversified in the different species, that it is scarcely possible to give a general description of them; and the species are so numerous, that to describe each would far exceed the limits of any ordinary work.

Molluscous animals present an endless number of varieties in their organs of feeding and of digestion. In some the stomach is a simple sack, in others it consists of several parts, and in others, again, the intestines are of considerable length. In many instances they are furnished with salivary glands, apparently for the purpose of moistening their food; and in all cases there is a liver of ample dimensions; but there is neither pancreas nor mesentery. The absence of the last of these organs is a confirmation of what we formerly stated of the veins in the mollusca being in themselves the absorbents; for the absence of a pancreas almost necessarily involves the absence of lacteal vessels;

and thus it appears that the veins at once take up the nourishment of the food, as well as the waste of the body, and convey them together into the circulating mass of the blood. It appears to be something connected with this double function of the veins, which renders a different arrangement in the circulating organs from that which takes place in fishes necessary for those animals. We have already said that the circulation of the mollusca provides for a vigorous propulsion of the blood over the body, by having the muscular ventricle situated at the commencement of the systematic arteries; whereas, in fishes, the muscular ventricle is placed in another part of the system, and produces a more vigorous circulation toward the breathing apparatus, than the systematic aorta produces toward the different parts of the body. This is a curious arrangement; but it is intimately connected with the economy of the animals. Those fishes which inhabit near the surface are very speedily deprived of life when taken out of the water; and on the other hand, the greater number of the mollusca are remarkably tenacious of life; so much so, that they can often bear to be dried, or otherwise to pass into a state of inactivity and apparent death, from which they again return when the state of the weather favours such an occurrence. This accommodation to circumstances is not yet so important in these mollusca which inhabit the sea; but it is highly so in the land ones, and also in such fresh-water ones as inhabit countries where they are subject to seasonal overflowings and falls of the water. Mollusca are not generally, or even in many cases, seasonal animals in their duration, though they are seasonal in their appearance; and therefore in countries which have great differences of season, they hybernate or lie dormant more than almost any other race of animals. With us, the land mollusca appear only in the warm months; and as our land mollusca are almost all vegetable-feeders, and feeders upon succulent vegetation, they retire early in the season. In this retirement they cease to feed, and in all probability to breathe, and consequently they suffer no waste in the substance of their bodies during this time, how long soever it may continue during the season, and possibly during several or even many seasons.

There is something very remarkable in this difference between the circulating systems of fishes and mollusca, when we come to consider it in conjunction with the economy and habits of the animals. The greater number of the mollusca are, like fishes, inhabitants of the waters; and the whole of them are so exclusively found in moist situations, that we may regard them as being upon the whole an aquatic race, and much more connected with the economy of the waters than with that of the earth or the air. Now, though in the open sea, where the water can, so to speak, avail itself of its fluidity, and circulate in currents, so as never to get below the temperature of freezing, except in the very high latitudes, and never to have its average depth materially reduced in the warm latitudes, from the hydrostatical pressure constantly bringing a supply from the more temperate parts of the ocean, to compensate for the waste by evaporation in the more torrid;—though this produces a greater uniformity in the sea than there is either on the earth or in the air, and in so far mitigates the extremes of variation to which these are subject; yet when water is cut off from the general mass, and when it lies in portions of comparatively small depth, it is more affected by seasonal action than either of the others,—it is carried off in vapour during the heat and converted into ice during the cold: and, therefore, those aquatic animals which have limited powers of motion, and are incapable of travelling as the season requires, have need of being fitted for meeting such seasons as they may have to encounter; and they are accordingly so fitted. The functions of respiration may be regarded as the index to the vigour with which the whole system of an animal works; and that, according as the respiration is more or less extensive and rapid, a continuous supply of food, and corresponding organs and powers of motion for enabling the animal to seek this food, become necessary. Fishes are, generally speaking, animals of rapid motion, and they are proverbially very great feeders. They are also well furnished with organs of respiration, some of them fully more so in proportion to their whole bulk than many of the animals which have a copious tide of red blood circulating through all the soft parts of their bodies. Therefore fishes have the heart so constructed as to send the blood forcibly to the lungs; while the circulation towards the body is weak, and the nourishment appears, in part at least, to go by the lacteals, without passing through the circulation, or partaking of that action of the air which the blood undergoes in the gills. In the mollusca, again, the respiration is comparatively limited, and can be suspended as emergency requires, suspending at the same time the circulation, the feeding, and all the other functions of the animal. Thus, as one part of their organization ties them down to their peculiar localities, and forces them to endure the vicissitudes of the season, much more than animals which are in some respects more active, another part of their organization fits them for enduring those seasonal changes much better than they are endured by animals which are not subject to similar necessities.

One of the most curious points in the history of all animals is their reproduction, because the commencement and the growth of the new animal, though they fall infinitely short of the wonderful mystery of creation, are the nearest approximations to it of which we can have any knowledge from observation. This provision for the continuation of the race is, in a general point of view, of greater importance than the mere preservation of the individual; and true to the general law of creation, that the provision made shall be always fully adequate to the necessity that there is for it, the means of continuing every race, both of plants and of animals, are always sufficient not only for insuring the numbers which are wanted in the average states of the seasons, but also for meeting every contingency that can possibly arise, and furnishing a surplus over and above this, upon which some other race is to a greater or less extent supported.

In general the principle, with the single exception of those animals which can be produced by mechanically dividing the bodies of living ones, is the same in all the races,—there is always an egg or germ, and this egg or germ has to be impregnated, in order to bring it into that condition in which it is fit for being awakened into life. This is a very important matter, because it is a universal and constantly repeated proof that mere matter, considered simply in itself, can produce or give origin to nothing; and, therefore, when this is fully understood, there is hardly another proof required of the fact of creation, and the existence of the Creator—and when this is once fully established, the result of the rest of our study of nature resolves itself into a most satisfactory and delightful contemplation of the attributes of that Great Being.

But though the principle as applied to all animated nature is the same, the modifications of it in different individuals are very great; and some of the most singular ones are found among the molluscous animals. There may be said to be three distinct kinds of organizations for the accomplishment of this purpose. The first, and the one with which we are most familiar, as it obtains among all the warm-blooded animals without a single exception, is that in which the sexes are in different individuals, and each individual of one sex only. A very considerable number of the mollusca have this organization. The second form is that in which the sexes are united in the same individual, and form what are termed androgynes, or hermaphrodites, that is, "male-females," and when this is the case every individual is equally endowed with both powers; and in their pairing, each of the two mutually impregnates, and is impregnated. The common slugs form instances of this modification; and it will readily be seen that by means of it a double production, as compared with that of animals of only one sex, is of necessity secured. Both these races are oviparous, or deposit eggs; those eggs are sometimes inclosed in shells of greater or less consistency, and, in other cases, they are merely invested with a sort of viscid covering, by means of which they adhere to places and substances, where the young are brought to maturity by the action of the elements, and without the smallest labour or care on the part of the parent animals. Those which have either of those types, are necessarily endowed with some powers of locomotion ; because, without such powers, the animals could not meet each other. It has, however, been mentioned already that some of the mollusca, indeed a considerable number of them, are as completely fixed to the bottom of the sea as plants are fixed to the earth, only their modes of adhesion are mere fastenings, and do not in any way contribute to the growth or nourishment of the animals. It requires no argument to show that these rooted animals, as we may call them, would not be continued beyond one generation if the sexes were in different individuals, whether those individuals were of a single sex or both sexes. Therefore a third modification is required of them ; and this modification consists in a power of self-impregnation, by means of which each animal can continue its race without any reference to another animal of the same kind. This is not only necessary for the continuance of animals which are incapable of motion ; but it is a security for that continuance, greater than any which can be possessed by animals which have distinct sexes. One oyster can, in this way, produce an entire oyster-bed, if a current of the water or any other means should bring it into a situation favourable to its growth : and as all animals which have this compound sex, as it may be called, or complete power of reproduction in their individual bodies, are of a very enduring nature, and can bear to be transported over long distances, if kept in their proper element, the security which there is both for the distribution and the preservation of such molluscous animals is very great. Indeed we may say that, as they are chiefly inhabitants of the water, there is no casualty short of the final destruction of our globe, or the turning of it to a cinder, (which last appears to be the condition of the moon,) that could exterminate those animals. We, in our common and limited mode of viewing things, are apt to look with scorn, or some feeling nearly approaching to it, upon the humble oyster, which remains for its whole lifetime at rest at the bottom of the sea, and with admiration at such animals as the lion or the elephant. But when we glance over the surface of the globe, we find that lions and elephants have been in the lapse of ages reduced to small fragments of the armies in which they once existed—that the elephant is nowhere found in the living state except in South-eastern Asia and Southern Africa, and that the lion is very rare in the first of these countries. The elephant of our own climate was laid in the dust before the origin of any historic record ; and the animals which appear to have made the nearest approach to the lion, as now existent, have shared the same fate. The oyster, however, has remained secure amid the changes ; and we have sufficient evidence in monumental rocks, and in presently existing races, that the oyster is elder born of nature than either the elephant or the lion, and perfectly secure against every such contingency as those which have blotted them out from the list of living creatures. These self-producing animals are viviparous, or produce their young ones in a living state, or not differing from the parent except in size. We have no means of ascertaining in what mode or manner the act of impregnation takes place in these animals; but still we have every reason to conclude that there is some process—some specific action, before a new being, be it of what kind it may, can come into life. It is not improbable that this may take place in so minute a state of the germ, as that even a million of individuals would not be discernible by the very finest of our instruments. This is, however, no argument against the necessity of action as essential to the production of those animals, just as it is essential to the production of all others. If, indeed, we could ever conceive it possible that those animals could produce their broods merely as matter, and not as living creatures, then the analogy might be applied to the whole of the rest of nature, and we should be virtually endowing mere matter with a creative power, and thereby saying at one and the same time, that it was matter and not matter; which is a manifest contradiction in terms, or impossible and absurd.

CHAPTER IV.

DIVISION OR CLASSIFICATION OF MOLLUSCA.

ANIMALS of this form are so exceedingly numerous, and differ so greatly from each other in their forms and their economy, that it is not possible to view the whole of them as one general class, as we can do with each of the four great divisions of the vertebrated animals. They are accordingly arranged into six classes, according to their natural organization; and it is necessary to know something of the general characters of each class, in order to have the elements of a knowledge of the whole, before we come to the more particular consideration of the genera and the individuals. At least if we do not take this general knowledge along with us, our information respecting individuals is unconnected, and consequently of little use.

Class I.—*Cephalapoda,* which means that the head and what may be termed the feet are closely united together in respect of position. They have the cloak united on the under part of the body, and forming a muscular sack, in which all the viscera are contained. In some this is simple in its margins, but in others it is produced so as to form a sort of fins. The head, which is round and furnished with two large eyes, projects from the opening of the cloak. This head is furnished with a number of fleshy arms or feet, capable of being bent in every direction at the will of the animal, and furnished with suckers, or prehensile discs, by means of which they can adhere very firmly to any solid body to which they apply these organs. Those feet are the instruments with which they seize their prey; and they also act as fins in swimming, and as feet in walking. When they swim, they have the head backwards; and when they crawl or walk, which is always at the bottom of the water, and never on land, they turn the head undermost, and carry the body upwards. The mouth is situated between the roots of the feet, and it is furnished with two strong horny mandibles, which bear some resemblance to the bill of a parrot. Some of them, though singular in form, are of considerable size; and they are proportionally voracious, preying indiscriminately upon fish and on crustaceous animals, the coverings of which last they can readily break with their strong bills. They seize the fish in the free waters, and cling to them by means of the suckers on their feet; but they often descend to the bottom to feed upon crustacea. One very remarkable part of their economy is the power which they have of discharging a considerable quantity of a dark fluid as black as ink, by means of which they conceal themselves whenever they are so inclined. This substance furnishes a colouring matter, which is said to be used in the arts in some countries, and to produce an intense and durable black.

In their internal organization those animals make a slight approach to the vertebrated classes; for they contain within a cartilaginous cavity of the head a large ganglion of nervous matter, which, in some respects, resembles a brain. A nervous cord proceeds from each side of this central ganglion, and expands into another ganglion in the orbit of the eye, by means of which that organ is very copiously supplied with nerves. The principal part of the nervous texture appears to be expended on the eyes, the mouth, and the feet, all of which are close to each other, and have powerful, and, considering the general character of mollusca, very rapid action. Their ears are very imperfectly formed, and little is known of their other senses.

As they are all, at least in as far as they are now found in the living state, aquatic animals, they of course breathe by means of gills: these gills are two in number, one situated on each side of the animal, and branched again and again, something like a fern-leaf; and the water, by means of which air is supplied to the blood in these structures, is received into the sack, and again expelled from it. There are two fleshy auricles attached to two branches of the vena cava, which propel the blood to those gills; and after it has undergone the change there, it returns to the systematic ventricle, by the action of which it is distributed over the body.

As those animals have free motion through the water, it is not necessary that they should have the third form of productive power, to which we have alluded, and, accordingly, the sexes are in different individuals. The flesh of some of them is eaten; the black secretion, already alluded to, is used in painting; and the spongy internal shell which is found within the cloak of some of them, is used for various purposes in the arts, and popularly known by the name of cuttle-fish bone.

This is, in many respects, a very extraordinary department of the animal kingdom. The living members of it are not very numerous; they are all inhabitants of the deep seas, and range freely through the water, though individuals are not unfrequently cast ashore. Some of them are furnished with shells of singular form; and in many instances these are divided into a succession of chambers, it being understood that the animal inhabits only the last-formed one, which, in many of the species, is larger than all the rest taken together. Those chambers are sometimes completely separated from each other by the partitions, and, at other times, these are perforated; and it is understood that, in the latter case, the animal has a sort of membranous tube, which it can inflate with air, and thus rise to the surface of the water by its buoyancy.

This is not very likely; because it is not in accordance with any one principle which we can consider as well established in any department of the history of nature. But the subject is one of considerable mystery as well as curiosity; and though the attention of mankind has been called to it from a very early period, and much has been said and written regarding it, it still remains undetermined. It was known long ago that, in the warmer seas, there are animals resembling the cuttle-fish in their general form, and also in their internal organization, which are found, in fine weather, swimming about on the surface of the water in very light and handsome shells, having their long arms extended over the back part of the shell, or rather over the sides; and two broader arms partially erected over the whorl or curled end of the shell, something like two leaves, upon which the wind might act as it would do upon little sails, while the arms or feet, extending over the shell and dipping in the water, might serve the purpose of oars. It has been observed, too, that when the weather is rough, and the water broken on the surface, these animals and their shells disappear; and it was long considered that these mollusca not only made their shells, and came to the surface to use them as pleasure-boats in fine weather, but that they had taught man the art of navigating the waters both by oars and sails. It so happens, however, that none of the animals found in those shells have ever had any part of their bodies in the least connected with the shell; and we know from the structure of all other shelled animals, and we may almost say, from the very necessity of the case, that no animal can make a shell without being attached to that shell, because the shell is a secretion which continues during the whole growth of the animal, and no animal of whose proper organization a shell forms part, can continue to live after the connexion between it and the shell is broken. But there is no connexion whatever between the *ocythoë* and the nautilus shell in which it has been so often found; and on the other hand, the animal has never been observed but in the shell. It is, therefore, impossible to conclude with certainty, whether the shell belongs to the animal or not; and this is one of the points in natural history upon which it seems very difficult to obtain correct information. More recent observers, who have examined a considerable number of the animals found in those shells, mention, that they have never met with any but females; and those females always contained a considerable number of eggs in an advanced state, in a part of the shell which the water did not reach. There is at least some glimmering of a reason for the singular economy of the animals in this, though it does not establish any necessary connexion between the animal and the shell. It may be that a higher temperature and more free exposure to the air are necessary to mature the eggs, than could be obtained at the depth at which the animals usually reside; but even this, though there is some shadow of probability in it, is not more fully established than the other parts of the history of this most singular animal.

Still, this is a point upon which it is very desirable that we should obtain information; for it is one which is deeply concerned in the ancient history of our globe; inasmuch as the shells of animals which, though not now met with in the living state, must yet have resembled this one in their economy, must have at one time been exceedingly abundant. Those shells are known by the names of *Belemnites*, *Ammonites*, and *Nummulites*, and though found only in the earth, they occur in all countries, and in astonishing numbers. The belemnite consists of two cones united at their bases, and the short one returning inward into the long, so as to leave a space between them. This intermediate space is divided into chambers by parallel partitions, and a pipe or syphon extending through the centre. These are not understood as being entire shells, but only inner portions of some species of which the external shape is not known; but they occur in vast numbers, in formations of chalk and limestone. The ammonites are twisted into a flat disc, bearing some resemblance to a ram's horn; and they, like the former, are exceedingly numerous in various formations, and in all parts of the world. There are miles of England where the rocks are full of them; and they are of all sizes, from some which are so small as hardly to be visible, to others which are several feet in diameter. There are some places near the summit of the great mountains in the north-east of India, where whole hills are composed of those shells, in which the chambers are usually found empty; and the poor benighted Hindûs pay divine honours to them; their superstition teaching them to believe, that they are marks made by the body of one of their false gods, while endeavouring to hide himself in the mountain from the vengeance of his brother. That any people should be the victims of such a superstition as this, is far more to be regretted, than our ignorance of the economy of the inhabitants of those shells, and of the state of the world at the time when they existed in it in such multitudes as to produce the mighty monuments which they have left. *We* know from their structure, and from its correspondence with that of the nautilus, that they must have been sea-shells; and that the waters of the ocean must have rolled for years over the places in which they are now found, before such numbers could be gathered together.

The third form of those very numerous shells found in the earth and in rocks are called nummulites. They have a spiral cavity divided into numerous chambers, without any apparent external opening; but what animals formed and inhabited them, we do not know. Singular, however, as those animal remains are, and much as it is desirable to obtain some knowledge of them, for the sake of many other branches of knowledge to which this would be an index, we must leave them and pass to the next class.

Class II.—*Pteropoda*, "wing feet," are also a singular order, not so numerous nor so mixed up with the great history of the earth as the last-mentioned. The known species are but few, and of small size; but they are exceedingly numerous in some seas, especially in those of the high latitudes, where, minute as they are, they form the principal food of that giant of the deep, the common black or Greenland whale. Like the former race, their habitation is in the free waters; and, indeed, it is more exclusively in these; because the animals are incapable of performing any motion but that of swimming, which they do by means of two wing-like fins attached to the sides of the mouth. The body is without any cloak, in some of the species; others have a sort of gelatinous envelope; while others have the terminal part of the body enveloped in a small and weak spiral shell. None of them are above an inch in length, if they be so much; but their numbers are astonishing, and they are generally found swimming near the surface. The whale swims along, often with great velocity, and with its huge mouth opened; and the plates of whalebone which are attached to the roof of the mouth, hanging down at the sides, and forming, by the fringed borders at their edges and extremities, a very efficient net, capture these little creatures in such multitudes, that they pass toward the throat of the whale in a continued stream, during all the time that it is feeding; and thus, large as the animal is, and small and simple as are the individual portions of its food, the whale fares as well, and perhaps has less exertion in feeding by the margins and in the openings of the polar ice, than any other wild animal has on the richest pasture to be found upon the earth. In the warm seas, mollusca of this class are not nearly so numerous; and, therefore, the whales of those seas are provided with teeth, and wide throats; and some of them are able to swallow a fish fourteen or fifteen feet long, more easily than the Greenland whale could swallow a herring.

Class III.—*Gasteropoda.* The general character from which this division is named, is the possession of a thick fleshy disc, having the power of adhering, either simply by its surface, or by slimy matter which it secretes. This disc is called the *foot;* and as it is placed upon the belly, or under-part of the animal, the name "belly foot" is quite appropriate.

The animals of this class are very numerous, and met with in all parts of the world, in the sea, in the fresh water, and on the land; so that some of them breathe the air by means of a sort of lungs, and others the water by means of gills. All of them are furnished with a cloak on the upper part; and in very many, this cloak produces a shell; but both the shell and the animal vary so much in the different orders and families, that no general description or definition can be made to apply. There are some in which the shell does not appear externally, but is inclosed within the cloak; and there are some in which the shell is entirely wanting. The head is placed at the fore part, and can be drawn within the mantle in most of the species; and upon the head, just over the mouth, there are usually situated tentacula, varying from two to six, which are understood to be very sensitive, and may be organs both of touch and of smell. The eyes, when present, are generally very small, and they are variously situated, being sometimes at the roots of the tentacula, sometimes on the sides, and sometimes on the points. Their organs of respiration vary much in form; but there is one character in the vital system of the whole, namely, that of having a single systematic ventricle, which sends the blood through the system.

The greater number are covered with spiral shells, or shells consisting of a greater or smaller number of whorls, or turns round. If the shell is coiled in one plane, in the same manner as a rope when lying flat on a ship's deck, it is called a discoid shell; but if it resemble a tapering screw, it is said to be turbinated. The top of each whorl sometimes conceals all the ones which were previously formed; and, in this case, the spire is said to be hidden. From the increase of the animal in diameter, as it increases in length, and the shell being always made to fit exactly, a complete shell of the spiral kind always inclines to one side, when placed on the opening or mouth. The inclination is, generally speaking, toward the right hand, though there are a few which have it turned to the left. The organs of respiration, and all the other more important ones in the economy of the animal, are always contained in the last whorl of the shell; and when the animal comes out of the shell, which it does for the purpose of locomotion, whether in the air, or under water, the head is always found toward that side from which the spire of the shell inclines; and thus, as the animal crawls or swims along, carrying, attached to the cloak on its back, the curious house which it makes for itself, and always keeps nicely adapted to its size, it inclines a little obliquely over the side. Such animals always retire into their shells for the purpose of repose; and the greater number of them are furnished with a little lid, called the operculum, which just closes the mouth of the shell, when the animal withdraws itself; and when the creature is completely in its shell, and this operculum is closed upon it, respiration, and probably all the other functions of life, pause or lie dormant until the shell is again opened, and the air or the water is admitted to the breathing apparatus. Thus the repose which one of these animals can take in its shell, is much more profound and perfect than that of any of the vertebrated animals. Some land shells are without the operculum ; and it is probable that they may not repose so profoundly as those which are provided with that appendage. But, in the case even of these, whenever the cold renders it necessary that they should retire for the winter, or when they are driven into retirement by long-continued drought, there is a temporary operculum made of glutinous matter, which very speedily consolidates, so as to resist the action of the weather, and most likely to cut off all communication with the atmosphere.

The animals included in this class are so numerous, that it has to be subdivided into many orders ; and a full description of the species which are known would fill many volumes, while there are many other species of which we have no knowledge whatever. Neither would it be easy to say what are the uses in the economy of nature of creatures so many and so varied. Some of them consume the superabundance of growing vegetables on the land ; and others appear to act as scavengers, more especially in the waters ; and then they themselves serve as food for a vast number of other animals, while their shells contribute to the formation of rocks and mountains.

Class IV.—*Acephala*, "headless animals."—Mollusca of this class have, as the name imports, no apparent head ; and the mouth is concealed between the folds of the cloak. This cloak is doubled over them, sometimes with the margins free, and sometimes with them united together so as to form a sack. In the greater number this mantle is furnished with two valves of shell which are united by a hinge, and capable of being opened and shut; but there are also others which are naked, or have the covering cartilaginous or membranous. Sometimes the shell consists of a number of valves or moveable pieces, and is attached to or covers only a part of the body of the animal; and there are some of them which can use the valves of this shell as very efficient instruments for boring into the earth, into wood, or even into stone.

The mouth is always without teeth in these animals, so that they can feed only upon such small particles of matter as the water brings within their reach; and they are quite incapable of moving from place to place in search of their food, or for any other purpose. The brain, or principal ganglion of the nervous system, is seated immediately on the mouth; and there are other two ganglions connected with the viscera. They have two gills; and besides the systematic ventricle which propels over the body the blood which has been aërated in the gills, they do not in general possess any other organ of circulation. All of them are self-producing animals, not requiring any union of sexes; and the numbers of the young are in many of the species beyond the range of arithmetic. All of them are aquatic; for animals of so simple a structure could not live upon land; and the greater number are found in the sea. They are, however, entirely bank and shore animals, and never found at any very great depth. Some of them have a very slow motion, but there are others which remain immoveable. They are divided into two orders, those which have shells, and those which have not.

Shelled acephala.—This includes by far the greater number, and may be said to comprise the most important species for the use of man of all the molluscous animals. It comprehends all the bivalve shells, or those which consist of two shells hinged together; and in addition to these it comprehends some of those which have more than two valves. The gills of these consist of four leaflets, which are inserted between the edges of the mantle, of which we have an example in what is called the beard of the common oyster. The mouth is at one extremity; and the heart, which is single, is situated near the hinge. When there is a foot for the purpose of motion or adhesion, this foot is placed on the under part, between the leaflets of the gills. This foot, in many of the species, possesses a very singular property, that of spinning threads, which are termed *byssi;* and there are some species in which those threads are so long and so abundant, that articles of clothing have been made of them, somewhat similar to those made of silk. The *byssus* always consists of a bundle or number of threads; these issue from the bottom or disc of the foot, but it has not been ascertained that there is any spinning apparatus for their production, as there is in spiders, and in those caterpillars which produce threads. They can, however, fix the ends of them to those substances to which they wish to adhere, and also replace them by means of the foot; but how those operations are performed by an apparatus apparently so very simple as this foot it is not easy to say.

These animals close their shells by means of muscular action; but when the muscles relax, the shells open by the contraction of an elastic ligament, so that the valves opened is the true state of repose in that animal; and there are some in which these valves do not shut completely close, though they do in the greater number. It is highly probable that those species which inhabit at a sufficient depth for being always covered by the water, never close their shells, except to protect themselves from enemies; but the littoral ones, which inhabit without low-water mark, and are thus exposed at every tide, are always found with the shells closed when the ground which they occupy is dry; and they appear to be capable of including between the shells a portion of water, which preserves them when the tide ebbs away.

There are five families of bivalves: oysters, mussels, *chamacea* or clam shells, cockles, and *inclusa*, or those which have the mantle closed for a certain part of its length. Some of these are celebrated for the pearls which they produce, others for their flavour and wholesomeness as food, others again for their immense size, and others still for the mischief which they perpetrate. Very many of them are highly interesting in a natural history point of view; but we have room to mention only one or two of the more remarkable.

First, the pearl-oyster (*Avicula margaritifera*). This species inhabits the sea, and is found only in the warm latitudes. The shell is nearly semicircular, of a greenish colour on the outside, but of a beautiful pearly lustre within. It is from a disease in the organs by which this pearly matter is elaborated, that the pearls so much esteemed are produced. The whole race of bivalves appear to apply animal layers to the inner surfaces of their shells; and they have the power of repairing an injury. The pearl is composed of matter fitted for forming the shell; but by some leak in the ducts which convey it to its proper destination, it collects generally inside the cloak. It occasionally occurs in all shells which are pearly on the inside; and we have met with a pearl in a common mussel. It is, however, in the species above-named that they are produced of the finest quality and in the greatest abundance. There are pearl fisheries in some of the tropical seas of America, in the Persian Gulf, and in various other places; but one of the most celebrated is on the west coast of the island of Ceylon, off the bay of Condatchy, about twelve miles south from the island of Manaar. This bay is the general resort of the boats employed in this fishery, and the persons connected with it. At this part of the country the soil is of a sandy character, and scarcely inhabited at all, except at the season of the pearl fishery, when it assumes the character of a populous town, with several streets, about a mile in length. The habitations are huts, which the Mahometan natives of the island are most active in erecting. The Singalese, however, are not divers; this is ascribed to their timidity of character. They resort to this place in great numbers at the season in question, as to a fair, the fishermen especially, to dispose of their fish to the multitude. About the end of October, in the year preceding a pearl fishery, during a short interval of fine weather, a survey of the banks takes place, and a few oysters are taken for a specimen. The banks, which are fourteen in number, extend over a space thirty miles long, and twenty-four miles in breadth. When the fishery is resolved on, notice by advertisement is given, for all concerned to repair to the ground on the 20th of the succeeding February, when the boats come from Jaffna, Ramiseram, Nagore, Tutakoreen, Travancore, Kilkerry, and other parts of the coast of Coromandel. The banks are situated about fifteen miles from the shore of Condatchy. The pearl-oysters are all of the same species, but they vary in their qualities according to the nature of the ground to which they are attached, and the appearance of the numerous, and often large zoophytes, which adhere to the outsides of their shells. Their number on the banks varies considerably, as they are liable to be washed away by the current of the tide, and also to be buried in the sand deposited by the current. The pearls are in the fleshy part of the oyster, near one of the angles at the hinge; and each individual generally contains several pearls. The fishery is let to one party for a stipulated sum, and two-thirds of this sum must be paid in advance. In 1804 the renter brought with him a large family with thirteen palanquins, to each of which thirteen well-dressed bearers were attached. He is allowed one hundred and fifty boats' fishing for thirty days. The boatmen are aroused a little before midnight with immense bustle, and, after their ablutions and incantations, they set sail for the fishing ground; and about half-past six in the morning the diving commences. A kind of open scaffolding is projected from each side of the boat, and from this erection the diving tackle is suspended. This consists of three stones of fifty-six pounds in weight on one side, and two on the other. The diving stone hangs by a rope and slip knot, descending a little way into the water. In the rope immediately above the stone there is a strong loop, to receive, like a stirrup, the foot of the diver, who puts one foot in the loop, and the other in a basket formed of a hoop and net-work. When all is ready, he grasps his nostrils with one hand, and with the other he gives a sudden pull to the running knot, and instantly descends; both the rope of the stone and that of the basket follow him. The moment he reaches the bottom, he disengages his foot from the stone, which is immediately drawn up to be ready for the next diver. The diver at the bottom throws himself on his face, and collects everything he can lay hold of into the basket. When prepared to ascend, he gives a jerk to the basket-rope, and is speedily drawn up by the persons in the boat. Using his exertions in warping himself up by the rope, he arrives at the surface of the water a considerable time before the basket makes its appearance. On arriving at the surface, the individual swims about, or rests himself by laying hold of an oar or rope, till his turn comes to descend again. Some of the divers perform the dip in one minute, and a minute and a half or two minutes is the longest time that any of them can remain under water without injury. The basket is often so loaded that it requires more than one man to haul it up. The shark-charmers form an indispensable department of the establishment. All those impostors belong to one family, and the natives will not descend without knowing that one of them is in attendance on the fleet. Two are constantly employed during the fishing, one in the head pilot's boat, and the other performing ceremonies on shore. Sharks are often seen from the boats and by the divers, but an accident rarely occurs. This superstition operates as a protection to the oyster banks from plunder at other times.

When the bed is rich, a diver often puts upwards of one hundred and fifty oysters into his basket at one dip; but when thinly scattered, sometimes not more than five. After diving, a small quantity of blood usually issues from the nose and ears. This is considered as a favourable symptom; and the diver performs his task with greater comfort after the bleeding has commenced. They account the labour a pleasant pastime, and never complain of fatigue, unless the banks are poor in oysters. Two divers are appointed to attend upon one stone, and they go down alternately. The time of working is from five to six hours each at a task. About one or two o'clock, when the sea-breeze sets in, on a signal being given by the head pilot, the fleet set sail, and return to the shore; which they generally reach about four or five, and are met by an immense concourse of people, who assemble to welcome their arrival. All the pilots and many of the divers being Romish Christians, they never fish on Sunday, and the day of rest is also convenient for the Hindûs. After satisfying various claims, the diver has a fourth part of the oysters he brings up; and he sells his share on the spot, to some of the numerous speculators who resort to the landing-place. In a successful season, each man carries home at the end of the fishery, forty or fifty pagodas. So various is the success of this fishery, that a boat has been known to land in one day thirty-three thousand oysters, and in another not more than three hundred. The oysters belonging to the renter are piled up in inclosures formed by palisades, and the opening of them does not commence till the fishery is considerably advanced; but adventurers on a small scale generally open theirs when they buy them, or on the following morning. By some the oysters are thrown away; but others leave them to putrify, for the purpose of obtaining with greater certainty the remaining pearls, should any remain, particularly those of small size. Two days are generally required for this putrefaction. Many precautions are used to prevent the secreting of pearls, but not with complete success. After the pearls have been separated from the putrid flesh of the oysters, and from the sand along with which the mass has been agitated, in boats for that purpose, they are sorted into sizes, by being passed through sieves or saucers full of round holes; those with the largest holes being first used, and the others in succession. The large ones are examined, to see if they contain any blemishes; and they are then drilled with great skill, though by very rude and simple tools. Many of the native merchants, who resort here from Madras and other parts, are extremely wealthy, and make a great display of opulence in their personal appearance, their retinue, and the quantity of specie which accompanies them. Pearls sell at a higher price in the market of Condatchy during the fishing season, than in any other part of India.

The only other animal of this class which our limits will permit us to notice, is one which is as remarkable for its destroying powers, as the one just mentioned is for the beauty of those ornamental pearls which are the result of a diseased state in the production of its shell. The one which we are about to notice is, the ship-worm, *Teredo navalis*, which is more destructive of vessels navigating the seas, than is all the fury of the elements. It is originally, at least in the most destructive species, a native of the warmer seas, though it has been introduced in the timber of ships in most of the maritime parts of Europe; and there is no means of protecting a ship against its ravages, but by having the bottom, as far as the water reaches, sheathed with copper or other metal. At one time this creature threatened destruction to the whole of those rich parts of Holland which are below the level of the tide. Those countries are defended from the sea by means of dykes; and as the waves break on them with great violence and irregularity, it is necessary to bind them together with timber. The teredo got into that timber, and multiplied to such an extent that the posts and beams were drilled into holes as if they had been honeycombs. Those holes or passages are carried through the substance of the timber in every direction, though the creatures generally avoid the outside; and thus, while the plank or the timber appears sound to the eye, its strength is entirely gone.

This species has the cloak extended farther than the two lozenge-shaped valves; and it terminates by two short tubes, which are cased in a kind of shelly covering, or rather have a sort of plate of shell upon each side. It is believed, that in order to penetrate as fast as it increases in size, the teredo excavates the wood or timber, by means of its valves. The tubes, however, remain near the hole by which it effected an entrance; and through this opening, by means of its palate, it obtains water and aliment. The apartment it resides in is lined with a calcareous crust, which exudes from its body, forming a second tubular shell for it. In the seaports of Europe it is a very noxious and destructive animal.

These singular creatures do not confine their depredations to the timber of ships, but extend them to all timber which floats at sea, in the warm latitudes. There are species in the colder seas also; and from the same vessels navigating the seas of all latitudes, they have, as it were, sown those animals indiscriminately over the deep. Originally, however, those of the cold latitudes were but little given to the destruction of timber; and in this we find a remarkable instance of the harmony that there is between the sea and the land in different regions of the globe. We mentioned formerly, that in the tropical countries, where timber is not wanted as fuel, countless myriads of insects are set over it to consume it; while in the polar countries, where timber is necessary for fuel, both in the recent state and after it has been converted into coal in the lapse of years, the animal destroyers of timber are comparatively few. We now see that the same thing takes place in the seas: the drift-wood of the tropical regions is speedily consumed by the teredo; while that of the polar regions is left entire, to supply the people of the woodless shores, in the extreme north, with timber for fuel, and for all other necessary purposes, or to form accumulations, which in the course of time are changed into coal. Who is there so blind as not to see in this, not only that there is purpose and design in the creation, but that all the parts are designed to work together for the good of man,—who has only to inform himself of their different natures and uses, in order to have the full enjoyment of them?

Shelless Acephala. These have the cloak formed into a sort of tube. They are but few in number, but some of them are very peculiar in structure. One portion of them are insulated, and others are united into a common mass, which sometimes takes the form of a star, and sometimes of a hollow tube, which swims in a peculiar manner by alternate dilatation and contraction. One of those tubes often consists of a great number of animals; and it is probable, that there are very many species by far too minute for being seen by the naked eye. Such as are known are strongly phosphorescent, or give out light when the water is agitated; and they often exist in such numbers, that all the little rippling waves produced by the stroke of oars or the passage of a ship, seem tipped with fire, in a manner which is equally astonishing and beautiful. It is likely, however, that this phosphorescence belongs to many other sea animals besides these; and even fishes, when they are just beginning to become tainted, shine in the dark. The wonders of the deep are, however, too many and too mighty for being fathomed by the understanding of man.

Class V.—*Branchiopoda.* These animals get their name from two arms, which extend from the body between the folds of the cloak, and which are capable of being coiled up and withdrawn. They bear some resemblance to the shelled animals of the preceding class. They have the cloak divided into two lobes, and each lobe furnished with a valve of shell; but they are furnished with a peduncle or stalk, by which they remain permanently attached to the rocks; and their arms, which are furnished with fringed extremities, and fleshy in their substance, are no doubt useful to them in seizing their food, and conveying it to their mouths. They are of course self-producing animals in the individual. In the living state, those animals are far from numerous in any part of the world; but there are some, the genus *terebratula* for instance, of which vast numbers are found in the secondary strata of rocks in England, and many other countries.

Class VI.—*Cirripoda*. The animals of this class are very peculiar in their structure; holding a sort of intermediate place between the mollusca and the articulated or jointed animals, but partaking most of the character of the former. They are covered by a cloak and plates of shell, which resemble those observable in several species of the acephala. The mouth is provided with lateral jaws. The belly is furnished with filaments called cirri, which are arranged in twos, composed of a vast number of little ciliated articulations, corresponding to a kind of fins or feet, similar in appearance to those seen below the tail of some of the crustacea. The heart is situated in the region of the back, and the branchiæ on the sides; the nervous system forms a series of ganglions on the abdomen. The cirri with which these animals are furnished, bear some resemblance to the articulated arms of some of the acephala; and in some parts of their internal structure they have resemblance to the bivalve shells. Their position in the shell is such, that the mouth is undermost, with the cirri opposite to its orifice; but though these agitate the water, they only assist the animal in its feeding, and not in the performance of locomotion of any kind. There are two divisions of them, the one with the shells and active part of the animal placed upon the extremity of a cartilaginous peduncle; and the other sessile or without any stalk, but immediately in contact with the substance to which they adhere.

