# MANUALS OF ELEMENTARY SCIENCE

# ZOOLOGY.

(NEW EDITION.—REVISED THROUGHOUT.)

ALFRED NEWTON M.A.F.R.S.

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MANUALS OF ELEMENTARY SCIENCE.

# ZOOLOGY.

BY

ALFRED NEWTON, M.A., F.R.S.,

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PUBLISHED UNDER THE DIRECTION OF THE COMMITTEE OF GENERAL LITERATURE AND EDUCATION, APPOINTED BY THE SOCIETY FOR PROMOTING CHRISTIAN KNOWLEDGE.

LONDON:
SOCIETY FOR PROMOTING CHRISTIAN KNOWLEDGE;
SOLD AT THE DEPOSITORIES:
77, GREAT QUEEN STREET, LINCOLN'S INN FIELDS;
4, ROYAL EXCHANGE; 48, PICCADILLY;
AND BY ALL BOOKSELLERS.

NEW YORK: POTT, YOUNG & Co

1874.

# PREFACE.

THIS little book professes to have no originality, except it be that of bringing together a good many matters seldom, if ever, introduced into an elementary Manual of Zoology. The scope of nearly all such works as I have seen is confined to what is technically called "Morphology"—the study of form, or at least that is made their most important feature. In one greater stress may be laid upon the external characters of the Animal, in another its anatomical structure, and this with greater justice, receives fuller attention. A smaller class of books contents itself with a series of anecdotes which may well amuse children. I am far from denying the merits of any one of these three kinds, but it seems to me that the treatment of Zoology in these days requires something more, and that an attempt, even in an elementary hand-book, should be made to bring the mind of the learner to reflect upon the marvellous inter-connexion of outward form, internal organization, mode of development and habits of life. Such an attempt then is this compilation. I have not hesitated to borrow largely from other writers, though I have not often quoted my authorities—simply because so many of their phrases and illustrations, from their aptness and felicity, have been so long stored in my memory that I should have found it almost impossible, at this distance of time, to say from whom they are derived. I must however declare that I am greatly indebted to Professor HUXLEY's admirable 'Lectures on Comparative Anatomy,' as well as to his 'Manual of the Vertebrata.'

A. N.

*Magdalene College, Cambridge,*
*May* 1, 1874.

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# ELEMENTARY ZOOLOGY.

## CHAPTER I.

Zoology, in the sense of the word that will be used in this book, means a knowledge of animals—a knowledge of where and by what means they live, what food they eat, how they grow and breed, what changes they undergo at various stages of their existence, what peculiar habits they possess, what they look like and how they are framed, a knowledge of their mutual resemblances and differences—in short a knowledge of all about them. This knowledge, too, is not confined to animals which are now living in this or other countries, it must be extended, so far as can be discovered, to the animals that lived in bygone ages, the animals whose former existence is revealed to us only by finding their remains imbedded in the ground and turned into stone—such remains as are called fossils. Furthermore, in order that we can write or speak of animals without fear of being misunderstood, we must know by what names they are called; while, that we may have clearer ideas as to the bearing of all we have learnt on the subject, we must have some method of arranging the facts we collect, so that they may be more readily remembered, that is to say, we must have some method of classification. When we have made more or less progress in this direction we may begin to reason upon such facts and even begin to consider whether what we term our classification may not be a kind of

index to the way in which it has pleased God to bring His creatures into being.

Zoology then in this sense constitutes one of the widest fields of research on which the human mind can exercise itself, for the various forms in which animal life is presented to us are countless, and so great is the number of men who, in nearly all civilized countries, are now applying themselves to the study of Zoology that not a day passes but some new kind of animal is discovered, or some new fact, more or less important, which has to do with animals is made known. Investigations carried on or published within little more than a dozen or fifteen years ago have tended to overturn in the minds of many beliefs which have had the sanction of centuries of concurrence. Now, this being the case, the example shows that caution is required in receiving new theories as accepted truths. In a rapidly-progressing study like Zoology what we consider proved to-day may be disproved to-morrow, and consequently theories, of what kind soever they be, would be entirely out of place in a book professing to deal with but the rudiments of a growing Science.

Still the number of recorded zoological facts is enormously large, and, when we are pretty sure that they are facts, we are not only bound to notice them, but we may justifiably attempt to reason upon them; remembering the while that our interpretation of them, as of all things within our ken, is liable to error though the facts themselves be undeniable.

Thus it is especially with that department of Zoology last mentioned—Classification. By many, and not without some good grounds, Classification is deemed to be the highest kind of knowledge of which the subject is capable. A very large proportion of the facts on which the divers systems of scientific classification are based are admitted by all, but their interpretation is widely different, and their significance is accordingly open to doubt. A man will allow that such and such characters or peculiarities of a certain animal or group

of animals exist, but he will attach to them only slight value, while another man will maintain that they are of essential importance in determining the place which their possessors should hold in the system. Others again will deny that Classification should be the chief end of zoological research.

Statements like these are not made with the object of discouraging the learner, but rather with that of forewarning him. As soon as he passes from the book to which he has turned after doing what he can to inform himself by direct observation, or from the book whence he has first acquired the rudiments of the study to another, he will be sure to find himself beset with difficulties of this nature. If he is unprepared to meet them, he will assuredly be bewildered: on the other hand, if he is aware of what he has to encounter, he will know that he has but to thread the mazes of a labyrinth and every step will bring him nearer to the goal which he is seeking, though this goal be one that he may never reach.

It follows, therefore, that the learner must not pin his faith on the system of Classification with which he will anywhere meet, including that which will hereafter be set forth in this book. In the present state of zoological science no Classification can be otherwise than in a great measure experimental or a matter of opinion, and accordingly all attempts to that end should be regarded with suspicion.

One thing, however, is plain. Whether those are right who set so high a value on Classification, or the contrary; some sort of Classification of animals we must have or all our ideas about them will be in confusion, and the trouble we take to get information will be lost to us. We must be able to make, in our minds at least, a list of the animals we study in order that we may set down in its proper place each fact as we learn it, applying it to that kind of animal to which it belongs; and moreover such a list must be arranged in some kind of order. How then ought we to make this list?

Suppose a bag of money—such as a shopkeeper,

doing a good business, may find in his till of a Saturday night—is put into our hands and we are told to give as full an account of its contents as we possibly can. It would not take us long to say how many coins of copper, silver and gold there were or to add up the amount. But that is going only a little way and is not enough for our purpose. We must then separate the coppers into farthings, halfpence and pennies, the silver into threepenny and fourpenny bits, sixpences, shillings and so on, and the gold into half-sovereigns and sovereigns. Even this is not sufficient; we must further sort out the various coins of each of these kinds according to the king or queen by whom they were struck, and still further according to the dates that they bear. Supposing that some of the coins are worn down so that we can no longer recognize the image or read the superscription: these we should have to compare with others that have been less defaced before we could decide to which king's or queen's reign they belong. Then, too, the bag may contain some pieces of money which are no longer in use—such as a guinea or a half-guinea, and perhaps a Colonial, a French or even a German coin may have got into it by accident. These will teach us much more. At last we suppose our examination finished as far as we can go, and we are able to give the answer that is asked of us. We shall quickly find that this answer may be given in several ways. We may, if we please, arrange all the coins according to the metal of which they are made, we may arrange them according to their date, we may arrange them according to their value and, perhaps, in other ways, or we may combine two or more of these several methods. Undoubtedly the best way of arranging them will be that which gives most information about them. But it is not at all an easy matter to say which way that will be. Is there a greater resemblance between a copper penny and a silver penny of Queen Victoria than between the former and a copper penny of King William IV.? Or again, is a bronze

penny of the Queen's to be put under the same division as one of her copper pennies or under a new division? One man will think that the fact of two coins being made of the same metal will justify their being placed together; another that two coins, though of different metals and values, but having been struck in the same year or by the same monarch, have a greater resemblance to one another. We must be careful to note all the resemblances and all the differences, and some of the differences will be very fine. We may find two sovereigns bearing the same date but one stamped with St. George and the Dragon and the other with the coat-of-arms of the United Kingdom. Other things also will occur to us. We shall not be able to find in our bag a florin of an older date than the year 1849, and we shall also see that in a good many respects the florins of that date differ from those which were coined afterwards. Does this show that florins were first introduced to this generation in 1849, and that afterwards their form was changed? Again we shall not find a guinea of a later date than 1813, nor a sovereign of an earlier year than 1817. Are we hence to infer that guineas were called in and that sovereigns took their place? The fact that colonial and foreign coins are to be found in the collection also tells something. A Jersey penny shows that the Channel Islands belong to the English Crown, but still with certain differences of laws and customs. A rupee proves that India is a British possession, a Canadian dollar or an Australian sovereign give the same evidence as to the country in which they were struck. Two or three French sous tell us that we have much intercourse with our neighbours, and then if by chance we come upon an old Roman coin—older by hundreds of years than any of the rest and yet paid in by some ploughboy or excavator who found it and took it for a farthing—what a vast amount of speculation it excites, and how it will set anybody thinking who cares to think!

This one Roman coin remains to us, but it is clear

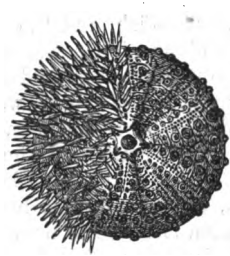
that there must have been many more exactly like it. Men would not have made the die which struck it to turn out a single coin. Where are the rest? No doubt by far the greater number is lost, but some perhaps will reappear. But then, again, it is hard to believe that we have been so lucky as to come upon a specimen of the earliest Roman coinage—the workmanship is too good for that. There has probably been a multitude of Roman coins in existence for years before this one was produced—and not only before but since—yet this only is present.

If, again, we were to try and make a catalogue of a second-hand bookseller's stock in trade, we should plainly have to deal with a still more complicated state of things. The folios, quartos and books of smaller size might fairly represent the gold, silver and copper coins. There would be the same question of dates in each, and the author's name would stand in place of that of the monarch. But we should also have to pay attention to the place at which each volume was printed and published, the kind of types used and the language in which it was written. Then, too, though of vastly less importance, we should have to take into consideration the binding, whether it was of vellum, leather, cloth, boards, or what not. There would also be pamphlets altogether unbound, or extracts from books without title-page or anything to declare their origin. Finally, there would be the question whether we should not class the books under the subjects of which they treat, and this in many cases would be a matter of great difficulty.

Now in Zoology we have just the same kind of thing. We need not perhaps trouble ourselves with the second illustration here given—that of the books—but may confine ourselves to that afforded by the bag of money. We find ancient—very ancient remains of animals in the form of fossils, we may liken them to the Roman coin, though from what Geologists tell us they are incomparably older. Albeit we have only a few of such fossils, we may be sure that the animals of

which they are the relics were once just as numerous as animals are now; and we may be also sure that many other animals more or less like them have perished without leaving behind them a trace that has been found or perhaps that ever will be found. This is not forming a theory, it is a process of just reasoning from the facts. Again, we have good ground for believing that there was a time when other animals of which we know did not exist. Some of these may still exist or of others we may only find the fossil remains, proving that they existed at a time subsequent to the former. Such animals may be likened to the guinea or other disused coin. Some animals there also are which, when they did exist, differed in a slight degree from those we now have around us and judge to be their descendants. These may be likened to the rupee struck by the old East-India Company before the Queen assumed the government of India. But there is still the same difficulty in knowing how to class them. It has been already said of the coins in the bag that we must pay heed to all their resemblances and all their differences. Let us try then to apply this rule and see what we can make of some examples of common animals, which we can without much difficulty or expense bring together.

STAR-FISH.



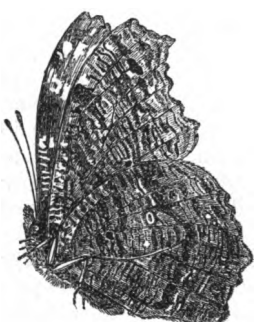
SEA-URCHIN.

Here is a dried Star-fish and the shell of a Sea-Urchin which, when the tide is out, may often be

picked up on the shore. Taking these in our hands we see that the Sea-Urchin's shell is a kind of globe of some hard substance, in shape not unlike an apple, with a biggish hole at the end where the stalk of the apple would be, and the shell is studded pretty closely with little wart-like, hard pimples, while a number of small holes, looking as though they might have been made by pins, appear between the pimples. When we first had it it was bristling with spines—a spine growing from each pimple; but nearly all these spines fell off while it was drying. The dried Star-fish is covered with a stout, rough skin, hard, but not quite so hard as the shell of the Sea-Urchin, and is remarkable for being in shape just like a star with *five* rays or arms growing from the flattish middle. At first sight, beyond knowing the fact that both the animals whose remains we have here are said to come from the seaside, and that both are covered with a more or less hard casing, one would not say there was any very great resemblance between them. But as we look again at the Sea-Urchin, we see that its pimples and pin-holes are arranged in a kind of pattern, and further we perceive that this pattern forms a kind of star, the middle of which is on the side of the apple-shaped box that is opposite the biggish hole, and moreover that this star-pattern shows plainly *five* rays. We cannot then but be struck with what we have just seen in the Star-fish, and the thought may seize us that if we could imagine a Star-fish with the spaces between its five rays filled up and the points of the rays curved upwards, so as to meet, we should have something that would not be so uncommonly unlike the Sea-Urchin. This idea is confirmed when we find that the lower side of each ray of the Star-fish has a double row of small holes, very like the pin-holes in the Sea-Urchin's shell, and then it seems to us not at all impossible that these two animals, the Sea-Urchin and the Star-fish, may be pretty much of the same nature.

Again, we catch a Butterfly and a Beetle. We have been accustomed all our lives to call both of them

Insects, and therefore we are prepared to think that they must have a good deal in common with one another, though their appearance is really very different, and, as we are watching them under a tumbler, they behave in a very different manner. Looking closely at them we find that each is made up of three parts or segments which seem as though they might be hinged together, and to the middle part or segment of each creature are attached three pairs of legs. The Butterfly is distinguished at first sight by having besides two pairs of wings, with which we know he can



BUTTERFLY.

BEETLE.

fly, and they are closed together over his back like the leaves of a book when it is shut; but he does not offer to run about. On the contrary, we see no wings on the Beetle, who is only inclined to use his legs. But while we are watching him, his back suddenly seems to open and displays a pair of fine transparent wings that have hitherto been folded up and hidden from our view beneath a horny sheath on each side. The horny sheaths also are brought forward, and the creature is clearly making itself ready to fly. There is now a much greater likeness between the Butterfly and the Beetle than at first appeared. Though we were before

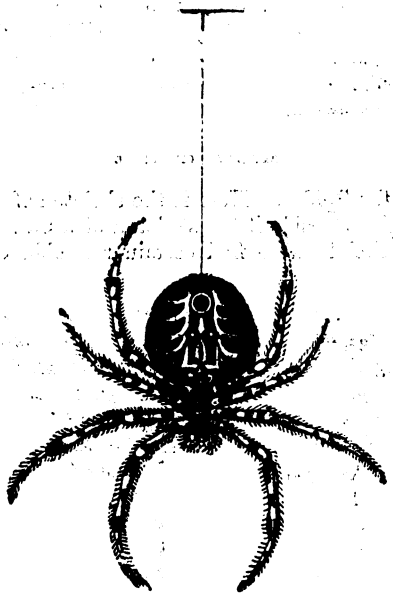
prepared to accept them both as Insects and therefore in some degree related, we now see that the relationship is much closer than we had thought. Here, in each case, we have a creature made up of three different parts or segments, and to whose middle segment are not only attached three pairs of legs but also two pairs of wings—for we can hardly help feeling sure that the hard horny sheaths which cover the filmy wings of the Beetle stand in place of the beautiful fore-wings of the Butterfly.

While we are thinking this over a Bluebottle-fly happens to alight on the table. He combines the activity of both Beetle and Butterfly, flying as strongly as the one and running as quickly as the other. We catch him, but it is no easy job to do so (there is no need to hurt him, though, poor fellow, he must be much frightened) and examine him. We find again the three segments of the body, the three pairs of legs growing from the middle segment, but—only one pair of wings! This seems a curious fact and worth studying. We accordingly look closer, or take a magnifying glass if our eyes be not good enough without that help. We then see that in position the Bluebottle's wings correspond to the fore-wings of the Butterfly, or the wing-sheaths of the Beetle, and in place of the hind-wings we find a pair of little, button-like knobs. Can these be the rudiments or the representatives of the hind-wings? We will not stay to consider this point, but we will be content with having observed that there is much likeness and yet some unlikeness between these three Insects.

BLUEBOTTLE-FLY.

Now in a corner a Spider's web catches our eye. While we are about it let us see how far the Spider agrees with the others. So, letting our Butterfly,

Beetle and Bluebottle go free, we go softly up to the Spider. She happens to be of a fearless sort, and we can look at her as she sits in the middle of her web and view her almost as well as if we had her in our hand. She has got eight legs, not six like the others. Again, she is not composed of three segments, but

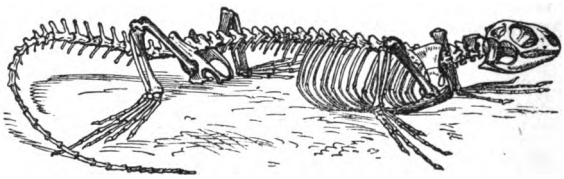


GARDEN-SPIDER.

is divided into two; and, as we knew before, she has no wings. It is pretty plain from this that, though we may go on calling a Spider an Insect, a Spider differs far more from such Insects as the Beetle, the Butterfly and the Bluebottle, than they differ among themselves.

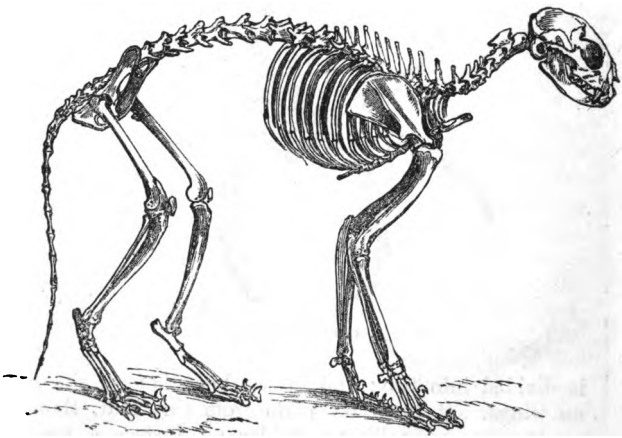
Now let us make a great jump and pass to a set of

creatures that have bones like ourselves, for bones there are none in the Star-fish and the Sea-Urchin, any more than in the Bluebottle, the Beetle, the But-



SKELETON OF LIZARD.

terfly or the Spider. Here is the skeleton of a Lizard, and we place beside it the skeleton of a Cat. In both of these skeletons we find certain resemblances—each



SKELETON OF CAT.

has a row of bones running along its back from the head to the end of the tail—*vertebræ* they are called. The head of each skeleton has a bony skull in which we

find that the chief organs of the senses are placed, and notably the eyes and ears. The skull, too, in each not only forms a case for the brain, but it is prolonged forwards so as to form jaws, and these jaws are beset with teeth. More of the teeth hereafter. The lower jaw both in the Lizard and in the Cat is hinged on to the upper jaw—not exactly in the same way, but that will

SKULL OF LIZARD.

do for the present. If we remove the skull from the end of the row of vertebræ, we find a difference in the mode in which it is set on. The Lizard's skull has at its back, below the large hole which we see in the skull of both animals, a half moon-shaped knob fitting into a corresponding hollow in front of the first separate vertebra; and the second separate vertebra on

SKULL OF CAT.

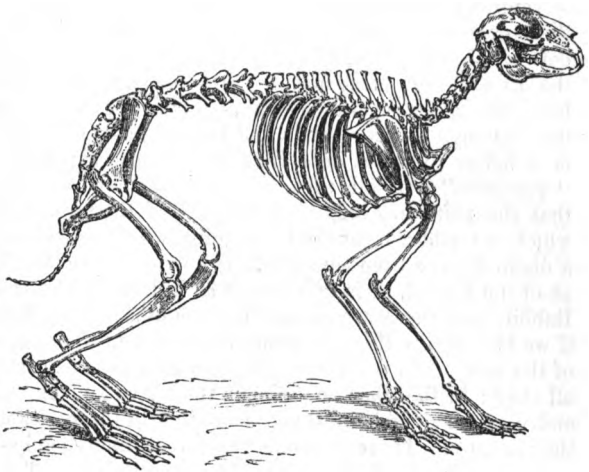
the whole resembles the first. Now the Cat's skull has two such knobs, not placed below the large hole, but one on either side of it, and these two knobs fit into, or (to use the scientific word) articulate with, two corresponding cup-like hollows in the front of the first separate vertebra of the creature's neck, which is in shape very unlike the second, being a

kind of wide, flattened ring of bone with a broad projection on each side, while the second is narrower and longer with no projection at the sides, but having a sort of prominent crest above, and in front a little spike-like projection which passes from behind through the hole in the middle of the first vertebra. Here then there is a good deal of difference. It is plain that when the Cat moves its head from one side to the other, the first vertebra being fitted to its two knobs must move with it, and thus the skull and first vertebra will turn upon the spike of the second vertebra as upon a pivot. On the contrary, when the Lizard moves its head from side to side, it will turn upon its own single knob, and the first vertebra will hardly move with it. These knobs are called "condyles."

Proceeding backwards along the row of vertebræ which forms the back-bone of each skeleton, we see first that just in front of the ribs the fore-limbs are attached by the shoulder-blades, and then beyond the ribs come the hind-limbs—for in each skeleton there are four legs. Now each of these limbs is made up of three similar portions. First there is the bone which in the fore-limb is nearest the shoulder-blade and corresponds with the upper part of our arm between the shoulder and the elbow. This is called the *humerus*. While in the hind-limb the bone which is nearest the trunk agrees with our thigh and is called the *femur*. Then we see that in the skeleton of both animals each of these bones is followed by two others, lying side by side and forming the second portion of the limb. These two bones respectively fill the place of our fore-arm or arm below the elbow, and of our shin or leg below the knee. In the fore-limb the *larger* of these two bones is called the *ulna* and the *smaller* the *radius*, and in the hind-limb the larger is the *tibia* and the smaller the *fibula*. After these in each limb comes the third portion, consisting of a number of small bones; but it is plain that they agree on the whole—the nearest set of them with our wrist and ancle, according as they belong to the fore

or hind limb, and the more distant set with our hand and foot. There is, therefore, not only a considerable resemblance between these two skeletons, but we can refer their principal parts to similar parts of our own body.

Now by the side of the Cat's skeleton there stands that of a Rabbit. If we compare these two we shall find that they agree in more points than the skeleton of the Cat does with that of the Lizard. At first sight we may see that the legs of the Lizard are turned out-



SKELETON OF RABBIT.

wards in a way that we do not find to be the case with that of the Cat or of the Rabbit. In the Lizard the four limbs stand out away from the trunk in a kind of sprawling attitude, so that the body is, as it were, hung between the four limbs, while in the other two animals the trunk more or less rests upon them. The way in which the Rabbit's skull is set on to the bones of the neck, namely, by the double knobs, resembles the way in which the Cat's skull is set on, and is quite unlike

the articulation of the Lizard's head with the neck-bones. Again, if we look closer we shall find that the lower jaw of the Lizard is composed of two pieces on each side, one pair of such pieces, that nearest the hinge-joint, articulates with a somewhat twisted, four-cornered bone, which intervenes between the two jaws, while in both the Rabbit and the Cat the lower jaw is composed of a single piece on each side and meets the upper jaw upon which it hinges directly without the intervention of any other bone. It is plain, judging from these evident facts alone, that there is a greater likeness between the Cat and the Rabbit than between the Cat and the Lizard—the existence in the Lizard's head of the four-cornered bone, which connects the two jaws, is of itself enough to prove that, and to save further trouble it is better to say at once that this bone is called the "quadrate." In all these animals we may also see that the teeth are lodged in the part of the lower jaw which is furthest from the hinge-joint, whether it forms a distinct piece from that which is nearest to the trunk as in the Lizard, or is united to it as in the Cat and the Rabbit, and there are no teeth at the other end. But if we look again there is much difference in the shape of the teeth. In the Lizard they are simple and nearly all alike; in the other two animals they have long fangs, and vary very much in shape according to the position they occupy. There is also a very great difference between the teeth of the Cat and of the Rabbit. The Rabbit has four large teeth immediately in front of its jaw, two in the upper jaw and two in the lower—these are called "incisors." Then comes a space without any teeth, until we arrive at the grinding teeth or "molars," which are set in the back of the mouth. But in the Cat the line of teeth, though there is a break in it, is almost without interruption. First, we have twelve small front teeth or incisors, six in each jaw, and then come two pairs of sharp-pointed, longer teeth —so much longer that they do not meet, but pass each other, those in the lower jaw, when the mouth is shut,

reaching to the root of the teeth in the upper jaw, and those in the upper jaw passing behind and reaching to the root of the teeth in the lower jaw. These teeth are the "canines," so called because they are especially remarkable for their size in the Dog and other animals of the doggish or canine family. The teeth that follow next in the Cat's jaws we find to work like the blades of a pair of scissors—one against the other, and their crowns


SKELETON OF SQUIRREL.

are beset with projections, called "cusps." In the Cat they are obviously not very fit tools for grinding grain or chewing grass, but they are admirable instruments for slicing flesh or other meat and tearing it into shreds. But in the Rabbit's jaws the back teeth, which agree with these in position, are quite flat at the top and form, the one against the other, excellent grindstones, and hence it is that the teeth placed in the hind part of the jaw are called "grinders" or "molars."