Of the pedunculated ones, the most remarkable is, that which is known to sailors by the name of the bernacle. It attaches itself to the bottoms of ships, to the under sides of floating pieces of timber, or even to the skin of marine animals. Their rate of growth is very quick; so that in brief space the bottom of a vessel may become covered with a crop of them, a foot or more in length, by which its progress through the water is much diminished. The peduncles are frequently branched; and the size of the shell part is always in proportion to the thickness of the peduncle: and it is understood that the germs of the animals are lodged in the peduncular part, which is rendered highly probable from the fact of the branching. Many of the germs are, however, committed to the waters; and there have been instances of some of the species being attached to a floating feather, and arriving at maturity before that feather was decomposed. The true bernacle (*anatifa*) is, however, chiefly found upon floating timber; and it is common in the seas even of the high latitudes. Floating wood has a tendency to "come ashore" when the waters are agitated; and when there are bernacles attached to it, it of course brings them along with it. The same storms, which are most violent in the early part of the winter, often exhaust some of the migrant geese, which spend the summer in the high latitudes, and migrate southward when the severe weather sets in. The floating wood, the bernacles attached to it, and the exhausted geese, are sometimes cast on shore together; and this, in the times of superstition, led to a very ridiculous fable concerning them, namely, that the bernacles were produced by trees, and that, in course of time, the said bernacles changed to geese: and on this account the particular goose to which this fabulous origin was imputed, is still called the bernacle goose, and sometimes the tree goose. Absurd, contrary to every operation in nature, and impossible, as those changes are, they were once regularly believed by writers on natural history: and some went even so far as to mention cases of the change which had been seen actually taking place, in some of the pools of fresh water in the central counties of England. Now the bernacle is never by any chance found, except in salt water; and the goose which the fables represented as being produced in this curious way, is rare in those parts of England at all seasons of the year, and never by any chance breeds there. The few remarks and illustrations which we have now made, are all that our limits will permit us to give relative to this very interesting division of invertebrated animals; and we must now briefly advert to those which are still more numerous, and of a different type from any which have been noticed.

CHAPTER V.

ARTICULATED ANIMALS AND THEIR SEVERAL CLASSES.

Though the articulated animals differ much from each other, in size, in form, and in habits, yet there is a general character which runs through the whole, and which agrees well with the general name. Like the mollusca, they have no internal bones of any kind; but they always have a covering of some consistency, and frequently of considerable hardness and strength. This covering, even when hardest, does not approach the nature of shell, but is wholly an animal substance, bearing a resemblance to horn, or rather to the hard plates with which the bodies of tortoises are covered.

This external covering preserves the shape of the animal, answers a purpose in its economy nearly similar to that of the skeleton in the vertebrated classes, and, for mere strength and endurance in motion, it is often far superior to any skeleton. The soft parts which are connected with the external action of vertebrated animals, are all external of the bones, whether they be organs of motion, of sensation, or of supply and repair to the others. They are therefore exposed to the vicissitudes of the weather; and when the animal comes quickly in contact with hard substances, those external parts are liable to be bruised and injured by being pressed against the bones of the animal itself. The external crust, or other firm covering of the articulated animals, protects all their active structures from any injury of this kind; because there is no soft part which can come between an external object, and that firm part of the animal which supports all the rest.

This covering, be its consistency what it may, is always made up of a number of rings or jointed pieces, whatever in other respects may be the form of the animal. Some of them have no distinct limbs or organs of motion of any kind, and no visible heads or organs of sensation. But even these have the body with a covering consisting of rings. In those again which have produced members, those members are also formed of jointed pieces.

In one or other of the races they are adapted for all kinds of motion. They crawl, they walk, they run, they leap, they swim, and they fly; and they perform each and all of those motions with far greater vigour in proportion to their size than animals with internal skeletons. Even those which, as is the case with the common earth-worm, have their coverings soft, and are without any external organs of motion, and thus limited to crawling, have greater power in the action of their bodies than those animals of other grand divisions which are without external members. Thus the common earth-worm can penetrate the soil with great facility; and in some of the warm countries there are leeches which can move rapidly, and pass through very small openings by drawing out their bodies as fine as a thread; and they can as rapidly bring them into that shortened form which the animal assumes when not in motion.

Those which have jointed members are all remarkable for their strength and the fatigue which they can undergo, without ever appearing to be in the least fatigued. In one respect they labour under a disadvantage as compared with skeletoned animals; because the external muscles admit of the bones being united by an endless variety of joints. But as the muscles of the articulated animals are within the hard parts which they move, there can be only two different modifications of joint. The first of these is a common hinge joint; and it is the only motion which can be produced if the hard parts are in contact with each other; because those parts must come into contact with each other on both sides of the opening through which the muscles pass. This fixes the axis of motion constantly to the line passing through those two points of contact; and as the motion of the joint must be at right angles to this axis, the plane of the motion is fixed. So also, if the hard parts are united by a flexible portion, as is the case in the bodies of many of those animals, the motion produced by the same muscles must always be in one plane only; and if it is to bend in different directions, there must be as many sets of muscles as there are directions. The joint where two internal bones meet each other, is not necessarily tied to one plane, even when acted on by one set of muscles only; for the muscles, considering them lengthwise, are applied about a line as an axis, whereas the muscles of the articulated animal are applied round the inside of a tube. The bending of a line takes place upon a mere point, and there is nothing to resist its being bent in one direction more than in another; but the bending of a tube is on a surface equal to the section of that tube; and thus it can be bent only in one way.

This is a part of the mechanical structure of animals which is well worthy of our best attention; because it points out to us the strict observance of the principles of mechanics which runs through the structure of animals; the beautiful adaptation of the structure of the animal to the kind and degree of sensation and resource which the animal has; and also how well the purely mechanical part of the animal structure agrees with what we know to be true in the case of our mechanical contrivances. The more simple that any machine is, it is the better calculated for performing its functions; that is, the same power putting it in motion enables it to do more work, though the kinds of work which it can do are limited by the simplicity. And when we increase the parts of our machine, and fit it for the performance of several kinds of work, its efficiency in any one kind, in proportion to the power applied to it, is always less as the number of kinds of work becomes greater.

It is precisely the same with animals: life in the animal, is that which answers to the power by which we put our artificial machine in motion; and, just as in the machine, the power applied is not derived from the matter which it moves, but comes from another source altogether—immediate creation, independent of the creation of matter, but probably coeval with it, in the first instance, and the peculiar mode of reproduction of the creature in every succeeding instance. If the functions which this life has to perform are many, then a complicated mechanical structure is necessary in the organization, or body, by means of which those functions are performed; and as the functions become fewer, the necessary organization always becomes simpler and simpler. In proportion as the functions are few and the body simple, a smaller exertion of living action is necessary for the performance of them, and in proportion as they are more numerous a greater exertion of living action is required. Man possesses the most universal body; and therefore, independently altogetherof the immortal spirit there is more exertion of the action of merely animal life in man than in any other animal. When we come to such animals as the articulated ones, the functions are, generally speaking, very limited in number; but they are performed with wonderful strength in proportion to the size of the performers. Man soon gets fatigued if he attempts to carry more than a weight equal to his own, and he cannot lift, even for a moment, very much more than this; and man is quite unable to make his way if that way is blocked up by perpendicular objects so much higher than himself as that he cannot reach the top of them with his hands. But an ant, which is a little creature, readily makes its way over perpendicular obstacles larger in proportion to it than castles and palaces are in proportion to man; and there are some beetles, and even some caterpillars, which can move weights as great in proportion to their own, as if man were to walk across a town pushing aside the houses, or lifting them and tossing them out of his way. Very many of the articulated animals are set to watch over, and to clear of refuse, places which only very minute animals can reach; and their great strength, in proportion to their size, fits them admirably for such purposes.

In their organization the animals of this division differ so much from each other, that it is impossible to give a general account of them; but they are conveniently divided into four classes—*Annellida, Crustacea, Arachnida*, and *Insecta*. By the older naturalists, all of these were considered as *insects*, and as the word insect means nothing more than that the body of the animal is "cut into," or divided into segments by markings more or less deep, there was no great objection to it—only the animals are so exceedingly numerous and so diversified, that it is desirable to sub-divide them; and the very first class was not considered by the same naturalists as insects, but as worms, the name which is invariably given to them in popular language. We shall very briefly notice the four classes, interspersing our notices with more detailed accounts of some of the most curious or characteristic species.

Class I.—ANNELLIDA. These are usually animals of a very simple form externally, of which the common earth-worm and the leech are specimens; but, simple as they are, they more resemble the vertebrated animals in some particulars than any other of the invertebrated races do. They have red blood, if not in the whole, at least in the greater number of the species; and for this reason they are often called red-blooded worms. They have a double circulation, and one or more fleshy hearts, which are well developed. Their bodies are more or less elongated, and always marked with numerous rings; and the first ring, which is called the head, is scarcely distinguishable from the others, except by the presence of the mouth. They have never any articulated legs, but many of them have a sort of little bristles, with which they can take hold of substances, and contrive to move. Their mouth is sometimes furnished with jaws, sometimes it is only a tube, and sometimes, again, it is a sucker. Their organs of sense are very obscure, though there are black points upon some of them which are considered as eyes. They have, however, but small occasion for the use of such organs, because they live in concealment either in the water or under the ground. Some of them have the skin soft without any protection, except the earth into which they retire; but others construct for themselves little pipes or cases of sand and various matters, which they solder together by means of an animal secretion; and others give out from their bodies a calcareous matter, of which they make a sort of tubular shell. The majority of them are hermaphrodites, and produce a reciprocal impregnation, and they are very productive. They contribute largely to the food of various races of animals.

Though they are almost without organs of sense, their sensation is in general remarkably keen. They are susceptible to sounds, and to the slightest changes of temperature: on which latter account they are sometimes used for indicating changes of the weather, as the coming change affects their extremely delicate bodies a considerable time before man has any knowledge of what is coming. The common leech is a good instance of this sensibility. If a leech is kept in a glass vessel partially filled with water, and so placed that the natural changes of the atmosphere have their full effect upon it, it invariably sinks to the bottom, and lies dormant there before storms, but comes to the top, and is active, before fine weather.

The internal structure of animals of this class is often very complicated; and altogether they form a singular department of living nature.

Class II.—Crustacea. The animals of this class are, as the name implies, covered with crusts, which differ in their consistency in different individuals; and their general characters may be stated in brief as follows:—Destitute of an internal skeleton, but its place supplied by the crust; the body variously divided, or marked into segments; furnished with articulated legs; breathing by means of gills, which are usually seated on the base of the legs or the lower jaws, and the pieces of which those legs are composed, often have cartilaginous plates attached to the crust at one extremity, and free at the other, which, however, are tendons rather than bones; the head in general not very distinct from the chest, and furnished with two pairs of antennæ or feelers, and a pair of mandibles, to which are jointed other members called palpi: four under jaws, and six foot jaws, the four hind ones of which are modified into legs in those species which have fourteen legs, so that ten legs is the normal number; the mouth is furnished with an upper lip, a tongue, and under lip, which consists of the first pair of foot jaws; the eyes, two in number, formed with facets, and placed on the top of peduncles or footstalks, which are often of considerable length. The sexes are distinct and separate individuals, and the young are produced from eggs.

The crustacea are, almost without exception, inhabitants of the waters; and they appear to occupy nearly the same place, and perform the same function in nature there, which the insects do upon the land; though some of them are of much larger size than any of the land insects. They are all symmetrical animals, or consist of two equal and similar parts, turned opposite ways, if divided on a mesial plane. Their bodies are of various forms, some oval, some a sort of four-cornered, and some elongated. Some, as for instance the common crab, are without any tail; and others, as the common lobster, are largely provided with an organ of this kind, which folds downwards by numerous joints when in a state of repose, but which the animals can straighten with great force; so that, resting the point of it, when curved, upon a rock, they can project themselves to the distance of many feet, as rapidly as though they were shot from a bow, and with more unerring certainty than if the bow were drawn by the most skilful archer.

There is often great beauty as well as great power in the jointed legs of these animals; though the kind of joints which they possess are not very well adapted for walking upon land. In those which have the crusts hard, the joints of the most efficient members are articulated with condyles and sockets; and as there are necessarily two of these, confining the motion to one plane, that motion is absolutely determinate, and not liable to the least shake or variation. In consequence of this, there must be as many distinct joints in the member as there are planes in which motion is required; but as each of these is as completely determinate in its plane as the others, the compound motion which results is also determinate. One of the claws of a common crab is a beautiful instance of this species of mechanism; and it is astonishing with what perfect precision a crab will seize even a very small object. The claw of the lobster is still more wonderful; because the lobster can dart to a great distance, and aim the prehensile pincers of its claw against its prey with the most unerring certainty. Those joints with solid articulations are chiefly confined to the prehensile members, the others being in general articulated by flexible membranes. The way in which the legs are articulated renders it necessary that the progressive motion should be sideways, or, at all events, oblique.

One of the most remarkable parts of the economy of those animals is the annual moulting, or casting of the shell, in the larger species, and the casting of it at much shorter intervals in the smaller species. We have a parallel case in the caterpillars of insects, which cast their skins several times before they are changed into the state of pupæ. That these should cast their skins is not wonderful; but when we look at a crab or a lobster, and consider the strength of its shell, and the peculiar shape and complication of its parts, we feel rather astonished that it should be able to come out of the shell. We use the word shell, as familiar in common language; but the covering of these animals is not a shell, but a crust. Animals which have shells do not cast them; for the shell is elaborated by a distinct apparatus; and this apparatus enlarges the shell by additions of new matter, according as the increased size of the inhabitant renders this necessary.

The hard crust, on the other hand, is not produced by a distinct apparatus, but by the skin of the animal, which appears to become weakened as the crust arrives at maturity. When the animal has once grown to such a size as that it completely fills the hard crust, of course it can grow no more; because there is no principle of growth in the crust after it has become hard; and the membrane which produced it is then, as we have said, exhausted. Either, therefore, the crustaceous animal must cease to grow in the soft parts after the crust has become solid, just as vertebrated animals with hard bones cease to grow in stature after those bones are once completely ossified,—either this, or, as an alternative, the crust must be thrown off; but we find crabs, lobsters, and other hard crusted animals of this class, of very different sizes, and yet with the crusts upon all equally consolidated, and we find them in the same places, so that we must believe that the small ones are younger, and the large ones older; and also that they could not have attained their larger size without casting their crusts.

At what intervals of time the different changes of the crust are made is another matter, and one on which our information is by no means complete. We know that the small ones, of which the production is immense, and the growth very rapid, change their crusts as often as six times in not more than two weeks; but in the larger ones it is probable that the changes are not at any time quite so rapid as this, though in the first years of their growth, especially in the very first, it is probable that there are a good many changes. It is only analogy, but still it is true to analogy with the rest of nature, that, as the animal increases in age and bulk, the periods between the successive changes of the crust should increase in length; and it is not improbable that a period at last arrives when the animal is no longer able to perform this change, and then, that death, which is the final lot of every material creature, passes upon it. We have a sort of collateral proof of this in the fact, that the crusts of large crabs are often in part covered with *serpula balanus*, and other adhering small shells; while the crusts of small ones never have any of these upon them. It must not be supposed that those parasites can attach themselves to a crust of the same year; for at the very time when they do attach themselves, the animal has no crust, but only a membranous covering in a very weak and flexible state. This is an exceedingly curious matter, but it is one upon which it is difficult to get the evidence of observation; because, for some time previous to the casting of the crust, and some time after it, the animal is in a state of concealment. Nor can we draw any conclusion from the fact that, though small crusts only are found strewed along the shores, large ones are not cast; because there is no question that the young crustacea undergo their change near the surface, while the old ones do it at depths beyond the limits of observation; and, as their crusts are heavier, and there is very little agitation of the water, at those depths, occasioned by even the severest storms, it is not easy to see by what means those large crusts could come to the shore.

In so far as the annual moulting of the crust is concerned, we have some knowledge of the circumstances. Towards the end of spring, the shells or the crustations become too small for their contents; and, as the animal can grow no longer, it ceases to feed, and becomes restless and languid. At length it crawls away into some close concealment; and, in that concealment, the contents of the crust gradually waste away to a very small fraction of what they were at the close of the season of growth. This wasting is so great, that the flesh in the large claw of a lobster dwindles to a fragment, not thicker than a quill. The other parts, of course, diminish at the same rate; and the crust itself becomes flexible, at least in some of the species. From this wearing away of the flesh, and partial softening of the crust, the animal finds no difficulty in withdrawing itself; and the crust is usually found with both claws and legs attached to it, and with only those parts more immediately connected with the living functions of the animal, which, when removed, leave a considerable opening in the crust, detached from it. It no doubt often happens that the extremities of the articulated members are in whole or in part left in the cast crust; but, as we shall see afterwards, the Author of Nature has not left these creatures without means of repair in the case of such casualties. The season at which the crust is cast is the very prime of the renovation of nature; and the small animals which serve as food for the crustacea are in such multitudes, that they literally encumber the water. Thus the animal which has cast the crust—we shall say the crab, for instance—has the bounty of Heaven brought to it without exertion on its part. Consequently, it waxes fat, and grows rapidly; and as its covering is a yielding membrane until it gains its full size, that size is arrived at in far shorter time than one would be led to suppose; and, in proportion to the health and vigour of the animal, that size is larger than it was previously. In this state, crabs and other crustacea, when they first leave their retirement, are very favourite food with many species of fishes, and on this account the fishermen eagerly seek after them as bait for their hooks. When the full size is arrived at, the covering begins to harden, by the depositing of salts of lime in the membrane. Those salts are partly phosphate, or earth of bone, and partly carbonate, or earth of shell: and thus the hard crust is intermediate between the solid parts of vertebrated and those of molluscous animals. When the crust is completely saturated with those salts of lime, the vigour of the animal is directed to new objects. First, to the restoration of the flesh, which has become exhausted and watery from the labour of consolidating the crust: and secondly, the work of reproduction. This last function, we have said, is in separate individuals. The eggs, which are very numerous, are brought forward to a certain stage within the body of the female, something in the same manner as the roe of fishes; but the impregnation is different, being internal, and the eggs come forth into the world, each containing the germ of a perfect life. In many species, as in the lobster, these are hatched upon the under part of the female, to which they adhere by their glutinous covering; but there are others which cast their offspring entirely into the deep. The eggs so cast are in such multitudes, that the surplus of them, after all the casualties of the year have been amply replaced, serves for food to a great number of creatures, just as the more early productions of the year supplied the crustacea with that food which brought them to the vigour necessary for the performance of this, the grand function of their lives.

How beautiful is this adaptation of one race of creatures to another! Both are apparently destroyers, if we look at them in the single act of feeding; but when we look at them in their relation to each other, both are preservers, and without the one the other would soon become exterminated. When each produces a surplus of its kind, beyond what the proper balance of the races would bear, it may with truth be said to sow that surplus as a seed, of which its young shall reap the harvest. Such is the extent and wisdom of design in all parts of creation, if we will but look upon them with an understanding eye.

It does not appear that the crustacea undergo any change of form, notwithstanding the repeated shedding of their crusts, any more than serpents do in the casting of their skins; and as the same applies to caterpillars, and other larvæ which repeatedly cast their skins while in that state, it affords a strong presumption against the old opinion of Swammerdam, that the parts of those insects which pass through different forms, and have very different habits while under each, all exist in the early larva, and even in the egg, the early forms encasing the later one, something in the same way as the coats of an onion encase each other. It is not long since this was the general opinion, and it has numerous advocates still; and as it was general at the time when this work first appeared, in a form somewhat different from the present, it was strenuously maintained by the excellent and amiable author. But the doctrine is a most unphilosophical one; and if one ventures to carry it as far as sound and searching analysis ought to be carried on every point of philosophy, it leads to absurdity, and points at atheism. We shall perhaps have occasion to revert to it; but we have mentioned it here because it is a vital and dangerous error, and because the analogy of the crustacea is one of the means by which it may be exploded.

We noticed that if, in casting their crusts, some parts of the articulated members of the crustacea should be broken off, the animals would not be permanently maimed thereby; and this we shall now briefly explain. If any of those members is broken off while the animal is in the living state, and has the crust compact, it very speedily grows again. The separation does not take place at the joints which have hard articulations; for these can hardly be dislocated even after the animal has been boiled. They take place at the membranous joints; and the joints by which the prehensile claws are united to the body are of this character, so that they can be separated without any dislocation of hard parts. Indeed it appears that, in some species at least, they can be separated by apparently very simple causes; for it is generally believed at least that a loud peal of thunder, or discharge of fire-arms, will cause so much excitement in lobsters that the claws will jerk off; and it is pretty well ascertained that if by being seized by a more powerful individual of the same species, or by any other means, a claw of this kind should be injured in any other part of its length, the animal jerks it off at the articulation with the body, as the only means of getting it replaced by another, which shall be perfect and useful. The experiment has been made under circumstances that admitted of the progress being observed; and the reproduction of the member was found to be very rapid. In a day or two, a reddish tubercle appears, which gradually lengthens, becomes cleft at the extremity; and in a very short time acquires the form and consistency of the other claws, though it is smaller in size. On the future sheddings of the crust, this new member grows more rapidly than the rest of the body; but the experiment has not been continued for a sufficient length of time for ascertaining whether it becomes at length equal in size with the one which has not been broken off. Crabs, and more especially lobsters, are very frequently seen with a large claw and a small one; and there is no doubt that in all these cases the small claw is a reproduction; and the fact of its occurring far more frequently in the lobster than in the crab, is a proof that the claws of the former are the more easily separated; and this again, though it does not prove, gives some ground for believing, that those claws may drop off when thunder or artillery throws the water into a tremulous state.

We know that such sounds must affect the water to a considerable depth; for it is proverbial that both thunder and artillery still the waves as well as moderate the winds; and they can do these only by imparting a tremulous motion, which breaks the vibration of the wave in the one case, and the current of the wind in the other. Sailors, who are always ready to avail themselves of little matters connected with the economy of the sea, without making much scrutiny into the truth of them, implicitly believe this; and when a lobster-boat passes a ship of war, the sailors jocosely tell the owner, that, if he does not send jolly good lobsters on board, the captain will honour him with a salute, and thereby shake the claws from his whole cargo.

That the re-produced claw should be smaller than the other, and grow faster, throws a little light upon the growth of those singular animals. It points out very clearly that the power of growth in the animal becomes less and less as the animal gets older; and this being strictly analogous to what takes place in every plant and every animal, of which we know the existence to have a measurable duration, we may safely conclude that a period must arrive in the life of those animals at which they must cease to grow; and this as naturally leads to a period when they shall cease to live, as the same middle epoch does in every other case.

The crustacea are so very numerous, that it would be impossible for us to give any detailed account which would at all explain the class. They are divided into two sub-classes: *Entomostraca*, or those which have swimming appendages to the legs; and *Malacostraca*, or those which have the legs simple. The first are small animals, and many of them inhabit the fresh waters. We shall quote a description of one by the late Dr. Shaw, as a specimen of the sub-class. It is the *Branchiopoda stagnalis*. "It is generally," says Dr. Shaw, "found in such waters as are of a soft nature, and particularly in those shallows of rain water which are so frequently seen in the spring and autumn, and in which the *Monoculus pulex* of Linnæus and other small animals abound. At first sight it bears some resemblance to the larva of a dytiscus; but, when viewed closely, it is found to be of a much more curious and elegant appearance than that animal. The legs, of which there are several pair (eleven) on each side, are flat and filmy, and have the appearance of so many waving fins, of the most delicate structure imaginable. The whole animal is extremely transparent, and the general colour is brown, slightly tinged with bluish-green.

"*Monoculus conchaceus* of Linnæus very frequently assaults them, and adheres with such force to their tails and legs, as sometimes to tear off a part in the struggle. It delights much in sunshine, during which it appears near the surface of the water, swimming on its back, and moving in various directions, by the successive undulations of its numerous fin-like legs, and moving its tail in the manner of a rudder. On the least disturbance, it starts in the manner of a small fish, and endeavours to secrete itself, by diving in the soft mud. It changes its skin at certain periods, as is evident from the exuviæ or sloughs being frequently found in the water in which these animals are kept.

"In March or April, the females deposit their eggs without any settled order, and perfectly loose in the water. They appear to the naked eye like very minute globules of a light brown colour, Each ovum, when magnified, closely resembles the farina of a mallow. It is thickly beset with spines on every side, and coated over with a transparent gelatinous substance, reaching just to the extremities of the spines, and is most probably intended to assist in causing them to adhere to the substance on which they may chance to fall, or as a security from the attacks of smaller animals. In about a fortnight or three weeks the eggs are hatched, and the young animals may be seen to swim with great liveliness, by means of three very long pairs of arms or rowers, which appear disproportionate to the size of the animal, and, indeed, it bears, in this very small state, not very much resemblance to the form it afterwards assumes; but, in the short space of a very few hours, the body assumes a lengthened form, and begins to acquire the tail-fin. The eyes in this state do not appear pedunculated. On the seventh day after hatching, they approach pretty nearly the form of the perfect animal; they, however, still retain the first two pairs of arms or rowers. The legs are at this period very visible. About the ninth day it loses the long oars, and appears still more like the animal in its advanced state."

Another species is worthy of notice, both on account of its curious habits and of the illustration that it gives of the reason why crustaceous animals are found in the empty shells of mollusca, with their own crusts in a soft state. This is the Diogenes crab (*Pagurus Diogenes*), which inhabits the shores of the Indian seas, where these are covered with vegetation, and climbs during the night, in order to feed upon wild fruits, as is done by various other crabs of the same seas. It also, however, can feed upon any sort of garbage, which is a very general practice with the whole class. It is of a yellowish-brown colour, and far more active than the large crabs on our shores. An intelligent writer says, "It is very diverting to observe this animal when about to change its shell; at which time it is seen busily parading the shore, along that line of pebbles and shells which is formed by the extremest wave; still, however, dragging its own incommodious habitation at its tail, unwilling to part with one shell, even though a troublesome appendage, till it can find another more convenient. It is seen stopping at one shell, turning it, and passing it by; going on to another, contemplating that for a while, and then slipping its tail from its old habitation to try on the new; this also is found inconvenient, and it quickly returns to its old shell again. In this manner it frequently changes, till it at last finds one, light, roomy, and commodious; to this it adheres, though the shell be sometimes so large as to hide the body of the animal, claws and all. Yet it is not till after many trials, and many combats also, that the soldier is thus completely equipped; for there is often a contest between them for some well-looking favourite shell, for which they are rivals. They endeavour both to take possession; they strike with their claws; they bite each other, till the weakest is obliged to give up the object in dispute. It is then the victor immediately takes possession, and parades in his new dress three or four times backward and forward upon the strand, before his envious antagonist." What is very rare among invertebrated animals, this species of crab seems to be possessed of voice; for it is said to utter a feeble cry when laid hold of, and to attempt to seize the assailant with its pincers; and if it once gets a hold it will suffer itself to be pulled to pieces rather than let go. It is a good deal sought after, being much esteemed as an article of food, when dressed by roasting it in the shell. There is one curious fact very generally stated with regard to all the crustacea which have pincer claws, but we cannot vouch for the truth of it from our own personal experience. It is alleged that when it once seizes with the pincers, the joint which unites that claw to the body becomes so firm and rigid, that it cannot be broken without a very great effort; but that if the opposite claw is wrenched off, which is easily done, the hold is immediately relinquished.

The fact that the Diogenes crab enters the shells only for the purpose of changing its crust, is a sufficient proof that all the species which are found in shells take possession of them for similar purposes.

The common lobster (*Astacus marinus*) is, perhaps, one of the most interesting and valuable of the species; and therefore a few particulars respecting it may be noticed. It is quite unnecessary to describe an animal so well known: but we may remark that the male has the edges of the middle plates of the tail nearly straight, and the female or lady-lobster has them round. They inhabit clear and deep water upon rocky shores; and seize their larger prey by springing upon it. They are exceedingly voracious, consuming not only a vast nunber of small animals, but sea-weed, and all sorts of dead animal matter and garbage. They are very prolific, a single female producing from ten thousand to twenty thousand eggs in a season.

The eggs are not completely hatched while attached to the body; but that takes place very soon after they are fastened to the rocks or buried in the sand. One of the best accounts we have of them is that by Mr. Travis, who studied their manners with great care, on the rocky coast near Scarborough. "Lobsters," he observes, "are found in great abundance, and very fine on that coast. The larger ones are in general in their best season from the middle of October till the beginning of May. Many of the smaller ones, and some of the larger sort, are good all the summer. They are in general from four to four inches and a half from the tip of the head to the extremity of the back shell. Commonly the pincers of one of the lobster's large claws are furnished with knobs, and those of the others serrated; with the former it keeps firm hold of the stalks of submarine plants, and with the other it cuts and minces its food very dexterously. The knobbed or numb-claw, as the fishermen sometimes call it, is sometimes on the right side, and sometimes on the left, indifferently. It is more dangerous to be seized by them with the cutting claw than the other, but, in either case, the quickest way to get disengaged is to pluck off the creature's claw; a new one will be produced in its place, though it will never attain the size of the former. The female or hen lobster does not cast her shell the same year that she deposits her ova, or in the common phrase, *her berry*. When the ova first appear under her tail, they are very small and extremely black, but they become in succession almost as large as ripe elderberries before they are deposited, and turn of a dark brown colour, especially towards the end of her depositing time. They continue full, depositing the ova in constant succession as long as the black substance can be found in their body, which, when boiled, turns of a beautiful red colour, and is then termed coral. Hen lobsters are found in berry all the year. It is a common mistake that a berried hen is always in perfection for the table. When her berries appear large and brownish, she will always be found exhausted, watery, and poor. Though the ova be cast all the year round, they seem only to come to life during the summer months of July and August. Great numbers of them may then be found under the appearance of *tadpoles*, swimming about the little pools left by the tide amongst the rocks, and many also under the proper form, from half an inch to four inches in length.

"In casting their shells, it is hard to conceive how the lobsters are able to draw the flesh of their large claws out, leaving the shell entire and attached to their body, in which state they are constantly found. The fishermen say the lobsters pine before casting their shell, till the flesh of their large claw is no thicker than a goose quill, which enables them to draw its parts through the joints and narrow passages near the trunk. The new shell is quite membranous at first, but hardens by degrees. Lobsters only grow in size while their shells are in soft water. They are chosen for the table by their being heavy in proportion to their size, and by the hardness of their shells on the sides, which, when in perfection, will not yield to moderate pressure. Bernacles, and other marine animals adhering to them, are esteemed certain indications of superior goodness. Cock lobsters are in general better than the hens in winter; they are distinguished by their narrow tails, and by having a strong spine upon the centre of each of the transverse processes beneath the tail, which supports the four middle plates of the tail. The flesh of the lobster's claw is more tender and delicate than that of the tail. The Scarborough fishermen do not take them in pots or kreels, as is usual in still and deep waters; they use a bag-net, fixed to an iron hoop, about two feet in diameter, and suspended by three lines like a scale. The bait is usually fish-guts tied to the bottom and middle of the net. They cannot take any in the day-time, except when the water is thick: they are most frequently taken at night, but even then it is not possible to take any when the sea has a luminous appearance. In summer the lobsters are found near the shore, and thence to about six fathoms water; but in winter they are seldom taken in less than twelve or fifteen fathoms. Like insects, they are much more alert in warm than in cold weather. In the water they can run nimbly on their legs or small claws, and, if alarmed, can spring, tail foremost, to a surprising distance, as swift as a bird can fly. The fishermen can see them pass about thirty feet, and, by the swiftness of their motions, suppose they go much farther. When frightened, they will spring from a considerable distance to their hole in the rock; and what is not less surprising than true, they will throw themselves into their holes in that manner, through an entrance barely sufficient for their bodies to pass, as is frequently seen by the people who endeavour to catch them at Filey Bridge. In frosty weather, if any should happen to be found near the shore, they are quite torpid and benumbed."

The common crab of the British shores is, like the lobster, so well known, that a description of it would be superflous; but there are some points connected with it which tend to establish what we have already mentioned, with regard to the seasonal operations of these animals. It is in season twice in the year, namely, from about the beginning of January to the middle of March; and the one of these periods seems to refer to the recovery of its flesh after having cast the crust; and the other to its second recovery after the eggs are deposited. The last, being the least severe operation, is understood to be the one which precedes the winter, or longest period of its being in season: and it does not appear that the change of the crust occupies a very long time; for crabs are found in the holes of the rocks pretty early in the summer. They are then usually in pairs; and they improve in condition till toward the time of their autumnal disappearance. When that takes place, the females at least bury themselves in the sand, in which it should seem that a great part of their eggs are deposited. After this they become less plentiful, if they do not wholly disappear, until the winter months are about half over, and then they again become active. At this time, however, the females do not contain many eggs; and, it is probable, that the next retiring is for the change which, as we have said, applies to the greater part of the flesh, as well as to the crust. Their habits are not very well known however, familiar as we are with the animals themselves.

Crabs of this species are found on many more parts of our coasts than lobsters, as they do not inhabit so deep in the water. They are understood to increase in size, and also in quality, in proportion as they inhabit more northerly; and very large crabs as well as lobsters are caught in abundance on the coasts of Norway. There is still another species, or rather, perhaps, more than one species, of which some notice may not be unacceptable. This is the *land crab* (*Ocypoda uca*) of the West India islands, and various parts of South America. We shall give, with some abridgment, the account of Sloane and Catesby, which is still the most circumstantial, and, indeed, it is one of the most singular portions of the whole animal economy. "These animals live not only in a kind of orderly society in their retreats in the mountains, but regularly march once a year down to the sea-side, in a body of some millions at a time, as they multiply in great numbers. They choose the month of April or May to begin their expedition, and then sally out by thousands from the stumps of hollow trees which they excavate, from the holes which they dig for themselves under the surface of the earth, clefts of rocks, and other hiding-places. At that time the whole ground is covered with this band of adventurers; there is no setting down one's foot without treading on them.

"The sea is their place of destination, and to that they direct their march with the utmost precision. They never turn to the right or the left for any objects that intervene, if they can possibly pass over them; and even if they meet with a house they will attempt to scale the walls. But though this be the general order of the route, they are, on other occasions, obliged to conformi to the face of the country; and if it is intersected with rivers, they are seen to wind along the course of the stream; but if only a small rivulet occurs, they force a passage across it. The procession sets forward from the mountains with the regularity of an army under the guidance of an experienced general. They are said to be commonly divided into three battalions, of which the first consists of the strongest and boldest males, that, like pioneers, march forward to clear the route and face the greatest dangers. They are often obliged to halt for want of rain, and to go into the most convenient encampment till the weather changes. The main body of the army is composed of females, which never leave the mountains till the rain is set in for some time, and then descend in regular order, being formed in columns of fifty paces broad, and three miles deep, and so close, that they almost cover the ground. Three or four days after this, the rear guard follows, a straggling undisciplined troop, consisting of males and females, but neither so robust nor so vigorous as the former. The night is the chief time of proceeding, but if it rains by day, they do not fail to profit by the occasion; and they continue to move forward in a slow uniform manner. When the sun shines and is hot upon the surface of the ground they halt, and wait for the coolness of the evening. When they are terrified, they march backward in a confused and disorderly manner, holding up their nippers. They try to intimidate their enemies by clattering their nippers together, as if it were to threaten those who come to disturb them. Their disposition is carnivorous, though they most commonly subsist on vegetables; for if, by any accident, one should get so maimed as to be incapable of proceeding, the rest fall on him and devour him on the spot, and then pursue their journey.

"After a march of sometimes two or perhaps three months in this manner, they arrive at their destined spot on the sea-coast, and then proceed to cast their spawn. The eggs are as yet within their bodies, and not excluded and retained, as is usual with animals of this kind, under the tail; for the creatures wait for the benefit of the sea-water to facilitate their exclusion. For this purpose the crab has no sooner reached the shore, than it goes eagerly to the edge of the water, and lets the waves wash over its body two or three times. This has been thought necessary by some to ripen the spawn in the ovary, as the crab, appearing satisfied after a slight bathing, immediately retires, and seeks a lodging on the land. After this, they say, the spawn grows larger, is excluded from the body, and adheres to the ciliations under the tail. This bunch is seen as big as a hen's egg, and exactly resembling the roes of herrings. In this state of the pregnancy they once more seek the shore for the last time; and shaking their spawn into the water, leave them to the chance of fortune and accident to bring them to maturity. At this time large shoals of hungry fishes are at the shore in expectation of this annual supply; the sea to a great distance seems quite black with them; and about two-thirds of the eggs are immediately devoured by these rapacious invaders. The eggs that escape are hatched under the sand, and soon after millions at a time of those little crabs are seen quitting the shore, and slowly travelling up to the mountains. The old ones, however, are not so active to return;

they have become so feeble and lean, that they are scarcely able to crawl along, and the flesh changes colour. The greater part of them, therefore, are obliged to continue in the plains and lower parts of the country, until they recover, making holes in the earth, which they cover with leaves and dirt, so as to exclude the light and air. In this cavity they throw off their old shells, which they leave behind them, as it were quite whole. At this time they are quite naked, and almost without motion for six days together, when they begin to grow fat, and are then most delicious eating. It is said they have under their stomachs four large white calcareous stones, which gradually decrease in proportion as the shell hardens, and when they come to perfection entirely disappear. Soon after this the animal is seen slowly making its way back, and all this is commonly performed in the space of six weeks. This animal, when possessed of its retreats among the mountains, is impregnable; for, only subsisting on vegetables, it seldom ventures out; and its habitation being in the most inaccessible places, it remains for the greater part of the season in perfect security. It is only when impelled by the desire of bringing forth its young, and when compelled to descend into the flat country, that it is taken. At that time the natives wait for their descent in eager expectation of their arrival, and destroy them in thousands; but, disregarding their bodies, they only seek for the small spawn, which lies on each side of the stomach, within the shell, of about the thickness of a man's thumb. They are much more valuable on their return, after they have cast their shells; for being covered with a skin resembling soft parchment, almost every part except the stomach may be eaten. They are taken in their holes by feeling for them with an instrument; they are sought after by night, when on their journeys, by flambeau light. The instant the animal perceives itself attacked, it throws itself on its back, and with its claws pinches most dreadfully whatever it happens to fasten upon. But dexterous crab-catchers take them by their hinder legs, in such a manner that they cannot make any use of their nippers, and thus throw them into their bags. Sometimes also they are caught when they take refuge in the bottoms of holes in the rocks on the sea-side, by clapping a stick to the mouth of the hole, which prevents their getting out; and then soon after the tide coming, enters the holes, and the animal is found, upon the water retiring, drowned in its retreat.

"The crabs are of various colours: some are reddish, variegated with black, some yellowish, and others black, inclining to blue. Those of a light colour are esteemed most, and when full in flesh are well tasted. In some of the sugar islands they are eaten without apprehension of danger, and form no inconsiderable portion of the food of the poorer negroes."

It is highly probable, indeed almost certain, that there are several varieties, if not distinct species of those very singular animals, some of which resort to the fresh waters, and others to the sea. Their system of breathing is, of course, to a certain extent pulmonic, or of air not through the medium of water, because they all reside habitually on the land, and resort to the water only for the furtherance of certain parts of their economy; and it is doubtful whether any of them can, under any circumstances, respire through the medium of water. Their physiology, however, is altogether very ill made out; and until we have better information respecting them, we must receive the published accounts with a great deal of caution.

Though the crustacea with which we are acquainted are not remarkable for any of the elements of beauty, there are some which, in the splendour of their colours, rival any plants or any animals which are to be found in the whole range of nature. In the waters of Australia there is a crab, than which it is hardly possible to imagine any thing more finely coloured. The upper part is bronze, in all imaginable tints of colour, and much of the under part and the inferior surface of the legs is of the finest ultramarine blue that it is possible to imagine.

The crustacea, taking them altogether, must be regarded as a sort of scavengers, or consumers of the waste and refuse of nature; and in this respect they are highly useful. The more powerful ones have crusts of so strong a texture that it is extremely difficult to do them any injury. Their crusts are much more durable than bone, and not nearly so brittle as shell; and when we consider their activity, their power of endurance, and all the different parts of their economy, we cannot help regarding them as among the most extraordinary productions of nature.

Class III.—Arachnida, or spiders and animals of spider-like form. These are also a singular race; and though many of them are repulsive to our common feelings, ignorant as we are of the designs of

Providence, yet still they exhibit very extraordinary displays of the wisdom and goodness of the all-seeing and bountiful Creator. The animals of this class agree in some particulars with the crustacea, and in others with insects; but they differ so much from both in other particulars of their structure, and also in their habits, that they are entitled to rank as a separate class. They are articulated animals; and the covering of the body, though seldom so hard as to be considered a crust, and never we believe containing any salts of lime, answers in place of a skeleton, in the same manner as it does in the crustacea. In the greater number of the species, the head and chest are united in a single piece as in crustacea, and not separated by an articulation, as is generally the case in insects. They have articulated members on each side of the body; the halves of which are symmetrical, if divided vertically on a mesial plane. Their principal viscera are contained in an abdomen, united to the posterior part of the thorax; their mouth is armed with jaws, and their head is furnished with a variable number of simple eyes. Their system of circulation is carried on by a dorsal vessel, which propels the blood into the arteries, and receives it back again from the veins. Their system of respiration varies. The greater number may be considered as pulmonary, or breathing by means of little sacks, which answer the purpose of lungs. The entrance into them is by *stigmata* or breathing pores, which are situated on the under part of the abdomen, and of which the number varies; being sometimes as many as four on each side, sometimes two on each side, and sometimes only one. All that have this mode of respiration breathe the free air, and are consequently inhabitants of the land. Their heart and system of circulating vessels are very complete, or at least very distinct, and they are all furnished with six or eight smooth eyes. They form a distinct order of the class. The others breathe by means of tubes, which are ramified through different parts of the body; but which do not, as in insects, form two parallel tubes, extending the whole length, and having numerous stigmata or openings for receiving the air. Their breathing apparatus is situated at the base of the abdomen, and consists of two lobes, or in some cases more. None of the animals of this class are furnished with wings for flight; but some of them run with great rapidity, and the numerous tribes which inhabit the waters are expert swimmers.

They are in general, or indeed altogether, rather small animals, but they are remarkably active and energetic; and though they can bear hunger for a great length of time, they are very voracious when food comes in their way. They are almost all carnivorous; and their principal office in the economy of nature appears to be to assist in keeping insects, especially winged ones, within those bounds which are required for the preservation of a due balance in the system of nature. Some of them, however, feed upon other substances; but, generally speaking, they do so only when those substances are in a state of incipient decay, and would soon become rank and injurious. Some of those which have this habit are very small, and just visible to the naked eye; and of these the cheese-mite is a familiar instance. Some of them resemble in their external figure some of the insects in certain stages of their growth ; but they differ from them in undergoing no metamorphosis, or change of appearance, or of habit. They moult, or cast their skins, in a manner similar to that of the crustacea ; but their structure, in the earliest stage at which they are at all visible, is exactly the same as when they have attained their full size.

The spiders, properly so called, are the most characteristic, and on that account, perhaps, the most interesting of the whole class. They are disliked, and lie under many vulgar prejudices; but notwithstanding this, they are very important animals in the economy of nature, and of no inconsiderable service to man. The web of the common house-spider is no doubt a little unseemly in places where cleanliness is neglected ; but even there it has a double use. In the first place it admonishes the inattentive; and in the second place, it destroys those house flies and other insects which, being attracted in great numbers by the dirty and slovenly state of the house, tend to make matters worse.

There is not one of the whole spider tribe, or indeed of the arachnida which is seriously injurious, either to man or to his property. It is true that the scorpion stings ; that some of the larger can bite a little ; and it is fabled, though not very true, that the tarantula spider bites in so singular a manner as to bring on a strange kind of delirium, and ultimately death ; the last of which can be averted, and the first removed, only by certain musical sounds. This fable evidently involves its own refutation ; because, if the sense of hearing can cure any complaint of the human body, it is pretty evident that it can only be a complaint which has been brought on through the medium of the sense of hearing; and upon this hypothesis, which is a very rational one, the hearing of the music can cure only a disease brought on by hearing that the bite of the tarantula is mortal, and attended with those singular symptoms which have been said to be produced by it.

The common spiders may, according to their habits, be divided into two classes,—snaring spiders and hunting spiders. The one class form by threads, which they spin, nets of various constructions, which they place in situations where their prey is most likely to be entangled in them. Some of these are placed in houses, and in houses only. They are of pretty close texture; and the spider erects for itself a den or nest, in which it lies in wait, until the house-fly is entangled in the net, and then it seizes the prey, carries it to the den, and devours it at its leisure. Others are placed on the ground, on commons and other retired places, where there are ground flies; and these also construct their nets of a comparatively close texture, and construct a retreat in which they conceal themselves, until a fly is entangled, and then they advance and seize it, carry it to their retreat, and feed upon it at their leisure. Other species, as the common garden spider, place their nets in a position which is vertical, or nearly so; have them more open in the meshes, and less easily seen, so that they catch their insect prey as it passes along on the wing. These last form no nest, or retreat, in which they themselves may reside in concealment, but remain quiescent, with the head downwards—the usual position of repose in such spiders, and wait with patience until a passing insect gets entangled in the net, and then they pounce upon it, finish it on the net if it is of small size, or deal with it after a different fashion, which we shall afterwards explain, if it is more large and powerful.

The whole race, however, may be said to be animal feeders; and it is not unworthy of remark, that they come into a state of activity at that very season when their labours are of the greatest service. In the early part of the season, and when winged insects are comparatively few, those spiders which weave their perpendicular webs do not make their appearance, because at that season the winged insects on which they prey are few in number; unless in the state of larvæ, or caterpillars, in which state they are the food of those summer birds which annually visit our woods, and groves, and coppices, and gardens, and make the season so delightful with their songs. In this state the insects are not available as the food of a spider which stretches its web in the air; and as most of the races of those insects perish in the autumn, and leave only their eggs deposited in appropriate places, to produce a new generation, spiders of the character of which we are speaking are not required, and could not find the requisite quantity of food. But when the summer is over and the birds are gone, and the larvæ or caterpillars which supplied the birds with ample food for the year, are, in the portion which has been preserved, transformed into winged insects, the spiders come abroad, and are on the alert. At this time, too, those winged insects upon which the spiders feed, range about more than they do at any other season. The females beat about for places in which their eggs may be deposited with safety; and in their search for such places, they have occasion to beat about in the very situation in which those spiders of the late summer and the early autumn prepare their webs, for the very purpose of catching the flies. Speaking according to the doctrine of reason in man, there is no contrivance or purpose whatever on the part of the spider, any more than there is purpose in water falling frozen, or in the state of snow, when the temperature sinks below a certain degree. But the Almighty Creator has ordained them for the performance of certain purposes; and they, without any knowledge, as we estimate knowledge in rational man, act so as to conduce, in the highest degree, to the accomplishment of this purpose. There is something very beautiful in this bringing the destroyer into the way of those insects, at the very time when the destruction of their surplus is of the greatest advantage. At that particular season of the year, the destruction of one female fly may involve in it the destruction of a thousand or of many thousands, and this circumstance greatly enhances the value of the spider in an economical point of view.

Besides those spiders which place snares for their prey in houses, in gardens, or in the fields, there are other races which do not spin any webs, but live upon the ground, and hunt for their prey, springing upon it with great rapidity, and capable of performing leaps far exceeding, in proportion to their size, those of the lion and the tiger, clearly showing the great superiority in point of power of the internal muscles above the external ones.

Nor is it unworthy of remark that when any peculiarity of circumstance renders a spider unfit for spinning a web, it can turn hunter. They do this often in the case of losing one of those legs which, being furnished with pincer claws, are essential to their proper action on the web. There is this resemblance between them and the crustacea, that when a leg is by any accident broken off it can be reproduced. We have a very interesting account of a spider from the late Sir Joseph Banks, to whose personal exertions and great liberality naturalists are so much indebted. As Sir Joseph was writing in his study, one of the web-spinning spiders, of more than the middle size, passed over some papers on the table, holding a fly in its mouth. Much surprised to see a spider of this description walking about with its prey, and being struck with somewhat unusual in its gait, he caught it, and placed it in a glass for examination; and then, in place of eight, he perceived that it had but three legs, which accounted for the inability of the creature to spin its web; but the curious circumstance of its having changed its usual economy, and having become a hunting instead of a spinning spider, as well as a wish to learn whether its legs would be renewed, induced him to keep the animal in the glass, whence it could not escape, and to observe its conduct.

On the following morning the animal had two flies given to it, when it sucked out the juices, but left the carcase entire. Two or three days afterwards, it devoured the body and head of the fly, leaving only the wings and legs. After this time, it sometimes sucked and sometimes ate the fly given to it. At first it consumed two flies in a day, but afterwards not more than one in two days. Its excrement which it voided, was at first of a milky white colour, but afterwards the white had a black spot in the centre, of a more solid appearance than the surrounding fluid.

Soon after its confinement, it attempted to form a web on the side of the vessel, but performed the business very slowly and clumsily, from the want of the proper number of legs. In about a fortnight it had completed a small web, upon which it generally sat.

A month after having been caught, it shed its skin, leaving the slough on the web. After this change five new legs appeared, not half so long as the other three legs, and of very little use to the animal in walking. These new members, however, extended themselves a little in three days, and became half as long as the old ones. The web was now increased, and the animal continued immoveably sitting on it in the day-time, unless drawn from it, or attracted by a fly thrown to it as its usual provision.

Twenty-nine days afterwards, it again lost its skin, leaving the slough hanging in the web opposite to a hollow cell it had woven, so as to prevent it from being completely seen when lodged in it. The legs were now larger than before the change of skin, and they grew somewhat longer still in three or four days, but did not attain the size of the old legs.

The animal now increased its web, and being put in a small bowl, as a more commodious residence, soon constructed a better web than the first. In this state it was left on the first of November. No farther observations have yet been made on the subject.

One of the most interesting of this curious race is the garden spider, *Epeira diadema,* which is very common in the warmer parts of England, though comparatively rare in the colder parts, and unknown in the north of the island. It is a very beautifully marked spider, and often grows to a large size. Its web, too, is the handsomest of which we have any instance in this country, and its manners are very interesting. In addition to these circumstances, it has the advantage of being easily studied; and it is so abundant in gardens in the more warm and fertile districts, that attention to its manners and modes of proceeding would, in the latter summer and autumnal months, give much additional interest to a walk in the garden.

Our garden spider is but a dwarf compared with some of the foreign species; and though its web is very strong in comparison with that of the house spider, and of many other smaller species, it is a mere cobweb in comparison with those formed by some of those foreign species, in particular by *Epeira clavipes*, or the pincer-clawed spider of the West Indies. The web of the last mentioned one is sufficiently strong for entangling humming-birds, and other small birds; though it is exceedingly doubtful whether this, or even the larger species of tropical America, *Mygale avicularia*, prey upon birds, even the smallest humming-birds. Indeed, from the boldness and the pugnacious disposition of those beautiful little creatures, they are much more likely to prey upon the mygale, than it is to prey upon them.

The hooked mandibles with which the garden spider kills its prey are large, sharp, and powerful; but still they are not able to penetrate the covering of even a hard-crusted fly, unless the spider has time to select a vulnerable part of the body. We have placed a common blue-bottle, or flesh-fly, on the web, so that it should be entangled; and the spider, if only a small one, has run off, in the same manner as it would do from a larger individual of its own species. Those curious spiders have a singular delicacy of feeling; and though ignorant persons have affected to ridicule the opinion, there is no doubt that, making allowances for poetical warmth of expression, this sort of spider at least

"Lives in each thread, and feels along the line;"

for in every case where the web is agitated by anything alighting on it and adhering, the spider instantly comes to the spot, or at all events tries the weight of whatever is in the web. If that weight is greater than its own, it retreats rather than advances; for these spiders are terrible cannibals, and, as the larger one is always the more powerful, they appear to have an instinctive feeling, that if anything heavier than themselves comes on the web, it is one of their own species, under the fangs of which they would certainly perish.

When the webs are near to each other, which they very often are in shrubby places where there are many flies, it is not unusual to observe one of them going upon a warlike expedition against another. The usual position in which they repose is at the centre of the web, where there is a little platform of the fibrous substance, uniting the stays which support the spiral threads. When the enemy comes to one of those principal stays, which support the web, he tries it with his foot, by putting the one claw across it, and pulling, though the pull is not so much as to cause any vibration of the web at all perceptible to the human eye. But the spider, which is stationed in the middle of the web, feels and understands it perfectly. If the intruder is of lighter weight than the owner of the web, the owner darts like lightning along that stay at which the trial was made ; and if the intruder cannot make his escape in time, his hours are very speedily numbered. On the other hand, if the intruder is weightier, he dashes toward the centre of the web the instant he gives the pull, and the owner escapes along one of the opposite stays. The enemy proceeds directly to the central platform, from which the owner has, generally speaking, made its escape. There he tries all the stays in succession, until he finds out the one at the extremity of which the owner of the web has taken up its position; for the owner does not quit the extremity of at least one of the stays of its web until the case has become desperate; and it generally retreats along a stay which is for a considerable distance clear of the meshes of the web, and above, not under, the principal structure. It remains there, resting its weight upon the leaf, the twig, or whatever else the stay is attached to ; but with the claw of one of its fore-legs upon the stay near its insertion. If the wind, acting on a leaf, favour it, so as to add to the pressure which its claw gives, this will sometimes affect the enemy as if a spider of greater weight were posted at the end of the stay ; and in this case it will turn and make its escape, not to the central platform only, but entirely off the web as speedily as possible. If nothing favours the owner of the web, the enemy advances ; but in the advance he takes care to leave a thread behind him, or rather to spin it as he goes along, in order that he may make it a means of retreat in the event of an " untoward affair." The owner, if on a favourable stay, waits till the enemy is close at hand; and just before he reaches, and when he is clear of all the meshes, the stay is divided by a sudden jerk of the claw, and the enemy and that part of the web are tumbled down.

If the weights are nearly equal, the owner of the web often stays to defend his property, and then comes the tug of war. The mode of fighting is, not by biting with the lateral fangs, but by each one endeavouring to choke or smother the other; and with nearly equal weights, the one which has been best fed, and consequently contains the greatest proportion of that glutinous matter of which the threads are formed, usually obtains the victory. A bite or two may possibly precede the smothering operation; but the moment that one gets the mastery of the other, it suspends it by a small bit of thread, and suddenly applying the spinnerets successively to points along that part of the abdomen of the other in which the spiracles, or breathing-holes, of that other are situated, it twirls it round with great dexterity, by which means a number of threads are wound around it so tightly as effectually to shut up the spiracles; and the moment that this is done, the enemy is subdued. The victor goes on, however, until the vanquished is completely shrouded in a case of web; and then it is usually borne, not to the central platform, but near the extremity of one of the stays, where it is carefully fastened; and if the contest has been a severe one, the victor generally requires to rest for some time before it makes a meal of the vanquished. If the sizes are nearly equal, the contest may be prolonged for two or three minutes; but if they are disproportionate, half a minute, or even a quarter of a minute, will suffice for doing all that we have described.

The cannibal dispositions of those spiders renders their love-making a matter of great caution. Like all the rest of the race, they are single-sexed animals; and to common observation the males and females cannot be distinguished from each other, unless when the latter are distended with eggs. There is no permanent pairing between them; and in their sexual approaches they can have little or no assistance from sight, because their approaches are made during the night, or at all events in the twilight. The stay of the web is tried in this case, as well as in that formerly mentioned; and it is supposed that the trial is always made by the male, but the fact neither is, nor can be, fully ascertained. There is, however, a difference between the trial of the stay as a matter of love and as a matter of war; and the first trial appears to be for the purpose of ascertaining the sex of the owner of the web. If that proves to be the same as the sex of the visiter, the love is instantly turned to war; and it is a retreat, or an advance, according to the weight of the parties. But if this trial answers, there is a mutual approach, though an exceedingly cautious one; and until the pair have actually shaken hands, so to express it, their suspicions of each other are not at an end.

When small flies alight on the webs of these spiders, they are eaten on the spot, because the glutinous matter of the web is sufficient to keep them fast. If, however, a large fly is entangled, the crooked jaws alone are not reckoned sufficient, and it is suffocated in the same manner as one of the spiders suffocates another, by twirling round the body and wrapping up the spiracles by folds of thread. The number of threads which a large spider can give out upon these occasions, and the rapidity with which they are given out, are far greater than one would suppose. The body of the victim is turned round very rapidly by the action of the foot, and the threads are so many that they have the appearance of a little riband coiling round the twirling carcass.

Unless the spider is very large, it does not venture to attack a wasp, or even a blue-bottle ; and indeed the latter appears to be the less manageable prey of the two. We have seen one fairly cased up and suspended by a spider of considerable size ; and we have watched the subsequent part of the process. In doing this, we have heard the sound of the hooked mandibles, scraping against the hard covering of the fly without being able to make any impression ; and we have continued our observation uutil the spider has given up the matter in despair, and cut adrift the unavailable prize.

There seems to be a good deal depending upon the condition in which the spider is, with regard to quantity of the matter of thread, when large prey is entangled in the web ; for we have observed the very same spider at one time seize, wrap up, and devour a large fly with great eagerness ; and at another time cut the very same species of fly from the web, and let it fall to the ground. When a leaf, a bit of straw, or any substance of that kind, is thrown against the web, and made to adhere, the spider does not advance to it with the same eagerness as it does to a fly ; for it seems to have, by means of the motion given to the web, a knowledge of the difference between the mere weight of a dead substance and the struggles of a living one. In a very short time, however, it approaches the substance, fastens a thread to it, cuts it from the web, and holding it aside a little by the thread, drops it to the ground; after which it sets about repairing the injury which the web has sustained.

The structure of the garden spider's web is very neat. The general form of it depends a good deal upon the place; and the size depends a good deal upon the size of the spider. The young ones form very small webs in sheltered places, and content themselves with gnats and other little flies; but the large ones will extend the principal stays of their webs to the length of a good many feet; and they always make them strong in proportion to the length. It is probable, that those main stays are formed during the night, or at least very early in the morning; for one can very rarely see the spiders engaged in making them, even when they are most abundant. In many cases the first thread of them is thrown out at random. It is very light, and constructed with a flocculent and glutinous extremity, by means of which it adheres to whatever it touches; and its lightness carries it in a horizontal direction. There are situations, however, in which accident could not carry the stays to the places to which they are affixed; and, in those cases, the spider must cling to the points to which they are fastened, and carry the end of the thread along with it; but by what means he discovers these points it is impossible to ascertain, for there is no reason to believe that the vision of those spiders reaches to any considerable distance. As the strength of those stays, or main threads, is always in proportion to the length, there is no doubt that they are made by successive applications of additional threads to the first one; and when the principal stays are once fastened, the animal shows considerable ingenuity in choosing that particular space within for the web, which is most in the way of the flies. The web is, for instance, never placed close against a dead wall, but always where there is a current of air, and generally in those places where flies are most frequently seen passing to and fro. This is, of course, a matter of pure instinct, although it is done with far more certainty than we could do it by the assistance of our faculties of reasoning and judgment. We must not wonder at this, however; for all instincts are direct and immediate operations or obediences of laws which God has appointed; and, therefore, they cannot but be far more perfect and unerring than anything which depends on the feeble and limited judgment of human beings; and we may find in those same spiders, humble as they are, and little as we heed them, demonstrations of Almighty power, and lessons of practical wisdom, which would be highly useful to us if we would but study them aright.

The threads of which the webs of these spiders are constructed are very elastic, and can be stretched out and contracted, which renders them much less liable to be injured by the wind than they otherwise would be. When one can get the solar light upon them, in the proper direction, they exhibit a very beautiful play of prismatic colours; and there is little doubt that they are electric. They are not liable to be injured by rain, though the water collects upon them in dew-drops, which often have a very beautiful appearance. The webs remain in autumn and early winter, long after the spiders are gone. In hoar frost they are finely fringed with specula of ice; and when the dew-drops are frozen on them, and the frost continues, they have all the beauty of little strings and festoons of pearls ornamenting the plants. Such are a few particulars respecting the common garden spider, one of the most interesting species which is found in this country; and we shall add a few more respecting the house spider.

Amazing wisdom is displayed in the make of the common spider. She has six teats, each furnished with innumerable holes. The tip of each teat is divided into numberless little prominences, which serve to keep the threads apart at their first exit, till they are hardened by the air. In every teat, threads may come out at above a thousand holes; but they are formed at a considerable distance, each of them having a little sheath, in which it is brought to the hole. In the belly are two little soft bodies, which are the first source of the silk. In shape and transparency they resemble glass beads, and the tip of each goes winding toward the teat. From the root of each bead proceeds another branch much thicker, which also winds towards the same part. In these beads and their branches is contained the matter of which the silk is formed, the body of the bead being a kind of reservoir; the two branching canals proceeding from it.

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

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

There are several species of spiders that fly, and that to a surprising height. "The last October," says an eminent writer, "I took notice that the air was very full of webs. I forthwith mounted to the top of the highest steeple on the Minster [in York], and could thence discern them yet exceeding high above me. Some of the spiders that fell upon the pinnacles I took, and found them to be of a kind which seldom or never enter houses, and cannot be supposed to have taken their flight from the steeple."

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

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

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

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

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

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

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

Another species of spider, very common in the warmer parts of this country, and very interesting in consequence of the singularity of its habitation, is the water spider, (*Argyroneta aquatica*). It inhabits slow-running fresh waters, but not such as stagnate and are liable to become putrid; and in such waters, in the vicinity of London especially, its nest may be seen at any time during the summer, and it is a very beautiful object. It is a little sack or nest, composed of meshes of fine thread, of the same consistency as an ordinary spider's web, with the threads rather close, but not in absolute contact with each other. Those threads are of such a nature that they strongly repel the water, and the interior is filled with air, so that the spider, which breathes air and not water, lives in it something after the same fashion in which men live under water in a diving-bell—an engine now very usefully employed in building the walls of harbours, the piers of bridges, and the foundations of other structures which have to be laid in the water, and which could not be so easily or so well made without the assistance of the bell.

The spider, however, has many advantages over man in its bell; for the bell in which man works must be solid, so as to exclude the water; whereas that of the spider has a sufficiently repellant power for preventing the water from entering the threads; and thus the inhabitant enjoys nearly as much light as it would enjoy if it were on the land. The supply of air, which requires to be constantly kept up, is a curious part in the economy of the creature; and it is not a little remarkable that it seems to be brought about by the very same power which excludes the water from the nest. This spider does not come up to the surface every time that it requires to breathe, as is the case with most air-breathing animals which inhabit and find their food under the water; it comes to the surface, elevates its abdomen, and discharges a little portion of the repellant fluid of which its nest is formed. This repellant force causes the water to retire from the under part of the abdomen, and the air of course occupies its place, so that when the spider descends, it carries with it a bubble of air; and in this way it fills the nest at the beginning, and keeps up a supply as the air which is there is deprived of its oxygen, and thereby rendered unfit for the purpose of respiration. The nest is attached to some aquatic plants, or sometimes to a stone. It is of an oval or hemispherical shape, and the opening is on the under part. In constructing the nest, it is begun at the top, and, as the spider works downward, it fetches from the surface a sufficient quantity of air to fill the portion which it has constructed. How the nitrogen of the air, which is lighter than oxygen, and also than the air in its entire state, is removed from the nest, it is not easy to say, for the whole economy of the animal is beyond our chemistry; but that it has some power of this kind cannot be doubted; and as the substance of the nest by which the water is repelled is simply a material substance not possessed of any life, it would be well worth while, if possible, to analyse it, and see of what substance it is composed; because the discovery of a repellant substance under water would be a very useful one in the arts.

This spider is an insect feeder, as well as other spiders; but it belongs rather to the class of hunting spiders than to that of snaring ones. It issues from its nest in search of water insects, carrying under its abdomen a bubble of air for the purpose of respiration; and in this way it contrives not only to find its own food, but to accumulate a store for its young, which serves them until they are able to follow its example, and provide for themselves. It incloses its eggs in a little silken bag, within the nest, and lodges beside them a number of water insects and larvæ; and then its last labour is closing up the aperture of the nest, after which it resigns itself to the common fate of all animated beings, at least such is the account given of the termination of its labours. Under water, the nest has a very handsome appearance; because the sides of the space containing the air reflect light of a bright silvery or pearly appearance. Their colour is blackish brown, with four black spots on the back, and an oblong spot of larger size in the middle of them. The male differs a little from the female. It has the abdomen considerably elongated, and curved at the extremity; the feet also are longer, and the size is rather larger than that of the female.

Another very singular section of this class of invertebrated animals are the *Acari*, or mites, which are of very small dimensions, but very numerous, and in some instances not a little annoying. One is the common cheese-mite (*A. domesticus*), familiar to every one. These inhabit houses, feeding upon cheese, and also on the farina of vegetables, but never till these have been long kept, which seems to be the state favourable for hatching the eggs of these curious little creatures. To the naked eye they appear to be nothing else than particles of the substance in which they are generated, in a state of motion; but when a microscope of considerable power is applied to them, they are seen to be animals very perfectly formed, with small heads in proportion to the size of their bodies, claws at the extremities of their legs, and reflected hair on the surface of their bodies. By means of their claws, they can adhere very firmly to those substances which they inhabit; while their small size, and the hairs on their bodies, enable them to make their way through very minute openings.

They are oviparous; and the eggs, which are very numerous, are of so very small a size, that the shell of a pigeon's egg would hold as many of them as there are human beings in Europe. The hatching of those eggs is left entirely to the action of the weather; and the time necessary for bringing them to maturity varies greatly with the temperature. In summer it takes rather less than two weeks; but it lasts much longer in winter; and when the temperature is very low, they are not hatched at all, though it does not appear that they are destroyed even by the severest cold. From their minute size, they are found in almost every place—on the bodies of animals, on plants, and on every kind of substance; though of course it is only upon substances, and in circumstances suited to their nature, that they make their appearance in the living state. A certain degree of putrefaction, and that chiefly of animal matter, appears to be that which is most favourable for them. We may thus view them as formed to remove corrupt matter from situations to which larger animals could not find access; and thus, small as they are, they are not without their use in the great system of nature, nor is the display of created power in them less wonderful, and less worthy of admiration, than it is in the elephant or the whale.

There are many species of them besides the common cheese-mite, and some of these are very troublesome to the larger animals, while others render diseases, which are loathsome enough in themselves, still more loathsome. The itch, which is but too common where living is poor and cleanliness neglected, is always attended by a species of *acarus;* and there have been some instances of these minute creatures breeding in the skin of all parts of the human body, and slowly consuming the flesh off the bones, thus subjecting the sufferer to death in the most dreadful form that the mind can picture to itself.

It is not to be understood that those little parasites are the originators of the disease; but their appearance shows that there is a diseased state of the body which favours the hatching of their eggs, of which there is of course a number previously existing on the skin; and when once these eggs have become quickened, the colony rapidly increases; and, by the irritation which they occasion, spread and prolong the disease, and very probably assist in the communication of it by infection. Even in these cases, however, and the yet more horrible ones which are occasioned by true insects, there is still goodness apparent, notwithstanding the miserable condition of the sufferers —there cannot be a more forcible inducement to cleanliness than the danger of its neglect bringing on such fearful calamities as those which we have mentioned; and though the subject is an obscure one, it is highly probable that the more grievous of these calamities have always been brought on the unhappy sufferers by some misconduct of their own.

Indeed, it seems that these creatures, small as they are, are appointed, in some one or other of their species, to watch over every living creature; for, in one or other of their own numerous varieties, they are met with upon all—from the elephant down to bees and beetles—until the size is so minute that the animal on which they live is barely visible. The eagle, in her pride of flight, is not exempted from them, and the powerful weapons with which the lion is armed are no defence against those small foes. To many of our beetles they are particularly tormenting; and one may often see some of the larger ones, with all the under parts of the body and all the joints, covered over with these little tormentors, so that the beetle is unable to walk, but lies writhing apparently in the greatest agony. Bees, especially the larger humble-bee, are very subject to their attacks; and a curious part of the instinct of this kind of bee was observed by a collector of insects. He had sat down on a bank to rest and refresh himself; and very shortly he observed a humble-bee alight near him, and begin to beat and scratch with its feet, and make a buzzing sound with its wings. It had alighted on an ant-hill; but, as the sun was under a cloud, the ants were not abroad. Ants are, however, very watchful creatures, and instantly come forth to attack any one who attempts to batter their stronghold. The disturbance produced by the humble-bee immediately brought them out in numbers around it. The observer watched them, and found that the bee was perfectly loaded with *acari*, which the ants set upon, and devoured on the spot, or carried to the interior of their hill. As this operation went on, the bee gradually became more tranquil, and apparently much more at its ease; and after a little time it rose on buoyant wing and flew off, humming its song of gratitude to its singular deliverers.

This is a very remarkable case of instinct—as much so, perhaps, as any which is to be met with among the most perfectly developed of the vertebrated animals. One can hardly imagine that the bee would have alighted on the ant-hill if it had not had some instinctive perception of relief to be obtained there. This is rendered still more probable by the fact of the bee performing that kind of operation which was sure to call out the ants, and also by its submitting to their running about and upon it, and clearing away its tormentors. The common garden-ants may be often seen performing similar operations to beetles—to the common dung-beetle in the early part of the season; and to the golden-green beetle when the season is further advanced.

Most of those parasites adhere by means of their claws, and make their attacks by the mouth; but there are some of them which appear to draw their nourishment by means of a little tube or stalk at the opposite extremity of their bodies. Thus appearing as if they were rooted in the animal on which they feed; and when this is the case, they are very often found adhering to each other. Altogether they are a very singular section of animated nature; and their vast numbers so far make up for their diminutive size, as to enable them to perform no unimportant part in the grand system of the living world.

The only animal of this class which our limits will permit us to notice is the *Scorpion*, which has long been notorious for its venomous quality, though the reality does not nearly come up to the written accounts. As it exists in the warmer parts of Europe—for it is not found in the temperate or the cold—the sting of the scorpion is not mortal, or, generally speaking, very dangerous; but we believe that some of the tropical species are more serious; these, however, differ from the European scorpion in some parts of their organization. That species is about an inch in length, with the body of a deep blackish brown, and the tail, which is yellowish brown, not quite so long as the body. The feet are yellowish. The pincer claws are really the palpi: and, considering the diminutive size of the animal, they are very formidable prehensile weapons. The last joint of the tail is also armed with an envenomed sting, the poison of which, though not, as we have said, mortal, or very dangerous, causes a great deal of pain. The tail consists of six annuli, or joints, the last of which carries the sting. The abdomen is closely united to the thorax, and furnished with four breathing-holes on each side. It is furnished with six eyes; and the pincer palpi, which are never used as feet in walking, are large in proportion to the true feet. One very remarkable character of all the scorpion family is, that the organs of reproduction are double in both sexes, so that, in this respect, each one, though of one sex only, is a sort of two animals, while in every other respect it is only one.

The scorpion is a very strong and formidable-looking creature in proportion to its size. The covering of its body is firm, and all its muscles lie straight between their points of insertion, so that they have the maximum effect in proportion to their quantity of matter. When it moves about, its attitude is peculiar; the prehensile palpi are carried advanced and elevated, with the pincers open; and the tail is bent forwards over the back, until the joint carrying the sting is as far forward as the head. Its motion is rather rapid; and it deals destruction to a number of small animals which inhabit the ground. It is not found to the northward of the forty-fourth degree of latitude; and it is most abundant among rubbish, and about ruins in dry places.

There are few animals of which the history has been more mixed up with fable than this one; for it is very generally taken as a sort of type of mischief. No doubt it is mischievous enough for its size and strength, and its strength is great in proportion to its size; but there is nothing about it to entitle it to rank as a formidable animal. As little is there any truth in the alleged story of its killing itself by the puncture of its own sting, when surrounded by fire; though it no doubt, under such circumstances, naturally throws its body and tail into that posture which it uses both for attack and for defence.

Class IV.—Insects. Numerous as are some of the other classes of invertebrated animals, the insects, properly so called, are perhaps the most numerous of the whole. At all events they are the ones that are most open to our observation; and in many respects their economy is far more curious than that of any of the others. Their modes of action are more varied than the others'; and they inhabit all countries, and almost every place in all countries. Many are in the waters; not a few are under ground, or at least in concealment, and never visit the light of day. There is hardly a plant which is without its insect inhabitant; every plant has often its peculiar species, and not only so, but a distinct species often inhabits every different part of the plant; as for instance, in a fruit-tree, there may be one kind which gnaws the bud, another which destroys the blossom, a third which bores into the wood, a fourth which attacks the roots, and a fifth which preys upon the fruit; and each of these may be confined to that one species of tree, and never found on any other.

With the exception of a few genera, which consist of a great number of rings, and have feet equally numerous, insects in their mature or perfect state are made up of three distinct parts: the head, which carries the antennæ, or feelers, as they are sometimes called, and also the eyes and the mouth; the thorax, or corslet, to which the feet are attached, and also the wings in all those species which are furnished with these appendages; and the abdomen, which is attached to the hind part of the thorax, often by a very slender peduncle, and contains the principal viscera.

Winged insects do not receive their wings till a certain stage of their existence; and those which are without wings also pass through some changes of form or of covering before they arrive at maturity. All insects, without exception, are produced from eggs; and the females evince many singular instincts in placing those eggs in favourable situations; and not a few of them are furnished with very curious apparatus, by the help of which this operation is performed. There are also other races in which the utmost solicitude is shown in taking care of the eggs, and nursing and feeding the young; and it is not unworthy of remark, that, in many which have this habit, the nursing is performed by undeveloped females, or by indviduals which are, strictly speaking, of no sex whatever, while the real mothers of these nurslings pay them no attention.

Before, however, we enter further into the economy of these animals, it may be necessary to explain, at a little greater length, the peculiarities of their structure ; because this is essentially necessary to the ready understanding of the other.

The proper division then, as affording characters, is into a head, a body, and members. The functions of the head, or the parts which it carries, have been already noticed. The head is variously articulated on the trunk, but always by one or more tubercles of the head, which move in corresponding cavities of the trunk. There are some instances, however, in which the connexion is formed by the application of one flat surface to another, and in this the joint admits of very little motion. In other articulations, there are two tubercles placed laterally ; and this articulation admits of the head being raised and depressed, but not of any motion from side to side. The third form is a single tubercle ; and this admits of more varied motion. These articulations are all in the crust, or external covering, and in the upper part of it, so that the occiputal foramen, or hole, is not interrupted by the motion of the joint. The muscles by which this joint is put in motion are inserted on the inside of the covering of the head, and have their other extremity in the opposite side of the trunk, so that they cross each other internally. The largest ones are those which depress the head ; and they are inserted in the upper part of the head and lower part of the trunk : those which elevate the head are inserted the opposite way ; and those which move the head laterally are inserted in the side of the trunk to which the head is moved, and in the opposite side of the head. This arrangement gives the muscle the utmost advantage which it can possess ; and we may remark once for all, that the muscles which give motion to any joint in an insect are all arranged in a similar manner, so that there is no need for loading the working structure with tendons or ligaments, neither is there any waste of power by bringing tendons over joints, or through pullies, as is often necessary in the external muscles of vertebrated animals. An insect is thus a far more perfect specimen of mechanical construction, in so far as the proportion of effect to power is concerned, than the vertebrated animal, and this is the reason why insects can be almost incessantly in motion without appearing to be in the least fatigued. The strength of an insect is proportional to the power of its muscles, and the firmness of the covering in which those muscles are inserted, taken jointly.

The head may be considered as forming one ring, and the trunk as being composed of the first and second; the second only is the thorax, and the third the breast, but these two are often so closely united as to appear but one piece. On its under side, the thorax bears the fore, or first pair of legs, and between their insertions there is generally a keel, or sternal elevation, often terminating behind in a spinous process. This part of the body may be considered as the general fulcrum, or fixed part, upon which all the motions of the body are produced,—those of the head anterior of it, and those of the breast and abdomen posterior of it; so that when the body admits of much motion, it is moved upon the thorax; and the thorax is the portion to which the first pair of legs are attached, so that those legs are the true supports for rest, and they may remain at rest, and afford a steady fulcrum to a great number of motions in all the other parts.

The breast is not always closely united to the thorax, but often appears to be more immediately joined with the abdomen. On the under part it has the middle and hind pairs of legs inserted on it; and the wings, in such as have wings, on the upper part; so that when an insect floats or hovers on the wing, it has complete command of the head, thorax, and fore legs, as well as of the abdomen; and thus it can use these, or any of them, for such offices as may be requisite, while the wings buoy it up, or enable it to shift from place to place. This double trunk, one carrying the head and fore legs, and the other the remaining legs and the wings, is necessary in order to give proper action to animals which have not flexible spinal columns; and though it does not admit of so perfect and numerous motions as spines of the mammalia, it is far superior in the case of animals which are to have equal use of their wings and feet, than the half-flexible spine in birds; which latter, if their habit be chiefly confined to running, as it is in the ostrich family, have very imperfect wings; or if it is chiefly confined to flight, as in the swallow tribe, the feet are very inefficient for walking. The winged insect has more incessant and varied labours to perform than either the running or flying birds, and this double structure of the trunk adapts it admirably for both.

The abdomen consists of a variable number of rings, which are united in some species by a simple adhesion of the margins; and in other cases the posterior margin of each overlays the anterior margin of the one behind it. When the unions are of this structure, there is generally some motion in the different rings, produced by muscles inserted in the two adjoining ones; but when the abdomen is closely united to the breast, there is usually but little motion in the different rings; while in those species which have the two united by a slender peduncle, the particular motions of the parts of the abdomen are often very considerable. This last provision is necessary in many of the species; because, in a very great number of insects, the extremity of the abdomen has important functions to perform.

The members of insects, as distinguished from the head and body, consist of two kinds, legs and wings; and in some species generally, and in others in certain stages of their existence, there are other appendages which partially serve as fins in the water, or as parachutes in the air.