Again, we take the skeleton of a Squirrel and put it

by the Rabbit's. The general form of each is unmistakably alike, and at first sight, except that one is much smaller than the other, and has a much longer tail, no very great differences present themselves. But looking more closely we shall find it otherwise, and two clear distinctions appear. First, though the arrangement of the teeth is generally alike in both, in the

SKULL OF RABBIT AND SQUIRREL.

Rabbit we shall find two small teeth growing immediately behind the two large front ones ("incisors") in the upper jaw, while in the Squirrel such small teeth are absent. Secondly, in the Squirrel we may see two bones (*cl*) on each side of the body in front, running from the upper end of the breast-bone to each of the shoulders —and corresponding to our collar-bones or "clavicles" if we do but feel for them. Thus, if we were to put down some of the points in which we have found these four skeletons agree with and differ from one another, we might have something like this:—

| | Lizard. | Cat. | Rabbit. | Squirrel. |
|---|---|---|---|---|
| Four limbs, each composed of three parts? | Yes | Yes | Yes | Yes |
| Skull followed by row of *vertebræ*? | Yes | Yes | Yes | Yes |
| Body hung low between limbs? | Yes | No | No | No |
| Skull articulated by one condyle? | Yes | No | No | No |
| Teeth alike? | Yes | No | No | No |

Or, again, following the formation of the teeth in the last three still further:—

| | Cat. | Rabbit. | Squirrel. |
|---|---|---|---|
| Line of teeth nearly unbroken? | Yes | No | No |
| Canine teeth present? | Yes | No | No |

In like manner we get the differences between the last two :—

| | Rabbit. | Squirrel. |
|---|---|---|
| Additional incisor teeth in upper jaw ? | Yes | No |
| Clavicles present ? | No | Yes |

All things then considered, it is plain that the skeleton of the Squirrel and the Rabbit agree with one another in more points than either does with that of the Cat, and it is equally plain that Cat, Squirrel and Rabbit have more characters in common than the Lizard has with any one of them—while all four, Rabbit, Squirrel, Cat and Lizard, to a great degree resemble one another, and this so that not any of the four Insects we before examined, nor either the Star-fish or the Sea-Urchin, come near them. If, instead of taking skeletons or other hard parts only, we examined the whole body of each animal, such differences and resemblances would still be borne out; but what has been described is enough for the present purpose.

Now the examination we have been making is strictly on the same principle as the examination of the coins in our supposed bag of money, and the grouping of the several animals, as the grouping of the several coins, is entirely founded on a consideration of their mutual likenesses and unlikenesses. There might seem to be no need to carry the parallelism further. The Sea-Urchin and Star-fish may stand for the coppers, the Insects for the silver, and the animals with bony skeletons for the gold coins. This, however, is far from exhausting the subject. In other countries and at other times other metals than copper, silver and gold have been or are used for striking coin. We have never supposed our bag of money to contain examples of all the coins used in this kingdom, much less in the world at large; but it did hold enough for us to form thence some general ideas as to what coins were and what relation they bore to one another.

So is it with animals. They are not all to be referred to the groups from which we have here chosen

examples. We are daily in the use for some purpose or other of some kind of Sponge, and the animal of which Sponge is the product is very different from any of those we have considered here. We may find in almost any stagnant ditch or pond creatures, of which the best known is one called a *Hydra*—English name it has none, common though it be. These creatures are quite unlike any of the former.* So also are Snails, Oysters, Periwinkles and so forth, with all of which we are more or less familiar, as are Lobsters, Crabs and Shrimps—or even Bernacles, which we may have seen at the sea-side or read of in books—to say nothing of countless other animals which need not here be mentioned. It is enough for us to recognize the fact that these animals differ from one another in very varied degrees, and according as we can group those together which differ least, and consequently resemble each other most, the better the classification we shall have and the more clear will be our ideas of the relations they bear to one another.

Whether this classification will ever lead us to an end so high as we first of all suggested, we need not now stop to discuss. We may take a humbler view. It is sufficient that a classification is wanted in order that we may have distinct notions of the animal creation, and some way of arranging the facts relating to it that we may collect. The mode of setting about such an arrangement and of arriving at such a classification has just been pointed out.

Yet before leaving this part of the subject we may further consider differences and likenesses. Now it is plain on reflection that the likenesses are of two very distinct kinds. We have a likeness wherein one thing is like another because it serves the same purpose or "function"—a functional likeness, as it is called, though it may be very differently constructed. We have a second sort of likeness, wherein one thing is like another because it is of essentially the same struc-

* See figure at page 62.

ture, though its function or the office that it performs may be quite different. Thus the wing of a Bird and the wing of a Butterfly furnishes either animal with the means of flight, but each wing is formed on an entirely different plan, as the most hasty inspection will show. So also the clasping suckers of a Cuttle-fish have the same function as the grasping power of our fingers; but there the likeness ends, for it needs no great knowledge of Zoology to see that the action of each is quite different. This kind of likeness is called ANALOGY. On the other hand the wing of a Bird, when stripped of its feathers, is found to be formed almost exactly on the same plan as the fore-limb of the Squirrel we have already seen. It is true that the Bird's wing discharges entirely different duties from those which the Squirrel's fore-limb does. The two are functionally unlike. One generally sustains its owner through the air in rapid flight: the other enables its possessor to climb trees and gather food; but each corresponds with each in all its important parts. Again, our own wrist corresponds essentially with that part of a Horse's fore-leg which is commonly known as the "knee," and, notwithstanding the difference of function to which the two are applied, the likeness between them is manifest. This kind of likeness then is called HOMOLOGY.

There is no means of avoiding the use of these technical words, HOMOLOGY and ANALOGY, and the sooner the learner becomes accustomed to them the better, for it is of the greatest consequence to any one beginning the study of Zoology that he should see the entirely different idea which each of them conveys:—

First, because hardly any dictionary will give an accurate and adequate explanation of them, and

Secondly, because it is *to* HOMOLOGY *and not to* ANALOGY *that we must look in attempting anything like a reasonable classification of animals.*

If we were to trust only to Analogy, we might be led to group Butterflies, Birds and Bats together—since they all have organs of flight which we call "wings,"

and we should certainly never be induced to place in one class creatures outwardly so unlike as a Rabbit and a Whale. In fact many of the older naturalists, not seeing this distinction, made these very mistakes, and placed Bats among Birds and Whales among Fishes—though the earliest naturalist of all, the great Greek philosopher, Aristotle, was quite alive to the distinction. Homology therefore, and *not* Analogy, must be our guide in classification.

Accordingly it will be well to take in from the first the difference between these two kinds of likenesses and to familiarize ourselves therewith :—

(1) HOMOLOGY means the likeness between the parts of an animal which are constructed upon the same plan, however different may be their function.

(2) ANALOGY means the likeness between the parts of an animal which have a similar function, however different may be the plan upon which they are constructed.

Though, as has just been said, Homology must be our guide in classification, this is not all. That department of Zoology which is known by the name of Comparative Anatomy consists almost entirely of the discovery of Homologies. But the detection and recognition of Homologies is one of the hardest tasks which lie in the path of the zoologist. The difficulties arise from the astonishing modifications which are undergone by what seems to have been originally the same organ or structure. Taking one group of animals only—that which is known as the *Crustacea*, and includes all the Crabs, Lobsters, Shrimps, Woodlice and many others, we find their bodies distinguishable into a variable number of parts or segments, called " somites," each of which may be, and some of them always are, furnished with a single pair of jointed appendages. Now in all these animals at least one pair of these appendages is so formed as to serve as jaws for dividing or chewing the food. Often several pairs are so formed; but others of these appendages are used as powerful pincers for gathering food or repelling the attack of an enemy,

as legs for running on the ground, or as oars for rowing the animal through the water, while, still further, some may be so adapted as to assist, if not even form part of, the mechanism by which it breathes, or may be so modified as to become suckers by means of which it adheres tightly to the place where it lives, or again they may be merely pouches for holding its eggs. While still further to complicate the matter, we may find from half-a-dozen to a dozen or more of the "somites" consolidated into one mass, the different portions of which are only to be recognised by their individual pair of appendages. Yet, however diverse may be the function or office discharged by the appendages, their homologies cannot be questioned any more than can the little knobs we saw on the Bluebottle-fly and then suspected that the knobs might be the representative of the hind-wings of the Beetle or Butterfly.

Now having seen something of what is meant by classification and of the means by which it is accomplished, let us go back again to our opening paragraph. In whatever kind of classification we adopt, and also in writing or speaking of animals, we must know by what names they are to be called in order that confusion may not arise through our being misunderstood. This question of the naming of animals is by no means so simple as it at first looks; and, though nearly all zoologists would fain be rid of what in nine cases out of ten is an actual encumbrance, taking them off the work they would willingly pursue and setting them to follow up some petty quibble which ends in giving them no new knowledge worth the trouble, yet the difficulties, which the art of applying names—Nomenclature, as it is termed—presents, must be faced sooner or later by every zoologist. Through ignorance of or inattention to it the most grotesque blunders have been made. Every one laments the time he has to give to nomenclature. Yet those who would profess to carry on zoological investigations without mastering its rudiments are like those who would run before they

could walk, or those who would speak a foreign language without knowing its grammar. The sooner a learner does become acquainted with its first principles the better. Its great aim is the employment of precise and unmistakable terms. Some of the animals mentioned not many lines back—Bernacles, Crabs, Lobsters, Periwinkles, Oysters and even Sea-Urchins—are in a general way talked of as "Shell-fish," and in common speech custom justifies us in so calling them. But not one of them is what a Naturalist means when he speaks of a "Fish": with him the word Fish is used in a particular and more limited sense for an animal of very different and more complicated structure—we may take an Eel, a Herring or a Minnow as examples, and therefore one far higher in the scale.

Thus it is at once evident that the Naturalist's language differs somewhat from that usually spoken, and it differs in being more precise. But the naturalist of one country has need to understand and be understood by naturalists of other countries. Hence some attempt at a universal language has been made, and the language admitted by common consent is the Latin, or words from other tongues put in a Latinized form. To such an extent has this practice been carried out that it is not easy, even in a book like this (as will have been already apparent) to get on without the use of some Latin words, not only as the names of animals themselves, but also of the parts of animals, since in English we have in many cases nothing by which to call them.

But this is not the only difficulty. Different writers at different times or in different places have applied different names to the same object—whether that object be an animal or the part of an animal. Such different names for the same thing are called "Synonyms,"—and, to make the matter worse, sometimes different things have had given to them the same name, which is then called a "Homonym." It has been repeatedly urged as a reproach that Zoology and Botany are but

sciences of names. In the case of some students of these sciences there is a certain amount of reason in the objection, but assuredly it does not hold true with regard to all or even to the majority. The names are but the means to an end, and as such they cannot be neglected without confusion ensuing. Here is an instance.