All true insects have six legs in their perfect state; one pair inserted in the thorax, and two pairs on the breast, as already mentioned. The leg consists of five distinct parts or articulations: the hip (*coxa*), the thigh (*femur*), the leg (*tibia*), the foot (*tarsus*), and the claw (*unguis*). In all the species the hip has comparatively little motion, but rather serves to give an extent of base, so that, by the wide spreading of its feet, the animal may stand firmly. In the hind legs, which often have to bear a considerable portion of the weight, the hip divisions are often consolidated with the breast, so as to have no distinct or proper motion at all. The thighs have seldom any other than a motion parallel to the mesial plane, as in the case of those mammalia which have no collar-bones. When those members are long and slender, the action of the legs is confined to walking or running; but when the creatures have to leap or swim, the thighs are very much thicker and shorter, and swelled out at the middle in order to give room and play for muscles of great power; and the distance which many insects are capable of leaping is almost as great in proportion to their length, as if an elephant were to leap a mile—such is the advantage of their peculiar structure, and such the bountiful provision which the Creator has made for little creatures that have severe tasks to perform.

The leg is always so articulated to the thigh, as to admit of motion in one plane only, which is necessary to keep the body of the animal steady; and the form of this part varies according as the principal use of the feet is walking, or swimming, or digging in the ground. If they merely walk, its form is simple; if they swim, it is long and flattened, and often margined on the outer edge; and in those which dig, it is very strong, and generally toothed at the outer margin.

The foot, which consists of the body of the foot and also the toe, is composed of several jointed pieces, which have more free motions than the joints of the leg; and those parts which are applied to surfaces along which the creatures walk, very often perpendicularly, or with the back undermost, with apparently little less facility than when they walk on level ground, are furnished with pads or cushions, similar to those which are met with on the feet of birds and mammalia, which preserve their claws for other purposes. It has sometimes been supposed that those pads are real suckers, which the insects apply in such a manner as to exclude the air, and enable them to retain their hold by atmospheric pressure. This, however, has not been proved in any one instance; and both the reason of the case, and observation, as far as that can be carried, are against the probability.

We are acquainted with no animal of sufficient size for being easily examined, which possesses articulated legs and suckers; and when a sucker is made use of in motion, as it is in the case of the leech tribe, it is always used for holding on until the body is advanced from it, if it is the hinder sucker, or drawn towards it if it is the fore one. It appears, too, that these insects whose habit it is to walk upon substances against which, from their flocculent nature, a vacuum could not be produced, and a sucker could not operate, can move in all directions with as much facility as those which move on the most solid substances. Indeed, the observation is against the use of the sucker altogether, for in proportion as the surface is smooth, and better adapted for the application of a sucker, it is less fitted for the feet of an insect; and thus glass traps are made use of for catching many species of insects. It is probable that the adhesion is generally, if not always, made by means of the claw. This claw is sometimes double, and sometimes single, but acting against a tubercle; as we find to be the case in various climbing mammalia, which have not thumbs against which the fingers can act. From the way in which the feet of an insect are spread out, it is highly probable that the claw of one foot acts against that of the opposite foot; and the way in which the joints of the feet are bent, gives reason to believe that this is the case.

The other members of insects are wings, of which there are many varieties; and as these are very conspicuous parts, they are selected as the characters according to which the animals are classed. A single class are without any wings, either on the males or on the females, at any one stage of their existence; and these are called *apterous* insects, which simply means that they are "without wings."

Another class have two wings, one of course on each side of the body; and articulated to the upper or dorsal part of the breast, or third ring, as has been already said. These are called *dipterous* insects, which simply means that they are insects having "two wings." In most of these dipterous insects there are lateral appendages, one on each side, under or behind the rings; these appendages consist of a little stalk, with a small knob on the end of it. They have been termed *halteres*, or "poisers;" but what purpose they answer is not very clearly known. It is probable, however, that they are in some way or other connected with the action of the wings, from their close juxta-position with these organs. They are not confined to dipterous insects; for they occur in some of the four-winged ones, such as the plunger, water-beetle, (*Dytiscas marginalis*); but we believe they are found only upon a few of the coleopterous insects, or those which have their wings of flight covered with hard cases, or *elytra*, when they are in a state of repose; so that in these also, they may serve as balances, and assist the animals in ascending or descending, when they are on the wing.

By far the greater number of insects are, however, possessed of four wings, all adapted for flight. Those wings are very various in their texture and appearance, so that they afford a foundation for dividing winged insects into classes, and the habits of the insects agree tolerably well with this ground of arrangement. The wings for flight are capable of exceedingly rapid motion; and it should seem that the two wings on each side supply the place of the successive articulations, and the twisting motions possessed by the wings of birds, and also give those directions upwards or downwards for which the tails of birds are more especially fitted. In the wing of an insect there is no apparent joint useful in flight, except the one by which the wing is attached to the breast. In those which do not fold the wings when in a state of rest, the wing may be considered as partaking more of the character of a single feather than of that of a bird's wing; and when the wings are folded up, as they are in most of the species which have elytra, the wings themselves are simple membranes, extended on a framework of elastic fibres, which are most incorrectly called *nerves*: there is fully as much resemblance to the flying membranes of bats, as to the wings of birds. Elytra never have any motion at all calculated for assisting in flight, they merely admit of being opened and shut; and there is every reason to believe that their principal use is the protection of the wings from external injuries; for the species which have them strongest, are those which burrow in the ground, or are otherwise exposed to frequent contact with rough and hard substances.

In the senses of sight and of touch, it is understood that insects are much more acute than crustacea: but that they possess other localized senses is not very well made out; neither is it ascertained that their general sense is of the same kind with that which we call touch. Indeed, the distances to which many of them find their way, and the places where they take up their habitation, or seek their food, are very often managed in a manner which to us seems perfectly unaccountable. Thus bees return to their nests or hives from long distances, in perfectly straight lines, though they fly at such a height and with so much rapidity that it is impossible for us to suppose that they can be guided by any kind of observation or perception at all analogous to that which is possessed by us. That the portion contained in the head of insects is the most sentient part of them we have reason to believe, because the largest ganglion of the nervous mass is seated in the head, just above the entrance of the gullet; but still, true to the general structure of invertebrated animals, this principal nervous mass is more connected with the gullet, and consequently with the system of nutrition, than with any other.

The alimentary system is worthy of a great deal of attention, on account of the endless variety of substances on which they feed, and of places in which they find those substances. The parts of their mouths are more complicated than the same parts of vertebrated animals. They have no appropriated English names; because our English names are all derived from the feeding organs of vertebrated animals; and therefore, in order to have some means of distinguishing those parts, when endeavouring to trace their forms, and observe the purposes for which they are used, we have no alternative but to make use of learned terms. There are four of these in the mouth of a perfect insect, namely, the *labrum*, the *mandibulæ*, the *maxillæ*, and the *labium*. The *labrum* is a sort of upper lip, which is articulated to the front part of the head, and its free edge extends downwards and covers the other parts of the mouth. The *mandibulæ* are two in number, articulated one on each side, just below the labrum; and they are variously formed and armed according to the use which is made of them. They answer for wounding, tearing, gnawing, cutting, and almost every purpose to which we can imagine two instruments acting together like the blades of a pair of pincers or scissors to be applied; and their action is often remarkably powerful in proportion to the size of the animals. The *maxillæ* are situated under the mandibles, and they are more complicated than these, being usually furnished with hairs on the inner surfaces, apparently for the purpose of preventing those substances which the mandibles divide or seize from falling away from the mouth; and they are often furnished on their external surfaces with palpi, which are possibly organs of sense; but the fact has not been and probably cannot be ascertained. The *labium* is a sort of under lip, corresponding to the labrum as an upper one; and sometimes there is an additional plate of hard matter at the posterior edge of each, the upper one being considered as a sort of nose, and the under one as a sort of chin; but they have no resemblance whatever to those parts of vertebrated animals. When these several parts of the mouth are formed of hard matter, and duly proportioned to each other, so that the insect can divide and prepare for the gullet solid substances, the apparatus altogether is considered as the most perfect form of an insect's mouth; but there are great differences of structure, more especially in the labium. In those insects which feed upon liquids only, the labium is formed into a sucker; and the sucker is of a different construction, according as the insect is destined to feed upon liquids which are ready prepared and free to it, or on those to which it must itself make an opening before it can reach them. The simple sucker is soft and membranous, as in the butterflies; when not in use it is rolled up spirally; and it is called the proboscis and sometimes the tongue. If the insect must open a passage for itself, as in those which suck the blood of animals and other juices, a different structure is required. In these the mandibles and maxillæ are converted into four plates; and in some forms of them the labrum and mandibles are nearly wanting: and so applied to each other as to form a sucker. These, which have crustaceous or horny points to the sucker, puncture the skins of animals with it, and often occasion a good deal of pain; but the varieties of this part of the insect are so many, that no general description can be framed which will apply to them all. Bees, and other races which have a sort of intermediate style of feeding, by scraping or licking up liquid substances, have the labium flat and soft, and something like a tongue.

In the internal organs of these animals, that best developed is generally the stomach. In all cases it is furnished with muscles; and in some it is a true gizzard, furnished with a sort of teeth on its inner surface. Neither heart nor distinct blood-vessels can be clearly traced in any of the insects; but there is a sort of dorsal vessel, which seems in a slight degree to answer the purposes of a heart. The lacteals connected with the intestines do not proceed in distinct lines; but the nutriment appears to be discharged through the walls of the intestinal canals into the general cavity of the body. It is here that it receives the necessary action of the air, from the tracheæ, or breathing tubes, which pervade all that part of the cavity which contains the viscera. There is a slight resemblance in this to the system in birds, whose blood in part receives the action of the air from cells and tubes; but the blood of birds is prepared by regular vessels, and circulated by a double heart.

The reproduction of insects is as singular as their structure. They are all single-sexed animals, with the males and females perfectly distinct. In all cases the impregnation is internal; and, generally speaking, it only suffices for a single race; but there are some species in which several races of females succeed each other in the course of the summer without any males among them; and these are often, indeed generally, viviparous, that is, the eggs are retained internally, until the young ones are hatched. In many of the *aphides*, or plant lice, which are such pests upon roses, cherries, and various other trees, this impregnation has been observed to continue through nine successive generations, and no males to make their appearance till the tenth.

In general, however, males and females appear in every successive generation, whether the duration of that generation be longer or shorter; but in many races the number of females is very small in proportion to that of the males,—one being sufficient for keeping up the numbers of a vast colony.

All insects are, as we have said, produced from eggs, whether those eggs are hatched externally or internally; and all of them go through certain changes in the covering, and in most cases in the form, of their bodies, to which there is nothing analogous in the rest of living nature. Of the wingless tribes, indeed, there are some which have only repeated castings of the skin, resembling some of those in the animals formerly noticed ; and where this is the case, the young animals are smaller in size than the mature ones ; but similar in shape and in habits. Some of the winged species too have rudimental wings from the first, and though those wings approach nearer and nearer to perfection at the repeated castings of the skin, the immature young, though unable to fly, have otherwise the same habits as their parents.

A very great number, however, make their first appearance as caterpillars or grubs, which have six true feet on the anterior part of their bodies ; and a greater or smaller number of spurious or temporary ones upon the posterior part. The technical name given to these is larvæ ; and it is in this state that insects are so very destructive of vegetable substances, though it is possible that a diseased state of the vegetables may, in all cases, precede their ravages ; and that this disease might, in many instances, be more destructive of vegetation, in a state of nature, than those larvæ are, though their depredations are very often most vexatious to man when practising the art of cultivation. We are, therefore, not warranted in concluding that even the most destructive of these creatures are natural evils. No one is justified in saying that there is any such thing in nature as an evil, unless in so far as it arises from our own ignorance and mismanagement. There is a proof of this in the fact, that the wild forests, and other collections of wild plants, in countries where man does not cultivate the ground, are quite as healthy, and generally more durable. All those caterpillars, in what situation soever they may be placed, are very voracious; and this is the case with many species which do not eat, and in fact are not provided with any organs for that purpose, during the very short time that they exist in the mature or winged state; and many which do eat in both states, do it by means of very different organs, such, for instance, as being furnished with hard and strong jaws for gnawing, while they are larvæ; and with simple suckers, after they have become perfect insects. In consequence of their voracity, such of those larvæ as are placed advantageously, very speedily become fat, too much so for the size of their skins; when this takes place, a new skin forms under the old one, and the old one is cast off. This operation is repeated a greater or smaller number of times according to the species; and the larvæ at its full growth is often very considerably larger than the complete insect, which is never the case in the young of animals which do not undergo transformation.

At last, however, a stage comes at which the larva is to grow no longer, and then it passes into the state of a pupa, in which state its appearance and habits vary according to the degree of transformation. If that is not great, and if the habits of the larva resemble those of the perfect insect, then the pupa is vigorous and continues to eat and move about; but if the change is complete, such as that of a crawling caterpillar into a winged butterfly, then the pupa continues for some time in a state of inactivity, shut up in a leathery case; in an envelope or, as it is called, a *cocoon*, of silken tissue, generally of much beauty, and sometimes of great strength, as happens in the case of the common silk-worm ; or in a cell in which it has been inclosed, but which it generally lines with a silken tissue, previous to undergoing the dormancy of its transformation. The different modes in which these take place, and the slight shade by which the one form of transformation passes into the other, are very numerous ; but besides the beautiful instances of design and contrivance which the whole afford, and the great usefulness of some of them to man, there are found in them, when we compare them with each other, various hints, well calculated for keeping us right in our reasonings and judgments respecting their economy.

Thus, for instance, these different degrees of time and labour, so to speak, which the transformation requires, being in proportion to the extent of the transformation itself, we have a very clear proof that the common notion of all the states of the insect being cased up, the one within the other, from the beginning, is not true ; but that, during each state, the egg, the larva, the pupa, or the perfect insect, is just itself and nothing else : and though, to those who do not reflect very much, this may seem a matter of small importance, it is not so in truth ; for if we do not suppose that the change takes place during the time that it apparently does so, and that the larva is simply a caterpillar, just as the perfect insect is simply an insect, then we entangle ourselves in the very common error of the materiality of the principle of life, as well as of the matter which composes the body of the living creature, and which remains the same to every test of matter after the life is extinct ; and when we once do this it is exceedingly difficult to refrain from a sceptical disposition regarding the spiritual nature of the soul of man, and even that of the Almighty author of life.

We shall now very briefly mention the different orders into which this innumerable multitude is usually arranged. These are twelve in number.

1. *Myriapoda*, or "many feet." These creatures are sometimes also called *centipedes*. They never have any wings, their abdomen is never distinct from the trunk, and they are generally provided with more than six feet, which is not the case with any others of the class. They live on the ground, lurking under stones; and some of them, known popularly by the name of scolopendra, and inhabiting the warmer countries, where they grow to a considerable size, are very much dreaded by the inhabitants, in consequence of the venomous nature of their bite. Some of them are phosphorescent, or have the property of giving out light in the dark, though for what purpose is not known.

2. *Thysanoura*. The animals of this order have only six feet; and they undergo no transformation. Their common legs are adapted for walking, but not so much for leaping. They however perform the last operation by means of appendages attached to the posterior extremity of the abdomen. Some of them live in houses, and are very frequently found in books when damp; others live upon trees; others, again, on the surface of stagnant water, which they sometimes cover in such multitudes, that it has the appearance of being strewed over with floating gunpowder. They are not animals of very much interest, in the way either of good or of harm.

3. *Parasita*, "parasites." These live, as their name implies, on the bodies of other animals; and

they are even more noxious and annoying than the acari, to which we alluded in a former part of this chapter; they are known by the general name of lice, though the name is not a very happy one, inasmuch as it is applied also to the acari, the aphides, and to some other races. It is very seldom that any one species of this order quits the particular animal upon which it is parasitical, in order to infest an animal of a different genus; but to those which they do inhabit they are perhaps more troublesome than the acari. They are found chiefly on the warm-blooded animals; and they extract the blood and juices by means either of a sucker, or of two lips with hooked mandibles, which retain their hold; and they also hold firmly with the claws on the extremities of their feet. The body is flattened, almost transparent, and divided into eleven or twelve segments; they cling very firmly to the hairs of mammalia and the feathers of birds, to which they attach their eggs so firmly that they cannot easily be removed. Several species are often found inhabiting different parts of the body of the same animal; but none of the race, properly so called, upon vegetable substances. One species is understood sometimes to breed generally under the skin of the human body, and to keep issuing from it in immense numbers, thus occasioning the most loathsome state that can well be imagined; and one of the worst circumstances of it is said to be, that while it is perfectly incurable, the miserable patient may continue under the burden of it for many years, without any very great falling off of the general health.

4. *Suctoria*, "suckers." These are, perhaps, not so tormenting in their attacks as the last-men-

tioned order; but they are, generally speaking, more painful. Their mouth is formed of three pieces, inclosed between two laminæ, which form a cylindrical tube, and furnished at the point with two sharp scales, with which they readily penetrate the skin of animals and suck their blood. Taken altogether, they form only one genus, known popularly by the name of fleas; but there are numerous species inhabiting the bodies of different animals, and they are much more disposed to pass from one animal to another than those of the last order.

The body of this animal is formed for leaping or for other rapid motions. It is oval, compressed laterally, and invested with a very firm skin, which is composed of twelve rings or segments, of which there are three in the trunk and four in the abdomen. The head is of small size, very strongly compressed, rounded above, blunt anteriorly, and furnished with a small round eye on each side. The legs are particularly strong, especially the coxa and femur, which are thicker in proportion than in almost any other animal. The tarsus is composed of five joints, the last of which is furnished with two long hooks. The fore legs are placed so far forwards that they have the appearance of being appendages to the head; and it is by means of their acting with the tarsi in advance, and of the others acting with the tarsi towards the rear, that the animal is enabled to take such prodigious leaps in proportion to its size. The position of the joints also greatly facilitates this operation; for they are so much bent in contrary directions, that the action of the muscles nearly doubles their length in an instant; and it is this sudden stretching of the legs which gives such impetus to the body of the animal, making it appear to start off, not by one single effort in leaping, but as if it were actually possessed of wings. All insects which are remarkable for power in leaping, have the legs bent, in a manner something similar, previous to taking their spring; and the same thing holds in leaping mammalia, and in hopping birds, though neither of them is possessed of so much energy.

Fleas differ from the other apterous or wingless insects, in undergoing a pretty complete transformation. The eggs are about a dozen in each hatch, and they are white and slightly viscid, which makes them adhere to substances. When the larvæ make their appearance, their bodies are very long, and shaped like small but very active worms, which are continually crawling about by a sort of twisting or serpentine motion. They have no feet and no visible eyes, but their head is covered with scales, and there are some projecting appendages near the mouth, which answer to rudiments of the large legs, and help them to wriggle forwards, in which operation a few tufts of hair on the rings of the body, and hooks at its extremity, also assist. They remain in the state of larvæ for about twelve days; and then they inclose themselves in cocoons of silky texture, from which they come out perfect animals in about twelve days more.

As is the case with all animals, the study of these is both curious and instructive; and they are not unfrequently made use of as microscopic objects; but still there is something repulsive about them; though the active motion of the flea renders it less so than the other. Like the acari, they have their use; for they are never found except in situations where there is some want of attention to cleanliness; and thus they compel those animals which they infest, to have recourse to washing, dusting themselves with dry mould, and performing other operations which tend greatly to a healthy state of the skin. The higher the temperature of the animal, the more it is subject to annoyance from these parasites; and as high-temperatured animals are those in which the skin has the greatest action, and is, in consequence, the most subject to be loaded with the matter of perspiration and other refuse, such animals stand most in need of the warnings of these little monitors.

In the case of man, the two orders last mentioned appear to perform separate functions; the parasita being more immediately the monitors to personal cleanliness, whether in the skin or the clothing; and the suctoria more the monitors of household cleanliness; for however careful people may be of their bodies and their wearing apparel, they are certain to be infested with suctoria, if they do not keep their apartments clean; not only this, but if they keep domestic animals in their apartments, without paying proper attention to their cleanliness, there is every probability, nay, certainty, that the species which more immediately attack those animals, will inflict their admonition on the neglecting master as well as on the neglecting animal. It is reported, though with what truth cannot now be determined, that, previous to the overthrow of the Mexican government in Central America, by the invading Spaniards, the rulers of that country used to exact bags of those personal and family tormentors from their subjects, as a means of enforcing the necessary and wholesome duty of cleanliness. The plan must have been a little equivocal, however, because the more of the animals that were in the house, the tribute would be the more easily collected.

The four orders which we have now briefly noticed comprise all the apterous or wingless insects, which can with propriety be included in this class; though there are others of which some of the sexes are apterous when full grown; and all the larvæ, without exception, are of that form, though some of them are exceedingly active, more so indeed than the perfect insects. Some of these orders are not properly insects, because they have many more feet; and others, though they have the same number of feet as the remaining orders, do not undergo any sort of transformation; whereas the true insects are always subject to at least as much change in arriving at maturity, as the receiving of wings, which they did not previously possess. These, however, are chiefly matters of arrangement; they are not of very great importance.

5. *Coleoptera.* This is the first class of insects properly so called; for the apterous ones, alluded to in the former articles, do not, as was then explained, pass through those changes of form, or as they are sometimes, but not very correctly, styled "metamorphoses," which are characteristic of the genuine insects; and which render them, in some respects, the most curious department of animated nature. The true insect always passes through the three states of egg, larva, and pupa, before it arrives at the final or adult state, to which the general name of *imago* is given, because this is the

only state in which the creature is the express image of the maturity of its race.

The grand characteristic of the coleoptera is that of having cases to its wings, which are not themselves organs of flight; but which serve as a very effectual protection to those instruments; and the meaning of the original name is nearly synonymous with the English words "sheathed wings." Generally speaking, the coleoptera are called beetles; and it is in allusion to the opening of the wing-cases, when the animal is on flight, that poets have applied the epithets of "sharded," and "shard borne," to beetles, though the last is not quite correct, inasmuch as the shards, or elytra, which cover the true wings, afford no assistance in the operation of flying.

All the animals of this class are not, however, called beetles in common language; for the blister-fly, which is so useful in medicine, and the turnip-fly, which is so troublesome to the cultivator of that plant, are both coleopterous insects, as well as those which we call beetles.

The texture of the wing-covers varies in different species of coleoptera; and the consistency of the general covering of the body always bears a corresponding proportion to these coverings of the wings; but in all which have the true character, the wing-coverings are sufficiently large for hiding these organs when in a state of repose, which is one of the principal distinctions between the coleoptera.

The number and variety of this class of animals are truly astonishing; and the fact is thus noticed by Mr. Westwood, in a clever article upon this class, in the British Cyclopædia of Natural History: "It is, however," he observes, "unquestionable, that the coleoptera exceeds, in point of number of species, any other order of insects, although the diptera and hymenoptera, now that more attention is being bestowed upon the minute species, are not far behind the beetles in point of numbers. The French collections are estimated to contain not fewer than 30,000 distinct species of coleoptera, and it is by no means improbable that at least 20,000 more are contained in the cabinets of other countries, wanting in the former. Thus, 50,000 species may be considered as actually existing in our collections; and when it is known that immense tracts of country in Asia, Africa, North and South America, New Holland, and the Islands of the Southern Ocean exist, from which not a single insect has been received, we may without exaggeration conclude that there are from 100,000 to 150,000 species of beetles in existence. This number will not appear too great, when it is mentioned that in our own little island upwards of 3,500 native species have been actually described."

Animals, of which the species are so very numerous, and the individuals far more numerous than the species, cannot be even characterised in a sketch, and no full account of their appearances and manners can be given in any work of ordinary size, or a knowledge of it acquired by the most industrious human being during the longest life. But, notwithstanding this, we must still suppose that the Creator is as faithful to his purpose of general benevolence, in those very minute animals, as in the remnants of the most powerful races, such as the elephant and rhinoceros. In their mature state, the only one in which they are capable of continuing their species, those creatures are clad in armour which defends their bodies against pressure ; their limbs are particularly strong; and as the greater number of them are provided with powerful wings, they are capable of distributing their progeny wherever there happens to be any thing suitable for its support. The larvæ are, generally speaking, exceedingly voracious ; and from their countless multitudes they destroy a vast number of substances both animal and vegetable, which but for them would encumber the earth in a very unseemly manner ; and though they often come in such multitudes as to cause the total destruction of useful vegetables over a great extent of soil, there is no doubt that they are useful even when thus occupied, though we are not able to say what may be the precise nature and extent of their usefulness. Those larvæ are usually in the form of a worm, with the head covered with scales, and the mouth generally powerful and resembling that of the matured insect. They have generally six feet, though there are some in which these are little else than rudimental. Many of these larvæ live in the earth, into which they plunge to a considerable depth during the winter of cold and temperate climates. In such situations they occasionally require several years before they arrive at their full size. But they all are inactive and cease to feed when in the pupa state ; and this inactivity is more complete and longer in duration, in proportion as the change which the animal has to undergo in it is more or less extensive.

We may mention the habits of the larvæ of one genus, which, on account of the beauty of its colouring, and the ferocity of its disposition, is often called the tiger beetle. These larvæ excavate in the earth a deep cylindrical hole, an operation which they accomplish with their mandibles and feet. In order to empty it they place the detached particles on their head, turn about, and climb up the ascent step by step, resting at intervals, and clinging to the walls of their domicile by means of their two dorsal mammillæ; when they arrive at the mouth of the aperture they throw down their burden. While in ambuscade, the plate of their head exactly closes the entrance of their cell, and is on a level with the ground. They seize their prey with their mandibles, and even dart upon it, and by a see-saw motion of their head precipitate it to the bottom of the hole. Thither also they quickly retreat on the least intimation of danger. If they are too confined, or the soil is not of a proper nature, they construct a new habitation elsewhere. Such is their voracity that they devour other larvæ, of the same species, which have taken up their abode in their vicinity. When about to change their tegument, or to become pupæ, they close the opening of their cell.

One very curious family of coleoptera consists in great part of those species which are known by the names of "glow-worms," and "fire-flies," in consequence of a sort of phosphorescent light which is given out, generally by the females, but by both sexes in some of the species. They are, generally speaking, softer in the covering than most of the class; and in those species which have the female luminous, that sex is without wings. The luminous matter occupies the under part of the last three rings of the body, and the part which has this property does not appear to be very essential to the life of the animal, at least the animal will live for a considerable time after it is removed. When the animal is alive it seems to have considerable power over this luminous matter; but still the luminousness appears to be a property of the matter of the insect, rather than of the principle of life in it. When it gets dry, it ceases to shine; but even in the dead subject, it can be partially revived by moistening the body with water; and it is remarkable that when one of these creatures is suddenly placed in hydrogen gas, it explodes much in the same way that phosphuretted hydrogen does. If the body of one of these insects is placed in warm water, it gives out a very bright light; but the light is speedily extinguished when the animal is put in cold water. These curious creatures are all nocturnal in their habits; and it should seem that the light is a love signal given to the female, which attracts her mate by this curious lamp of nature. The male is a winged insect; and as both are solitary in their general habits, one cannot help admiring the beautiful contrivance whereby the purpose of nature is, in the case of them, brought about. It is one of the wonders of creation that the very same result is brought about by an endless variety of means; and that, however they may vary from each other, those means are all equally effective. Nor can we omit noticing, as a proof that there is no waste in all the provisions of nature, even where they seem the most exuberant, that those genera of this family, in which both sexes are provided with wings, are not phosphorescent, though, like the others, they are nocturnal.

Another curious family of coleopterous insects are the *dermestidæ*, which are of small size, and not numerous in species, but exceedingly destructive. They are destroyers of animal substances, and get their name from the Greek *derma*, a skin, as they consume the skins and other hard and dry parts of animal bodies, which are left by the flesh-flies, and others which feed upon animal substances only when those substances remain juicy. Their depredations are most extensive, extending to skins, furs, feathers, horns, and all sorts of firm parts of animals, and even the entire carcasses, when these have been spared by other destroyers, so as to have become dry in the fields. It is in museums of natural history, in the warehouses of furriers, and in the stores of those who collect untanned hides, that these little creatures do so very much mischief; and the extreme minuteness of their size renders the destruction of them a matter of the greatest difficulty. It is only while they are in the larva state that they commit these ravages; for the perfect insects do not consume animal matter of any kind, but are found sporting among flowers; though their instinct guides them to substances that smell very differently from flowers, for the purpose of depositing their eggs.

As we have observed already, however, it is utterly impossible to embody any general description that will apply to even a moderate number of those insects; for they are tempered to every shade of variety, in country, climate, season, and substance; and their eggs are so distributed everywhere, that it is scarcely possible that the proper food of any one species of beetle can occur in any one place without breeding, that is, maturing the egg of the very beetle which suits best for clearing away the particular substance; and as the number of larvæ is, in all such cases, very nicely proportioned to the work required to be done, and the expedition requisite in the performance of it, it is impossible not to be equally astonished and delighted at the perfect certainty with which these little labourers come to their work, and with what certainty and expedition they perform it. Indeed, it is highly probable, that were it not for those insect labourers, the earth could not be inhabited by man, or by any of the larger mammalia; for when we consider that of many of the smaller races of animals, and of some plants, which in their decay are nearly as rank and offensive as any animal matter, there are many successive generations in the course of the season, we can readily conceive that, if their dead bodies were to be cast upon the earth, and left to the natural progress of decomposition in the atmosphere, that fluid would soon become so tainted with the matter of putrefaction, that it would be the poison of death, rather than the breath of life, to all the higher orders of animated being. Upon the whole, we may receive it as a maxim in the philosophy of nature, that, how imperfectly soever we may be able to judge of it, not one production of nature comes naturally, until its presence is required, and not one delays its coming after its presence is requisite. Herein is the beauty of the system: not one thing which God has made, requires to pause for a single moment, waiting the necessity that there may be for it; for the very same circumstances which form the necessity, involve in themselves the production of that which is necessary; and therefore, whatever to our limited understandings may seem to be a disease in nature, is in reality a cure. But we must pass to another order of insects.

6. *Orthoptera.* The insects of this order have the covering of the body much less compact than the coleoptera; and they get their name, which signifies "straight-winged," from the wings folding lengthwise; thus not being shortened as they are in the coleoptera, which have the folds across, by means of which the wings are shortened, so as to be completely covered by the elytra. In the orthoptera, the elytra seldom cover the wings, and they are partially of a membranous character, and strengthened by horny ribs or nervures. The front of the head is furnished with a helmet; and very few are without a tooth-piece, extending over the jaws. Considered as insects, they are much less perfect than the coleoptera; for though they pass through the same number of states, they differ much less in those states. The larva and the pupa move about, and feed in very nearly the same manner, and on the same substance, as the perfect insects; and the chief difference consists in the absence of wings, the rudiments of which are, however, always visible in the pupa. The females of some of the species are furnished with ovipositors, consisting of two perforating blades, inclosed in a sheath; and by means of these they can insert their eggs into places where they are safe from external injuries. No species of this order is known to inhabit the waters; and though some of them are carnivorous, and others miscellaneous in their feeding, by far the greater number feed upon living vegetables; and many of them are exceedingly destructive, on account of their numbers.

There are two distinct families of this order of insects,—those which are adapted for walking, and those which are also capable of leaping. The walking ones have the fore legs very little longer than the hind ones, and the females never have an ovipositor. The ear-wig and cock-roach are familiar instances of the walking species; though there is no reason to believe that the former gets into people's ears, but it is destructive to plants.

Of the leaping ones, the most remarkable character is the great strength of the fore legs, which are in many species, as in the common grasshoppers, fitted for leaping to a great distance; while in others, as in the mole-crickets, the feet are most efficient digging instruments; and the rate at which these last can open up a way for themselves in earth of pretty firm consistency, is truly astonishing. The males of this family have the power of emitting a sort of stridulous sound, which is sometimes, but very improperly, termed singing. It is not song, neither is it voice of any kind; for from their structure these animals can have no voice, as there is no passage of air toward any part of their bodies at all fitted for such a purpose. The sounds which they emit are, like the sounds made by all insects, produced externally, and by the medium of the common air. In this family there are two ways in which the sound is produced: in the first, the one elytron is beaten against a tight and elastic membranous portion of the other, which produces an effect not wholly dissimilar to the beating of a little drum; and the second mode of procedure consists in rubbing the thighs backwards and forwards against the edges of the elytra, which produces a kind of hissing or grating sound. Our house-crickets and common grasshoppers are comparatively harmless creatures; and though the mole-cricket sometimes does a little mischief in gardens, that which it does is not great. Many species of locusts are, however, remarkable for the depredations which they commit; but their ravages seldom extend into temperate climates, and rarely if ever into cold ones. They are not unknown in Poland, where the summer is generally very dry, and the soil light and sandy; but even there they are not very destructive. In tropical climates, especially those which are subject to long periodical droughts, their appearance is much more serious; and when they come in the full muster of their army, their march is not to be arrested, even by a brook of considerable width and depth. They press onward, rolling in heaps, and tumble each other into the stream, until at last so many dead bodies are accumulated as suffice to form a bridge, across which the succeeding numbers pass. A remarkable instance of this kind occurred lately in New South Wales, where the invading cloud, which appeared to come from the central deserts, contrived to cross a stream of considerable breadth upon this most singular kind of bridge. Nor is this all; for, while the lion and the elephant turn back in fear from the light of a torch, the column of locusts will march right onward upon a line of fire, until they have extinguished it with their bodies, in the same manner as they employ them in bridging the waters.

7. *Hemiptera.* The name of this order implies that the animals which compose it are but half-winged; and besides the two preceding orders, they are the only insects which have elytra or

covers to their wings. These elytra are generally crustaceous or leathery for a portion of their length, but simply membranous for the remainder of it. Their best character, however, is founded in the structure of the mouth, or other sucking apparatus, whatever the apparatus may be. In them, it is a sort of rostrum, which, when in a state of rest, is folded backwards on the under part of the head; but when the animal extends it, it is found to have a groove on the upper side. This contains and supports three very finely pointed bristles, covered with a tongue at their base, and having one of them divided into two parts, so that the instrument has four points, by means of which it can penetrate the bark of a plant, or the skin of an animal, according as its habits are to prey upon the one or the other. There is reason to believe, from the pain that the punctures made by those creatures occasion, that there may be an infusion of acrid juice into the wound, by means of which the parts of that which is attacked are irritated, and an unnatural action brought on, which favours that production of the juice or blood, of which this order of insects is always in search.

They are all animals which live by suction; and though they undergo the changes of the three states after they leave the egg, those changes are but trifling; and the habits of the animals are the same. They are produced from eggs in the form of small, active, six-legged larvæ, preserving an almost exact resemblance of the perfect insect, though totally destitute of wings or wing-covers. After repeated sheddings of the skin, by which an increase of size merely is gained, they appear as pupæ; still active, however, and differing only by having the wings and wing-covers enclosed within separate cases on the upper part of the body. Another shedding of the covering transforms them into the imago or the perfect insect, and their wings are then fully developed. In the wingless species, the transformations consist merely in gradual increase of size, at the different sheddings of the covering. The hemiptera in the pupa state requires the same quantity of nourishment as it does when in the larva state.

As an example of this order of insects, we may mention the house bug (*Cimex lectularius*), which, though a repulsive insect, is a curious one. The history of this insect in a domesticated state, for it is very strictly and pertinaciously a household animal, is involved in a good deal of absurdity if not obscurity. Bugs are by no means fond of the pungent smoke which arises from the burning of wood, or turf, as fuel, especially when, as in the case of the old and ill-constructed hovels of our ancestors, this smoke habitually occupies the upper part of the dwelling, and is left to find its way out as it best can. Smoke of this description contains a very great quantity of pyroligneous oxide, and therefore in those places of the country where wood and peat are employed as fuel, and the houses are without close chimneys, and have merely holes for letting out the smoke, no such thing as a bug is known; and, though objectionable upon other grounds, houses warmed in this manner are more free from insects of almost every kind, than more fashionable houses which are heated by fires of coal. There is, no doubt, a great deal of pungent matter in the smoke even of coal; but there is not nearly so much as in that of wood and peat; and, as the application of pungent effluvia to the breathing spiracles of all insects is the surest means of destroying them or driving them off, it has generally occurred that the bug has very speedily followed the introduction of coal as the general article of fuel; and this has sometimes led to the supposition that the insect has come from quarters and by means which are quite incorrect. Southall, in his treatise on these insects, states that they made their first appearance in London after the great fire in 1666, "which learned men," he observes, "united in thinking were imported with the new deal timber, as the bugs were naturally fond of turpentine woods;" but Mouffet records an instance which occurred in 1503, which shows that they existed in this country at this early date. Two noble dames, residing at a village called Mortlake, had been so alarmed by being bit by bugs, conceiving that the visitation augured symptoms of the plague or some other contagious malady, that they instantly sent for their physician to procure his aid. The doctor came in great haste, and having examined his patients, pronounced their case to be anything but a dangerous one; and, having some acquaintance with the natural history of the bug, he in so far succeeded, by explanation and other means, as to soothe the fears of his noble patients. The antiquity of the bug may also be established by its having been noticed by Aristotle, Galen, Pliny, and other ancient naturalists, under the name of coris. These naturalists ascribe medical properties to the insect, and especially of its acting as a remedy for the bite of serpents; but as the belief in those days was that every substance was medicinal in the same proportion as it was repulsive to the feelings, the bug owed its imaginary virtues to its demerits, not to its merits. It was also applied in numerous other diseases, and, according to Mouffet, who bestowed great pains in collecting both the ancient and modern history of the bug, four bugs, taken fasting every morning for four successive days, were considered a sovereign remedy for the colic. Bugs have, however, long ceased to have any medicinal reputation, and modern art has been more directed towards the means by which the insects themselves can be destroyed.

As happens in all cases where people meet with a good deal of annoyance, and do not themselves understand how to get rid of it, the pretended eradication of bugs from houses has led to the employment of numerous quacks and quack nostrums; but in spite of them all, and even in spite of the presumed superior cleanliness of modern houses, bugs have multiplied greatly in those places where they were formerly introduced, and they have also been introduced into others in which, in earlier times, they were unknown. Among all the remedies that have been recommended for the eradication of this obnoxious pest, we have no hesitation in pronouncing that a strict attention to cleanliness is the best; and indeed, without this, all other means will be unavailing. Fumigation by brimstone has been found to act powerfully in clearing houses of bugs. But it may be added that very many of those prescriptions which have been recommended are, from their poisonous nature, very dangerous, and require to be used with the greatest caution. Though the bug belongs to an order of insects which have, generally speaking, wings, yet they are not provided with these organs, but they have elytra or wing-covers.

Other insects of this order inhabit the water, and are carnivorous, feeding on other insects, which they follow with great energy. Others, again, feed exclusively on plants, of which they suck the juices; and of these some are furnished with curious drums, by beating upon which they produce not an unpleasant sound. The females are provided with an ovipositor, consisting of three pieces, nearly enclosed in a sheath. With this the female penetrates dead twigs, where she deposits her eggs; but the larvæ feed in the ground, at least for some time before undergoing their changes. Nor is it unworthy of remark, that the females of those insects should have the instinct of selecting those twigs which are most likely to be blown down by the winds, and thus most readily to bring the young into that situation which is most congenial to their growth. These creatures are most abundant in the warmer countries, where they puncture the trees, and occasion various exudations, and, among the rest, that substance which is known by the name of manna. To this order also belong the aphides, the gall insects, and a variety of others, which are remarkable for the ravages they commit on the buds, young branches, and, generally speaking, the tender bark of trees.

8. *Neuroptera*, or "nerve-winged" insects. These differ from the three preceding orders in the character of their upper wings, which are of the same texture with the under ones, and formed of a thin and usually transparent membrane, spread out upon a very elegant net-work of fibres, which are improperly called nerves. Their mouths are never formed for sucking; and they are not provided with stings, nor has the female an ovipositor, except in a few species. The greater number of

them are carnivorous insects, and they are usually very energetic in the pursuit and capture of their prey. They admit of several subdivisions. Some have their larvæ inhabitants of the water, active and voracious while there, and undergoing only a partial metamorphosis; others, still carnivorous, undergo a complete metamorphosis; and of these some larvæ inhabit the water, and others the land. A third form have terrestrial larvæ with an imperfect metamorphosis, and are miscellaneous in their feeding. Others still have a complete metamorphosis; and the larvæ inhabit the water, constructing dwellings which they move about under the water.

The dragon-flies, which are accused of stinging horses, and other acts of mischief for which their structure does not at all adapt them, are one very familiar instance of this order of insects. Their larvæ invariably live in the water, in which they are very voracious feeders. They are armed with strong crooked mandibles, which open and shut like a pair of pointed pincers; and with these they assail and kill a vast number of their smaller fellow-tenants of the pools and streams, not in wanton cruelty, but for the purpose of satisfying their appetites. The full-grown insects, which live in the air, though they frequent the margins of waters, are equally voracious as the larvæ; and the number of insects which they destroy is immense. Thus, in as far as man is concerned, they are the ministers of good, and not of evil.

The ephemera or May-flies are another remarkable instance of this order. They make their appearance in immense numbers, so that they resemble a shower of snow, and, in places and states of the weather favourable to their growth, those showers will continue descending for a great part of the night. The only object that we can discover in their brief lives is the continuation of the race; for when the operation necessary for that purpose is accomplished, they tumble down to the earth and on the waters literally in heaps; and so greedily are they sought after by various sorts of fresh-water fishes, that the fishermen look upon their appearance, in more than ordinary numbers, as being a sort of special providence. Perhaps the most extraordinary insects of this order, however, are the ant-lion, and the white ants of tropical countries, of both of which some notice will be given in the next chapter.

9. *Hymenoptera*, or insects with membranous wings, in which the frame-work is not nearly so conspicuous as it is in the Neuroptera. In some respects this is the most interesting order of all the insects; and it is so both on account of the indirect advantages which they bestow upon man, and also on account of the incredible number of more destructive insects which they destroy, and the curious manner in which that destruction is brought about. Some of them, are, however, in their turn capable of doing a good deal of mischief to useful vegetables, and others are annoying in consequence of the envenomed stings with which they are armed.

The order is very extensive, and diffused over every part of the world; and the operations which they perform in the economy of nature are often of the greatest importance, more especially to the vegetable tribes, either in promoting the fertility of flowers by distributing the pollen of the anthers over the style, or by destroying the larvæ, especially of those insects which are so destructive to vegetation; and which would, in spite of all the labours of the birds of song, defeat the purpose of nature in many instances, were it not that the insects of this order reach them in their most secret recesses, and effectually operate their destruction.

It is not easy to give a general description which will apply to the whole of this order of insects, though there is a family likeness that runs through the whole. They are all mandibulated, or furnished with jaws opening and shutting laterally, and also with maxillæ or lower jaws; and the under lip is usually formed into a sort of tongue or sucker, by means of which they can lick or suck honey from the nectaries of flowers, which is their principal food. For this purpose, the tongue or sucker is often very considerably elongated; and we are presented with the singular spectacle of creatures having a double mouth,—that is, a mouth, the one part of which is adapted for eating, and the other part for sucking. The last of these is the feeding part; but the cutting part is also devoted to many very important purposes; for by means of it, assisted occasionally by the feet, these insects elaborate the most singular structure that can well be imagined. They form waxen cells, they burrow into the ground, they collect moss, often in very considerable quantities, for the formation of nests. They mine their way into timber, and partially even into stone; they form a sort of paper or pasteboard, by scraping off the substance of dry wood, and pasting it together with a natural cement secreted by their mouths; they even unite particles of sand and dust in the same manner into firm structures; and they roll up green leaves in the form of little cylindrical casks, of which the heads or ends are as truly circular as if they were marked off with a pair of compasses. The labours of those insects are, indeed, wonderful; and when we contemplate them, we are constrained to admit that the labours which men are capable of performing, by the exercise of the best cultivated understanding, and the use of the most convenient tools, fall immeasurably short of what can be done by those feeble creatures, implicitly obeying those instincts which their Almighty Maker has given them.

In nearly the whole order the females are provided with a sort of horny appendage to the posterior part of the body. This appendage takes three general varieties of form, according to the use which the creature has to make of it. If it is for defence, then it is a powerful sting, which infuses venom into the wound which it makes, more or less virulent, according to the nature and size of the species. If it is the habit of the young to feed upon the green leaves of plants, then this appendage in the females is very generally formed into a pair of saws, wherewith a slit is very quickly made in the bark of a tree, and the egg deposited in the slit, there to remain secure during the winter, or till circumstances, favourable to the existence of the young insects which it contains, shall call that insect into life and activity. In others again, and they are very numerous, though many of them are of diminutive size, this appendage to the female is lengthened out into an ovipositor, by means of which they can insert their eggs into the bodies of other insects, chiefly when in the larva state; but sometimes in the perfect insect, and in others even in the egg. From this last division of the order, there is no concealing the eggs or the young of those other insects over which the species in question appear to be set as regulators of their numbers. Many of these deposit their eggs under the bark of trees, or in dry and decaying timber; but let their concealment be ever so perfect, ever so inscrutable to the human eye by any external indication, and yet the parasitical hymenoptera will find them out, and insert an egg in them with the most unerring certainty, which in due time quickens into life, and feeds upon the insect into which it was deposited.

When we state that this order of insects contains all the families of bees, of wasps, and of ants, together with the sand-wasps, the saw-flies, and the ichneumons — which last are sometimes called cuckoo-flies, because, like the common cuckoo, they insinuate their eggs into the nests of other creatures, and by that means effect the destruction of the young bees,—when we mention that all these are contained in the order *hymenoptera*, we trust that we have said enough to recommend them to every reader.

The order is conveniently divided into two sections, or sub-orders: the first comprising those in which the appendage to the abdomen of the females consists of a sting; and secondly, those in which it consists of saws, or of an ovipositor. There are differences in the habits of these creatures, corresponding to these differences of structure in this organ of the females. They all provide for their young; but those with the sting provide by collecting a store of provisions for them, in which they often show the most remarkable perseverance and industry; and those which have the ovipositor in place of the sting, are equally assiduous in placing their young in situations where a supply of food can readily be found. There is a difference in the organisation of the young, which shows how beautifully the want and the supply are adapted to each other in nature. Those hymenopterous larvæ which are placed in a situation where there is abundant food for them, whether that food has been collected by the parent insect, or the egg has been deposited in it, are always without feet; as to them such organs would be useless, because they require not to move until they have undergone their transformations, and have come forth in the perfect or imago state. But in the case of those saw-flies which deposit their eggs in notches of the bark of trees, and whose young are to feed, not on the bark, but on buds and leaves, which are not developed at the time when the eggs are deposited, the larvæ are always furnished with legs, by means of which they can climb about in search of their food; and, as is the case with most larvæ or caterpillars which feed among the leaves of trees and range about in their feeding, they are furnished with a spinning apparatus in the under lip, by means of which they can anchor themselves to a leaf in case of danger, and even drop down when an enemy appears, and hang suspended by the thread until that enemy is gone.

The parasitical division, or those which, instead of providing for their own offspring, place it so as that it shall feed upon provision otherwise obtained, whether animal or vegetable, have less labour than those which provide for their families. Still they are not idle; for it costs the females no small ranging about, before they can find the substances which are best adapted for receiving their eggs. These, however, are all solitary; never living in communities, or having different portions of their number destined to the performance of different kinds of labour. Even the larvæ are, generally speaking, placed so as to be solitary, or one only in the egg, caterpillar, or insect, in which they are deposited by the mother. To this, however, there are exceptions, especially in the case of very small ones, which are deposited in caterpillars of considerable size; for in the case of the small ichneumon (*Microgaster glomeratus*), which renders so essential a service by preying upon the caterpillar of the common white-cabbage butterfly (*Pontia rapæ*), there are often a dozen, twenty, or even more, which issue from the body of the caterpillar, and immediately spin their little cocoons of yellow silk, in which they undergo their transformation without any further feeding than that which they have previously enjoyed in the juices of the caterpillar, whose empty skin is left in the middle of the cocoons, as a trophy of their labours.

Those races which have no ovipositor, but generally a sting in the females, and which have to perform severe labours in providing for their young, are social in many of the species; and the habits of one or two of the more remarkable of these will be briefly noticed in the miscellaneous chapter on insect life. There are others, however, which are solitary; and among these the females have often to perform more severe labours, in proportion to their size and apparent strength, than any other known race of animals. Those species in which the labours of the females may be regarded as being most severe, are, generally speaking, very seasonal in their action. As the cold weather sets in, they all perish, with the exception of a few impregnated females, which contrive to survive the winter by burying themselves in the ground, or creeping into holes and crannies ; where they remain in a dormant state, without exercising any of the functions of life, until the warmth of a new season awakens them from their death-like repose. They betake themselves to those hiding-places the instant that the act of fertilisation has passed upon them, and their progeny make no progress, even in the egg, until they have been for some time active during the spring. This spring activity is not wholly or chiefly devoted to the finding of their own food ; for the grand seasonal labour of these solitary females, which have escaped the severity of the winter, is the founding each of a new colony, to perform the labours of the summer, and act in nature that part which is ordained them. Those of the bee family prepare wax until they have built a certain number of cells, and collect honey and the pollen of flowers until a certain number of those cells are stored with provision, at a comparatively early period of the season. But while this is carried on, the foundress of the colony, or rather that instinct or law of nature by means of which, all unreasoning and unknowing of her part, she performs her curious labours, lays the foundation of an assistance, which shall increase in proportion as the activity of the year renders an increase necessary. It is also equally wonderful and instructive, that, while the demand is only for an additional number of hands, so to speak, for the performance of the labour of the season, the young which are produced are all females ; and though, in those colonies which have a solitary foundress, it is probable that the females are all perfect animals, and not sexless neuters, as is the case with those which live in permanent societies, yet the season is pretty far advanced before the foundress of the colony deposits any eggs from which males are produced. Indeed, it is highly probable that in the greater part, if not the whole, of those colony-founding insects, the males are useful only for the purpose of preserving the race during the winter, though for this purpose it should seem that all the females are, toward the latter part of the year at least, capable of being fertile; and thus every one which can escape the winter, awakens from her lethargy in the spring, in a proper condition for founding a colony. It is not so with those social races which are permanent in their dwellings; for in these the greater number of the females are undeveloped or infertile, and they survive the winter, as well as the fertile females, while the males are all chased off, or if necessary killed, before the severe weather sets in.

The last-mentioned races do not hybernate, though they all enjoy a seasonal retreat from the open air, during those months when the fields are barren of their adequate food. All such provide for themselves a winter store; and though their diminished activity renders a much smaller supply of food sufficient for them, they do continue to feed during the winter.

Of the races which collect the bodies of other insects, and not honey or pollen, or any other part of plants, for the food of their offspring, the nest which is formed is a mere nidus for the young while they are in the larva and pupa states; and neither the parent insect nor the matured young make use of it as a dwelling-place. The mother collects into a proper repository as many bodies of flies or other insects as suits the instinct by which she is governed: and having done so, she deposits in the same place as many eggs as shall produce larvæ sufficient for consuming the food thus stored up, but not more; and when the store of food is at an end, it happens, on the average, that those larvæ are ready for passing into the pupa state; nor is it long before they burst from their nursery, and mount on the wing, as perfect insects. We must, however, close our few general remarks upon these wonderful creatures; for so abundant are their numbers, so varied are their manners, and so interesting are they in every variety, that the more the subject is entered upon, there is the greater difficulty in turning away from the contemplation of it.

Still there is one family which we cannot pass over without some notice, in consequence of its singular manners and equally singular usefulness. This is the family of the *Ichneumonidæ*, or those who are more particularly set over the caterpillars to regulate their productive numbers according to the necessity that there may be for them in the general economy of nature. And here, if our minds had sufficient grasp, or if we had sufficient activity and perseverance, for bringing to the task an equal knowledge of all the departments of nature—if we could stand apart, as well-informed spectators gifted with the necessary powers of observation, and behold how the sun, and the atmosphere with its moisture, and the other parts of its composition, and the climate, and the season, and every plant, and every animal, work together for the general good and greatest perfection of the whole; we should find in those seasonal insects the keys to many a mysterious volume of the book of natural knowledge. In this life the scales of mortality are upon our eyes, and we see darkly as through a glass; but it is our glorious hope that a day will come when all those matters shall be as clear and legible to our disembodied and unencumbered minds, until the final period, when the heavens shall depart as a scroll when it is rolled together, and the elements shall melt with fervent heat. This is our special hope, given by the gracious mercy of our God to us, and to us only, of all living creatures wherewith he has peopled this our earth; and if we take this hope along with us, as our stay and comfort by the way, then, indeed, we may run the paths of the knowledge of all that He has made, with ineffable and indescribable, but heartfelt and indestructible, delight.

But to return to the ichneumon family. They get this name, because they were supposed by the ancients to perform for the husbandman services similar to those which, as it was then believed, the ichneumon performed for the inhabitants of the banks of the Nile, in clearing the land of offensive creatures. The parallel holds more closely than was then supposed; for the quadruped ichneumon destroys crocodiles, and other large reptiles, only by destroying their eggs; and the ichneumons of which we now speak destroy the spoilers of the vegetable world, only by depositing in their larvæ eggs which hatch there, and prey upon the substance of that which contains them, carefully abstaining from those parts which are essential to the life of the larvæ, until they have eaten enough, attained their full size, and are ready to undergo their change. In some instances the young ichneumons remain in the body of the caterpillar until they have undergone their final transformation; and in such cases they issue from the dead caterpillars in the state of perfect insects. The period of their progressive growth at which they come forth, depends of course upon the kind of caterpillar, and the degree of advance which it has made when the eggs of the ichneumon are lodged in its body. The whole family do not, however, deposit their cocoons in or near the remains of those caterpillars upon which they feed when in a state of larvæ; for some of them attach their cocoons to the stems of plants or the leaves of trees. Some members of the family are favourable to other hymenopterous insects. There are some insects which deposit their eggs on the hives of bees; and the larvæ feed upon the wax of which the cells are composed; and it should seem that one species of ichneumon, at least, finds out the places where those parasites are deposited; and, by depositing its eggs within them, contrives to make its progeny in the parasite—contrives to spoil the spoiler.

One of the most useful of those little creatures is that which destroys those aphides which are so destructive of many sorts of valuable trees; and, perhaps, in British gardens the most interesting is the *Aphis rosæ,* which, however, does not feed on the rose tree, but on the spoilers of the rose tree; and is not confined to the spoilers of roses, but attacks also those which are found on other trees. As the manners of this one are illustrative of those of many of the others, and as they have been carefully observed and correctly described by Mr.

Haliday, we shall quote his description, only remarking that the aphis which this fly attacks is called a puceron in his account. "This," says Mr. H., "is the species most frequently noticed by authors, being a familiar inhabitant of our gardens, where the male may be seen throughout the summer hovering over the rose trees, or creeping under the leaves. His partner is of less roving habits, and generally will be found busy in providing for the establishment of her numerous progeny. Placed at her birth amid the myriads of pucerons which encircle the young shoots of the rose, she has no dwelling to construct with artful industry, nor stores of food to collect by distant rovings. With extended antennæ and wings shivering with desire, she paces leisurely among the defenceless herd, and as soon as she has selected one, by a light touch of her antennæ, she stops short at about her own length from it; and raising her stiffened legs, bends her abdomen under her breast, till the end of it projects beyond her mouth; then erecting her thorax by depressing the hinder part, she simultaneously makes a plunge forward with the abdomen, which is thus extraordinarily lengthened, and by a momentary touch deposits an egg on the under side of the puceron near its tail. The victim will sometimes kick and sprawl, so as to discompose her, but being anchored by its sucker plunged in the bark, can make no effectual attempt to elude the deadly weapon. Should it, however, be wandering at large, and free to struggle, she shows great activity in traversing around it in the attitude of attack, till she can take it in the flank. The delicate sense of the antennæ seems to warn her where a germ has been already deposited, as she will pass by those which have been stung some days before; and I have never found more than a single grub on one individual. When all the interior of the puceron is consumed, it will be found separated from its fellows, and motionless, usually on the upper side of a leaf, to which it is glued by some viscid exudation. It now appears distended, and of an opaque hazel or lighter tint. If opened, the full-fed grub of the aphis will be found doubled up and filling the cavity, its head being next the tail of the puceron. In a short time the parts of the perfect insect are developed in a quiescent state, and in the same position the integuments of the grub being shrivelled up, as if in black grains. Like cynips and callimomes, it spins no cocoon for its transformation, being adequately protected by the indurated skin of its victim. A few days are sufficient to give consistence to its parts; and while the new-risen sun is yet glistening in the early dews, the winged insect by a push of its head detaches the latter rings of its case; which separate in the form of a circular lid, often springing back to close the orifice after the inhabitant has gone forth, born, in the maturity of her energies and instincts, to renew the circle of her existence."

Those species which find out the larvæ of other insects in concealed places are still more curious; and for this reason we shall give in substance an abridged account of one of the largest of the family (*Pimpla manifestator*), as described by Mr. Marsham from his own observations, and detailed by him in the third volume of the Linnæan Transactions. This species is of a black colour; with some blue spots on the thorax, and two of the same colour upon each ring of the abdomen. Its antennæ are very long, constantly in motion, and apparently endowed with an acute sense of some description or other. The body is attached to the abdomen by a short peduncle, and the third or hinder pair of legs are much longer than the rest, obviously for the purpose of enabling the creature to work its ovipositor. The ovipositor is very long, nearly as long as the whole body and the antennæ; and it consists of the central piece, or ovipositor, properly so called, together with two lateral pieces, which are reflected upward when the central piece is in use, and therefore must be considered merely as protection to that more important organ upon ordinary occasions. Mr. Marsham observed a female of this species running along the top of a post in Kensington Gardens, with its antennæ in a state of excitement. It soon introduced them into a hole of the post which had been made by some insect, and repeated this three times, as if the first and second trial had not been sufficient to complete the discovery as to whether the hole in the post contained anything fitted for the reception of its egg. After a third trial, it turned about, and, dexterously measuring its distance, reflected back its abdomen over it, head and thorax, lowering at the same time its long and slender ovipositor, which it inserted into the hole, remaining in this situation two minutes; it then withdrew its ovipositor, turned round and again introduced its ovipositor, repeating the operation three different times. On another occasion, Mr. Marsham witnessed a number of these insects at work; but these appeared bent on piercing the solid wood with the middle part of their ovipositors, which they ultimately managed to do to the entire length of the instrument, which he observed they supported in a straight position with their posterior thighs. It seemed very surprising to see an instrument apparently so weak and slender, with the force of so insignificant an animal applied to it, able to penetrate solid wood to the depth of three quarters of an inch;—but it was discovered that it was inserted into the centre of a minute white spot, in appearance like mould or mildew, but which on close inspection was found to be small particles of fine white sand, nicely closing up a hole made by the wild bee for containing her cells, and in which the larvæ of that insect were no doubt deposited.

Some of the *cynips*, or insects which deposit their eggs in plants, and endow them with a singular property of converting the juices of those plants into a substance partaking of the nature of the vegetable, but differing from it in structure, are often very curious. When the substances thus formed are circular, or bear some resemblance to a spurious fruit, they are termed galls or gall-nuts, of which the one formed upon the oak, and used along with sulphate of iron in the manufacture of common ink and in dyeing black, is one of the best known and most useful. Sometimes those creatures, notwithstanding their general injury to vegetation, are often serviceable to it. Thus, for instance, there is a species which is employed for fertilizing the fig-trees, in countries where figs are much cultivated. The pollen, or matter of fertilization, does not come to such maturity in the late crop, which is the valuable one of cultivated figs, as it does in the wild fig-trees, the fruit of which last is of comparatively little value; but there is a species of cynips, the larva of which is deposited in the blossom of the wild fig; and when the insects come to maturity, they leave those wild fig-trees with their bodies covered with pollen. In this state their instinct leads them to seek the cultivated fig-trees for the purpose of depositing their eggs; and the cultivators, instead of preventing them, open the eye of the fruit, in order to admit them into the interior; for as they carry the pollen there, and rub it against the stigmas which are contained in the fruit, they are the means of causing the fruit to swell and come to maturity, which it would not do, at least so well, without their assistance. We must, hower, proceed to the next order.

10. *Lepidoptera*, or insects with scaly wings, or rather perhaps wings covered with very minute feathers. This is one of the most gay and beautiful divisions of the living world; and it comprises the whole of those insects which are popularly known by the names of butterflies and moths.

All the members of the family are, in their perfect state, furnished with four wings, the scaly covering of which is easily removed by a touch of the finger. In this state they do not gnaw or divide any substance, and their mouths are by no means adapted for such a purpose. The efficient part of the mouth consists of a sort of tongue, which, when not in use, is coiled up spirally between two scaly or hairy palpi; and this tongue, which acts as a sucker, is the instrument used by these animals in feeding. Their food consists of the nectar of flowers, which they suck up by means of the instrument now described; and the other parts of the mouth, except in so far as they serve to support this sucker, are very little developed. The abdomen of the females is composed of six or seven rings, and it is attached to the thorax by a very small portion of its diameter, while the posterior part has no sting and no ovipostor, though in some species the posterior portion is retractile and pointed; and the larvæ of such as have it of this form very generally gnaw their way into the bark of the wood of trees, where they often commit very serious depredations.

The females of many of the species are exceedingly fertile, and the whole of them either fasten their eggs to the surfaces of vegetables, or place them in situations where vegetable matter is easily reached; though of course there is no more foresight in the doing of this than in any other phenomenon which takes place in mere matter. Those eggs are often placed with great neatness on the twigs of trees, and in various other situations; and as during the larva state, when they are most voracious as feeders, they are almost wholly parasitical upon trees or plants of some kind or other, so it may in general be said that each species is confined to one plant, or at all events to one natural family of plants.

The lepidoptera are perhaps the most seasonal of all insects, if we take them as an order, and as they are found inhabiting the temperate climates; for though some of the smaller ones occasionally appear late in the autumn, or early in the spring, it is very doubtful whether any of them remain alive in the perfect state during the winter. They appear to be more especially set over the leaf and the blossom of vegetation than any other order of creatures; and the methods upon which they fall, or rather to which they are directed by their instincts, of protecting themselves from their enemies, and from the casualties of the weather, are exceedingly numerous; and though some of them display great apparent ingenuity, yet we are not to attribute this ingenuity to any sort of reasoning in the animal.

To enumerate the whole of their particular habits, or even as many of them as would furnish a general notion of the order, would far exceed our limits: but we may mention that they are, according to the time at which they come forth to sport and feed, divided into three sections,—diurnal, twilight, and nocturnal. The first are the butterflies, properly so called. They sport and feed during the day, and display their beautiful colours in the light of the sun. There is no play of metallic reflections about them, as there is in the elytra, and general covering of many of the beetles; but in respect of purity, intensity, and variety of tints, there are scarcely any productions of nature which come up to them,—hardly even those flowers over which they hover and sport, and from which they collect the food which they require when they are in the winged state. These wings are often very large, in proportion to the size of their bodies, though these are considerable in many of the species; and their flight, though performed by means of internal muscles, as is the case in all winged insects, bears some resemblance in its style to the flight of birds.

The greater part of the lepidoptera fly in perfect silence; and none of them make the same buzzing sound as is made by those insects which have naked wings. It would appear that their scaly, downy, or feathery wings take a much better hold on the air than naked wings do; and that in consequence of this they can hover with the wings apparently motionless, or glide along with more apparent ease, than most other insects.

The twilight race, or hawk-moths, are not so gay in their colouring as the butterflies; and they are altogether rather more unwieldy. The death's-head moth is the largest species which is found in this country; and it gets its name from a spot on the dorsal part of the thorax, which has a slight, though rather fanciful, resemblance to a skull and cross-bones. This section gets the name of hawk-moths, not from any disposition to hawk which they possess, but from the resemblance of their flight to that of these birds. They fly with a rapid and rushing motion; and it appears that they do not see very well, for they often rush against obstacles: many of them fly with great velocity from flower to flower, and utter a humming sound as they hover about; but this sound, like all the sounds produced by insects, is an external one, produced by certain parts of the body striking against each other. The nocturnal ones, or moths, properly so called, are numerous; and their caterpillars are more destructive to vegetation than those of any of the former sections. They are found on plants of all kinds; but they are especially destructive to fruit trees when vegetation happens to be suddenly checked in the early part of the season, and the young sap loses that acerbity of taste which is characteristic of a healthy growth, and becomes sweetish. The larvæ of all the order are known by the name of caterpillars. These caterpillars have all six hooked feet, corresponding with the legs of the perfect insect; and as these feet are situated on a small portion of the fore part of their bodies, they are supplied during the larva state with additional feet of membranous texture, which vary in number from four to ten. Two of these last are always situated at the posterior extremity of the body; and when there are only four or six of those membranous feet, all of them are near the hinder part; and thus the caterpillar has six feet at the fore end, and four or six at the hind, while a great part of the centre of the body, very often considerably longer than both the footed parts, is without any feet at all.

Caterpillars which have this arrangement of the organs of motion are called geometers, or geometrical caterpillars, because they seem to take measure of that along which they walk, as if it were with a pair of compasses. The caterpillar fastens the hind feet and part of the body to which those feet are attached to the twig, along which it marches; and then, advancing the fore part of the body, but not to the full extent of its length, it applies the fore feet to the twig, while the middle stands up like a bow. When the fore feet are fastened, the caterpillar loosens the hind ones, and brings up the rear of its body, while the middle stands out in a loop. After this it again advances the fore part, brings up the hind when that is fastened; and thus it makes its way by a rather slow but very singular species of motion. Their mode of resting is sometimes as singular as their march; and it is probable that, in addition to the repose which it gives them, it is a means of protection against their enemies, the chief of which are the tree birds, whose young are in great part fed on the caterpillars of lepidopterous insects. When they repose, they adhere firmly to the twig by the feet at one end of the body, while the rest of the body, and by far the greater part of its length, sticks out in form and appearance so like a little withered twig, that pretty close inspection is required before one can decide whether it is or is not a caterpillar. The length of time which they can remain in this position is very great; and it does not appear to signify much in what manner gravitation acts upon the body, for it stands upwards, downwards, or laterally at any angle, with apparently the same ease. This seems but a trifling matter when we look at it in an animal of this kind; but if we attempt to hang by the arms, or even to remain with the arm extended at full length, we shall find how inferior our muscular powers are to those of these humble caterpillars; for we could not possibly keep the arm extended, or even the finger pointed, with the elbow supported against the side, for even a twentieth part of the time during which the caterpillar can keep its body at perfect rest, and in a projecting position; and this must be done by muscular force alone; for the skin of the caterpillar is comparatively soft; and thus its muscles have no fulcrum, or point of resistance to which to refer their action, except the small portion of the twig to which the feet adhere.

For the accomplishment of this and other very peculiar motions and states which are necessary in the economy of caterpillars, there is required a degree of muscular complication and perfection, for which we might seek in vain in any of the vertebrated animals, or indeed in any of the insects in their perfect states, in which their motions are analogous to those of the vertebrated animals. But even here there is no failure in the grand provision which is so bountifully made for all the children of nature, according to their several necessities. The number of muscles contained in the body of a caterpillar would be beyond all credibility, if the fact had not been ascertained by direct observation, the accuracy of which no one can call in question. Lyonnet, an accurate observer of the insect tribes, counted, in the caterpillar of the goat-moth, no fewer than four thousand and forty-one muscles, each capable of being exerted singly, or the whole capable of action to the full extent of every permutation and combination of that immense number; and it is no exaggeration to say, that a hundred years, ay, even a thousand, would not be sufficient for repeating once over all the motions which such a set of muscles could produce, even though the time of each motion were limited to half a second: such are the resources which the all-bountiful Author of nature has given to these, which we reckon among the most insignificant of his creatures.

These caterpillars, or larvæ, have in general the body long, nearly cylindrical, of a soft texture, variously tinted, sometimes clad with hairs, tubercles, and spines. It is composed of twelve segments or annuli, besides the head, with nine stigmata on either side. The head is invested with a horny or scaly skin, and presents on each side six bright granules, which seem to be ocelli; and it is also furnished with two extremely short and conical-shaped antennæ; and the mouth is formed of strong mandibles, two maxillæ, a labium, and four small palpi. The silky matter which they employ in the formation of their threads, and which, though it speedily acquires a good deal of consistency after it is exposed to the air, is a liquid while in the body of the animal. It is secreted by, or at all events collected in, two long and tortuous vessels, which become slender toward their anterior extremities, and both terminate in the lip, where there is a tubular nipple of a conical form, which serves as a spinneret in the construction of the threads, its aperture contracting or expanding according as the thread requires to be smaller or thicker; and the caterpillar instinctively knows how to husband its store, so as to proportion the strength of the thread to the length to which it requires to be drawn out. When the caterpillar drops by the thread in order to escape from danger, it has the power of converting the thread into a ladder, by means of which it regains the point to which the thread is attached; and though the feet are made use of in working upwards on the thread, there are some of the species, at least, which have the power of absorbing the thread, so that it may be available on future occasion without any waste of substance. How this is done it is not easy to say, though it is probable that it is taken in by the mouth, and not by the spinneret, in the same manner as spiders may be often seen devouring the webs of other spiders of inferior size, which they have driven off, in order to add the substance of the web to their own store of material. Most lepidopterous caterpillars feed on the leaves of plants; some gnaw their flowers, roots, buds, and seeds; others attack the ligneous or hardest parts of the trees, softening it by a fluid substance, which they disgorge. Certain species attack our woollens and furs, thereby doing us much injury;

even our leather, bacon, wax, and lard, are not spared by them. A few species confine themselves to one description of food, but by far the greater number are less scrupulous of their diet, and devour almost every substance that comes in their way. Some of them are of social habits, and live in community together, under the shade of silken tents, spun by the parties in mutual concert; others are of solitary habits, and construct for themselves sheaths, which are sometimes fixed, and sometimes portable; others again make their abode in the parenchyma of leaves, where they ingeniously form galleries for their accommodation. The most part of them are diurnal; but there are several that are only seen at night. The severity of winter, so fatal to most insects, does not seem to affect certain species of moths which appear during that season; but the moths which so appear, at least in temperate climates, are not so strictly vegetable feeders, or so dependent on the season of growth, as the great majority of the lepidoptera. They are chiefly those moths whose larvæ feed upon dried substances, animal or vegetable; and which, on this account, have no immediate or necessary connexion with the season of growth.

Caterpillars generally change their skins four times previous to their passing into the state of nymph or pupa; most of them spin a cocoon, in which they inclose themselves. A liquor, which is frequently of a reddish colour, which lepidopterous insects eject at the moment of their metamorphosis, softens or weakens the cocoon, and facilitates their emancipation; one of these extremities is generally thinner than the other, or presents a favourable issue by the peculiar disposition of the fibres. Other caterpillars are contented with connecting leaves, particles of earth, or of the substances on which they have lived, and thus forming a rude cocoon. The chrysalides of the diurnal lepidoptera are ornamented with golden yellow spots, they are hence called chrysalides; they are entirely naked, and fixed by the posterior extremity of the body. The pupæ of the lepidoptera exhibit a special character. They are swathed, and resemble mummies. Several insects of this order, particularly of the diurnæ, undergo their metamorphosis in a few days; and even frequently produce two generations in the course of the year. The caterpillars of others, however, remain during the winter in one of these states, and only appear as perfect insects in the spring or summer of the following year; and, generally speaking, the eggs laid in the fall are not hatched till the ensuing spring. The lepidoptera either come forth from their envelope in the usual manner, or through a slit in the back of the thorax.

In the larva state, the moths are by far the most destructive of the lepidoptera; and as they come abroad only in the twilight, or during the night, and fly softly, they are not so much under the control of insectivorous birds, as the diurnal butterflies. Thus, their eggs are insinuated everywhere; and, perhaps, there is not a bud in the forest, or a flower in the garden, in which the egg of one of those insects is not insinuated, ready to be awakened into a living destroyer, if any diseased action of the bud or the flower shall render this necessary in the economy of nature.

11. *Rhipiptera*. This is a very limited order, they form two genera, and are parasitical in their

habits. In the larva state, they are found between the abdominal scales of several species of andrenidæ, and wasps of the subgenus polistes. They are remarkable for their anomalous form, and for their irregular habits. The wings of these insects are large, of membranous texture, and fold together longitudinally, in the manner of a fan. They are furnished with two false elytra, seemingly bestowed by nature for the purpose of enabling them to disengage themselves from between the abdominal scales of the insects which they infest.

Altogether they are minute and obscure insects; and their history furnishes little or nothing that can be in any way interesting to the general reader.

12. *Diptera.* These, as their name imports, are insects having only two wings, but they have in addition two moveable bodies above the wings, which are called balancers. Their mouth is always formed into a sucker of some construction or other. Of course they are fitted only for living upon fluids; but when the fluids on which they live are inclosed within vessels, or coverings of any kind, the sucker is provided with instruments like lances, by means of which they pierce the covering and drain the fluid. The external proboscis serves merely as a case and covering to the sucking instruments, and is thrown back when the other parts are in action. Some of them have, in addition to the balancers, two membranous valves placed above these, which are always larger in proportion as the balancers are less; but the use of neither of these appendages is correctly known. The abdomen is often attached to the thorax by only a portion of its transverse diameter. It consists of rings, varying from five to nine; and where the apparent number

is small, the females usually have the remaining rings formed into an ovipositor, which is withdrawn by each piece sliding into the piece above it, unless when the animal is using it.

Insects of this order are those which are more correctly called flies; and the common house-fly, which follows man in all his migrations over the world, and is at once an annoyance and a service to him, is a very familiar instance. Many of these flies are troublesome in a very high degree: some of them, by sucking the blood of man and domestic animals; others by lodging their eggs under the skin, or in the nostrils and other parts of animals, in which places the larvæ cause inflammation and putrefaction, and, in some instances, mortal disease. Others of them deposit their eggs, or rather, perhaps, their young in the pupa state, upon the hair of domestic animals, and contrive to tickle the skin so as to make the animal lick it, by which operation the pupa is taken into the mouth, and so to some part of the alimentary canal, where it adheres and feeds until the time of undergoing its final transformation; and then it makes its escape. It is understood, that all those species which are parasitical upon domestic animals in the early stages of their existence, live for some time in the ground before they come forth in the winged state. Other species of these insects attack provisions and grain, and others, in the larva state, consume the roots of vegetables, or the young leaves. But, notwithstanding all the annoyance which these insects occasion, they are, upon the whole, highly serviceable, by destroying noxious insects, consuming dead bodies and other putrefying substances which, in warm and humid countries especially, would taint the air, and render it wholly unfit for the purposes of life. They also assist greatly in promoting the removal of stagnant water, and clearing it of those substances by which it is rendered offensive.

All the species undergo a metamorphosis. Some cast their skin before they become pupæ; others spin cocoons; but there are others which do not cast their covering, and, in these last, the covering becomes sufficiently firm for being a pupa case. In them there is a very remarkable metamorphosis. As the animal begins to be detached from the case internally, the external parts which it possessed while in the larva state are left with the integument, and the living animal is merely a soft jelly-like mass, in which hardly any organisation can be traced. But this mass very speedily begins to show the lineaments of the future fly; and when these come to maturity, it bursts the covering, and mounts into the air, in which the duration of many of the species is very brief.

There are two distinct sections of this order of insects. In the first, the change of the larva to pupa always takes place external of the body of the mother, and in the other, and by much the smaller section, the young are born in the pupa state. They are all parasites upon warm-blooded animals—mammalia and birds, and some of them are exceedingly troublesome; though not so much so as some of the parasites which pass their larva state external of the mother.

There are several families of them. The first consists of the gnats or mosquitoes, and the crane-flies, which last get their name from the great length of their legs. Both of these are very troublesome insects; the first on account of the direct annoyance which they offer to human beings, by piercing the skin, sucking the blood, and often occasioning, in moist and warm countries especially, the most intolerable annoyance. They are found in almost every climate, though in high latitudes they disappear during the winter months; but in the moist woods of such latitudes, they are more abundant and more intolerable, during the nightless weeks of the Polar summer, than they are in countries of moderate temperature. In addition to blood, which they can rarely obtain in proportion to their numbers, they feed on the nectar of flowers, and on various other juices. Their manners are not a little curious; for they are aquatic until they undergo their final transformation, but afterwards they live in the air.

The female deposits her eggs on the surface of the water, and unites them in so symmetrical a manner that they form little boats, which float on the surface. The insects themselves can endure very intense cold; and many of the females survive the winters in concealment, and come abroad with the first warmth of the spring, to deposit their eggs in ponds and ditches. Though the larvæ inhabit the water, and can dive and swim about with great rapidity, they breathe the air, and the breathing apparatus is at the posterior part of the body, which is generally furnished with feathery appendages. We shall have occasion to take some further notice of those singular creatures in the next section.

The *Tabani*, or horse-flies, are well known from the annoyance they give to horses and cattle by piercing the skin and sucking the blood. They bear a good deal of resemblance to large flies of the common house species; but their bodies are a little hairy, their head is as wide as the thorax, and almost the whole of the sides of it are occupied by two very large eyes, generally of a golden green colour, with beautiful reflections of purple. The larvæ live in the ground. They are long, cylindrical, and slender towards the head. The pupa spins no cocoon; but when the time of its change comes, it rises to the surface, leaves its skin there, and mounts into the air a perfect tabanus, ready to perform its blood-sucking operations.

The *Œstri*, or gad-flies, are still more annoying to domestic animals than even the tabani. They resort to them for the purpose of depositing their eggs, and the larvæ are parasitical upon the animals until they change into pupæ.