Not long since a most distinguished French naturalist brought before the Academy of Sciences at Paris what at first, coming from such an authority, seemed to be a most remarkable and important fact. He declared that the Swallows which inhabited the old part of the city of Rouen built their nests in a certain fashion necessitating the use of a very large quantity of the mud with which Swallows are wont to build their nests, but that in the newer parts of the city the Swallows had adapted themselves to the more modern style of architecture, and had found that a far smaller quantity of mud was sufficient for their purpose. Upon these grounds, the result, it would seem, of his own observation, he not unnaturally argued that Swallows—and perhaps other animals—were not only competent to avail themselves of the improvements introduced by civilization, but that their intellectual faculties were greater than they had been credited with, since their instinct was not so blindly followed as had been supposed. This asserted fact and its presumed consequences of course excited no little attention, and another naturalist was thereby induced to investigate the matter for himself. He found one fact to be as had been stated: the Swallows of the old town built a certain kind of nest, and those of the new town another kind, but there was just one point which had been overlooked by the former observer—the Swallows of the old town were of one sort, and those of the new town were of another sort, but each of these sorts built at Rouen exactly the same kind of nests that they were accustomed to build elsewhere.* The distinguished naturalist, ne-

* 'Comptes Rendus de l'Academie des Sciences,' 1870, i. p. 492, ii. p. 77.

glecting the niceties of nomenclature, had called both sorts of birds by the same name, had indeed been misled by a Homonym, and hence the mistake into which he fell—a mistake of which almost any observant country-boy would have kept clear, though in France these two birds have not distinct common names as they have in England, where one is called the Swallow and the other the Martin.

Again, another source of trouble is that people do not see the difference between names and definitions, and think that names ought to be definitive if not descriptive. Hence when a name is not strictly applicable to a creature, or ascribes to it qualities which it does not actually possess, they seek to change it for a name that they imagine to be so, often finding in the sequel that some later discovery proves the new name to convey an idea as equally imperfect or erroneous as the old one did. The commonest reflection ought to show such people that they are mistaken in this notion. With us the name of Smith is borne by thousands of men, women and children who never in their life wielded a hammer or worked at an anvil. Yet there is no need to change it on that account. Mr. Black is not necessarily a negro to deserve the name which was borne by his father before him. Mr. Whitehead may have hair of any colour, and Mr. Armstrong may be as weak as a baby. Among ourselves we do not associate qualities with names; we leave that to be done in some cases it is true by nicknames, and such nicknames are usually bestowed only in jest. Why should we wish to act otherwise when we have to do with other creatures. Names are only names, given most of them, no doubt, for some good reason originally, but not to be taken as definitions, or still less as descriptions, and not to be changed because they happen to be unsuitable to the subjects to which they are applied.

Thus there is no need to call the little quadruped commonly known as a Hedgehog by any other English name, though it is undeniable that it has no near

affinity to a Pig; nor ought we to object to call a certain bird a Goatsucker because there is no probability of it ever sucking Goats. It is sufficient for us to account for the origin of the name by finding that this bird was once supposed, by people who knew no better, to have such a habit.

The right principle on which we should act is to find the name by which any animal or part of an animal was first called and keep to that name if possible. There are some cases in which custom, more or less universal, hinders us from doing this, but they will be found in practice to be comparatively few. No other principle than this—the principle of Priority it is called—can be discovered which can be thoroughly trusted for guiding us through the perplexing maze of Nomenclature. Still the principle, it must be acknowledged, is not always easy of application, and, owing to the vague descriptions given by older writers, which in very many cases renders the identification of the animals they meant very uncertain, it has been found expedient in practice to limit the application of the rule which is to guide us to the time when the mode of Nomenclature now in use was perfected by the great Swedish Naturalist Linnæus, somewhat more than one hundred years ago—namely, in 1766 and 1767.*

This Linnæus was the first man who propounded a definite scheme of nomenclature in Natural History, and his scheme, though opposed by some of the writers who were his contemporaries, has since his time, from its simplicity and convenience, been almost universally followed in theory. Prior to his time naturalists had been in the habit of making mention of the creatures they described—whether plants or animals—not by mere names but by definitions. Thus about two hundred or a hundred and fifty years ago we had the great

* Some naturalists prefer carrying back the limit to the year 1758, when this mode was first introduced by Linnæus into his works, while others accept names given by any prior writer if they chance to consist of two terms only.

English Naturalist John Ray writing (in Latin, as was the custom then for naturalists to write) of "*Sedum acre flore luteo*" * and "*Rhombus maximus asper non squamosus*" †—the first being the plant commonly known as the Stonecrop, and named by Linnæus simply *Sedum acre*, and the second the fish called the Turbot and by him named *Pleuronectes maximus*. The method of Linnæus was to give each creature an appellation composed of two words. Just as each one of us has a name by which we are known from other members of our own family, and a surname by which we are known to the world at large as belonging to that family, so he gave a family or (to use the scientific term) a *generic*, and a particular or a *specific*, name to each. This is what is called the "Binomial" method of Nomenclature. In the cases quoted *Sedum* and *Pleuronectes* are the family or *generic* names, and *acre* and *maximus* the particular or *specific* names; but in either case, by the use of these words in combination, we are at once referred not only to the group or *genus* of creatures but to the precise sort or *species* of creature belonging to that group. There may be dozens or scores of *species* belonging to either *genus*, but by this means the sort we want to speak of or write about is thus especially shown and distinguished from all the rest. It may be said that this end might equally be reached by giving to each species a name consisting of a single word, but when we think of the countless species which exist that becomes a manifest impossibility. Of flowering plants there may be, at least, 120,000 species known; among animals considerably over 100,000 species of Beetles alone are believed to exist in collections. How then would it be possible to find so many single words as would enable us to distinguish them? By using a combination of two words much of the difficulty is removed, but even now it is not easy for naturalists to use names which have not been applied to some other creature;

* "The pungent *Sedum* with a yellow flower."
† "The largest *Rhombus*, rough but not scaly."

and, indeed, botanists and zoologists have been obliged almost to give up the hope of not interfering with one another in this respect.

Enough has now been said on this subject, for though its troubles often affect the beginner, it is not until he is well advanced in his studies that they become intolerable. It must never be forgotten that Nomenclature is only the means to an end. Classification, though a very important part of Zoology, is not the whole of it, much less then is Nomenclature. It enables us to show clearly what animals we mean, but it goes no further.

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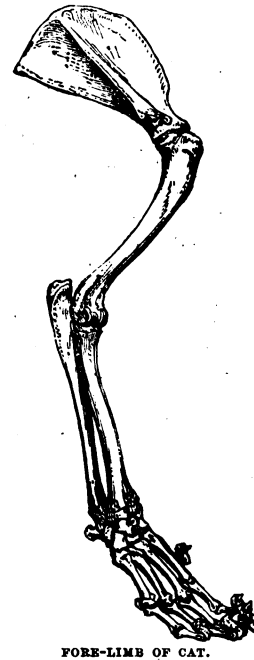
## CHAPTER II.

It is known to almost every one that there was a time when this globe which we inhabit was not tenanted by animals such as are now found upon it, any more than the Roman coin which we supposed to be in our bag of money is now in circulation. The evidence of this is irresistibly strong, and cannot be doubted by any unprejudiced mind, so that it would be lost time to argue the question. We find shells more or less like that Sea-Urchin's, of which we before spoke, wings more or less like those of the Beetle or the Butterfly, or bones more or less like those of the Lizard and the other animals with which we compared it—all of them turned into solid stone, but presenting outwardly many of the essential features that mark similar parts of animals of our own day. Especially do we find shells of creatures more or less resembling those of our Snails, Periwinkles, Mussels or Oysters. It is, of course, within the zoologist's duty to make himself acquainted with the remains thus found—the "fossils" we have before mentioned; and this particular branch of Zoology is commonly known as "Palæontology," that is properly the study of ancient beings, and therefore including equally the study of ancient plants with that

of ancient animals. In practice its use is commonly limited to this last.

Now the way these ancient animals are to be studied is precisely the same as that already described as the mode of studying modern animals, and lies in the comparison of their several resemblances and differences. But generally it is a more difficult task. In the case of an animal of our own time, we can most commonly examine minutely every portion of its structure. In the case of these ancient animals, we frequently have only a fragment left to us; and if we wish to form an idea of what they were like we must depend upon our observing what peculiarities are in living animals associated together, for by seeking we shall find that such associated peculiarities are innumerable. Whatever good work in this direction others may have done before him, it was the great French Zoologist, Cuvier, who first brought to perfection this subsidiary science of "Comparative Anatomy." Now, Cuvier proceeded in this wise. To take the case of a few quadrupeds only: by observation of the skeletons of animals such as now live—Cats, Tigers or Lions, Deer, Antelopes or Oxen —he found that certain peculiarities in the arrangement or number of the teeth—the "dentition," as it is called—coupled with a certain structure of the lower jaw and of other bones of the head, were always accompanied by certain peculiarities in the structure of the limbs. We have already had before us the skeleton of a Cat, and noticed some of its features. Now, it is undeniable that in all the animals of the Cat kind there are the large pointed "canine" teeth to pierce and arrest the prey; behind these are other teeth, adapted for cutting and shutting against each other, as was before said, like the blades of a pair of scissors, to sever the food; and the reason why they shut against each other is plain directly we examine the hinge by means of which the lower jaw is articulated with the upper jaw. We find that the lower jaw is almost incapable of any other than a straight, up-and-down

motion. The hinge, or, to use the scientific word, the "condyle" of the lower jaw is received into a corresponding groove-like socket, and is so closely fitted that there is not room for any swaying or side-motion. Then again the projecting plate of bone at the upper side of the hinder end of the lower jaw, to which is affixed one end of the chief biting-muscle (the other end being attached to the beast's temple), is broad and high, and above the temples the bones of the skull rise in a ridge or crest, showing that this muscle has strong attachments, and therefore possesses correspondingly great power. Looking at the fore-limb of a Cat or any of the Cat-kind we find that the paw has five fingers, the inmost and shortest of which answers to our thumb and has *two* joints, or "phalanges," while the rest have *three* phalanges, all possessing much freedom of motion, but their chief characteristic is to be observed in the *third* phalanx, which is capable of being drawn upwards and backwards, and from its base grows a broad and thin plate of bone, encompassing like a sheath the bony core of the sharp horny claw in which the finger terminates—this claw being thus brought into use or not at will. Every one who knows anything of Cats' habits, and has ever examined a Cat's foot, is aware that the animal, when at rest and unexcited, withdraws, or



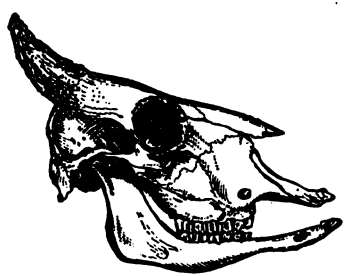
FORE-LIMB OF CAT.

rather lifts up its claws, and that it is only when roused by resentment or the expectation of prey that it desires to avail itself of these weapons, and then, pressing them downwards, it inflicts the wounds which they are capable of causing. No Dog or animal of the Dog-kind has such claws — "retractile," as they are called. But further, these five fingers are the continuation of as many sets of bones, called "carpals," forming the wrist, and lying between the fingers and the two bones (the *ulna* and *radius* before mentioned) of the second portion of the limb, which two bones correspond with those we can feel in our own fore-arms, and they are articulated to the bone of the upper arm (*humerus*) by a joint which permits great play and freedom of motion, so that the animal's paw is capable of being rotated or turned round inward—not, indeed, to the same extent that our hand is, but still sufficiently to allow of its being a useful instrument in the capture of prey. Many other peculiarities may also be observed which constantly attend the structure we have described of the teeth, lower jaw, skull and fore-limb, but enough has been mentioned for our present purpose.

Now, taking an animal like the Ox, we find that such "canine" teeth as we have seen in the Cat are absent.* The back teeth ("molars") instead of being many-pointed (or "cusped"), and shutting against each other in the scissors-like way we have in the Cat, have broad, flat crowns, roughened with hard ridges, and meeting each other when the jaw is closed. The lower jaw in the Ox, too, is not received into a deep groove as it is in the Cat, but hinges on to the skull by means of a flat condyle, permitting a freer motion side-ways, and, to a less extent, backwards and forwards, so that any food taken between these molars is ground between the ridged crowns of the teeth in a way

* This statement refers to the Ox when fully grown. In the very young state the "canines" have been detected; and what appear to be the outer "incisors" of the lower jaw are by some authorities believed to be modified "canines."