They resemble large flies, thickly covered with hairs, which often form bands of different colours. In the perfect state they are very rarely seen, the localities which they inhabit, and the times of their appearance, being both very limited. As the gad-flies generally, if not invariably, deposit their eggs on the bodies of various grazing animals, it is in the woods and pastures that they are to be found. Each kind of gad-fly generally selects the same species of animal on which to place its eggs; and it always chooses that part of the body where the larvæ can be most conveniently supplied with food. The horses, oxen, asses, deer, antelopes, camels, sheep, and hares, are the only animals which have been well ascertained to be subject to the annoyance of these parasites. This annoyance is very great; for the sound of the fly will throw a whole herd of cattle into the utmost alarm, and make them scamper about as though they were deranged. They inhabit three kinds of places—immediately under the skin, in the frontal sinuses, and in the intestinal canal.

The ox gad-fly is more than half an inch long, very hairy, with a yellow thorax crossed by a black band. It always deposits its eggs upon healthy animals, and rarely upon such as are more than three years old. They are usually situated near the spine, where they form tumours, on the purulent matter of which the larvæ feed. This species also sometimes attacks the horse; but it is not understood very seriously to injure either animal.

The gad-flies of the sheep and the rein-deer, and also of all the rest of the deer which are affected by them, find their way to the frontal sinuses, and sometimes in such numbers, that, in the rein-deer especially, they occasion sickness and death in vast numbers of the animals; and thus the Laplanders, whose rein-deer form the principal part of their wealth, look upon the gad-fly as one of their worst enemies.

The horse gad-fly places her eggs on the legs and shoulders of horses; and they lick the place, and thereby convey the eggs to the stomach, where the larvæ are considered as one species of bot.

The true flies, of which the common house-fly, and the flesh-fly, or bluebottle, are well known specimens, deposit their eggs in putrid matter in vast numbers, and the larvæ, when hatched, very speedily consume those matters. In this way they contribute much to the cleanliness of the earth and the purity of the air, and, like other creatures, they are found in the greatest numbers in those places where there is the most need for them. Their larvæ all resemble short whitish worms without feet, rather thick and blunt at the hinder extremity, and tapering towards the opposite one, the point of which is furnished with two hooks. They use these hooks for dividing those matters which they inhabit, and upon which they feed; and by means of this division, the decomposition and dissipation of the putrid matter is greatly promoted. In the cess-pools of farm-yards and similar places, the rank mud is often literally filled with those larvæ, which keep the surface in a state of constant motion, as if the mud itself were possessed of life.

The second section of two-winged insects bring forth their young in the state of pupæ, which acquire a sort of firm crust, that is provided with a sort of operculum or lid at the one end, by raising which the perfect insect is enabled to make its escape. Some of these are possessed of wings, and others are without any. Both sorts are parasitical upon other animals, and run sideways, often with great rapidity. They are sometimes called spider-flies; and all of them, but more especially the wingless ones, bear a considerable resemblance to spiders.

Such is a very brief and imperfect outline of the insect world, in which almost more than in any other, the wonders of creative wisdom are displayed. We shall add a short chapter on the habits of a few of the species.

CHAPTER VI.

MISCELLANEOUS NOTICES OF SOME OF THE MORE REMARKABLE INSECTS.

The Bee is perhaps the most interesting as well as the most valuable of the whole race of invertebrated animals; and, on account of its structure, physiology, and economy, it has engaged the attention of the naturalist in all ages and countries; nor have its peculiar instinct and active industry been forgotten to be celebrated, by the poets of old any more than by those of more recent ages. In Holy Writ, especially, the assiduous labours of the bee are conspicuously held up as a pattern worthy our imitation, if we would provide against that indigence and misery which is invariably the result of mis-spent time; and whether we follow the example of this interesting little creature in our duty to our Creator, to our neighbour, or to ourselves, the results will be found to be equally profitable and advantageous.

Whilst this insect formed a theme of song to the illustrious Virgil, many of the most celebrated of the ancient philosophers and moralists devoted their attention to the study of its character and habits; and it is recorded by Pliny that Aristomachus spent no less than sixty years in investigating the natural history of bees; and it is also recorded that Philiscus secluded himself in a remote and desert forest, that he might prosecute his observations of them undisturbed. In modern times, much has been said and written on the management and economy of bees; and in the mass of counsel given on the subject, it is not wonderful that much that is erroneous has been inculcated, seeing that, in so complicate and minute a branch of natural history, nothing like much correct observation can be arrived at without more lengthened and laborious efforts than the majority of writers are willing to bestow.

In our necessarily brief glance at the natural history of the bee, the common honey-bee first presents itself as claiming our more especial notice; and in giving a sketch of its character, our observations shall be based either on our own personal observations, or on the observations of such writers as we conceive to be worthy of credence.

Apis mellifica, or "Hive Bee." This species is distinguished from the other bees by having the middle joints of the hind legs covered on the outer surface with a pollen plate of a concave form, and by the absence of spines at the extremities. In the workers, the basal joint of the tarsi is of an oblong form, and its inner surface is covered with a coating of extremely small hairs, which are disposed in transverse layers; the body is of an oblong shape; and the feelers of the tongue sheaths are formed of a single joint, and seem almost entirely useless to the animal. The oral apparatus are of an oblong form, and the sting is a serrated weapon encased in a channelled sheath, with the painful effects of whose stab every schoolboy is well acquainted. One striking peculiarity of these insects is the existence of individual animals, which have been pretty generally considered as a third sex. Modern observation, however, has set aside this notion; and though there is an apparent absence of generative organs in them, it is now ascertained that the *neuters* or *mules*, as they have been called, are females, whose sexual organisation is in an undeveloped state. On this class depends all the laborious duties of the community. They explore the country in quest of every article of domestic use, which they assiduously gather and transport to the hive, and appropriate to the various purposes for which they are required; they wait upon her sovereign majesty the queen, and throw their choicest treasures in her lap; and they also carry on the war offensive and defensive, when that becomes necessary. There is only one perfect female in each hive. She is termed the queen, and her chief duties consist in the laying of eggs, and in commanding the swarm when it goes off on its periodical emigrations from the parent settlement. In all her movements the queen is attended by a strong force of workers; who are ever ready to supply all her wants, and to pay her the most devout attention and the most loyal homage. The influence the queen bee possesses over her numerous subjects is truly astonishing; and, were it not demonstrable by actual observation and experience, would look more like romance than matter of fact. It is ascertained beyond all question, that a hive without a queen cannot survive for any length of time. In her absence the occupation of the workers is at an end. They immediately become inactive, and they not only cease from labour, but also from taking their food; and, consequently, soon cease to exist. In the animal kingdom, generally, the male is acknowledged to be the nobler animal; but in this species the order is completely reversed; for the male bee or drone, as he is contemptuously called, is held to be the most ignoble individual of the race. The impregnation of the female is the only duty he is ever known to perform. He is a complete idler; and, as the sisterhood do not patronise sinecurists, as soon as he has accomplished the purpose, for which alone he seems to have been created, he is laid hold of by the workers, dragged from the hive, and despatched without ceremony. The drones are of larger size than the workers, and altogether have a more thick and clumsy appearance. They are not provided with a sting, which in some measure accounts for the apparent tameness and non-resistance with which they submit to their hard fate. The abdomen, which contains the male organs of generation, is less pointed than the female; and the humming noise it makes in its flight is louder. The queen bee is the largest of the swarm, and she is easily distinguished from the others by having the abdomen of larger size, and more pointed at the extremity of the body: she is also provided with a sting. There is generally only one queen in a hive, and she is often the parent of many generations. The number of drones is at no time very great, seldom exceeding one to forty or fifty of the population, even in the spring, and when the time comes for the extermination, they totally disappear; and at this time even the male larvæ and pupæ are entirely destroyed by the workers, so that no trace of the drones is left behind. The population of a hive is very various, being sometimes only a few thousands; and at other times not less, perhaps, than fifty or sixty thousand. Besides the queen bee, the worker, and the drone, there appear to be two descriptions of females. The difference in them is, that the one is of a considerably larger growth than the other; but Reaumur accounts for this difference by ascribing it to the state of the eggs in the body. There is also another kind of males, not larger than the workers, which are believed to be produced from a male egg laid in the workers' cell. According to Huber, there are likewise two sorts of workers; the first he denominates cirières, wax-makers, as the collecting of food and secretion of materials for the building of the nest, are their duties; the second, which he calls nourrices, or nurses, are smaller and more weakly, whose office it is to attend to the rearing of the young, and the other domestic concerns of the colony. The same author likewise notices another kind of individuals, which he calls black bees. They do not appear to be fixed settlers in the hive, and they are, consequently, liable to share the fate of the drones on the slightest emergency. They do not differ from the workers in any respect, except in having the head and thorax of a darker shade; and Kirby and Spence hinted that these black bees may be superannuated workers, which, having lost some hairs from off their bodies, and being unfit for taking part in the labours of the nest, are banished by the younger members.

In order to ascertain the number of bees that could be contained in a certain space, Mr. Hunter filled a pint pot with drowned ones, and then counted them out, and found the number to be 2160; and Reaumur, by weighing a quantity, ascertained that one ounce contained 336 bees.

The food of bees consists chiefly of the fluid secretions of vegetables, contained in the nectaria of flowers, and pollen, or the dust of the antheræ. This latter substance is also called bee-bread, farina, raw wax, &c. They are also found to feed occasionally on honey-dew, sugar, treacle, and other sweet substances.

One peculiarly striking characteristic in the natural history of the bee is, that the determining of the sex of the young depends entirely on the treatment the eggs receive in the operation of hatching. The eggs, to all appearance, are exactly alike when dropped by the female, whatever the character of the being they are to produce may be; and it is at the option of the workers or nurses to determine, as occasion requires, whether the progeny shall consist of a greater or smaller number of queens, labourers, or drones. This is effected by placing the eggs in the different cells, and nourishing and attending to them in different ways.

The organs employed in the collection of their food, are fitted for the division of solid substances, and also for the reception of liquid aliment. Like all other hymenopterous insects, they are provided with a long and flexible proboscis, or trunk. This organ may be said to be a lengthened tongue, but it is perhaps better denominated by being termed a continuation of the under lip. Until the days of Reaumur, this instrument was described as a tubular trunk, through which the animal sucked up its aliment; but that naturalist has clearly proved that it is merely used as a tongue by which the food is licked up; and that the application of any part of the member is equally efficient for this purpose, which could not have been the case had it been constructed in a tubular form, which necessarily would have had its opening or mouth at the outer extremity. From the construction of a pedicle which supports this trunk, it is susceptible of contraction and extension; it is guarded by a double sheath. The external sheath is formed of two scales, which are furnished by a portion of the labial palpi, and the internal one is formed by the extension of the outer portions of the jaws. Bees are furnished with two stout mandibles and four palpi, which are more commonly used by the animal in breaking hard substances than in eating its food. These organs are larger in the working bees than in the others. Like the jaws of other insects, those of the bee play horizontally; they are furnished with two sharpened teeth, formed of concave scales. Reaumur points out an aperture above the root of the proboscis, which he conceives to be the mouth of the gullet, and immediately above this orifice is a small, sharp-pointed, fleshy organ, which he considers to be the tongue, which assists in the swallowing of the food. Latreille, however, is of opinion, that no such aperture exists, and that the aliment is simply conveyed into the stomach by the sides of the tongue. It has two stomachs, the first of which is rather capacious. It is formed of a membranous substance, quite transparent, shaped sharp in the fore part, and swelling out behind in the form of two bags or pouches. This first stomach serves a somewhat similar purpose to the crop of birds. It retains the fluid of the nectaria for a considerable time; but it does not appear that any substance undergoes anything like a digestive process by being placed in it; and from the muscular construction of this depository, the animal is enabled to bring back its contents to the mouth, so that they may either be deposited in the cells of the hive or distributed to other individuals. The second stomach is of a cylindrical shape, is placed in conjunction with the middle of the posterior end of the former, and serves the purpose of digestion. Communication is obtained by an inverted pylorus, which conveys the food to the stomach by a very minute aperture in its centre. At the entrance from the first to the second stomach, there is a valve which opens inwardly. This valve prevents the possibility of regurgitation from the former to the latter.

By means of a brush of hair which grows on the tarsi, the working bees collect the pollen of flowers, which they knead together into a lump, and place it in what is termed their basket, which is situated at the middle joint of the hind legs. Surrounding the basket, there are rows of hairs which prevent the load from falling off. In addition to the brush on the tarsi, as a means of collecting pollen, the bees are sometimes observed to roll their whole body on the flower for the same purpose, and then carefully to brush it off with their feet, and knead it into balls, and carry it off, as above described. As, in order to get at the pollen, the bees are often obliged to tear open the capsules of the flower, and as the tenants of one hive alone will often carry off not less than one pound of this fecundating substance, some agriculturists have been apprehensive that the vegetation of various plants might be seriously injured by this robbery; and in consequence of this apprehended danger bees have been exterminated in some districts. But this apprehension has not only been shown to be entirely groundless, but that the labours of the bee rather tend to promote vegetation than otherwise. They not only agitate the flower, thereby diffusing the germinating principle over the stigma; but it is also to the labour of the bee that we owe the existence of the many hybrid flowers that are met with in its range.

Bees consume a large quantity of water, consequently they require a plentiful supply to keep them in a healthy state; and, what is rather remarkable, they will take it in a putrid state, in preference to the purest stream.

It was long the opinion that pollen required only the application of a certain pressure, and a sort of kneading by the feet of bees, to convert it into wax; but it has since been proved by the researches of the naturalist, that it is a secretion from the abdomen of the bee, and that it does not in any degree depend on the pollen which the insect may consume, but on the quantity of honey or other saccharine matter which it receives into its stomach. It was the opinion of Wilhelmina, so far back as 1768, that wax, instead of being rejected by the mouth, exudes from the rings which inclose the posterior part of the body: and Huber has clearly proved by a series of experiments, which places the question beyond dispute, that, in a state of nature, the quantity of wax secreted is exactly in proportion to the honey which is consumed. He has further shown that an equal or even a greater quantity will be produced, provided the bee is fed on a solution of sugar and water.

It is the honey collected by the bee, however, which is the most valuable part of the economy of that industrious little creature, and we cannot find a more forcible expression for the value of this honey, than the description of the land of Canaan, as held out to the children of Israel—"a land flowing with milk and honey." The first of these, "flowing with milk," is finely descriptive of the productions of the plains and valleys; and the second, "flowing with honey," is equally expressive of the great fertility of the rocks, the wild woods, and the wilderness itself; for in such climates as that of Judea, these are the places where wild bees, which are social, and in numerous swarms in those countries, as the domesticated bees are with us, chiefly fix their habitations: the hollow of a tree serves them for a hive; and the wild flowers of the uncultivated places are their finest pastures.

The usual practice of obtaining honey from domestic bees was one of great, and, as it should seem, wanton and unnecessary cruelty; the little creatures, after they had toiled throughout the whole season, were not only deprived of all the winter store which they had accumulated, but they were smoked with sulphur in the hive, by means of which both old and young were entirely cut off. There is a degree of unfeeling cruelty in this at which the mind revolts; because, though all creatures are in some way or other adapted for the use of man, the destruction of the creatures is no part of man's legitimate occupation. He has, undoubtedly, a right to his share of every production of the earth, which can, in any way, contribute to his comfort; but it is his duty, and his interest, to take that share in wisdom, not in wantonness; and he could, upon every occasion, so manage matters, as that the quantity which he takes might benefit that which is left; and thus, while he uses, he might ameliorate and improve all that grows and lives around him; and so be the adorner of creation, and not the destroyer.

Many plans have been resorted to for the preservation of bees, and the leaving of as much honey as shall support them during the winter. One of the most recent, and perhaps the best of these, is that introduced by Mr. Nutt, a cultivator of bees in Lincolnshire. In this method, three boxes are placed together, with a door for entrance in the central box only, but with a communication between it and each of the lateral ones. By means of ventilation, the two side boxes are kept at a heat which is well adapted for labouring bees; but below that at which the young are hatched. The bees are placed at first in the central box only; and when the first swarm of the season is produced, and would depart, admission is given to one of the side boxes; and when that is filled, similar admission is given into the other. The temperature of these is regulated by means of ventilators; and when it is ascertained that one of them is full, as much ventilation is given to it as drives all the bees into the central box, the communication between them is closed, and the box is removed without the destruction of a single bee.

This is not the only advantage which is gained; for the honey is purer, and altogether of superior quality. The low temperature of the side-boxes not only prevents a queen bee from taking up her abode in them, but none of the eggs, the young, or the substances required for their nourishment in the larva state, are ever deposited in those boxes. Thus they contain only honey-cells and honey;

and as those cells are constructed only as they are required, the combs are always full. This method appears to fulfil many of the conditions which are desirable for the proper management of bees; and which are thus stated by Dr. Bevan:—

"First, an economical division of labour, which causes a larger quantity of wax and honey to be collected, than if the bees were to swarm, and to carry on their operations in separate families.

"Secondly, the facility with which the bees may be deprived of a consderable portion of their honey, without destroying their lives, or communicating to the honey any unpleasant flavour from the sulphurous gas.

"Thirdly, the power which is afforded to the bees, of employing themselves usefully in wet weather.

"Fourthly, the saving of that time which is unnecessarily spent in the construction of the fresh combs in the new habitation, at a period of the year, it may be observed, when nature is most lavish of her flowers for the development of their sweets.

"Fifthly, the saving of time usually lost in the preparations for swarming, when the bees hang inactively in clusters on the outsides of the hives for many days, sometimes for weeks, particularly if the weather prove favourable."

By this means, from one swarm of bees, cultivated for five years, Mr. Nutt obtained 737 pounds of honey, and left 712 pounds during the currency of the time for the maintenance of the bees, the increase of which was regularly progressive during the whole time which, from its superior quality, would be worth fourteen guineas on the average of every year, besides the expense of bringing it to market. There are very many situations in this country, where every cottager might cultivate one such establishment of bees, the profits of which would suffice to furnish himself and his family with comfortable clothing, and also to replace their household furniture.

Assisted by the ingenuity of man, bees may be enabled to produce a greater quantity, and also a finer quality, of their useful commodity, than in a state of nature; but in this state they are perfectly adequate to supply to profusion all their own wants. They are totally independent of the assistance of human artifice in the construction of their habitation; for, in the hollow of a tree, or other cavity that is presented by nature, they can erect their miniature city, and devise and construct its complicated architecture, on the most perfect geometrical principles, and the most symmetrical plan. And when we consider the order and social union which characterise the government of the hive, although we may not positively affirm that, in their wonderful operations, bees are guided by what is termed instinct, yet we may venture to say, that they are endowed with wisdom and foresight, surpassing anything hitherto observed in any other class of insects.

When a new place for their nest is fixed on by a colony of bees, the first duty of the workers is to have it properly cleaned out; and whilst one party is engaged in doing this, another is sent to scour the country in quest of propolis, a species of glutinous matter, of a resinous, tenacious quality, derived chiefly from the wild poplar, for laying the foundation of the new abode, and for stopping up any crevice that may appear in it. These preparations made, they next proceed to construct the combs to receive the eggs which the queen bee is about to lay. Wax is the substance of which these are constructed, and to procure the requisite supply the hive is actively astir, collecting honey, which they bring home and impart to the housekeepers, who, having filled their crops, hang together in clusters from the roof of the hive, in a state of inactivity for a considerable time, during which the process of secretion is going forward; and, when the necessary quantity is produced, the building is commenced. The combs very generally occupy the whole extent of the hive. They are placed in parallel and vertical layers, of about an inch in thickness. The space between the surfaces of each of these layers is about half an inch, and this forms a passage for the bees over both surfaces. The combs consist of thin partitions, which inclose hexagonal cells, in dimensions about half an inch deep, and a quarter of an inch in diameter; they are open on both surfaces of the comb, and closed by a partition, composed of a collection of rhombs, which occupy the middle space between the combs, and is common to both sides. In the constructing of the combs, the greatest attention is paid to the economising of matter and space, and in this particular the bee-hive presents a paragon of perfection, inimitable in the whole scope of human experience.

A sufficient number of cells having been constructed, the deposition of the eggs commences.

The method of doing this has been more carefully observed by Mr. Jesse than by almost any other individual, and it is so well described by him in his delightful Gleanings in Natural History, that we cannot resist quoting the passage:—"I have," says Mr. Jesse, "some experimental hives, which enable me very accurately to inspect the operations of my bees. From the construction of the hives, the combs are necessarily built between two panes of glass, so that on drawing the sliders the two surfaces of a comb are exposed to view. In this way I am able to see almost everything that is going forward.

"When the queen bee has an inclination to deposit her eggs, she goes forth, accompanied by six or eight working-bees as a guard, and whose stomachs are filled with honey. She is very deliberate in her motions, and seems to proceed with great caution. She first looks into a cell, and if she finds it perfectly empty, she draws up her long body, inserts her tail into the cell, and deposits an egg. In this way she slowly proceeds, till she has dropped ten or twelve eggs, when, perhaps feeling exhausted, she is fed by one of the attendant bees, who have attended her for the whole time. This is done by the bee ejecting the honey from its stomach into the mouth of the queen. When this has been done the bee goes away, and another takes its place. The operation of laying her eggs again goes on, and is succeeded by the same mode of feeding—the attendant bees frequently touching the antennæ of the queen with their own. When the operation of laying the eggs is completed, and it generally occupies some time, the queen retires to that part of the hive which is most filled with bees. During her progress, the surface of the comb is very little intruded upon, and the space seems purposely to be left unoccupied. Some few of the cells, however, of a brood-comb, are passed over by the queen, and are afterwards filled either with honey or farina. These serve as deposits of food, from which the neighbouring brood may be fed more readily, as such cells are never covered with wax.

"With the hives alluded to I have been able to follow many of Huber's experiments, and can bear witness to his general accuracy, except in regard to the fecundation of the queen bee. I have bestowed much time and pains in endeavouring to discover any of the circumstances he mentions relating to this fact, but without success. Neither have I ever seen a cell visited by one of the drones *after* the egg had been deposited, which a modern writer has asserted they do. I have for many years watched my hives with the greatest assiduity, but have never seen the queen bee leave the hive, except at the time of swarming. I have also spoken to several experienced bee-masters on the subject, and they are of the same opinion with myself—that she never quits it. Her person is so easily distinguished from the other bees, by any one at all conversant with them, that, if the queen absented herself from the hive, in the way Huber describes her as doing, it seems next to impossible that she should not have been perceived, either on her departure from, or on her return to, the hive. And yet we have an English writer on bees (and we have many acute and observant ones) who has even hinted at the probability of the queen's leaving the hive in the manner Huber asserts that she does. It is now many years since his work was published, and no part of it is more curious or more satisfactory, if correct, than what he says of the impregnation of the queen bee. Curiosity has, in consequence, been much excited, and many persons like myself have been anxious to ascertain the accuracy of the statements. It does not appear, however, that any one in this country has succeeded in doing this, though we have many very patient observers. Is it probable, therefore, that it should have been reserved for Huber alone to ascertain a fact which had escaped the notice of naturalists, not only for ages before, but, what is more important, for years since the publication of his work? It should be recollected also, that Huber was blind, or nearly so, and that he was obliged to rely much on the reports made to him by his assistant Burnens. It is, however, with considerable diffidence that one would venture to doubt the accuracy of this statement of Huber's, especially when the objection turns not upon a contradictory circumstance, but upon what myself and others *have not been able to discover*."

After the labours of the queen in laying her eggs have been completed, the workers eagerly set about providing food for the larva, which resembles small white worms without feet. This food consists chiefly of pollen, with a small admixture of sugar and water; and, after it has been partly digested in the stomachs of the nursing bees, they eject it into the larva, which may be seen opening its lateral pincers to receive it. Five or six days suffice to bring it to its full size, when it ceases to eat, and is closed up with wax in its cell, which it now nearly fills, by the bees. For the next thirty-six hours it is busied in spinning its cocoon; and in other three days it is converted into pupa, of a pure white colour. The perfect form of the future bee is now discoverable through its transparent mantle, which, in a week more, it forcibly rends asunder, and emancipates itself from its prison. On the instant, it is received with caresses by those individuals on whom the care of the young devolves, and a plentiful supply of food is set before it. The metamorphosis of the male bee occupies a few hours longer than that of the female workers.

In rearing the queen bee, the process does not much differ, except that there is more attention bestowed, and more abundant and stimulating food supplied to the larva. By this means the perfect insect is matured about twelve hours sooner than the imperfect females. Notwithstanding these attentions bestowed in bringing the queen bee to maturity, however, it depends on circumstances whether she is either to be allowed to ascend the throne instanter, or whether she may not be destined to fall a sacrifice to the relentless fury of the reigning monarch, who will not suffer a rival to live, unless she is on the eve of heading a detachment of her subjects for the purpose of forming a new colony. On account of the sanguinary propensities of the queen-mother, great circumspection is necessary on the part of those individuals who have charge of the young queen; and, therefore, if they wish her to be their future sovereign, they are most solicitous to prevent contact between the royal rivals. But if, on the other hand, there is no intention on the part of the reigning sovereign to abdicate, no regard is manifested to protect the lives of the royal brood, and consequently they are butchered one after another, as soon as they are seen to approach the precincts of the royal cells.

When the old queen quits the hive at the head of the first swarm, the young queens are released from their cells in succession, and as swarm after swarm leaves the hive, they mount their thrones in the same order, and, what is very remarkable, no sooner has one of these baby monarchs ascended the throne, than she instantly uses her utmost endeavours to exterminate every rival within her reach; and, but for the vigilance of their guards, the last one of the young princesses would be massacred by her. The number of swarms sent off from a hive, in a summer, in this country, seldom exceeds three; and, as the swarming depends on the increase of population, it is of course regulated in a great measure by the supply of food, and the warmth of the climate within the bees' range.

The drones do not accompany the swarms in great numbers. They are suffered to loiter about the hive, till they have accomplished the duty of impregnation; but, when this is done, and no new swarms anticipated, they are set upon by the workers, and exterminated without mercy; and their eggs and larvæ are also totally destroyed at the same time, lest a single trace of a drone might remain. Should it so happen, however, that a hive is without a queen, the drones are allowed to live for a whole winter.

After the extermination of the drones, the bees occupy the remainder of the summer in gathering food for the coming winter, and every species of plant that offers the slightest nutriment is explored and robbed of its sweets; and after the flowers have ceased to supply the requisite demand, the neighbouring hives are assailed and plundered, should the assailant be the stronger party. In this species of warfare, both in the attack and in the defence, the most consummate generalship is manifested, and the utter extirpation of whole hives is frequently its consequence. The bees of different hives often join in marauding parties, and in these cases a fair scheme of division is invariably observed in sharing the plunder.

At the end of autumn, the out-door labours of the bee terminate, and they then feed on their well-garnered store till the severity of the weather reduces them to a state of torpidity: from which they are aroused by the genial warmth of the ensuing spring, when they again resume their toils. Should it so happen that any of them are allured from the hive by the tempting rays of a winter's sun, they very quickly pay the forfeiture of their life for such temerity.

It is not easy to guess at the average duration of the life of the bee; but it is generally believed, that it does not extend beyond one year. They are very liable to casualties, which greatly tend to reduce their number. The fruitfulness of the queen-bee is very remarkable; for it has been ascertained by counting the number of mature bees and larvæ, that, in some of the warmer parts of Europe, a single individual will produce not fewer than from thirty thousand to sixty thousand eggs; and it has been proved by Huber, that a single impregnation of the male is sufficient for the fecundation of all the eggs which are laid by a queen in two years; and from this, it is probable that one single act is sufficient to produce an equal effect on all the eggs that might be produced by the same female, though her life might extend for many years. From the care which the bees take to have successive queens always in progress, and also from there being drones produced as part of every successive swarm, whether it be necessary for that swarm to quit the hive or not, it is highly probable that the queens, after their one excessive production, may not be able to bear another. This, however, is a point upon which we have no precise information.

Bees sometimes take up their habitations in strange places, even in this country, though not so frequently as in warmer climates, where they are more abundant. Samson's riddle to the Philistines, respecting the wild bees which he had found taking up their abode in the carcass of the lion, is a remarkable instance, but by no means an improbable one. One of the most remarkable places in which we have seen the common hive-bee dwelling in large multitudes, and comparatively in a state of natural freedom and security, was in a large and curious sundial which stands in front of the castle of Glamis, in Strathmore, Forfarshire. The dial is built of a great number of stones; and the tables and styles for showing the hours upon it, are almost countless. The place was neglected at the time alluded to, in consequence of the long absence of the proprietor; and the stones composing the upper part of the dial had opened into large fissures on their sides, though they were closer at the top, and the openings there filled up by earth and wall plants, which formed a sort of roof. The day was warm and sunny, and the country around very flowery; and we observed the bees departing and arriving in currents and counter-currents, almost solid, in the immediate vicinity of all the fissures of the southern side, and forming a visible cloud at the distance of a good many yards. No doubt many instances have occurred in which their habitations have been still more singular than this; and these things show how ready the bee is to come near the dwelling of man, while what has been formerly mentioned proves how valuable it might be rendered by proper care. The encouragement of bees necessarily involves the culture of flowers; and thus, while it enriches, it also adorns.

The *Ant*, even as it appears in this country, and without reference to the countless myriads that are found in tropical climates, some of which are ants, and some not, though they all go by that name, is another singularly interesting instructive insect, from the labour which it performs, and its strength and assiduity in performing that labour. Ants, like other insects, are produced from eggs, which are hatched into small larvæ that are without feet. These larvæ change into large white pupæ, and are vulgarly called ants' eggs; though they are much larger than the ants themselves. They are not eggs, however, for they are the second stage of the ant, after the egg. In our notice of the ant, we shall not detain the reader with any lengthened narration of the many fanciful notions and marvellous transactions that have been recorded of them, such as their being guided in their motions by the phases of the moon; of their dimensions, in the northern parts of India, being as large as Egyptian wolves; and of their winter's occupation being that of digging up gold from the bowels of the earth, with the apparent view of enriching the natives of their immediate locality. Even in later times than when these notions were entertained, very erroneous ones have been promulgated regarding these little insects; and their provident habits, though they must be admitted to be a provident class, have been very much exaggerated. The doctrine that their larvæ resembled grains of corn, and that these were laid up in store to supply their winter's keep, has been unceremoniously exposed by Dr. King and others, who have observed the successive changes of the larva from the egg to the perfect insect.

Like a vast number of other species of hymenopterous insects, ants possess what may be termed three sexes,—namely, males, females, and neuters. The neuters have the complete form of the perfect females in every respect, except that they want the wings ; and, on minute examination, they are found, like the labouring bees, to be unprovided with perfect sexual organs. Like the same description of individuals in the bee-hive, they perform all the laborious duties of the colony.

The economy and domestic policy of the ant, of which there are numerous species, have formed the subject of many treatises ; but that by Huber, on those inhabiting the vicinity of Geneva and elsewhere, has, perhaps, thrown more light on their natural history than anything yet published on this department of entomology. This industrious naturalist contrived an apparatus, by means of which the inmost recesses of the ants' nest could be viewed, and their most minute operations observed ; and the results of his labours, as given in his work, are of a peculiarly interesting and instructive character.

Male ants have four wings and three lucid points on their head, and their eyes are larger than those of the females or labourers. They are not found in the nests at all seasons, but only at particular times. It seems they are killed (like drone bees) as soon as the season for impregnating the females is over.

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

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

They bring out their young every day, and spread them near their nest, in little heaps, on a kind of dry earth, provided for that purpose. They carry them back at night. But it is observed, they never bring them out unless in a day that promises to be fair. In the prognosticating of this they show great sagacity. Where it is dangerous to expose them in the daytime, by reason of the birds, they vary their rule by bringing them out in the night, and carrying them back in the morning.

They do not eat at all in winter, but remain dormant, as is the case with most other insects. There is a straight passage into every ant's nest, about half an inch deep; after which it goes sloping into their magazine; which is a different place from that where they eat and rest. Over the entrance to the nest they place a covering to protect them from the rain. In a fair day, this entrance is left open; but when they foresee that it will rain, and every night, the covering is drawn over, with great ingenuity as well as labour. A host of the strongest of them surround the covering, and draw and shove in concert; and the same pains are taken every morning to thrust it back.

They are prohibited on pain of death from visiting any other nest but their own; and consequently there are few instances where this hazard is run.

They do not bite, as is vulgarly supposed; but red ants have a sting, which emits a corrosive liquor, that raises a slight inflammation. The black ants have no sting.

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

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

Every morning, during the summer, they bring up the pupæ near the surface of the earth. And from ten in the morning till about five in the afternoon, they may be found just under the surface; but if you search at eight in the evening, they will be found to have been carried deeper down; and if rainy weather is apprehended, they lodge them at least a foot deep.

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

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

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

The labouring ants, being of no sex, are wholly employed in providing for the young, which the queen deposits in the cells. In whatever apartment she is present, universal joy is shown. They have a particular way of skipping, leaping, prancing, and standing on their hind legs. Some walk gently over her, others dance round her, and all are eager to express their loyalty and affection. An illustration of this race will be seen by placing the queen and her retinue under a glass.

The queen lays three different sorts of eggs; male and female in spring, and neuter in July and part of August. The common ants then brood over them in little clusters, and remove them to and fro, in order to obtain the requisite degree of temperature. The young disengage themselves from the membranes that enclose the eggs, just as the silkworms do. The female eggs put on the form of worms some time in February; the male, by the latter end of March; the neuters, by September. The first summer they grow little, and still less in winter. By the beginning of April the second year, they visibly increase every day. By the end of May the male and female attain their full growth, and are ready for another change. This long continuance of ants in the larva state is peculiar to no other class of insects. The larvæ in a few days infold themselves in a soft silken covering, and assume the form of pupæ, which are commonly mistaken for ants' eggs. As soon as they exhibit symptoms of life, the workers give them air, by an aperture in the end of the covering, which they gradually enlarge for a day or two, and then take out the young.

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

In all other insects the loss of their wings lessens their beauty, and shortens their lives. But ants gain by this loss—as it is a prelude to their ascending the throne.

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

Perhaps in warm climates, ants do not pass the winter in sleep, as they do with us. If so, they need a store of food, which in our climate is quite needless. Accordingly, those who have accurately examined their most numerous settlements could never find out any reservoir of corn or other aliments. And those who have carefully observed their excursions from, and their return to, their colonies, could never observe that they returned with any wheat corn, or any other vegetable food, though they would eagerly attack a pot of honey, or a jar of sweetmeats.

But is it not said, Prov. vi. 8, "*She provideth her meat in the summer, and gathereth her food in the harvest?*" It is: but this does not necessarily mean any more, than that she collects her food in the proper season. Nor is anything more declared, ch. xxx. 25, than that ants carry food into their repositories. That they do this against winter, is not said: neither is it true in fact.

In England, ant-hills are formed with but little apparent regularity. In the southern provinces of Europe, they are constructed with wonderful contrivance. They are generally formed in the neighbourhood of some large tree and a stream of water. The one is the proper place for getting food; the other, for supplying the animals with moisture, which they cannot well dispense with. The shape of the ant-hill is that of a sugar-loaf, about three feet high, composed of various substances; such as the leaves of plants, bits of wood, sand, earth, particles of gum, and grains of corn. These are all united into a compact body, perforated with galleries down to the bottom, and along the winding paths within the structure. From this retreat to the water, as well as to the tree, in different directions, there are many roads formed by constant assiduity, and along these the busy insects pass and repass continually; so that from May or the beginning of June they work continually till the bad weather comes on.

The chief employment of working ants is in finding a sufficiency of food. They live upon various provisions, as well of the vegetable as the animal kind. Small insects they kill and devour; sweets of all kinds they are particularly fond of. Having found a juicy fruit, they swallow what they can, and then tearing it in pieces, carry home their load; but they seldom think of the wants of their community till they have gorged themselves to satiety. If they meet with an insect above their match, several of them will fall upon it at once, and having torn it in pieces, each will carry off a part of the spoil. If they meet with anything that is too heavy for one to bear, and yet which they are unable to divide, several of them endeavour to force it along, some dragging, others pushing. If any one of them makes a lucky discovery, it immediately gives advice to others, and then at once the whole republic put themselves in motion. If in these struggles one of them happens to be killed, some survivor carries him off to a great distance, to prevent the obstructions his body might give to the general spirit of industry.

In autumn they prepare for the severity of the winter, and bury their wheat as deep in the earth as they can. It is now found that the grains of corn, and other substances with which they furnish their hill, are only meant as fences to keep off the rigour of the weather. They pass four or five months without taking any nourishment, and seem to be dead all that time. It would be to no purpose therefore for ants to lay up corn for the winter, since they lie that time without motion, heaped upon each other, and are so far from eating that they are utterly unable to stir. Thus, what authors have dignified by the name of a magazine, appears to be no more than a cavity, which serves for a common retreat, when they return to their lethargic state.

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

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

One of the most dreadful enemies of the ants is the formica-leo or "ant-lion," so called from the havoc which it makes among the ants and other small ground insects. It is the larva of *Myrmecoleon formicarum* of Linnæus, which is a neuropterous insect, about an inch long, of a yellow colour spotted with black, with transparent wings having the fibres black interspersed with white, and a whitish spot near the extremity of the wing. The full-grown insect is very slender in the body, and with long wings. It is found only in the warmer countries, where it clings to plants in a state of rest during the day. The larva is very different both in appearance and in manner. Its body is composed of several rings: it has six legs, four joined to the breast; and the other to a long part, which may be termed the neck. Its head is small and flat, and it has two remarkable horns, the sixth of an inch long, as thick as a hair—hard, hollow, and hooked at the end. At the origin of each of these horns, it has a clear and bright black eye.

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

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

But if he is to make a larger pit, he first traces a circle in the sand. Then he buries himself in it, and carefully throws off the sand beyond the circle. Thus he continues running down backward in a spiral line, and throwing off the sand above him all the way, till he comes to the point of the hollow cone, which he has formed by his passage. The length of his neck, and the flatness of his head, enable him to use the whole as a spade; and his strength is so great, that he can throw a quantity of sand to six inches' distance. He likewise throws away the remains of the animals he has devoured, that they may not fright other creatures of the species.

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

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

When his pit is finished, he buries himself at the bottom of it in the sand, leaving no part above it but the tips of his horns, which he extends to the two sides of the pit. Thus he waits for his prey. If an ant walk on the edge of his pit, it throws down a little of the sand. This gives notice to toss up the sand from his head on the ant; of which he throws more and more, till he brings him down to the bottom between his horns. These he then plunges into the ant, and having sucked all the blood, throws out the skin as far as possible. This done, he mounts up the edges of his pit, and if they have suffered any injury, repairs it carefully. He then immediately buries himself again in the centre, to wait for another meal.

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

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

A very extraordinary kind of insect is that which is called a death-watch, on account of its making a noise like the ticking of a watch. They are of two kinds. One is a small beetle, somewhat more than a quarter of an inch long, of a dark brown colour spotted, and having a large cap on the head, with two feelers springing from beneath the eyes. Dr. Derham observed it to draw back its mouth, and beat with its forehead. He kept two, a male and a female, in a box for some months, and could bring one of them to beat when he pleased, by imitating its beating. And he soon found this ticking to be the way whereby they wooed one another.