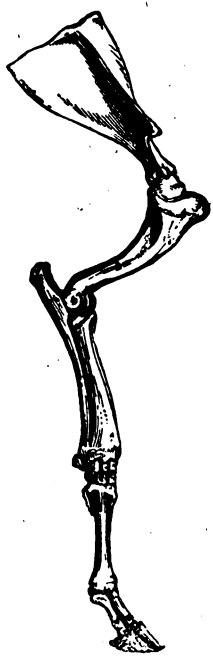
that is impossible in the Cat. The projecting plate of bone at the upper side of the lower jaw behind is very slender, and we see no such marks of powerful biting muscles as we have in the Cat; so that, altogether, in place of the formidable apparatus for tearing the flesh of other animals, we have a harmless piece of machinery adapted to the mode of life of the "calf that eateth hay." Turning then to the fore-limb of the Ox, how strangely it differs from that of the Cat. Instead of the five toes, each ready to aid the predatory attacks of the flesh-eating beast, we have but two on which the animal rests its weight; and these are destitute of those sharp and relentless claws, but are shod in horny hoofs, while behind them, and of no use that we can see, since they do not touch the ground, hang two smaller hoofs similarly shod. But stranger even than this, the five bones of the wrist, to which the toes of the Cat are attached, give place in the Ox to one single bone—the "cannon-bone," as it is called; and the joint by which this single bone is articulated to the *ulna* and *radius* is so formed as hardly to admit of anything but a simple movement forwards and backwards in the direction of the axis of the animal's body, so that there is little of that side-motion of the extremity of the fore-limb which we observed in the Cat.



SKULL OF OX.

Now if we examine all the different animals of the Cat-kind, and all those that are allied to the Ox, we find that these kinds of structure invariably go together. No animal having such teeth or jaws as the Ox ever has a fore-limb ending in toes armed with cruel claws;

and no animal having such teeth or jaws as the Cat ever has a fore-limb ending in toes shod with hoofs.



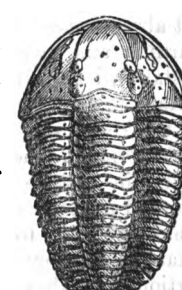
FORE-LIMB OF OX.

The least reflection will show us that a carnivorous or flesh-eating animal would be at a disadvantage with the extremities of its limbs encased as are those of the Ox, and that to a herbivorous or grass-eating animal the formidable talons of a Cat would be perfectly useless. The association, therefore, of rotatory fore-limbs and sharpened claws with the peculiar dentition of the Cat, and of non-rotatory fore-limbs and hoofed toes with the peculiar dentition of the Ox, may be taken for granted. So that if we find a fossil tooth which corresponds in form with that of a Cat we may feel assured that the animal to which it once belonged had similar claws, while again the fossil which corresponds with the hoof-bone of the Ox indicates that its former possessor not only had a "cannon-bone," but teeth also to match.

But this is not all. The association of characters is by no means confined even to such parts of the skeleton as have been named. It is found by experience that all living animals having the same dentition as the Ox have the habit of "chewing the cud," or that each mouthful of food, having been crushed between the teeth and slavered over by the animal's spittle, is hastily swallowed, to be succeeded by other mouthfuls so long as the creature goes on eating. Then it stands

still or lies down to rest, and, forcing back into its mouth the mass of lately-swallowed food, forthwith begins to chew it afresh, until the whole is reduced to pulp, when it is finally and absolutely swallowed, and then the animal begins grazing again. But an operation like this necessarily requires a special structure of the gullet and stomach, which there is no need here to describe—the stomach, indeed, being very complicated. It is sufficient to say that all this, and perhaps much more, can be safely inferred from the examination of a fossil hoof-bone or cannon-bone.

Now the association observed between such peculiarities as these—whether they belong to the bones or the bowels of an animal—forms what is called the "Correlation of Structure," and it is this upon which we must almost entirely rely when we are trying to discover what kind of animal it was that once owned any particular part which we find fossilized. The cases we have cited are from the higher groups of animals, but the principle of application holds equally good with the lower ones. We may have one of those pretty little fossils called "St. Cuthbert's beads": by comparison we know it to have been once portion of an animal like that which naturalists call a *Pentacrinus*—there is no English name for it—and applying the principle of "Correlation of Structure," we may proceed to draw an outline of the entire animal, of which it was only perhaps the five-hundredth portion, finding possibly, to our great satisfaction, that a lucky discovery in some quarry will show that our outline has not been so far from the mark. Again, we may have in a slab of rock the remains of a very queer-looking creature, such as naturalists have named a *Trilobites*. At first sight it seems impossible to say what it is. Applying the prin-



TRILOBITE.

ciple of "Correlation of Structure," we find that one of its nearest existing kin is what is called a King-Crab (*Limulus*), and, though in the fossil there is not a vestige of a limb, we may not unreasonably infer that the Trilobite, when living, possessed some such appendages, and, as has actually happened years after, the discovery of a more complete specimen has proved that the rule here held good.

This practice, first brought to perfection (as has been said) by Cuvier, of working out the forms of the unknown by the known, seems to the popular mind nothing short of miraculous. The ignorant cannot understand how, when a fossil tooth is put into the hand of a competent Comparative Anatomist—a tooth, be it supposed, of a kind which he has never seen before, water-worn even and defaced, that Comparative Anatomist will proceed to say what the animal to which it belonged was like, and, if he knows his business, will do so without any great error, as a future discovery of further remains may probably show. The process is not always easy—far from it, and men of the greatest learning and experience sometimes make pardonable mistakes, but in the end the process is almost always certain.* Occasionally, however, it is obvious, startling as the result may be. When from New Zealand were first brought the bones of unknown and gigantic birds, in stature taller than men, the friends of the eminent anatomist whose good fortune it was to describe them, are said to have besought him not to risk his established reputation by pledging himself to the assertion that they were birds' bones. As well might they have asked him to distrust his own identity. It was not a matter of belief; it was a matter of know-

* A notable exception, however, is that of the large extinct animal named *Toxodon*, whose remains have been discovered in South America. Though its skull, teeth and most important limb-bones are known, no one has ventured to predict the character of its feet, and still less to say anything of its internal organization. Even its place in any arrangement of the *Mammalia* is very doubtful.

ledge. The principle of Correlation of Structure, which is the leading principle of Comparative Anatomy, here had perhaps its greatest but its easiest victory.

Now the single defaced tooth which we have just imagined to be put in the hand of a Comparative Anatomist may also be likened to the worn coin of our first illustration. There is so little to tell us what it really is that we can only come to any determination after the closest examination and comparison. In the worn coin perhaps a single letter or numeral is visible, but yet we can by its means unfailingly tell when, where and by whom it was struck, though all else of the image and superscription it bore be obliterated. We find many fossils in a condition exactly similar, and it is only extensive practice that will enable us to decide that this was once the bone of an animal more or less like an Ox, and this other the tooth of an animal allied to the Cat. Some fossils have been so much worn down that their determination is a matter of the greatest difficulty; but whenever characteristic features are preserved we may be perfectly sure that a good Comparative Anatomist can scarcely be mistaken in referring them to their allies.

Yet there is a further difficulty in such work as this. As a general rule, but one by no means without exceptions, we find that the older the geological formation from which a fossil comes the more it differs from anything we have alive upon the earth at present. And it differs in this way, that we can see in it indications of its relationship to more than one of existing animals. It is not necessarily just midway in the gap between any two such existing animals, but it presents a combination of certain features which it has in common with each of them. Thus the researches of an American Palæontologist, Dr. Leidy, into the fossils of the ancient miocene and pliocene* rocks of Nebraska have

* For an explanation of these and other geological terms used, the reader is referred to Mr. Bonney's Manual, published in the present series.

shown that a remarkable group of animals once existed there, to which the name *Oreodontidæ* has been given. These had feet like Pigs', and the number of their teeth agreed with that of the Pig; but the form of their back-teeth, or molars, is precisely that of the Deer-tribe. In the same manner Cuvier discovered remains of an animal called *Palæotherium*, which flourished in the later eocene period, and possessed some characters which are now found in the Horse, others now found in the Tapir, and others now found in the Rhinoceros. We cannot take upon us to declare that in the economy of nature the *Palæotherium* in itself filled all those parts which are now played by the Rhinoceros, the Tapir and the Horse; but it does not seem such a very unlikely supposition. Savages or other races of men, with whom implements are scarce, can seldom afford to have a tool or weapon for each special purpose, and the multifarious and fine distinctions which progress in the mechanical arts have made familiar to us are to them utterly unknown. Their rude implements must serve for general purposes; the tomahawk that will slay an enemy will equally well cut a log for the fire; the arrow-head that brings down their game serves also as a knife to flay it. When such men in process of time become somewhat civilized, they find the advantage of having tools and weapons distinct; and when the arts begin to be still more cultivated the distinction goes on increasing, until at last not only each trade has its own peculiar tools, but each tool, such as a spade, chisel, hammer, trowel and so forth, has its own especial use, instead of being generally applied to all manner of purposes. Thus it is with these ancient and extinct animals; they exhibit what is technically called a more "Generalized" form as opposed to the more "Specialized" structure of modern beings.

This fact then, by many persons thought to be very suggestive of other interesting considerations, with which we need not now trouble ourselves, would seem

to affect, and in some degree to limit such deductions as are to be made from the principle of the Correlation of Structure before described. And so it does, but it need not much disturb us. We may meet with remains of an animal that combined some characters of the dentition of the Pig and of the Deer, or remains of an animal in which certain characters of the Horse, the Tapir and the Rhinoceros unite; but it is not likely, so far as we are able to judge from past experience, that we shall ever encounter those of an animal in which the dentition of the carnivorous Cat is combined with the peculiar build of the fore-limb of the Ox, or the rotatory structure of the Cat's paw is conjoined with the jaw-conformation of the herbivorous Ox. If we can imagine an ancient form which may present certain features common to both Cat and Ox, we may be sure that it will be so "generalized," that any blending of these highly "specialized" qualities, just mentioned, will not be discoverable, simply because they did not exist as separate features at the time when such an animal flourished. Therefore the doctrine that ancient forms are comparatively "generalized," while recent forms are comparatively "specialized," is not inconsistent with the principle of "Correlation of Structure."

But there is another consideration which the study of extinct animals, when taken in connexion with that of recent forms, offers to the reflective zoologist. Through research it becomes evident that in some parts of the world the animals which once existed, but are now extinct, were akin to or had essentially the same structure as those now inhabiting the same countries. This is particularly the case in South America and in Australia. In South America, and there alone, we find numerous quadrupeds, having in some respects affinity to each other though with their structure so far modified as to be adapted to very different habits. For instance there are the Sloths which live among the branches of trees, feeding on their leaves and never

descending to the ground, and the Armadillos which cannot climb trees, but pass all their time on or under the earth. In many points, which we need not stay here to enumerate, these two tribes of animals agree so much that zoologists with one accord class them in the same group, to which the name *Edentata*—best explained perhaps by the term irregularly-toothed animals—is commonly applied. When we come to examine the fossils which numerous places of South America have yielded up to investigators, we find among them a great preponderance of remains of animals plainly allied to the Sloths and Armadillos, though many of them were of wondrous size, incomparably bigger than the puny beings which now represent them. There was one creature, to which the name of *Mylodon* has been given—some eleven feet in length—undoubtedly a relative of the Sloths, but most likely (since one cannot conceive trees fit for such a monster to climb) obtaining its food by uprooting forests. Then we have a beast, *Glyptodon* by name, allied to the Armadillos, clothed in somewhat similar but more solid armour, and likewise of gigantic stature—one of the smaller kinds measured nine feet in length. These are among the more remarkable of the former inhabitants of South America. They are extinct and have left no progeny; but there were also many other kinds of Edentates, equally extinct and closely allied in size and other characters to those which still exist.

Then to take the case of Australia. In that country also were there of old time "giants upon the earth," and the case is all the more interesting because with very few exceptions the land-quadrupeds of that part of the world are now to be at once distinguished from the denizens of almost every other country. Nowhere but in Australia do we find Kangaroos and Wombats, belonging to the group of *Marsupialia* or pouched animals. Some of the former are of large stature—one of them, the great Boomer as the colonists call it, stands as high as a man or higher; but the skull of its mighty

predecessor in the land, the *Diprotodon*, was three feet in length, and yet the two have the same dentition. So likewise an enormous Wombat, as big as a Donkey, once flourished where now the largest beast resembling it is of the modest dimensions of a middle-sized Dog. It would appear from the fossils of all countries that the conditions which favour the life of the larger quadrupeds were once widely extended over the world, but what those conditions were no one has ever satisfactorily conjectured.

However it is not the greater stature of the old tenants of the globe that is the main point of interest in this place. If it were so we need not, as has just been hinted, travel to Australia or South America for instances, because here in England we find that in the comparatively recent times, when the peat of the fens of the Great Bedford Level (comprising parts of Huntingdonshire, Cambridgeshire, Suffolk, and Norfolk) was first forming, the Stag which then abounded was far larger than the British Stag of the present day; while the Stag of the still older gravel-deposits in the same district just as much exceeded in size the Stag of the peat as that was larger than the existing Stag. The main point of interest is that the creatures now inhabiting a country are generally more or less closely allied to those which formerly dwelt there. True it is that *Marsupialia* are not now limited to Australia and its neighbourhood, for some are found in South and even (as the Virginian Opossum) in North America, while there was a time, very long ago indeed, when they lived in Europe. Equally true is it that some *Edentata* occur in Africa, in India, and in the Malay countries (as the Aardvark and the *Manis* or Scaly Anteaters). But it is undeniable that ancient remains of no quadrupeds but Marsupials have ever been found in Australia, which is still the metropolis of that group of animals; while remains of Edentates characterize the earlier fossil-deposits of South America just as the existing Edentates are most numerous in that part of the world

now-a-days. On the other hand, notwithstanding that this wonderful relationship on the same continent between the dead and the living may be extended to some of the quadrupeds of the Old World, and the like law has been shown to hold good with many other animals—even with sea-shells, though (owing to their wider distribution) it is not so well displayed by them, yet there are some remarkable exceptions. The quadrupeds of North America formerly partook strongly of the present character of those of South America, and, in this respect, South America was formerly more closely allied than it now is to North America, while Northern India was once more nearly related in the same respect to Africa than is the case at present.

It follows therefore that a study of the Geographical Distribution of animals is essential to the proper study of Palæontology, and that being a very important part of Zoology, the study of Distribution must on no account be neglected by any one desirous of knowing what the whole science is. Furthermore it will presently be perceived that this branch of the subject, in the deductions which may be legitimately made from it, is of overwhelming interest. A hundred years ago hardly any zoologist had any conception of the true bearings of the questions which arise from it, and even now-a-days there may be some persons who profess their inability to understand that it is more than a matter of idle curiosity, about which it is indifferent whether learners puzzle themselves or not. Scarcely any of the undoubted inferences which are among the results of a close comparison of the animals inhabiting America with those inhabiting Europe had occurred to our grandfathers—much less to any preceding generation, if we except the brilliant and accomplished French Zoologist of the last century, De Buffon. It was perhaps not until the strange forms of animal life which inhabit Australia became well known to the zoologists of Europe (which, it needs not to be said, was hardly a hundred years ago) that the idea seemed to dawn upon

them that all things were not with our Antipodes as with ourselves, and, long afterwards, that by a process of sound reasoning we might learn much of the past history of our globe and of the causes which have led to its being peopled by its present occupants from these present occupants themselves.

Some facts as to Geographical Distribution—whether of plants or animals, have, it is true, been long known, indeed they present themselves on the slightest inquiry. Every one is aware that Elephants and Tigers do not roam in our woods now-a-days, whatever may have been the case aforetime. Many persons have read that Horses were unknown in the New World at the time of its discovery by Europeans and were subsequently introduced by its Spanish conquerors. Some may even know that Humming-birds are not to be found in the Old World, and that (as has been already said) the so-called "Marsupial" animals are at the present time, with a few exceptions, confined to Australia, as well as that in that country nothing like Vultures or Woodpeckers are to be found.

The assemblage of animals which inhabit any portion of the earth's surface, whether it be land or water, is called its "Fauna," in the same way that the plants of a country are called its "Flora." To be entitled to the former term it is unnecessary that the animals composing the assemblage should not be found anywhere else; it is enough that they occur there and impress upon the district, be it large or small, certain more or less well-marked peculiarities. Nor does it follow because certain kinds of animals are found to inhabit two districts that these two have the same Fauna. We have to take the whloe assemblage as a whole, and abide by the verdict which the majority of kinds affords us. Now by collecting such facts as those stated in the preceding paragraph, and such facts can be collected by the hundred or the thousand, we are able to get hold of a general idea of the Geographical Distribution of Animals, and when the results of all the knowledge on this sub-

ject which we can acquire are brought together, it will appear that the earth may be partitioned into several great Zoological Regions—each separable in Subregions, Provinces, Subprovinces and so on. It is impossible here, for want of space, to go into details, we must be content to mark the chief Regions of the globe, distinguished by having each a more or less characteristic Fauna. These chief Regions are believed to be *six* in number, and they may be recognised in the map here introduced.

America is divided into two Regions—the "Nearctic" and the "Neotropical," which meet in Mexico at about the 22nd parallel of North Latitude:—

(i.) The NEARCTIC Region (that is the Northern part of the New World) includes the Aleutian Islands, besides Greenland and the Bermudas with all of what is generally called North America.

(ii.) The NEOTROPICAL Region (that is the Tropical part of the New World) comprises the West India Islands, the Galapagos, and the whole of South and Central America.

Passing to the Old World, it is separable, as may be seen, into four Regions.

(iii.) The PALÆARCTIC Region (or Northern part of the Old World) including that portion of Africa which lies to the northward of the Great Desert, the Atlantic Islands (Madeiras, Canaries, and Azores), the whole of Europe from Iceland to Greece, besides Asia Minor, Palestine, Persia, probably Affghanistan, the whole of Northern, Central and Eastern Asia, lying to the northward of the Himalaya Mountains and of China proper, as well as Japan.

(iv.) The ETHIOPIAN Region consists of Africa, excepting Morocco and Algeria (which, as already stated, belong to the preceding Region), as well as of Arabia and of course the adjacent islands

from those off the Cape Verd to Madagascar and Socotra.

(v.) The INDIAN Region includes possibly Beloochistan, all British India, Burma, China proper (that is, without Chinese Tartary), Cochin China, the Malay Peninsula, Sumatra, Java, Bali, Borneo and the Philippine Islands.

(vi.) The AUSTRALIAN Region is very trenchantly divided from the Indian at the Straits of Macassar, and, beginning with the islands of Celebes and Lombok, comprises all the groups between them and Papua or New Guinea, as well as Australia, Tasmania, New Zealand and, generally, all the islands of the Pacific Ocean, except those already otherwise appropriated—as Japan, the Aleutian Islands and the Galapagos.

It is true that all this must be taken upon trust by the learner. To prove the several statements now advanced would occupy many times more pages than this little book contains. Yet it may be added that though the preceding outlines of Geographical Distribution were first laid down with reference to the most vagrant class of animals in creation—namely Birds*—their truth has since been in the main confirmed by nearly all those zoologists who have studied the subject in reference to particular classes in the knowledge of which they themselves stand pre-eminent.

Yet it may not be unreasonably expected of these six Zoogeographical Regions, that they are not all equally distinct, and it is quite possible that future researches may show that their boundaries require some rectification. Thus the Nearctic Region has chiefly negative characteristics, that is to say it is distinguished rather by the absence of many forms of animal life which are found in the Palæarctic than by the presence of many which are peculiar to it; while most of those it does

* See Sclater, 'Journal of the Proceedings of the Linnean Society, Zoology,' ii. p. 130.

possess which are not shared by the Palæarctic it shares in common with the Neotropical. At the same time this very mixture gives it a certain character of its own, and, combined with the comparatively few forms which are peculiar to it, perhaps entitles it to recognition as a distinct though composite Region. Then again the Indian Region very probably requires modification. The Fauna of the country which we generally speak of as India, excluding that of the lands lying to the eastward, is possibly made up of two other Faunas—the Ethiopian, on the one hand, which would seem to prevail over the western parts of the Indian Peninsula and even to affect the eastern coast, and, on the other hand, a Fauna which would appear to have its stronghold in the Malay countries. It is therefore quite probable that this Indian Region may have to lose a considerable portion of its western territory, which must in that case be annexed to the Ethiopian Region, while the rest may, no doubt, be left. In that case "Indian" will be an inappropriate name for it, and we must regret that another appellation had not been originally given to it. By some it has been called the "Malayan" Region. As to its south-eastern boundary, however, there can be no doubt. It has been already said that the Australian Region is trenchantly divided from it at the Straits of Macassar, and it has been very justly proposed that the line of demarcation should bear the name of "Wallace's Line," after the celebrated naturalist and traveller who first pointed out the complete distinctness of the two Faunas which abut, without any intermingling, on the shores of the narrow but exceedingly deep channel of water running between the islands of Bali and Lombok to the southward, and to a less degree of Borneo and Celebes to the northward.

In fact so well marked is this line that we find the difference in the Fauna of the Indian (or Malayan) and the Australian Regions greater, in spite of their close approximation, than the difference which exists between

any other two Regions on the whole of the earth's surface. Consequently it has been proposed, if we wish to group together the various Regions so as to get a clearer notion of their resemblances and differences, not to divide the globe into a New World and an Old World, as might at first sight appear natural, and for other purposes is found to be convenient, but into a Northern World and a Southern—"ARCTOGÆA" and "NOTOGÆA"—this last being made up of the Australian Region and that which, on many accounts, has the greatest affinity to it—the Neotropical Region, while all the other Regions go to make up the "Arctogæa."

There is a consideration of remarkable significance in the circumstance that the well-defined boundary called "Wallace's Line" should pass through so narrow and yet so deep a channel. It shows that no communication by means of dry land can have existed between the two opposite shores for a very long period of time, for had it been otherwise there must have been an interchange between them of their animal life. Apart from their Fauna the two sides of the passage present the same physical aspect, and we may be sure that had there been from either side an immigration to the other, some if not many of the colonists would have made good their footing and have existed to the present day. But there is no indication of this, and hence we may reasonably conclude that the water-way between the islands of Bali and Lombok is of very great antiquity, which amounts to saying that the distribution of animals in this part of the world furnishes us with a fact of much importance in the history of the earth.

To take another case. It has been stated, and that on the very best authority, that the marine Faunas of the two coasts of the Isthmus of Panama, which joins the two continents of North and South America, have but 30 *per cent.* of species in common. Now what does this show? No doubt the very considerable antiquity of the barrier which exists between the Atlantic and the

Pacific Oceans—for if, in anything like recent times, there had been a break in this barrier, within the Tropics where the sea is warm, then assuredly we should have had a very much larger interchange of the species which inhabit its two sides, or perhaps we should even find precisely the same Fishes, the same Shells, the same Crabs and the same Corals in the harbour of Colon on the one side and that of Panama on the other. As it is we have Corals on the Atlantic coast of the isthmus and on the Pacific none whatever, while, as before said, of the rest of the marine Fauna (the Fishes especially) not more than 30 *per cent.* are common to both. It is moreover particularly to be noted that there seems to be no other reason than the one here assigned for this difference. Very many sorts of Fishes and of Shells which occur on one side so much resemble those found on the other that the distinction between them is only such as can be recognized by expert zoologists, yet this distinction is constantly to be observed—they form what are called "Representative Species," that is, one kind of Fish or of Shell on one side is exactly represented by another kind of Fish or Shell on the other.