The other kind is a greyish insect, which beats slowly for some hours without intermission; whilst the former beats only seven or eight strokes at a time, but much quicker. It is very common in summer, in all parts of our houses, nimble in running to shelter, and shy of beating, if disturbed; but it beats readily in answer to your beat, if the place where it lies is not shaken. It performs this operation generally in the paper or wood-work of the apartment. It is at first a small white egg, and hatches in March, when it creeps about with its shell on, though smaller than the egg itself, and soon grows to its perfect size.

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

"Possibly the insect may sometimes woo its mate by beating thus; but it was not the case now.

It had not any other of its kind near it. It seemed therefore to be preparing its food. It was about a quarter of an inch long, of a dark dirty colour, having a broad helmet over its head, which it could draw up under it, so that it is a notable defence against the falls to which it is continually exposed, creeping over rotten and decayed places.

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

This seems to be the smallest of the beetle kind. A gentleman describes one of a very different sort in the Philosophical Transactions. "On the removal of a large leaden cistern, I observed at the bottom of it black beetles. One of the largest I threw into a cup of spirits (it being the way of killing and preparing insects for my purpose). In a few minutes it appeared to be quite dead. I then shut it up in a box about an inch and a half in diameter, and throwing it into a drawer thought no more of it for two months, when opening the box I found it alive and vigorous, though it had no food all the time, nor any more air than it could find in so small a box, whose cover shut very close. A few days before a friend had sent me three or four cock-roaches. These I had put under a large glass; I put my beetle among them, and fed them with green ginger, which they ate greedily; but he would never taste it, for the five weeks they lived there. The cock-roaches would avoid the beetle, and seem frighted at his approach; but he usually stalked along, not at all regarding whether they came in his way or not. During the two years and a half that I have kept him, he has neither ate nor drank.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The *Ephemeron*, or fly that lives but part of a day, appears usually about Midsummer. It is produced about six in the evening, and dies about eleven. But before it becomes a fly, it exists three years as a worm in a clay case. It never eats from the time of its change to its death, nor has it any organs for receiving or digesting food. The business of its life is summed up in few words. As soon as it has dropt its clay coat, the poor little animal, being now light and agile, spends the rest of its short, winged state, in frisking over the waters. During this the female, being impregnated, drops her eggs upon the water. Those sink to the bottom, where they are hatched by the heat of the sun into little worms, which make themselves cases in the clay, and feed on the same, or on what the waters afford, without any need of paternal care. Thus, they are inhabitants of the water till the time comes for shaking off their shell, and emerging into air.

Of one sort of ephemeron, Mr. Collinson writes thus: May 26, 1744.—I was first shown this by the name of May-fly. It lies all the year, but a few days, at the bottom of the river; then rises to the surface of the water, and splitting open its case, up springs the new animal, with a slender body, four shining wings, and three long hairs in its tail. It next flies about to find a proper place where it may wait for its proper change. This comes in two or three days. I held one on my finger, while it performed this great work. It was surprising to see how easily its back split, and produced the new birth, which leaves head, body, wings, legs, and even its three-haired tail behind, or the cases of them. After it has rested a little, it flies nimbly to seek its mate. The males keep under the trees, remote from the river. Hither the females resorted, and when impregnated soon left the males, sought the rivers, and kept continually playing up and down on the water. Every time they darted down, they ejected a cluster of eggs. Then they sprang up again. Thus, they went up and down till they had exhausted their stock of eggs and spent their strength, and being so weak that they can rise no more, they fall a prey to the fishes, and this is the end of the females. The males never resort to the river, but, having done their office, drop down and die.

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

How poor an end, to our apprehension, is answered by the life of this, and innumerable other animals!

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

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

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

The wings of butterflies fully distinguish them from flies of every other kind. They are four in number; and though two of them be cut off, the animal can fly with the remaining two. They are in their own substance transparent; but owe their opacity to the beautiful dust with which they are covered, and which has been likened by some to the feathers of birds; and by others, to the scales of fishes. If we inspect the wing of a butterfly with a good microscope, we shall perceive it studded over with a variety of little grains of different dimensions and forms, generally supported on a footstalk, regularly laid upon the whole surface.

Nothing can exceed the beautiful and regular arrangement of these little substances. Those of one rank are a little covered by those that follow: they are of many figures; here may be seen a succession of oval studs; there a cluster of them, each in the form of a heart: in one place they resemble an open hand; and in another, they are long or triangular; while all are interspersed with taller studs that grow between the rest, like mushrooms upon a stalk.

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

Butterflies as well as moths employ their short lives in a variety of enjoyments. Their whole time is spent either in quest of food, which every flower offers; or in pursuit of the female, whose approach they often perceive at above two miles' distance. Their sagacity in this particular is astonishing; but by what sense they are capable of doing this, is not easy to conceive. It cannot be by sight, since such small objects must be utterly imperceptible at half the distance; it can scarcely be by the sense of smelling, since the animal has no organs for that purpose. Whatever be their powers of perception, certain it is, that the male, after having fluttered, as if carelessly, about for some time, is seen to take wing and go forward, sometimes for two miles together, in a direct line to where the female is perched on a flower.

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

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

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

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

Some caterpillars, all the way they walk, spin a thread of silk, which marks their journey. A little observation will show the end served by this thread; for if we trace the animal till it chances to stumble, it will be seen that the thread, being fastened to leaves and twigs, breaks the fall. Nor is this all. It can also, by means of this thread, re-ascend to the place whence it fell, and having got safe up again, it continues its motion as before.

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

Many species of butterflies lay a great number of eggs in the same place. These are all hatched very nearly at the same time, and one would naturally suppose that the young brood of all would be inclined to continue and live together. But this is not the case; for the different species have different inclinations. Some keep together from the time they are hatched till they change into pupæ; others separate as soon as they are able to crawl, and seek their fortunes singly; and others again live in community till a certain time, and then each shifts for itself. Those that live wholly together begin by forming a line with their little bodies upon a leaf, their heads all standing even, and in this manner they move and eat together; and there are often several ranges of this sort, which make so many phalanxes, and eat into the leaf they stand on with perfect equality.

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

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

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

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

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

The hairs found on the cast skins of the hairy caterpillars seem at first, like the other part of the exuviæ, to be only the covering of the hairs enclosed. But that is not the case, for they are solid things themselves, not barely coverings; and in fact the creature when first hatched has all its skins perfectly formed, one under another, each furnished with its hairs, so that the old ones fall off with the old skins. And probably the erecting these is one great means of forcing off the old skins.

This miscellaneous chapter on the insect tribes would not be complete unless we gave a short notice of those which are most annoying to the cultivator, whether of the garden or of the field; this therefore we shall endeavour to do in as few words as possible.

Among these the *coccus* family may be mensioned as being especially obnoxious to the cultivators of the vine, the pine apple, and the generality of hot-house plants, as well as the most useful of our fruit trees out of doors. In the early part of their lives these insects are exceedingly minute; and at this stage they are most active. In appearance they resemble small tortoises, and are of a dull reddish colour; they fasten on the leaf or stem of the plant, and with a long and sharp beak, with which they are furnished, they pierce it in such a manner as causes great injury to its vegetation, and sometimes even total barrenness. There are several species of this family: they are the American blight, so pestiferous in our orchards; the brown scale, which inhabits the orange myrtle; and such plants as possess leaves of a firm consistency; the migratory white one, which is frequently seen on the pine-apple plants; the vine-fretter, which locates in the hot-house, and on peach trees and vines; and some others, which are found in the woods, hedges, and the garden. The economy of the various species does not seem to differ materially; when young they wander about pretty much; but on attaining the adult size, both sexes fix themselves to the stems or plants, where they remain stationary; and after impregnation, the female increases in size to about a line in length. The bag of eggs is deposited on the surface of the bark, in the middle of a layer of white gummy matter, and gradually drawn under the body of the female, which now assumes the appearance of a skinny covering formed out of the upper and under tunics; and, what is rather singular, the eggs are now found under these tunics, though they were before situated between them. On the eggs being hatched, nature being exhausted in the female, it is understood that she immediately dies the instant her young ones are able to shift for themselves.

The male is without a mouth, and seems destined only for the propagation of the species. Destructive as these insects are to vegetation, they are not without their use, for some of the species are eagerly sought after on account of the rich red dye which they yield. The most valuable species is the cochineal insect; but there is another species which inhabits trees, chiefly ever-green oaks, in the south of Europe, which was highly esteemed previously to the introduction of the American cochineal. It is called kermes, and is still very much used, though the colour which it yields is not nearly so beautiful.

The ravages committed by these insects (for none of the British species are useful in the arts) have led to many expedients for their destruction; and among others, a skilful writer on gardening recommendsthe following wash: — "2 lbs. soft soap, 2 lbs. flour of sulphur, 1 lb. leaf tobacco, 2 oz. nux vomica, and one quart train oil, all boiled together in 8 gallons of water. Pine plants require to be anointed all over with the liquor, and when re-potted in fresh soil, and in a well-cleansed house, are freed from the pest."

The *Green fly*, "Aphides." This is, perhaps, the most numerous family of noxious insects which devastate the vegetable kingdom. They are commonly classified into different species, according to the different colours; but it seems probable that they are almost all of the same species; and that the different hues of black, green, and red, which they assume, are merely the effects of the quality of the juices which they feed on. They are exceedingly prolific; and when they effect a settlement in a field of pease, the crop is speedily stripped of its principal value, and nothing left but the almost valueless straw. When these destructive insects attack an extensive field, it is impossible to stay their ravages; but this may be conveniently effected by the smoke of tobacco, when they appear on house-plants or in the garden.

The *Gall fly*, or "Cynips." These insects are chiefly remarkable for the singular forms of those lodgments which the larvæ produce upon the leaves and stems of plants. Many of them so much resemble small apples, that they have been considered as a sort of fruit; or, at all events, a production of the tree without the assistance of any insect; and the Cedeguar, again, so much resembles a tuft of moss or lichen, that it might readily be taken for a parasitic vegetable. It has, however, been clearly ascertained that the whole of these galls, whatever may be their form and colour, are produced by insects of the Cynip family, though all that family do not produce galls, as many of them lodge their eggs in the kernels of fruits and farinaceous seeds. Generally speaking, there is only one larva in each excrescence; but in some cases the single excrescence contains a colony. The injury they do to vegetation is not very serious.

The *Turnip fly, or beetle*, "Haltiaca oleracea." This tribe of insects is equally annoying to the farmer and the gardener, and there has not yet been any adequate remedy discovered to protect either the field or the garden from their injurious effects. They appear in the garden early in the spring, and their attacks are directed to the vital leaves of the cauliflower, the cabbage, the radish, and other plants, which very soon fall sacrifices to their blighting effects. In the field they attack the turnip plant on its appearance above ground, and a crop of many acres is speedily nipped in the bud, sometimes subjecting the farmer to the expense and labour of repeated sowings in the course of one season; and, what is worse, sometimes to the total failure of the crop. Of the economy of this insect very little has yet been discovered; but, like other beetles, it inhabits the earth during the first three stages of its life, and comes forth in the summer at different periods, according to the degree of heat.

The *Wheat fly*, "Cecidomya tritici." This is a very small gnat, of an orange colour, which makes its appearance in the British Islands during the blossoming season of the wheat, towards the middle of June. They have a long retractile ovipositor, by which they introduce their eggs into the ear at the time of its shooting, and the larvæ thereby produced are believed to consume the pollen, and to prevent the impregnation of the germ. In an interesting account of the proceedings of this enemy of the farmer, Mr. Shireff says—"The fly almost always preferred the ears emerging from the vagina, to those farther advanced, for depositing its eggs, and as one side only is exposed when the plant is in this stage of growth, the other side generally remained uninjured. The fly deserted the fields as the crop advanced to maturity, and was found longest in the spring-sown portion of the crop. It seemed to feed on the gum adhering to the newly emerged ears; and as there is a great diversity in the time of sowing wheat in this neighbourhood (East Lothian), and consequently of the ears escaping from the vagina, I attribute the unusual length of time it has existed this season (1829) to the supply of food thus gradually furnished." Mr. Shireff is of opinion that no effectual check can be given to the ravages of this destructive insect, unless a variety of wheat be obtained, whose chaff so closely envelops the cups as to be impervious to its ovipositor. The damage to the wheat crops, occasioned by this insect in some parts of our island, has been estimated at no less than thirty per cent.; but there is another of the same genus, the Hessian fly, a native of North America, whose ravages are much more ruinous to the growers of wheat in that continent. In order to give the reader some idea of the devastation committed by this insect, we quote the following passage from Messrs. Kirby and Spence's description of it:—"The ravages of the animal just alluded to were at one time so universal as to threaten, wherever it appeared, the total abolition of the culture of wheat, though, by recent accounts, the injury it occasions is much less than at first. It commences its depredations in autumn, as soon as the plant begins to appear above ground, when it devours the leaf and stem with equal voracity, until stopped by the frost. When the return of spring brings a milder temperature, the fly appears again, and deposits its eggs in the heart of the main stems, which it perforates, and so weakens, that when the ear begins to grow heavy, and is about to go into the milky state, they break down and perish. All the crops, as far as it extended its flight, fell before this ravager. It proceeded inland at about the rate of fifteen or twenty miles annually, and by the year 1789 had reached two hundred and fifty miles from its original station. Nothing intercepts them in their destructive career, neither mountains nor the broadest rivers. They were seen to cross the Delaware like a cloud. The numbers of this fly were so great, that in the wheat harvest the houses swarmed with them, to the extreme annoyance of the inhabitants. They filled every plate or vessel that was in use; and five hundred were counted in a single glass tumbler, exposed to them a few minutes with a little beer in it." The popular name of this insect originated in the idea that prevailed among the Americans, that it was introduced into their country among the straw which accompanied the Hessian troops when they landed in Long Island in 1776; but that is a mistake, for the insect is unknown in Europe, unless when imported from America.

The *Wire-worm* is the larva of the *Elater castaneus*. It is a yellowish grub, with a brown head, rather less than an inch in length. They are found in almost every description of soil—more especially in newly broken up leys, and fresh loam; and they seem to feed indiscriminately on the root of every plant within their reach; and are consequently equally destructive to the flower garden and the corn field. A liberal admixture of lime, in the dressing of the land, is the best method of providing against the devastations of this grub, as well as of the others of a similar species, all of which are very hurtful to young vegetables.

The *Weevil*, "Curculio granarius," infests granaries in which wheat is stored, and is very destructive to their stores; but it is understood that this insect prefers the unwashed fleece of wool to this grain. There are other curculios which, in their perfect state, feed on vegetation. One of these is particularly annoying in nurseries, where it lurks at the roots of the young trees during the day, and after nightfall ascends the stems, and commits serious havoc among the newly sprung plants, the buds of which it selects for its prey. It is a tough insect, and not easily got rid of; but perhaps some nauseous lotion, applied to the stems of the plant, might act as a protection to the buds.

The *Red spider*, "red acarus or tick," is a very minute insect, without wings. It gets the name of spider on account of its forming a sort of web; but this fabric is not used as a snare, but merely to protect itself against humidity, to which it is very subject. It is particularly annoying to the forcing gardener, as it commits great havoc in the hot-house by puncturing the cuticle of the leaves of the young shoots of peach-trees, vines, and other plants, whereby their vitality is quickly destroyed. The frequent and forcible application of water is a successful method of destroying this insect, when that can be done without injury to the plants; but when they become very numerous, as they frequently do, it is necessary to get rid of them by suffocation. This may be done by smoking the flues with a vapour of flour of brimstone, or by the use of a chafing dish, constructed for the purpose. They can also be extirpated with copious moisture and high temperature. There are various other kinds of the plant tick, but they are not so hurtful as the one above described.

Thrips. These are also very small insects, destitute of wings; they resemble an aphis in appearance. Their destructive habits are similar to the red acarus, and the same means may be successfully used in extirpating them.

Ear-wigs, "forficula," are sufficiently notorious for the injury they inflict on plants and fruit; but their ravages may be easily stayed by entrapping them with hollow tubes, smeared over with a mixture of sugar and water being placed near their haunts. The wood-louse (*oniscus*) and the ant may also be got rid of by the same means.

Gooseberry and Currant Moth. The destructive caterpillars of these insects are frequently destroyed by washing the stems with lime-water, and forming pits under the trees to bury the fallen ones; and they are also successfully dispersed by the effluvia of sulphur or other suffocating fumigation.

In providing against the baneful effects of the above-named insects, as well as others which might be enumerated, it is better to endeavour to prevent the introduction of the diseases they occasion than to cure them when formed; and if proper care were taken by the cultivator to secure the trees and plants against the seasonal deposition of the eggs of insects, by periodical washings with such mixtures as are suitable for the different species, much good would be effected both in the preservation of the fruit, and in the saving of the expense and labour that are often bestowed in vain at later periods of the season. In speaking of the seasonal deposition of their eggs by insects, an intelligent writer observes, that "the careful mothers seek the furrows of the bark, and the indentations round the buds and branches, as safe dépôts for their ova. But did they find these recesses already occupied by any quality offensive to them, they would seek a place elsewhere." Mildew would seldom appear on nectarine and peach trees, if they were regularly washed in autumn, summer, and spring, with a ley made of soap and water; and there is no doubt a variety of mineral and vegetable substances, that have not yet been employed as preventives of the destruction of vegetation, but which might be profitably applied for this end; and it should be the study of every cultivator to add such specifics as are within the reach of his observation and experience to discover. It has been confidently stated by those who have tried the experiment, that potato water, thrown on fruit trees, is an excellent preservation from the effects of the caterpillar. The best mode of doctoring accidental wounds in trees is to scoop out the decayed parts, and apply a salve composed of tar, mixed with a small quantity of tallow and saltpetre. This salve ought to be laid on pretty thick at first, and renewed in proportion as it is inhaled by the tree.

The observations which we have made in the latter part of this chapter do not refer to every insect which interferes with man in cultivation, and the nature of which it is consequently important that he should know; but the more common and the more important ones have been mentioned, at least in so far as the British Islands are concerned; and thus it is hoped that these remarks may be found useful.

CHAPTER VII.

RIDIATA, OR ANIMALS, MANY OF WHICH ARE BY THE OLDER NATURALISTS STYLED ZOOPHYTES, OR ANIMAL PLANTS.

We now come to the last of the four grand types or distinctions in the organic structure of those animated beings which can be the subjects of human contemplation through the medium of the senses. This may be considered as the ultimate bourn of matter as endowed with life; and the one in which the animal faculties, as we find them displayed in the warm-blooded animals, and the more perfectly developed of the invertebrata, are the least perfect, or at all events the least palpable, to our observation.

Still, however, the wonders of creative wisdom and power are not less displayed, at this extremity of living nature, than they are in those species in which all the senses, as we judge of them, are the most perfect, and the resources of the animal the most numerous and varied. Nowhere, in all the wide and wonderful empire of nature, throughout all its kingdoms, and in all their departments, hath He left himself without a witness; and though the lines in which the testimony is written vary much in their character, yet they are all so conspicuous and so legible, that they who run may read with pleasure and profit.

There is, indeed, if possible, more interest in this, which is regarded as the lowest type and confine of the living world, something of even deeper interest, than we find in those animals whose organisation we can analyse in all its parts, and whose manners we can study in all their details. When we come to the extreme boundary, to the *infusoria,* or animalcules, as they are called, we stand as it were upon the very verge of nothingness in regard of extended dimensions and material substance; for we do not, with all our philosophical helps, with all the "euphrasy and rue" of philosophical contrivance and skilful execution, which have increased the powers of vision many thousand fold,—we do not, with all the improvements which have in this way been made, and they are very many, and very wonderful, see the extreme boundary beyond which, in point of magnitude, a creature cannot live; nor are we sure that our utmost improvements in instruments, and correctness in observing, may be even one half or one tenth downward in the scale, toward which, in the indefinitude of its smallness, there may be countless thousands of races, each less in proportion to the one above it, than a mouse is in proportion to an elephant. It has sometimes been fancied by ingenious men, who have taken spiritual views of the power of God in creation, that there may be a plurality of worlds in the minutest portion which our observation can distinguish of the most solid substance. That, for instance, every particle—far, far below the ken of our best microscope—of gold, of diamond, or of any imaginable substance, more dense than the one, and more firm than the other, may be, in the sight of Him to whom "a thousand years are as one day, and one day as a thousand years," and the universe is as a mote, and the mote as the universe, every particle may be in reality, as it is in the sight of its Maker, a world, proportionally as well peopled as the world which we inhabit; and in so far as animal existence is concerned, it may be as instinct with life, and as redolent of enjoyment. When the Eternal Son of God, embued with the wisdom and girded with the power of the Trinity, came forth to the glorious work of creation, amid the choral songs of the morning stars, and the joyful shouts of the spiritual children of the same Almighty Parent,

"Number to that day's work was not ordained, nor magnitude;"

the rejoicing spirits who witnessed those wonders of creative energy upon which it is not given to the eye of flesh to look, and before which the mind of man falls down humbled and revering, in its own littleness, had only to stand and behold the wonders of his power—

> "Stand still, in bright array, ye saints! here stand,
> Ye angels!"

Some of the living creatures which come within this division of the animal kingdom are so very minute, that one hundred and twenty thousand of them, taken in their largest dimensions, would not exceed an inch in length; and therefore, a single cubic inch of space would contain one thousand seven hundred and twenty-eight billions of them; or, expressing it by the common figures of arithmetic,

1,728,000,000,000,000

which is a number that the whole human race could hardly have counted over in individual beings, although they had been occupied at it in their successive generations since the days of Noah.

Of course, when we come to those mysterious bounds, our knowledge is vague; and all the particular indications and functions of life are blended or lost in the single one of motion. There is, however, a wonderful correspondence of advantage in our observation of the motion, and of the apparent magnitude of that which moves; because the same property of the microscope, which magnifies the apparent volume of the substance, multiplies in exactly the same proportion the rate of the motion; and thus the revealment which science gives us of the living creatures substantively, and of life as a function, is the same in extent and perfection.

We find also, from careful examination of some of those creatures which, though not so exceedingly minute as those alluded to, are still beyond the power of the naked eye, a distinct organization, and the functions of life going on with great vigour and activity, in feeding, in reproduction, and in all the more essential operations of the animal system, as we find them displayed in the largest animals with which we are acquainted. Such being the case, it is not for us to affix the bounds of our limited powers to what the Almighty can produce; and therefore there is no more impossibility in an animal, a countless number of times less than the smallest which we have mentioned, being as completely organised and as energetic in all its functions, than there is in a caterpillar consisting of a much more curious and elaborate muscular system than a whale, or than there is in a flea being, in proportion to its size, an incalculably more energetic animal than an elephant.

In fact, it is in these, which we are apt to consider as the more insignificant and less perfect parts of the system—and we do this, merely from the tendency which we have, very incorrectly, and therefore very unwisely, to associate superior power with mere bulk,—it is in these parts that we obtain our most correct notions of creation and the Creator; because they let us see, that though He is pleased, in every case, to work by means, yet the means are so under His government, that He can direct them to the accomplishment of any purpose of His will. These reflections, and numerous others of the same strain and tendency, very naturally present themselves to the mind, when we turn our attention to this division of the animal kingdom; but we must leave the reader to follow out his own reflections; and briefly advert to the general characters of the grand division, and of the classes and orders of which it is composed.

Radiated animals differ even more in shape, and in size, and in consistency, than any other of the invertebrata; so that if we were to attempt any general definition or description of them from those appearances which they present to the eye of common observation, we should not be able to find anything at all applicable to, or in any way descriptive of, the whole of the grand division, or even the whole of one of the classes into which it has been formed.

There is only one common character in these animals, and it is an internal one, rather than an external; but still, after we once understand it as applicable to the internal structure, we find that it is equally applicable to the external form. This character will perhaps be most clearly understood, if we contrast it with that of all the other grand divisions, which, how much soever they individually differ from each other, have yet one character in common. All animals which are not radiated, are organised upon a mesial plane, which has a definite situation in the body; so that if the body is divided, or supposed to be divided upon this plane, the two halves are symmetrical, or the exact counterparts of each other. It sometimes happens, indeed, that the one half is a little more developed than the other; and we sometimes can assign a reason for this difference of development, and sometimes not; but still if we do not find all the parts and members in the one side which we find in the other, when we divide the animal on the mesial plane, we consider it as an imperfect production, whether the imperfection happens to consist in the one side having a part too few, or the other side a part too many. In all those organs which are single in the body of the perfect animal, the mesial plane divides the common organ; but there are some organs which connect the two symmetrical halves of the animal; and, therefore, the halves of these have not necessarily exactly the same function, and consequently not the same structure, taken in the details. But if we make allowances for this, we can say, with perfectly general truth, that all animals except the radiate are capable of symmetrical division upon the mesial plane. This plane is generally speaking vertical, or perpendicular to the horizon, when the animal is in what we call its natural position, and it invariably divides the body lengthways. The plane cannot be turned from side to side, so as to divide more on one end of the animal and less on the other, neither can it be inclined from the perpendicular so as to divide more from the one side and less from the other at its opposite edges, without destroying the symmetry of the two parts; and it is this constant reference of both ends and both edges of the mesial plane, to the same points in the surface of the animal, which makes the organisation fixed to this plane, or as it were founded on it. A plane has both length and breadth, or is developed or extends in two ways crossing each other; and, though we cannot perhaps distinctly draw any very important conclusion from it, it is not a little curious that all those animals which have this double development, or development in two directions crossing each other, as the basis, so to term it, of their organisation, have that organisation the most completely developed in all its parts. There is one other circumstance worthy of notice in this organisation upon a plane; and that is, that the plane, being as it were tied to two directions in the animal, does not admit of any kind of change of position; and, therefore, animals which have a proper mesial plane, are never reproduced by dividing the body of the *one* individual in what direction soever the division may be made:—such are the foundations of the organisation of all animals which are not radiated; let us now turn to those which are, and mark the leading distinction.

The radiated animals have, as their common character, the basis of their organisation not a mesial plane but a line, or one or more lines proceeding like rays from a centre, or ranging parallel to each other, each as a centre of organisation, without any necessary reference to their being in the same plane. It is to be understood in the case of these as well as of all other animals, that when we speak of a plane, a line, or several lines, as the basis of the organisation, we make no allusion whatever to the origin, the production, or even the function of growth, in the animal. What we allude to is the mere situation of the plane or line upon which the body of the animal can be symmetrically divided; and when the radiated animal has its organisation based on a single line, it may be symmetrically divided in any plane which coincides with that line, however it may be situated in the cross direction. If, therefore, we take the circumference or surrounding parts of the animal about this line, we find that those on all sides of it in the same cross-section have exactly the same relations to it, which is not the case with animals that have their organisation based on a plane.

The general form of organisation in these animals is either radiation or parallel lines—generally the former; and the radiation is in many instances so perfect that the animal assumes the form of a star.

The modes of production among these animals vary considerably; but very many of them can be produced by mechanical division of the bodies of the existing ones; and in the natural way very many, probably indeed the greater number, are produced by new radiations from the basal lines—something after the same manner as the buds or seeds of plants, which also are produced by extensions of certain lines within the plant; which lines in the better developed, and more easily examined plants, bear some resemblance to the radiating lines in the animals under consideration.

From this coincidence we receive a lesson which is not without its use. Those central lines, at the extremities of which the germs and seeds of plants are produced, have in themselves nothing to do with the production of the germ or seed, or even with the function of life and growth in the plant. In most trees, perhaps in all which enjoy a winter's repose, the wood of the tree ceases to have any direct share in the living function of the tree after it has been encased in even one layer of wood; and the same year's growth, or the substance actually produced during the year, never produces seed or fruit twice over; for unless a new production is made after once fruiting, the tree is for ever barren. In this we see that the foundation of the organisation and the origin of the life are very different matters; that, in fact, the organisation from its very beginning is a product of the life; and it does not appear that the genuine germ of a plant, which is the seedling, ever contains in its substance a single atom of the matter of the parent plant, except in so far as that matter has been stored up as food in the seed or otherwise, and is assimilated by the organs of the young plant, and thus rendered a new substance before it becomes part of the new structure.

We must therefore look upon the production, origin, and function of life in animals as something distinct from the matter of which those animals are composed, and as having power over it, just as a workman has power over his materials, but only to a much higher degree of perfection; and that this addition to the mere existence of matter, considered as substance, which is from its very nature passive to life and even to growth, can be nothing other than action of some kind or other; because in all the varieties of the material creation, after the act of creating had once passed upon it, we cannot, without the most palpable confusion and absurdity, admit of anything besides matter as a substance, and those laws or modes of action, general or particular, which are set over it to control it as a substance. In this view of the matter, though we can understand from the form of the organisation, which is of course determined by the law of life which has been given to every species, how one species of plant or animal can be propagated by mechanical division of its substance, and another cannot; yet we cannot, without involving ourselves in the most palpable absurdity, imagine that either plant or animal can produce upon itself a mechanical division of this sort, without some consent or conjunction of two principles, however obscure or even inscrutable—some act of organisation, however small and rudimental; and whether, according to our common modes of speaking, the parent may be of one sex, or two sexes, or apparently of no sex at all; which last is generally the condition of those gemmiparous animals which produce their young in buds without any apparent sexual intercourse which we can trace.

In every case, however, the principle is the same: there is a descent from a parent, or rather from the consent or conjunction of two parent principles, which forms an act of life, whether that life shall be sooner or later developed, or even developed at all; and thus, down to the most apparently humble animal or plant, though certain modifications by external circumstances are necessary, and for that reason exist in all, there is no more power in any one species to change to another, than there is in one piece of matter essentially to create another piece. We can understand the modifications, and also see how necessary it is that they should be, in order to give the play which is necessary in the working of a system which consists of so many parts. We can understand this, just as we can understand how a workman can mould and fashion a piece of gold by beating it on an iron anvil with an iron hammer; but we can no more imagine that external circumstances—which are nothing more to the animal or the plant than the anvil and the hammer are to the gold—can originate the animal which they modify, than we can imagine that the anvil and hammer can originate the gold. Nor is it unworthy of remark, that the transmutation of metals was a general belief in the days of ignorance; and that it is precisely akin to the transmutation of plants or animals, or that transmutation which is sometimes supposed to take place between them and matter, the doctrine of which is always now and then breaking out in one form or another, by those who bring to the study of nature more of the waywardness of fancy than of the wisdom of philosophy.

The nervous system is never very apparent in any of the radiated animals; and in the greater number it cannot even be traced as a distinct system of organisation; but in all cases where it can be traced, it is always in a radiated form, proceeding from one or more centres; and when there are more centres than one, however indistinctly traceable they may be, each centre when separated is capable of producing the complete animal.

There is never any true system of circulation in animals of this division. Some species, indeed, have a double organ of vessels; one part of which is attached to the intestines, or alimentary apparatus, where it appears to perform in some way the function of respiration, or at least a function similar in its effects; while the other part serves merely for inflating or erecting those simple organs which serve as substitutes for feet. In very many, however, no vessels whatever can be traced; and in these there can be nothing at all answering to a system of circulation, by means of which the nourishing fluid goes successively to send returns from the different parts of the body of the animal. Hence the nourishment which is applied to the different parts must be wholly appropriated there; and it does not appear that there is in the system any waste which it is necessary to remove by successive actions of an absorbent system. Indeed the functions which these animals have to perform are so few, and the performance of them is so slow, that there can be little waste in the system; and thus, while they are the most passive, they appear also to be the most enduring of all animals. Some of them have a distinct alimentary canal, with an opening at each extremity; but others have the interior of the body a simple sac, with only one opening for every purpose. Some have even no visible mouth or opening into the body at all; and therefore they must receive whatever nourishment they require by means of pores in the skin. In some species there are distinct sexes, though very many are within themselves complete hermaphrodites; but there are also others which have no local or perceptible organs of generation, but which reproduce their kind by buds or germs, which are produced indiscriminately in different parts of their bodies.

It does not appear that any of those singular creatures are capable of living in the free air. The greater number are inhabitants of water, and some are found in other liquids; and there are a considerable number which inhabit the internal parts of other animals.

In one respect several of them resemble those mollusca which grow in clusters, as was formerly mentioned of the bernacle; but the radiated animals which have this habit are far more numerous, and the congregations of them form structures of an almost endless variety of forms, and composed of matter of various degrees of hardness and tenacity; but, generally speaking, consisting of salts of lime cemented together by animal matter. The whole history of this grand division of the animal kingdom is imperfect and obscure; and therefore the arrangements which have been formed of them are only rude approximations upon which implicit reliance cannot in every instance be placed. They are usually divided into five classes, the characters of which are, however, not very precise; neither is it possible so to name and define them, as that each shall be expressive of all the animals which it is necessary to include under it.—We shall now mention the leading characters of these five classes.

1. *Echinodermata,* or "spiny skinned animals." These appear to be the most perfectly developed of the whole grand division. They have, generally speaking, spinous appendages to the skin, which answer the purposes of a very slow kind of locomotion; and their organisation, though by no means of a high degree, is much more developed than that of most of the others. They have a distinct alimentary canal, with organs of respiration, generation, and at least a partial circulation; and some

of them make slight approaches toward some molluscous animals. They are all inhabitants of the waters, though some of them burrow in the sand or mud at the bottom.

2. *Entozoa*, or "inhabitants of the bodies of other animals," chiefly the intestinal canal, on which account they are termed "intestinal worms." Some of these have a true cavity in the body; but they are all much inferior in their organisation to the animals of the first class.

3. *Acalepha*, or "sea nettles." These have no organs of respiration which are visible, and no approximation to a circulating system. They have only one opening to the body; and the body is generally round or radiating, and consists, in many of the species, of a thin gelatinous liquid, with a few vessels floating in it: and this liquid is often of so caustic a nature as to blister the skin; and even the dried substance of the animal produces very unpleasant sensations.

4. *Polypi*. These are gelatinous animals, often of small size, but differing both in size and in form. Their numbers are almost incredible; and considering their small bulk, the labours which some of them perform in the waters, would, if not well established by actual observation, exceed the bounds of all ordinary credibility.

5. *Infusoria*. These are the exceedingly minute beings to which we alluded in the early part of this chapter, and which were very little known before the invention and improvement of the microscope. The numbers of them are perfectly incredible, occurring chiefly in stagnant waters, and, generally speaking, presenting merely a gelatinous body, without any appearance of viscera. When examined by high powers, however, many

of them exhibit a very curious internal structure; and they are also remarkable for their activity, and the tenacity of their lives. We shall mention a few of the leading divisions of each class.

Class I.—ECHINODERMATA. This is a very singular and by no means uninteresting class of animals. They have no skeleton, and they are without any of those specific organs which characterise the more completely developed animals; but still there is a beautiful display of wisdom in their structure. They are always covered with a well-organised skin, which in some of the species, as in the echini—or sea hedge-hogs, as they are often called, from the appearance of their covering, or sea eggs, from the shape of their bodies—has the consistency of shell, or rather of crust. The covering of these is furnished with spines, which are articulated and moveable at the pleasure of the animals, so that they answer the purpose of a sort of feet. The whole class have an internal cavity to the body, containing distinct viscera; and they have the rudiments of a system of circulation and respiration; but the connexion of this system at the one extremity is with the intestinal canal, while the other part of it appears to be chiefly directed toward the moving of the feet. They are also furnished with a sort of fibres, which are supposed to be nerves, though this part of their system is not so regular and complete as the rest; but it is consistent with the general economy of nature, that we should find the greatest approximation to a nervous system in that part of the order which is endowed with the nearest approach to a regular system of organs of locomotion.

The echinodermata are conveniently divided into two orders—those which are furnished with appendages to the skin, or rather with certain cylindrical elongations, which are protusile through apertures of the skin. These are generally cylindrical in their form and membranous in their substances, terminated by small discs on their extremities, which act something after the manner of suckers, as the animals can adhere by means of them to the surfaces of rocks, or other fixed substances; and they can also change their localities by the help of the same organs. The other orders are destitute of these appendages, and have the body invested in a leathery skin. The first order are, on account of their imitation feet, called *Pedicellata,* and the other order, from the want of these appendages, are denominated *Apoda,* or footless.

Pedicellata. The distinguishing character of these animals has been already mentioned, namely, their substitutes for feet; and though these are without distinct articulations, and generally speaking of a soft consistency, and capable of being in great part withdrawn within the general covering of the animals, yet they are by no means so inefficient, either as feet, or as a sort of hands, as one would be led to suppose. These feet are extended by the animal propelling into them a portion of the fluid which is contained in the general cavity of the body; and of course they must be furnished with numerous and curious muscles for the performance of this operation. Those feet exist in hundreds on the same animal; and they are capable of protrusion or shortening in all directions, so that many of the species at least can either adhere or move from place to place with any side of their body uppermost, according as may be necessary. The genus most common on the British shores is that which, from its star-like form, has been called the star-fish (*Asterias*). This consists of tapering rays, formed like those with which a star is generally represented in painting, all emanating from a centre, the axis of which across the direction of the points or arms, is considered as the centre of radiation. The rays or arms are, generally speaking, five in number, of equal size, and placed at equal distances. In the centre of these, and underneath, is placed the mouth, which is the only opening into the cavity of the body. These animals consist of a sort of frame-work of crustaceous pieces; and the mouth is furnished with a sort of teeth of bone, by means of which they can break the shells of the small mollusca and crustacea upon which they feed. The common red star-fish is themost abundant one upon the British shores, where it inhabits rocks or sands, but more frequently the former, and generally between the lines of high and low water. The colour, as the name imports, is reddish, and each ray of the star is marked on the upper side by a furrow; while the central part of the body to which the rays are united, is nearly a hemisphere, or rounded on the upper part, and flat on that which contains the mouth. The tentacula, or organs of prehension and motion, are on the sides of the rays, and they are exceedingly numerous, amounting to fifteen or sixteen hundred in some single specimens; so that with the exception perhaps of some other members of the same order, thesesta r-fish have a greater number of feet than perhaps any other animals. When the animal is thrown on its back, the motion which it makes in protruding and withdrawing those tentacula is considerable. So, also, when it is in the free waters, it can make considerable use of the rays as organs of swimming. From the cavity of the body into which the mouth opens, there extends a canal or tube into each of the rays, which tapers towards the extremity in the same manner as they do; and it is from this canal that those branches are given off which assist in working the tentacula, by injecting them with fluid. It must be understood, however, that those rays, and the canals which extend along them, are not in the direction of the axis upon which the animal is organised, but in the cross direction. These animals have the same power of restoring parts which are broken off, as we formerly remarked in the crustacea; though it is not clearly ascertained, that, if the central part of the body is divided, the segments of it will produce perfect animals; but if one of the rays is by any means broken off, that ray is soon replaced, and it is sometimes replaced by two, or by one and a branch, either of which gives the animal an irregular form. These animals serve as the food of various kinds of rock fishes; and it is supposed that, at certain seasons of the year at least, they impart a poisonous quality to the fishes which feed on them, though the fact rests more on conjecture than on positive evidence.