But this difference between the marine Faunas of the two coasts of the Isthmus of Panama not only proves its long duration as a barrier of dry land, but some other deductions follow naturally enough. What is called the "Gulf Stream" is a current of water which sets across the Atlantic Ocean from the west coast of Africa, and, passing through the Windward Islands of the West-India Archipelago, enters the Caribbean Sea. There its westerly course is impeded by the barrier of which we have been speaking, this Isthmus of Panama, and the current is diverted towards the north, and, following the coast-line, reaches the Gulf of Mexico. Sweeping round this Gulf, from which it takes its name, the stream re-enters the Atlantic between the peninsula of Florida and the island of Cuba, and makes its way in a generally north-easterly

direction till it strikes the shores of Ireland, Scotland, and Norway.* Now the water composing this current (having been heated by the greater power of the sun in the tropical regions through which it has been passing) is considerably hotter than that of the rest of the North Atlantic, and, aided by the general flow of warm surface-water from the equator towards the poles, its effect is to modify the climate of the countries just mentioned to such a degree that their winters are very much less severe than those of lands, though situated a great deal nearer the equator, whereon no such genial influence is excited, thereby fitting Ireland, Scotland, and some portions of Norway for the habitation of beings which could not otherwise have lived there. Even in the most northern part of Norway, about lat. 70°, it is very unusual for the sea to freeze, yet round the coast of Newfoundland, which is more than 30° further to the southward, the sea not only freezes every year but remains frozen for some months. How different too are Ireland and Labrador, lying in almost the same latitude. In Labrador every lake, every river, every bay is locked by ice for more than half the year. In Ireland we know that such a thing happens more seldom than in England. There is no other known cause of this but that Ireland has the benefit of the warm water striking her shores, and Labrador enjoys no such advantage. But it is also tolerably clear that the Gulf Stream must have been running pretty much the same course that it runs now so long as the barrier presented by the Isthmus of Panama has existed. If it were not for that barrier the current would have continued its westerly flow onward

* This statement has of late years been disputed, and it must be admitted that the magnitude of the Gulf Stream in the North Atlantic had probably been overrated by previous investigators. Still, no one who has picked up a *Lausnarsteinn* on the coast of Iceland, or seen the "Horse-eyes" so constantly found on the shores of the Hebrides—as the seeds of *Entada scandens*, a plant growing only in the West Indies, are called—can doubt the important influence of the Gulf Stream.

to the Pacific Ocean. Now we have seen that the difference between the marine Faunas of the two sides of the isthmus proves its long duration. Hence we may fairly conclude that for so long has the Gulf Stream been flowing and helping to soften what would otherwise have been the rigorous climate of Ireland and Scotland, thereby materially affecting their Fauna.

But as we have now been led to speak of the Fauna of our own islands, let us see if we cannot find so near home another interesting conclusion that may be fairly deduced from this subject of the Geographical Distribution of Animals. Every one knows the old legend of St. Patrick, and how he is said to have banished all noxious Reptiles from his favourite island. As a matter of fact only one kind of Reptile proper is found in Ireland. This is the Viviparous Lizard, a harmless little animal which also occurs in Great Britain and generally throughout the continent of Europe. But in England we have besides a second kind of Lizard, commonly known as the Sand-Lizard, and this also is spread over the Continent, where they have in addition, even in Northern France, a third kind, the Green Lizard, which does not inhabit any part of Great Britain or much less of Ireland. It is therefore a not very unlikely deduction from these facts that the Viviparous Lizard had made its appearance in this part of the world at an epoch when Ireland was joined to England by dry land, and England was in like manner connected with France, and that that epoch was earlier than the time when the Sand-Lizard appeared, for if the latter had then occurred it would in all likelihood have spread to Ireland. But if we suppose, and geologists tell us we may do so, St. George's Channel to have been formed before the English Channel was, then it is plain that a Reptile extending its range from the middle of Europe would have been able to get into England, but not into Ireland; and this supposition would account for the limited distribution of the Sand-Lizard. While again a third Reptile, like the Green Lizard, coming

at a subsequent period, after the Straits of Dover were formed, would find them before him and be unable to set his foot off the Continent.

Thus in whatever way we regard them, the not unreasonable deductions afforded by the facts which a study of the Geographical Distribution of animals makes known to us are of very great importance. We may of course be wrong in some of our inferences, we very likely shall err, as some of our predecessors have done, but the facts remain whatever construction we put upon them, and, as they go on accumulating, we may be sure that errors by degrees will be swept away, and perhaps the genius of man by this means alone may explain one of the mysteries of Creation.

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## CHAPTER III.

WHAT animals look like and how they are framed, as well as their mutual resemblances and differences, were in the opening sentence of this book declared to be among the chief subjects that the zoologist ought to study; and several pages have been already occupied in showing how we should set to work so as to recognize such resemblances and differences in some examples of various kinds of animals. More on this head must be said, while infinitely more might be said were there here room for doing so. It will appear, however, from what we have even now seen in the different cases we have taken, that the lesson taught us is that there is a unity of the main plan in the way all creatures of any particular group are constructed, combined with a very great diversity in the way that plan of structure is carried out in details. This was especially shown in the different Insects we compared; in the different kinds of Crustaceans—Crabs, Lobsters, Shrimps and so forth—of which we spoke; and in the different kinds of Vertebrates whose skeletons we partially examined. It is

this unity of plan which alone enables us to form any kind of classification grounded upon what, as we have already explained, are called Homologies—likenesses between the parts of animals which are constructed upon the same plan however different may be their function.

It does not seem to be beyond the range of possibility, so far as human reason can reach, that every animal should have been constructed upon a separate plan of its own, having no reference to the plan upon which any other animal was constructed. For any cause we can discover to the contrary, what we term Animal Life might have been the result of, or might have been made manifest in, a series of organisms indefinitely unlike one another, had it so seemed good to the Creator; and there is nothing in the nature of the case that would have led us to suppose that creatures so different in appearance and habits as a Sheep and a Whale, a Sparrow and a Lizard, a Shrimp and a Butterfly had anything in common more than animal life. Had animals been thus separately framed, each kind perfectly distinct from any other, and independently playing its part in creation, "working out its life," as has been well said, "by a mechanism peculiar to itself," such a classification as zoologists attempt to construct —a classification based upon Homologies of structure, that is essential agreements of structure—would be obviously impossible. But, on the contrary, as a matter of fact, no such mutual independence of animal forms exists in nature. We find, and what has been already advanced as regards Correlation of Structure tends to prove it, that the different members of the animal kingdom are interconnected in a wonderful manner. "Every animal has a something in common with all its fellows: much, with many of them; more, with a few; and, usually, so much with several, that it differs but little from them."*

* Compare Huxley, 'Lectures on Comparative Anatomy' (pp. 2, 3), from whom this paragraph is adapted.

But what is this common bond which unites all animals? First, there is Animal Life—Animal Life as distinct from Vegetable Life. Of that we may be very sure, though it will puzzle the wisest of us to set down in words such a definition of either kind of life as will meet all cases. Next there is that principle upon which many, perhaps the majority, of the greatest naturalists of the day insist—Community of Descent. But here we come to a theory, and in a book like the present, as has been already said, theories should have no place. We must therefore stop at this point, though no one now-a-days can prosecute investigations of the higher branches of botany or zoology without being confronted by this principle. The strongest believers in this prin-

FORMS OF AMŒBA SUCCESSIVELY DRAWN FROM THE SAME EXAMPLE.

ciple, by what theory soever they account for it, will hardly venture to maintain that they have proved its existence, even though the evidence they are able to accumulate in its support seems to be overwhelming. The most that can be urged in its behalf is that by its adoption more things otherwise inexplicable are capable of explanation than can be explained by any other means, while, on the other hand, many things remain enigmas, as far from solution as ever.

Leaving then this theory let us follow the search for facts. For this there is nothing like beginning at the beginning or so near to it as we are able. The simplest creature which can with apparent reason be safely

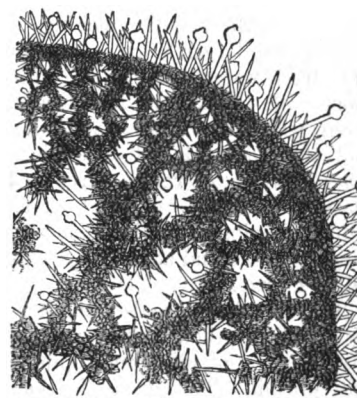
dignified by the title of an animal is perhaps that which has been called an *Amœba*. It may be found in stagnant water, but is only to be observed under a microscope of high power, yet even by means of that instrument there is nothing worthy of the name of organization to be discovered in it. In the words of Mr. Gosse:—

"You see a flat area of clear jelly, of very irregular form, with sinuosities and jutting points, like the outline of some island in a map. A great number of minute blackish granules and vesicles occupy the central part, but the edges are clear and colourless. A large bladder is seen near one side, which appears filled with a subtle fluid."*

Now these words "jelly" and "bladder" must not mislead the reader. They are only intended to express what these parts of the animal look like, not what they are. Its "jelly" is void of structure or organs, and is without definitely-formed parts. Nevertheless the creature possesses all the essential properties and characters of life. It is produced from a body like itself, it is capable of receiving food and of exerting movements. While we look at it its form changes, its outline becomes quite unlike what it was at first, the position of the "bladder" or "bladders" it contains varies, and this feature perhaps entirely disappears. All these movements take place without intermission and without any rule or order that can be recognized. Furthermore many animals as unformed as the *Amœba* and, so far as we can see, hardly differing from it, are capable of producing a shell, a structure, in many cases, of wonderful complexity and of singular beauty. If we watch one of these Rhizopods, as they are called, alive, we may see it thrusting out one or more filmy portions of its substance. Some of these fasten upon such particles of solid matter as may happen to lie near and draw them into the little mass of the body. There included, some process, akin to that which we call digestion, goes on

* 'Evenings at the Microscope.' Society for Promoting Christian Knowledge, 1874, p. 379.

and the indigestible parts are rejected. Others of these projections effect locomotion, but all seem to be altogether uncertain in their action. Sometimes they unite with one another, forming a kind of net-work, and they are all capable of being withdrawn into the mass of the body—one cannot say, at will, for one cannot conceive its possession by an animal so wanting in any structure that may lodge organs of intelligence that may embody a will. Among the many wonders which nature offers there are perhaps few so absolutely marvellous as this *Amœba*, and nothing that more thoroughly tends to show that Life — the gift of the Creator — is the cause and not the consequence of organization.



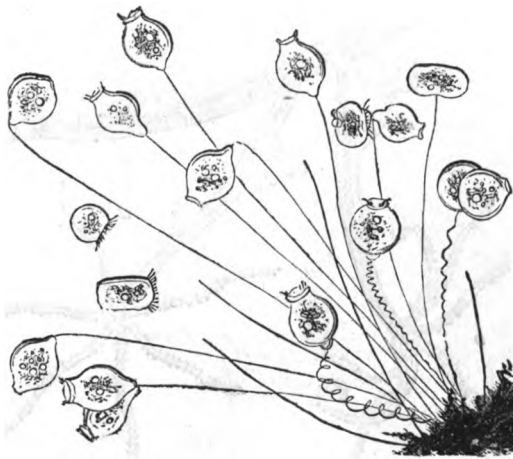
SECTION OF SPONGE (HALICHONDRIA) MAGNIFIED.

Essentially similar to an *Amœba* is each of the particles that forms the living portion of a Sponge, when considered apart from the frame-work which connects all these particles together. This frame-work or skeleton, we may call it, consists of a mass of horny fibres, in many cases strengthened by needles which vary in substance—being in some composed of calcareous or chalky matter, in others of flint and in others looking as though made of glass. The living portion is a continuous glairy film, interrupted only here and here by small openings, which for a time exist and are then closed, while other small openings appear in their stead, and at more distant intervals are large holes. All these orifices communicate with pipes or canals that branch

out and run in every direction throughout the whole mass, expanding in certain places so as to form chambers lined by Sponge-particles, each of which particles, as before said, is like an *Amœba*, but is furnished with an exceedingly fine hair, called a *cilium*, capable of almost constant movement—though how the movement is exerted is unknown. The effect however is very manifest. As these fine hairs or *cilia* sway backwards and forwards always in the same manner, they sweep the water into the canals in the same direction, and produce constant currents in it, the currents always entering at the smaller openings and being discharged through the larger holes. As the water is thus swept out, fresh water takes its place, and the currents carry along with them such matter as may be suspended in them, which matter is drawn into the Sponge-particle and, if fit for food, is digested, just as in the case of the *Amœba*, while the refuse is rejected, and thus the whole mass is nourished and kept alive. As we know of no animals having a simpler structure than such as these, they seem to stand at the beginning and are collectively called PROTOZOA.