There are a good many species of this genus; and of one at least, the Medusa's Head star-fish (*A. caput Medusæ*), various marvellous stories have been told; such as that it can so entangle a ship's boat as to draw it under the water; and that it can seize with its arms, not only fishes of considerable size, but even the albatros, and other large sea birds, when they alight on the surface. There is very little probability in any of these stories; and the fact that when the animal swims it generally has the mouth undermost, and the rays bending in the same direction, tends in no way to increase the probability. It is, however, a very large animal, considering the division to which it belongs; its habit appears to be much more that of swimming in the free waters and feeding there, than that of the species which are found on our shores; and to assist in this more habitual swimming, and ranging the ocean in search of its food, the rays of which it is composed are much more developed and complicated at their extremities than those of the common star-fish. The principal divisions are five, as in the others; and they are placed at regular distances round the centre of the body. But here the parallel ends; for each ray soon divides into two, each branch into two, and each of these secondary branches into two again; until, in a large specimen, the ultimate points are between two and three thousand in number. Whether this extreme branching of the rays, which appears to go on as the animal increases in size, is intended for the capture of any sort of food, or merely for swimming, and for producing a current which may bring food within the reach of the mouth, has not been ascertained; but in the dried specimens which are met with, the terminations of the arms, or rays, are often so completely entangled with each other, that it is not easy to separate them, or to count their number. From the peculiar form of the rays in this one, some naturalists have formed it into a separate genus; and there are some others which have the rays differently divided; but still only five original ones, united to a crustaceous or shelly disc on the back, or side opposite to that in which the mouth is placed. Some of these last have an additional set of rays under the others, which are not branched at their extremities; and which are possibly used for the purpose of seizing the food and conveying it to the mouth. Those larger species, which swim and feed in the free waters, and probably entangle their prey in the living net with which they are so curiously furnished, are chiefly found in the tropical and southern seas; but besides the one which we have mentioned, there are several others which inhabit the temperate and polar seas, some of which are free swimmers, and form part of the food of the whalebone whales.

The Encrinites (*Encrinus*) have their rays or arms jointed and divided into a number of branches variously ramified. Only one small species is known as inhabiting our seas in a living state; but as is the case with the sea-stars, there are larger and much more complicated ones in the warm seas; and there are vast numbers found in the earth in a fossil state.

The Sea Hedgehogs, or Sea-eggs, (*Echinus,*) are, if possible, still more singular. They have the body nearly globular, but flattened a little on the upper and the under part, in the middle of the last of which the mouth is situated. The covering of the body is a calcareous crust, formed of segments very neatly and uniformly joined together, and pierced with a vast number of little holes, placed in very regular rows, through which the moveable appendages or feet are protruded. The crust is also beset with hard spines, articulated upon small tubercles, by means of which they also contribute to the locomotion of the animal, which can at pleasure move them in all directions upon the tubercle. There are also other appendages in the form of flexible membranous tubes; so that the covering of the animal is not altogether unlike that of the common hedgehog when it rolls itself into a ball. The mouth is furnished with five teeth, resembling the panes of a five-sided lantern; and the intestinal canal is ample, and coiled in a spiral form round the inner side of the crust. They feed upon small shelled mollusca, which they seize by means of their tentacula; but their motions are comparatively slow. They have two openings to the body; and regular apparatus for the production of their young, which apparatus is five-fold. There are a good many existing species of them; and some of them are not uncommon in the European seas; though the crusts are much more abundant than the living animals, unless the latter are sought for in some depth of water. It is not known whether they cast their crusts in the same manner as the crustacea; but the number of crusts that are met with on the beaches, compared with the number of living animals, renders this at least not improbable.

Holothuria, sometimes called sea-slugs, are of an oblong form, with an opening at each extremity; their covering is leathery, and their mouths are furnished with complicated tentacula. One species of a black colour, found in the Mediterranean, measures a foot and more in length; and there are others of still larger dimensions in the tropical seas, especially on the coral bottoms in the clear water. Some of these are finely coloured; and when seen among sea-weeds, corals, and other productions of the warm seas, where life is equally singular and active, they resemble cucumbers and other fruits of that family, whilst some of the radiata of other classes have much of the beauty as well as the form of flowers.

Apoda. The footless echinodermata bear a considerable resemblance to the genus holothuria ; but they generally have the body enlarged at the head, and furnished with appendages at the opposite extremity. Their skins are of a leathery texture ; and, like the former order, they are produced from eggs. Many of them are anxiously sought after by the fishermen for baiting their hooks; and some of them are used for human food, but not held in so much estimation as are several members of the former order. The echini form a considerable part of the subsistence of some of the rude nations which inhabit the margins of the waters, particularly among the oriental islands, and toward the north shore of New Holland; one or two species of holothuria are captured in great numbers by the Malays, who carry them chiefly to the Chinese market, in which they fetch a very high price. They are prepared by being split open and dried ; and as they consist of very fine gelatine, they are described as forming the substantial ingredient of a very wholesome and nutritious soup.

Class II.—Entozoa. These are very remarkable creatures, because the greater number, if not the whole of them, are incapable of living and propagating their kind in any other situation than within the bodies of living animals; and so generally are they distributed, that there is scarcely one species of animal which does not afford, within the substance of its body, a home and a pasture for various species of these singular parasites. It is also rare to find the same species upon two animals, unless those animals are very nearly allied to each other. Their abode is not confined to any one locality in the animals, as is the case with some other parasites which are found only in the intestinal canal, or taking up their abode in some one locality of an animal's body, for passing one stage of their changeful life. The entozoa live only in the places which have been described; they take up their abode permanently in those places; and each selects, or, to speak more correctly, is brought to maturity only in that part of the animal which agrees with its peculiar habit. Some are found in the intestinal canal, and in the ducts which discharge their contents into that passage; others are found in the liver, others again in the cellular tissue of various parts; and some are found only in those parts which appear to be most secured, by the structure of the animal to which they belong, from the inroads of everything foreign,—such, for instance, as the internal substance of the brain in man, or the other warm-blooded animals.

The notion which we naturally attach to these internal parasites is anything but pleasant; and yet it appears that, just as is the case with the parasitical caterpillars which feed upon the internal substance of caterpillars of other and larger species, these parasites are not speedily or decidedly mortal in their attacks; neither do they occasion a very great deal of inconvenience, unless in the event of their numbers increasing to such an extent as that the structure of the part in which they take up their abode is destroyed. They are of various forms, and divided into two orders, which contain many species. One of the most annoying to man, if we are to give full credit to the reports concerning it, is the Guinea worm. This belongs to the genus *Filaria*, or those which are thread-shaped. One or other of them is found in almost every species of animal that can be named, and they make their appearance in places where there appears to be no entrance for them, such as in the substance of membranes, and the internal parts of the viscera. They often exist there in vast numbers, and sometimes in bundles enveloped in a common tunic or capsule, which they appear to make for themselves, out of the substance of the animal upon which they live. We must not wonder at this, because there are many diseased states of local parts of the system, in which the diseased matter forms a cyst or capsule for itself; and in extirpating the production of the disease, if this capsule is not removed along with the substance which it contains, the disease is not eradicated; and the matter of the disease breeds and accumulates again. Parasites of this description are not confined to the larger animals, but are met with also in insects, in the larvæ of insects, in molluscous animals, and indiscriminately in almost every living creature. The most annoying to man, however, as we have already observed, is the Guinea worm, which is slender, but of considerable length, and seems to be produced by buds which can arise from any portion of its body. It is very common in hot climates, where it is said to introduce itself under the skin of the human body; where it grows in length until it attains, according to reports, the length of ten feet, or even more. It is understood that, if it takes the direction of those parts of the body which are not immediately connected with the functions of life, it may remain for years without occasioning any very great degree of pain; but, on the other hand, if it takes the direction of parts which are very essential, or very much endowed with sensation, the effects which it produces are of a very painful and disagreeable character. While it remains wholly concealed in the interior of the body, it cannot be extracted or destroyed by any known means; but when it appears externally, an attempt is made to remove it, by slowly drawing it from the body. Great care must be taken, however not to break it in the performing of this operation; because, if it is broken, the fragment which is left, whether the head or the tail, is said to retreat deeper into the interior of the body, to grow more rapidly than before, and produce the most serious mischief. Some particulars told respecting this animal require, however, to be verified by a more careful examination, though there is no doubt that, from the accounts, it must be a great annoyance.

Other species which are peculiarly annoying to the human body, are those which are termed tape-worms (*Tænia*), the common tape-worm (*T. lata*), and the solitary tape-worm (*T. solium*). The common tape-worm is very long, flat, and composed of a number of joints, more or less conspicuously distinguished from each other. These joints or articulations are broad and short, and furnished with two lateral pores in each; and adhering by the head, which is slender, it grows joint after joint, till it very often extends to more than twenty feet in length, and sometimes even to upwards of a hundred. It draws its subsistence from the intestines by means of four suckers; but whether its nourishment is the substance of the viscus, or the chyle, as taken up by the lacteals, it is not very easy to determine. The solitary tape-worm is not very correctly named, inasmuch as the common notion that only one can infest the bowels of the same person at the same time is not correct. The joints of this one are longer than those of the common tape-worm; but the animal itself does not attain the same length, being generally under ten feet, though sometimes much longer. Both species are exceedingly injurious and exhausting to those who have the misfortune to be afflicted by them, as the great rapidity of their growth occasions a vast drain on the system, and it is not without the greatest difficulty that they can be expelled. The pores which we have mentioned as being seated on the joints are the orifices of the ovaries; and it should seem that whenever the joint is fully developed, the ova contained in it are in a condition for speedily attaching themselves to the intestines, and continuing the work of exhaustion, even after the parent animal in the greater part of its joints, or in the whole, is expelled. Tape-worms may be regarded as among the most distressing and exhausting parasites which infest any description of animals; and, under peculiar states of the human body, they occasion very grievous diseases. That they are not developed when the body is in vigorous health, whether the germs of them happen to be present or not, is tolerably well ascertained. But how the germs come into the body, or what are the particular forms of disease most favourable to their development and growth, has not been very clearly ascertained. Hence the expelling of the tape-worm opens a large field for the machinations of impostors, by whose ignorant pretensions and inadequate nostrums the health of the patient is but too frequently injured in other respects, without any relief being procured from the depredations of the parasite. The fact is, that both species of the tape-worm are of very difficult expulsion, and very tenacious of life; and they often resist an exhibition of very powerful medicine, by the effects of which upon the system the patient may be brought almost to the gates of death, and the ravages of the worm encouraged by the additional weakness of the organs, instead of being expelled from the system. The history of all the entozoæ, more especially those which infect man and the more useful domestic animals, have been investigated with patient and scientific research by Rudolphi and others; but the subject is still very obscure.

Those species, often denominated *hydatid*, which are found in the liver and other parts of the hepatic viscera of various animals, and even in man, are also exceedingly troublesome. They occur in most of the ruminating animals, and in the hog and the horse. The common form is that of a small oval leaf, pointed at the posterior extremity, and narrowed in the fore part, which forms as it were a sort of stalk to the leaf-shaped part. The feeding sucker is at the extremity of this narrowed portion, and it leads to the gullet, or a sort of intestinal tube, from which other smaller tubes ramify to the various parts of the body, and convey to these the bile of the plundered animal, which is the substance on which this kind of parasite chiefly feeds. Behind the feeding sucker there is a little tentaculum, and behind that the second sucker; and great part of the body is occupied by the organs of generation. One species of this genus is peculiarly destructive to sheep. It is sometimes popularly called the "sheep fluke," from a fanciful resemblance in its shape to that of a flounder. It is very liable to infest sheep which pasture on low and humid grounds; and in circumstances favourable to its growth and reproduction, it soon multiplies so fast, that the sheep are seized with dropsy, their flesh wastes away, and they very speedily perish; nor does it appear that the malady admits of any cure, except by the removal of them to dry and wholesome pastures, as soon as the slightest symptom of the attack appears.

Class III.—ACALEPHA, or sea nettles as they are vulgarly called, are all swimmers; and they get this name from the painful stinging which many of them give to the hand when touched. They are all inhabitants of the sea; and they float freely in the water without attaching themselves to any solid substance. While swimming they are often very conspicuous, and the fine membrane in which these gelatinous, and in great part fluid substances is invested, often has a rich play of prismatic colours; but when they are stranded on the shores, which very often takes place after storms, as they have but little means of extricating themselves, they appear a shapeless mass of jelly, and if the membrane is broken they very soon disappear. The most characteristic of the simple ones, or those which swim in the water by means of alternate contractions and dilatations, are the *Medusæ*, of which there are a good many varieties, or perhaps even sub-species, but all have something of the appearance of the head of a mushroom in the upper part, at least in form; though in the other parts of their organisation, if organisation it can be called, which consists of little else than a portion of liquid inclosed in a tender and flexible membrane, they differ considerably from each other. Some have a kind of tentaculæ for seizing that upon which they feed, and others have the mouth elongated on a sort of peduncle, but the mouth is always on the under part. Simple as their organisation appears, many of them are social animals, and swim about in considerable numbers, all moving in the same direction. They are found in most seas, but in greater numbers, of larger size, more beauty of prismatic colouring, and they cause more acute pain from their power of stinging, in the tropical and warm seas than in the cold ones.

The hydrostatic *acalepha* are characterised by having one or more sacs appended to their bodies, which they can fill with air, or empty at pleasure, and by means of these they ascend and descend in the water. The body is also covered with numerous and variously formed appendages, which are its principal organs; but as there is no apparent mouth, the food and mode of feeding are not known; the various members of this order are chiefly found in the tropical seas, where they swim on the surface when the water is still, but descend when it is agitated. Some of them are described as having the same burning or stinging property when touched which characterises the sea nettles, properly so called. One genus is very curious, inasmuch as two animals are always found together, the one enclosed within the body of the other, though they can be separated without injury to either. Some of these are in the form of a pyramid, others bell-shaped, and in some of them the containing animal is differently shaped from the one which it contains. Whether the two distinct portions of the pair are a male and a female, or both are double sexed animals, has not been correctly ascertained.

Class IV.—POLYPI. The name of this class literally means many feet, an appellation which was given to the cuttle-fish by the ancient naturalists. They approach nearly to the lowest verge of animal life, and some of them are of exceedingly small size; but they are very numerous, and the part which they act in the great system of the earth's economy appears to be more important than that of even the largest of the warm-blooded animals; for they are in some measure the conservators or renewers of the land, by forming the substance of most extensive reefs of rocks, and, ultimately, islands, raised from great depths in the widest oceans. They get the name of polypus, not from their number of feet as organs of motion, but from that of their tentacula, as organs of feeding. The body has only one opening, situated in the centre of the tentacula; and sometimes the body beyond this is nothing more than a simple sac; but there are others in which faint traces of vessels may be observed; and such as have these vessels produce their young in the form of eggs; while those in which no vessels can be traced propagate by germs or buds. They are divided into three orders:—fleshy, gelatinous, and coral-bearing.

The fleshy ones (*carnosi*) are popularly known by the name of animal flowers; and sometimes they are named after particular flowers, as anemones, marygolds, or any others to which they may appear to have a fancied likeness. The animals of this order consist of a fleshy body, usually of a cylindrical form, and having the mouth, which is the only opening, placed in the middle of the upper end. This mouth consists of a greater or smaller number of leaflets, ranged round the opening, and bearing no small resemblance to the parts of fructification in a compound flower. Around this central formation there are a number of tentacula, very like the petals or flower-leaves of a flower. These last, and also the central ones which more immediately surround the mouth, are often of the most brilliant colours; and when they are expanded under water they might very readily be taken for real flowers of vegetable growth. They are generally found attached to rocks, but they have the power of locomotion; and this appears to be performed by the basal part of the animal. There are at least two distinct genera of them, *actinia*, or sea anemone, and *zoanthus*, or living flower. In the individual animal these do not differ very greatly, but the actinia has only a single animal on the same base; whereas in zoanthus a considerable number are united together, sometimes on a flat disc, and sometimes on a kind of creeping stem.

When these animals are in a state of repose they are folded up, and bear some resemblance to figs in a half-grown state; but in a state of activity they spread out their tentacula like a full-blown flower, and open their mouths to a very considerable extent. They are all inhabitants of the waters, but never at any great depth. They are, in a remarkable manner, children of the sun, or more sensitive to light and heat than almost any other animals: a passing cloud will make them withdraw their tentacula; but when the sun breaks out they again expand. They do so, however, only when they are completely submerged; for when exposed to dry light, their conduct is exactly the reverse; and they will close at the light of a candle, and expand again after the candle is withdrawn. This sensibility to light, even when precautions are taken that there shall be very little difference of heat, is a curious fact in animals which are wholly unprovided with eyes, or organs of vision of any description whatever; because it shows us that sensation is one thing, and a specific organ of sense another, not necessarily connected together; for though the organ cannot perceive without the sense, it thus appears that the sense can perceive without the organ. Hence, an eye, or any other structure, to which we ascribe the power of receiving certain impressions of external objects, is considered as mere matter, nothing more than a passive instrument, under the control of the living power, and framed for enabling that power to exert itself in a particular manner; but having no part of the power inherent in itself, as an organic structure.

In the seas of warm latitudes, the species of these curious animals are exceedingly numerous, and very elegant; and the water, at a moderate depth, in those seas, is as transparent as crystal, so that in rowing over the shallows in still water, the bottom displays all the beauty of a splendid flower-garden. In temperate climates, the numbers are not so abundant; but there is at least one or more on the rocky shores of the British Islands, where it can be examined with the greatest ease, as it is found adhering to the rocks, and often in the bottoms of the shallow pools, when the tide ebbs away. The last are the best situations for observing its habits; because, when it is in the pool, it is as active as though it were in the sea;

but when it is on the dry rock, its tentacula are withdrawn, and its mouth contracted like a purse. It is exceedingly voracious, and possessed of very vigorous digestive powers. Its principal food consists of the smaller mollusca and crustacea, from which it very speedily extracts the substance, and then ejects the shell or crust. The tentacula are used for seizing the food, and drawing it to the mouth; and it appears that they have a very peculiar structure, which fits them for performing this operation in a singular manner. Those tentacula, though they have the appearance of the petals of a flower when expanded, are tubes; and when anything moveable touches the point of any of them, they have the power of instantly converting themselves into adhesive suckers. The manner in which this is done, is not very easily explained. The mere point of the tentaculum first touches the moving substance, and then it gradually doubles inward, or inverts itself, and thus soon forms a considerable base, to which the substance adheres by the joint pressure of the atmosphere and the water; and in this way a single tentaculum will bring to the mouth a substance of considerable size. This substance is instantly swallowed or inclosed within the sac, even though only a stone or an empty shell; but if it is such, it is very speedily ejected again. On the other hand, if it is a strong-shelled animal, such as a common periwinkle, which is not only inclosed in a hard and firm shell, very much convoluted, but has the aperture or mouth of the shell closed with a horny operculum, it is retained within the cavity of the body, until the substance is extracted, and then the shell is thrown out.

The power of life in these animals appears to be very great. In the usual mode of generation they are viviparous, and the young are discharged by the mouth. It is the base, however, which seems to be the essential part of the animal; and it is here that the ova are originally formed. Some curious details of experiments on these animals, by the Abbé Dicquemarre, are given in the sixty-third volume of the Philosophical Transactions, which are in substance as follows:—In the first instance, the abbé cut off the tentacula, which were reproduced in a month, and he repeated the operation for a second and third time with the same result. The upper part of one of the animals was also cut off, and the base was found in a few days after to have fallen from its place; but the creature very soon after recovered its limbs. After cutting one of them in two, the abbé presented a piece of mussel to the detached part, and the limbs seemed again to receive it; they pulled it into the mouth, and it was instantly swallowed; but there being no body to contain it, the piece came out at the opposite end, just, as the abbé expresses it, as a man's head, being cut off, might be supposed to let out at the neck whatever was taken in at the mouth: it was offered a second time, and again received, and retained till the following day, when it was thrown out. It was fed in this manner for some time, the pieces, when they did not pass through, appeared considerably altered on their re-appearance at the mouth. If the base itself of any of these anemones be injured by an incision, the wound generally proves fatal to the animal. On being put under an exhausted receiver, these animals did not appear to experience any bad effects, or to suffer any inconvenience from being deprived of atmospheric air. If the tentacula happened to be expanded when placed in the receiver, they remained in that position, and not the slightest contraction was visible when the air was withdrawn. Some of these actinia lived upwards of a year on the animalculæ afforded them by the sea-water in which they were kept, without any other food. When shelled mollusca, bits of fish, or raw flesh, if not too large for the size of the mouth, were offered to it, they were always swallowed; and though the shells of a bivalve were closed when taken in, they were ejected, completely empty, in the course of a day or two. We have often fed the common species, *actinia verrucosa*, with periwinkles, shrimps, and other shelled and crusted animals, marking the shells or crusts as we placed them on the tentacula; and unless there was some agitation of the water sufficient to carry them away, we invariably found the shells and crusts ejected, and completely empty, even to the small claws of the latter.

The *Lucernariæ* bear a considerable resemblance to the former, only they are softer in the substance, and attach themselves by a very slender pedicle to the leaves of marine plants and other substances; and their tentacula, instead of being expanded like a flower, are reflected downwards in the form of a small umbrella.

The gelatinous polypi have no firm covering, nor any axis in the interior of their bodies. They are exceedingly simple, and their whole organisation is a sort of little horn of gelatinous matter, with fringes, which are the tentacula of the animals, with which they seize their food, and by means of which also they can swim. Notwithstanding the extreme simplicity of their organisation, some of these animals can crawl, or even walk, by alternately applying their extremities after the manner of leeches, and the geometrical caterpillars. The most extraordinary part of their economy, however, at least in the *hydræ*, which are the most characteristic species, is the manner in which they may be propagated. Naturally, the young are produced, not by specific organs allocated to particular parts of the body, but indiscriminately from almost every part; and they appear at first like little buds or sprouts, which increase till they acquire the form of the perfect animal, and then they separate. They may, however, be produced by mechanical division in almost any manner; so that it is difficult to find any portion of the body in which there is not a germ, or principle of life, which will produce the other parts, and speedily change the fragment, or each fragment, if the body is cut into several, to a perfect animal. We have here, in so far as growth is concerned, a remarkable coincidence with the coronal plates of some roots, and the cambium or living matter of many species of trees, in both of which a bud, of which there is no previous trace, can be formed; and this bud may, generally speaking, be separated and become a perfect plant, just as the segment of one of these creatures becomes a perfect animal.

Many animals of this singular order are found in fresh water; and not a few of them are too small for being at all discernible by the naked eye. Some have pedicles or foot-stalks, by means of which they adhere to the bodies of other animals; and it is probable that, in many instances, they have been considered as organs of the species to which they are attached.

The *Coral insects*, as they are sometimes called, though they are not insects but radiated animals, in which the structure of the individual part is very similar to the polypi already mentioned, form the third and last order of this peculiar class of radiated animals. The most remarkable circumstance about them is that they are clustered animals; and though it is probable that there is a separate life in each when it is disconnected from the rest, so that it can grow and produce its kind, yet they remain attached to each other, sometimes by an internal connexion, resembling the pith of a tree; sometimes by an external tunic, or covering of hard matter, approaching more or less to the consistency of crust or shell; and sometimes by a flexible substance, in which in some of the species there has not, hitherto, been traced anything like distinct developments of parts of animals, but merely a flexible substance, containing innumerable pores or openings, all communicating with each other, and containing, when in the living state, a peculiar liquid, which liquid, as well as the mass in which it is contained, partakes of the common characters of animal matter.

Animals of this description are so much produced by radiation from a centre, or by ramifications from a principal stem, that they were long considered as vegetables. They are chiefly, if not exclusively, inhabitants of the sea; and many of them in their appearance very much resemble stems of shrubs, very much divided into branches, and adhering to stones or other supports, but without bark or leaves. They are divided into three families, which are named from the general form of the aggregate, or substance, both containing and contained, which makes up the compound animal, or the colony; for it is difficult to draw a definite line of distinction between the one and the other. The families are: first, *Tubularii*, or those which have cases or dwellings of a hard substance, generally carbonate of lime, in the centre of which there extends a gelatinous substance, and which has openings for the different animals, or different feeding developments of the compound animal. Some of these inhabit the fresh waters, but the greater number are met with in the sea. Some also are free and endowed with a power of motion; but the greater number are fixed. They grow by buds; and some of them grow with vast rapidity, are curious in their structures, and beyond all power of arithmetic in their numbers. The individual parts of them very much resemble the gelatinous polypi, or consist of simple sacs, furnished with tentacula at that extremity which may be considered as the mouth; but their other extremity is always connected with the principal gelatinous cord, which unites the colony together; and it is so whether this colony floats freely in the waters, or is rooted to a particular place. Their mode of production is invariably by buds, which buds appear to be produced on the connecting cords rather than on the developed parts, which we would naturally consider as distinct animals. It should seem that the cord in these cases bears a considerable resemblance to the base of the sea anemones, only that it is produced in length, while the base of these has its production in breadth.

The second family are *Cellular*, that is, the animals, or developments of the compound animal, are lodged in cells of horny matter, or horny matter united with salts of lime; but though the individual parts are produced in succession from each other, there is no tube and connecting cord as in those formerly mentioned. The communication of these with each other appears to be by means of an exceedingly thin epidermis or cuticle, which is extended over the whole compound animal or colony, and which appears to be capable of producing new developments at all points. It should seem also that there is a division of this cellular and thinly integumented family, in which the organs, or, as they may be termed, the individual developments, are so obscure, that they have never been observed. These have occasioned some disputes among the natural historians of plants and those of animals; but it is now well ascertained, that, however simple and destitute of distinct organs, they are real animals and not vegetables. The corallines, which are often so elegantly formed and finely branched that the lightest-growing shrubs are not more elegant, may be taken as an instance of these. They have no cell or opening; but consist of a kind of horny matter, mixed with more or less of salts of lime; and when they are dried, as we usually find them in museums, they appear to consist of nothing else than this substance, which, though divided into a vast number of branches which become slender as they are farther from the root, is of the same texture throughout, and neither contains the cell of any animal, nor anything which can be considered as the remains of an animal organ of even the most simple description. It should seem, therefore, that the only part of them which is alive is the epidermis, which invests all the other matter; and from the way in which they are branched, this appears capable of producing buds or multiplications of the substance at any point, the multiplication being made by a deposit from the inner surface of the epidermis, upon the core which the epidermis invests. Some of these corallines have been employed in medicine; but it does not appear that they have any particular merit in this way, farther than from the calcareous matter and the soda which they contain.

The third family are styled *cortical*, or those which have an internal substance like the former family, but are enveloped in a thick fleshy or gelatinous substance, in which there are cavities for the reception of the individual developments. Still there is the same gradation in these as in the former ones; for while in some the individual parts are very distinct, there are others in which it is impossible to trace them. One tribe have the internal axis flexible or horny, and variously branched. This is covered with a soft skin or bark, in which particular developments may be observed in some of the tribe, but not in others. The skin or bark which contains the developments, and may be considered as the living part of the animal, very speedily perishes after death; but the rest, which seems to serve only as a support to the living part, is far more durable. These are styled false corals, and sometimes black corals.

A second tribe of this family have sometimes been styled stone plants; because their internal substance is of the consistency of stone, and always grows rooted. One genus furnish the coral of commerce, which is well known for its beautiful red colour, and the polish of which it is susceptible. This coral grows without any joints, but it is slightly furrowed in a longitudinal direction. The cortical or living part is of a reddish colour, and contains a good deal of carbonate of lime; and the developments of the animals are furnished with eight toothed arms, which appear upon the stem not very unlike little flowers on the stem of a leafless plant. This coral is found abundantly in the Mediterranean, the Red Sea, and various other warm seas.

The madrepores have some resemblance to the coral, though the matter of which they are composed is not so valuable in the arts. They consist of branched, rounded, tabular, or leaf-shaped masses, always produced in layers, and proceeding from centres. They often attain a large size, and are of singular shapes. As they appear in collections, they resemble fantastically formed masses of stone; but, when alive, they are invested with a thick skin, which is the seat of life, and which is developed into separate polypi; and both they and the skin, when alive, are exceedingly sensitive to the touch.

There are other polypi which resemble the last mentioned in their general structure, only they float in the free waters. They consist of a calcareous axis, wholly enveloped in a living membrane. The polypi are confined to one part of the axis, so that the whole bears some slight resemblance to a feather. They in general give out a very brilliant phosphoric light.

Sponges are the last form of this extraordinary class of animals. They assume a vast number of shapes, from which the species are determined. It is not easy to distinguish the sentient or living part of these animals from the part not endowed with life. They contain little or no earthy salt, but are wholly composed of vegetable matter divided by a vast number of pores and tubes, all of which communicate with each other. The action of the sponges, when alive, is understood to consist in alternate expansions and contractions; and when a sponge is recent, a peculiar fluid can be pressed out of it; but hitherto no trace of a separate organic development has been found, though there is no doubt of its being an animal production; and in all probability each sponge is, with the exception of the liquid above alluded to, an entire and separate animal.

Class V.—INFUSORIA. These are the animalculæ to the extreme minuteness of some of which we have already alluded. They form the confine of the animal kingdom, and were indeed altogether unknown until the invention of the microscope. Some of them are furnished with organs; some have the power of changing the shapes of their bodies. Some appear harmless, or at least do no violence to anything that our instruments can discover. But there are others which are proportionally as voracious as the tiger on the land, or the shark in the sea. Altogether they are an extraordinary race; and their extreme minuteness, and wonderful powers of self-enjoyment and preservation, perhaps impress us more forcibly with the wonderful working of the Creator than any animals of larger growth. But the details of their history are not exactly adapted for popular purposes, inasmuch as they can be observed only by those who have the best instruments and abundant leisure for the use of them. We shall therefore pass them over, and close this volume by a few reflections on the subjects contained in it and the preceding as one general subject of rational and improving contemplation.

CHAPTER VIII.

GENERAL OBSERVATIONS AND REFLECTIONS ON ANIMATED NATURE.

FROM what has been stated in this and the preceding volume, but more especially in this, the reader will see that the variety of living creatures is almost beyond our power of numbers, even within the range of the eye, or the eye aided by the microscope; and we do not know how many more races may be too minute for our most perfect instruments, or what number and variety may exist in the wide expanses and unfathomable depths of the ocean, which have not hitherto come within the limits of our observation. The functions which these perform, and the parts which they act in the grand system of nature, are as extensive as their numbers, and as varied as their structures. Similar functions, too, are often performed by organisations which are very different; so that, when we contemplate the whole, we cannot fail to perceive that He who formed the whole is capable of causing any end to be accomplished, and causing it to be accomplished by any means; and not only so, but that every means which He has appointed, however it may differ from others, is the very best for the accomplishment of its appointed end.

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

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

But again; though God has tempered the blood and bodies of most fishes to their cold element, yet, to show he can preserve in the coldest water a creature as hot as the land mammalia, he has placed a variety of the cetacea in the northernmost seas. And the copious fat wherewith their body is inclosed, by retaining the internal heat, and keeping off the external cold, keeps them warm even in the neighbourhood of the Pole.

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

In man and many other mammalia, the food first chewed is received into the stomach, where it is concocted and reduced into chyle, and so evacuated into the intestines, where, being mixed with the bile and pancreatic juice, it is farther subtilized, and rendered so fluid, that its finer parts easily enter the mouths of the lacteal vessels.

In birds there is no chewing; but in such as are not carnivorous, the food is immediately swallowed into the crop or ante-stomach, where it is moistened by some proper juice, and then transferred to the gizzard, by the working of whose muscles, assisted by small pebbles, which the birds swallow for that purpose, it is ground small, and so transmitted to the intestines.

In oviparous reptiles, and all kind of serpents, there is neither chewing nor comminution in the stomach, but as they swallow animals whole, so they void the skins unbroken, having extracted the nutritious juices. Here, by-the-by, we may observe the wonderful dilatibility of the throats and gullets of serpents. Two entire adult mice have been taken out of the stomach of an adder, whose neck was no bigger than one's little finger.

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

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

Were it true that brutes were mere machines, they could have no perception of pleasure or pain. But how contrary is this to the doleful significations they give when beaten or tormented! How contrary to the common sense of mankind! For do we not all naturally pity them, apprehending them to feel pain just as we do! Whereas no man is troubled to see a plant torn, or cut, or mangled how you please. And how contrary to Scripture! *A righteous man regardeth the life of his beast; but the tender mercies of the wicked are cruel.*

—Prov. xii. 10. The former clause is usually rendered, *A good man is merciful to his beast.* And this is the true rendering, as appears by the opposite clause, That *the wicked is cruel.* Cruelty then may be exercised towards beasts; but this could not be, were they mere machines.

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

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

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

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

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

Secondly, what admirable provision is made for some of the most helpless creatures, at a time when they must otherwise utterly perish! The winter is an improper season for affording food to insects and many other animals. When the fields, trees, and plants, are naked, and the air is chilled with frost, what would become of such animals, whose tender bodies are impatient of cold, and who are nourished only by the produce of the spring or summer? To prevent their total destruction, the wise Preserver of the world has so ordered, that, in the first place, those which are impatient of cold should have such a peculiar structure of body as, during that season, not to suffer any waste, nor consequently need any repair. Hence many sorts of reptiles and invertebrated animals pass the whole winter without any food; and most of them without any respiration. It seems that all motion of the animal juices is suspended; for though cut in pieces they do not awake, nor does any fluid ooze out of the wound. This sleep, therefore, is little less than death; and their waking than a resurrection—when the returning sun revives them and their food together.

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

And what a prodigious act is it of the Creator's indulgence to the poor, shiftless irrationals, that they are already furnished with such clothing as is proper to their place and business! With hair, with feathers, with shells, or with firm armature, all nicely accommodated, as well to the element wherein they live, as to their several occasions there. To beasts, hair is a commodious clothing; which, together with the apt texture of their skin, fits them in all weathers to lie on the ground, and to do their service to man. The thick and warm fleeces of others are a good defence against the cold and wet, and also a soft bed; yea, and to many a comfortable covering for their tender young.

All the Polar mammalia are clothed with a soft, warm fur. And what is still more surprising, and what draws all attentive minds to admire the wisdom and goodness of Providence, is, that the very dogs and cats which are carried thither from England change their appearance on the approach of winter, and acquire a much longer, softer, and thicker coat of hair than they originally had.

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

No less curious is the clothing of crawling animals. How well adapted are the rings of some, and the contortions of the skin of others, not only to fence the body sufficiently, but to enable them to creep, to perforate the earth, and to perform all the offices of their state, better than any other covering!

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

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

Admirable likewise is the sagacity of many animals in the conveniency and method of their habitations. Their architectural skill herein exceeds all the skill of man. With what inimitable art do some of these poor, untaught creatures lay a parcel of rude ugly sticks or straws together! with what curiosity do they line them within, yea, wind and place every hair, feather, or lock of wool, to guard and keep warm the tender bodies, both of themselves and their young! And with what art do they thatch over and coat their nests without, to deceive the eye of the spectators, as well as to guard and fence them against the injuries of the weather!

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

Another instance of the wisdom of Him that made and governs the world, we have in the balance of creatures. The whole service of the terraqueous globe can afford room and support to no more than a determinate number of all sorts of creatures. And if they should increase to double or treble the number, they must starve or devour one another. To keep the balance even, the great Author of nature has determined the life of all creatures to such a length, and their increase to such a number, proportioned to their use in the world. The life, indeed, of some hurtful creatures is long; of the lion in particular. But then their increase is exceedingly small; and by that means they do not over stock the world. On the other hand, where the increase is great, the lives of those creatures are generally short. And, beside this, they are of great use to man, as to other animals, either for food, or on other occasions. This, indeed, should be particularly observed, as a signal instance of Divine providence, that useful creatures are produced in great plenty; others in smaller numbers. The prodigious increase of insects, both in and out of the waters, may exemplify the former observation. For innumerable creatures feed upon them, and would perish, were it not for this supply. And the latter is confirmed by what many have remarked; that creatures of little use, or by their voraciousness pernicious, either seldom bring forth, or have but one or two at a birth.

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

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

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

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

He spread under the plains, beds of clay, or compact earths, there to stop the waters, which, after a great rain, make their way through innumerable little passages. These sheets of water frequently remain in a level with the neighbouring rivers, and fill our wells with their redundancy, or, as those subside, flow into them again.

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

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

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

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

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

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

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

If we turn our eyes to the minutest parts of animal life, we shall be lost in astonishment! And though everything is alike easy to the Almighty, yet to us it is matter of the highest wonder, that, in those specks of life, we find a greater number of members to be put in motion, more wheels and pulleys to be kept going, and a greater variety of machinery, more elegance and workmanship (so to speak) in the composition, more beauty and ornament in the finishing, than are seen in the enormous bulk of the crocodile, the elephant, or the whale. Yea, they seem to be the effects of an art, as much more exquisite as the movements of a watch are than those of a coach or waggon.

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

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

Glasses discover to us numberless kinds of living creatures, quite indiscernible to the naked eye

And how many thousand kinds may there be, gradually decreasing in size, which we cannot see by any help whatever! Yet to all these we must believe God has not only appointed the most wise means for preservation and propagation, but has adorned them with beauty equal at least to anything our eyes have seen.

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

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

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

"In all the animal world, we find no tribe, no individual neglected by its Creator. Even the ignoble creatures are most wisely circumstanced, and most liberally accommodated.

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

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

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

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

"If the swan has large sweeping wings, and a copious stock of feathers, to spread over her callow young, the wren makes up by contrivance what is wanting in her bulk. Small as she is, she will be obliged to nurse up a very numerous issue. Therefore, with surprising judgment she designs, and with wonderful diligence finishes her nest. It is a neat oval, bottomed and vaulted over with a regular concave: within made soft with down;

without thatched with moss, only a small aperture left for her entrance. By this means the enlivening heat of her body is greatly increased during the time of incubation. And her young no sooner burst the shell, than they find themselves screened from the annoyance of the weather, and comfortably reposed, till they gather strength in the warmth of a bagnio.

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

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

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

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

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

"Even the spider, though abhorred by man, is the care of all-sustaining Heaven. She is to support herself by trepanning the wandering fly. Suitably to her employ, she has bags of glutinous moisture. From this she spins a clammy thread, and weaves it into a tenacious net. This she spreads in the most opportune place. But knowing her appearance would deter him from approaching, she then retires out of sight. Yet she constantly keeps within distance, so as to receive immediate intelligence when anything falls into her toils, ready to spring out in the very instant. And it is observable, when winter chills the air, and no more insects rove through it, knowing her labour would be in vain, she leaves her stand, and discontinues her work.

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

"Let us step into another element, and just visit the watery world. There is not one among the innumerable myriads, that swim the boundless ocean, but is watched over by the Sovereign Eye, and supported by his Almighty Hand.

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

END OF VOL. II.

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