To them belongs also another group of creatures, about which, though it has for a long time occupied the attention of observers, opinions the most opposite still prevail. This group is that which is known as Infusories, from the fact that if we make an infusion of certain animal or vegetable substances—that is, pour water upon them, and leave the mixture to stand for some hours or days—we shall find it swarming with creatures. How these creatures get there is not now a question to be discussed, it has puzzled some of the most learned of naturalists. But there they are. They are very varied in appearance, and it may at once be said that the animal nature of many of them is denied by certain high authorities, who declare that a large proportion of the so-called *Infusoria*, as they are scientifically termed, are really vegetables. But some are admitted to be animals. Most if not all of them are charac-

terized by being furnished with innumerable *cilia*—those delicate hairs, waving to and fro so mysteriously, such as we have already said were to be found in the Sponges, though there each Sponge-particle has but a single *cilium*, whereas the *Infusoria* generally are beset with them. If these Infusorial animals are sedentary or fixed in position, then the motion of the *cilia* creates currents in the water after the manner of a whirlpool,

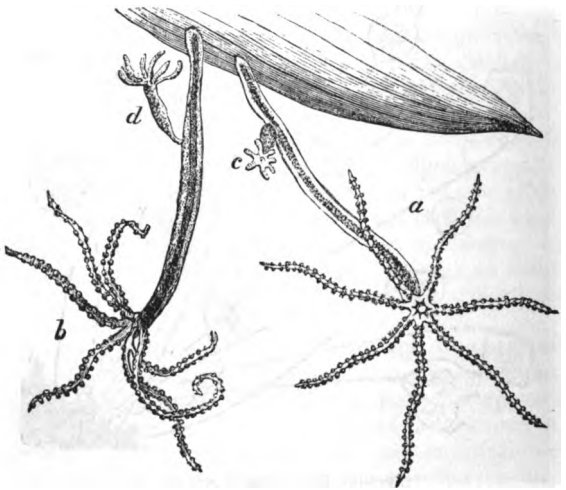


INFUSORY (VORTICELLA) MAGNIFIED.

wafting the matters suspended in the fluid within reach of the creature's mouth. But if the animals are themselves free or locomotive, then it is to the *cilia* that they owe the means of swimming about—the *cilia* acting like oars, in quest of food. However differently formed these creatures may be, digestive cavity they can hardly be said to possess. There is a mere gullet opening directly into the soft mass of the body. Down this gullet the food passes and is not only taken into the mass, but is there by some means circulated up

one side and down the other, until all the nourishment it contains is extracted from it and the refuse is ejected; not, as in the case of the next group we have to consider, through the passage by which it entered, but through another which is opened near the mouth as occasion requires.

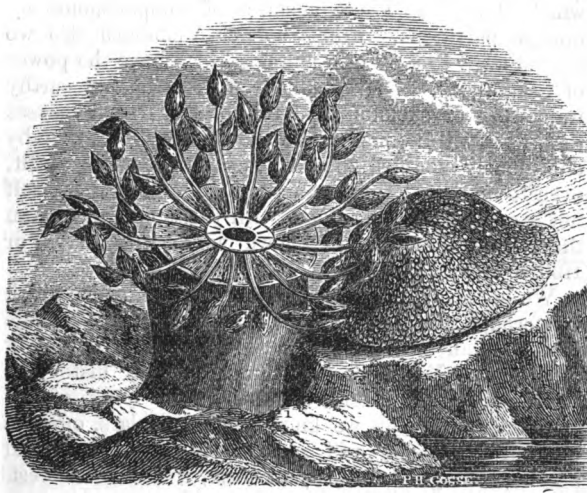
Now from these very humble manifestations of animal




HYDRA: *a*, *b*, ADULT; *c*, *d*, YOUNG SPROUTING FROM THE PARENT.

life, let us go to another and comparatively-speaking much more highly-organized group, of which the *Hydra*, before mentioned, may be taken as an example. Here we have, instead of the simple and structureless mass of the *Amœba*, a well-defined body, composed of at least two distinct layers, an outer and an inner layer, each made up of exceedingly minute cells, and the whole so arranged as to form a digestive cavity, surrounded by but separated from the substance of the body. The *Hydra* is a little tube-shaped animal, and

round the mouth of the tube, which is also that of the animal, are set a number of long arms or tentacles, that it has the power of waving in any direction. These tentacles are complicated in structure, but of that there is no need here to speak. By their means it captures prey—smaller animals than itself, as they swim past, and drags them through its always open mouth into its



SEA-ANEMONES.

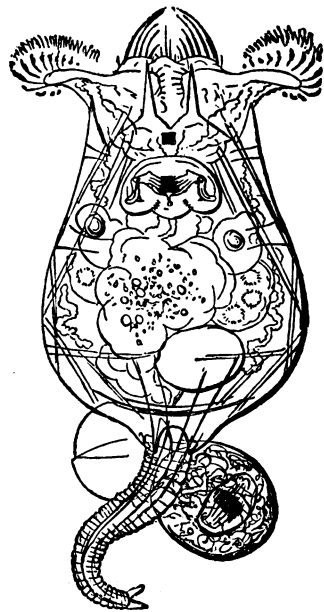
digestive cavity to which has constant access the water in which it lives, perched upon a stone at the bottom or hanging from a weed by means of a small sucker or prehensile disk. But the *Hydra* can itself swim, for detaching its body from the spot to which it has been fixed, and exposing that end of it to the air, the disk soon dries and serves as a float, from which the animal hangs and rows itself along by means of its tentacles. Or, again, it can move from place to place by grasping any neighbouring substance with its tentacles, unfixing

the disk by which it is rooted and transferring itself to a new station.

Allied to the *Hydra* are, among many other animals, those which we commonly know as Jelly-fishes and Sea-Anemones, but their structure is much more complex. In the latter, instead of there being but a single continuous body-cavity, we find the digestive chamber opening into another distinct chamber, and divided from the walls of the body by an intervening space, which is separated into a series of compartments by upright partitions. From the Sea-Anemones also we are led away to the Coral-animals which have the power of forming or, as it is called, of secreting an earthy framework or skeleton, and this often in such masses that, as it will by-and-bye be shown, they have thereby enormously modified the very face of the globe itself, even to an extent which no other animal, man himself not excepted, has ever done. All these creatures from the *Hydra* upwards are known as CŒLENTERATA or Hollow-bodied animals.

We have now to consider a group of animals, which is perhaps the only group of any extent that the zoologist can be excused for regarding with a feeling of disgust. Yet there is so much in their history to excite the wonderment of every true lover of the creation, that, when we know the particulars, our not unnatural aversion will be turned into a real and abiding feeling of curiosity at least, if not of interest. The extraordinary changes which in the course of their life are undergone by the animals commonly known as Intestinal Worms—animals which infest the bodies of their fellow-creatures, ourselves included, and thrive at our expense, will be briefly related in the next chapter. So varied are these Intestinal Worms, or *Helminthes*, as they are scientifically called, in structure, that without going into greater detail than space would allow, it would be impossible to describe them, and the only character that they possess in common, and is yet distinctive of them as a whole, is one which

can be hardly made intelligible without the use of learned language. They have what is termed a "water-vascular system"—a remarkable set of vessels, which communicate with the exterior by means of one or more apertures situated on the surface of the body, and branch out more or less extensively into its substance. Some of them are not provided with any distinct digestive cavity. But all the animals included in this group are not parasitic, as, for instance, those little red Worms—Hair-Worms, as they are commonly called, from their likeness to horsehair, which we may find in stagnant and muddy water.



ROTIFER (BRACHIONES) MAGNIFIED.

Then we have the *Rotifera* or Wheel-animalcules. These obtain their name from the fact that the *cilia* with which they are furnished are so distributed that, when in active motion, they give the appearance of a rapidly-revolving toothed-wheel. The cause of this singular phenomenon—a mere optical delusion—has been sufficiently explained by Mr. Gosse,* and there is no need here to dwell upon it further. These creatures, like the *Helminthes*, possess a "water-vascular system," and, though sufficiently varied in form, they have their body more or less in the shape of a cylinder, the end next the mouth being provided

* 'Evenings at the Microscope,' pp. 223—225.

with *cilia*, but there are no *cilia* on the rest of the body. A very marked distinction between them and the other animals already mentioned in this chapter is the existence in their digestive cavity, which may be fairly termed a stomach or a gizzard, of a contrivance for crushing the food between two or more hard substances —we may almost call them jaws—which are worked by muscles, and in this respect, as well as in their possessing a system of nerves, the Rotifers present a very remarkable advance in structure, exceedingly small though they be, for nearly all are invisible to the naked eye, and affording one of the many proofs that Nature is greatest in the least of her works.

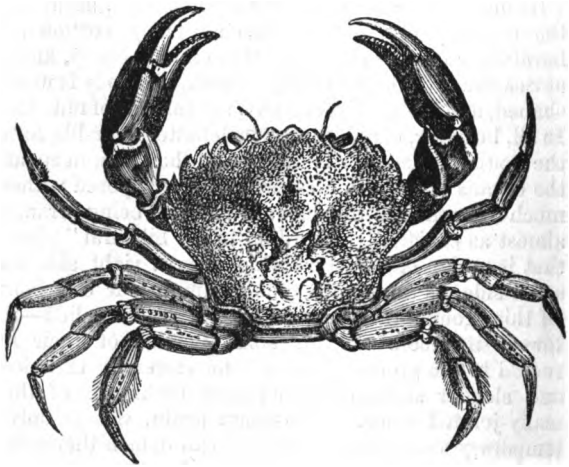
Next we have to treat of the true Worms, or Worm-like animals—*Annelida*. This is like the *Helminthes*, a large and varied group, containing among others the creatures we know as Leeches, Earth-Worms, Lob-Worms and the curious Sea-Mouse. All these have the body made up of rings, which are more or less distinctly visible, and they all have a system of nerves running the whole length of the body on its lower side, through which system of nerves the gullet passes on its way from the mouth to the digestive cavity. They besides have very generally a system of vessels for the conveyance of fluids to all parts of the body; and, as the walls of these vessels are elastic, the contained fluid (which is commonly of a red or green colour) flows through them by a succession of pulses, and the whole action may be likened to the circulation of blood in ourselves, but there is nothing that can be properly called a heart. Some of these animals, as the Leech, have the body perfectly smooth, but others are beset with fine bristles and scaly appendages, often of extremely complex structure. Even the Earth-Worm possesses such bristles, which, though invisible to our eyes, may be felt by softly rubbing the creature "the wrong way." All these animals, from the Intestinal Worms upwards, we may term VERMES.

Now we must take the group of creatures containing

the Star-fish and the Sea-Urchin, whose acquaintance we have already made in a former chapter. Nearly all of these animals are characterized by being more or less star-shaped or "radiate" in form. In some, as the Star-fishes proper and others which, though differing materially from them in many remarkable features, present much the same outward appearance, this radiate structure is manifest; while in others, as the Sea-Urchins, the mark of a star with five rays, separating the covering of the body into as many portions, is hardly less discernible. But there is one group, known as Sea-Slugs or Sea-Cucumbers, where the body is worm-shaped, and there is little, if any, appearance of radiation. In all, however, except those of a definitely star-like form, the radiate character is little more than skin-deep, and the organs of digestion especially, are disposed without much reference to the outward pattern, being arranged almost as constantly according to a "bilateral" plan—that is a plan of structure which has a right side and a left side, as the homologous organs in our own body. Of this group—the ECHINODERMATA, as it is called—the lowest members are for some portion of their life rooted to the ground, fixed at the extremity of a long and slender stalk, obtaining food by means of their many-jointed arms. In others, again, this is only a temporary arrangement, for they can detach themselves from this stalk and creep over the bottom of the sea, or swim at will in the water. Others are at all times endowed with locomotive power, effected either entirely or in part by the movable spines they bear, aided by beautifully-constructed sucking-feet. Others there are which depend entirely upon these feet, while at last we arrive at some animals in which these feet become again of very secondary importance, and their sluggish movements seem to be due almost entirely to the power of contraction and expansion which their soft and leathery body possesses.

But starting also from one of these groups of animals, perhaps from that of the *Rotifera*, we are led on to an

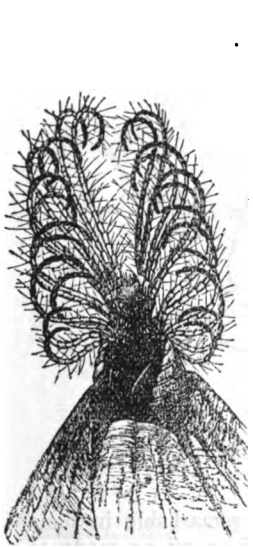
enormously large assemblage, to which is applied the name of ARTHROPODA, signifying animals with jointed feet, and this assemblage is plainly divisible into two great groups. First of all there are what may in a very wide sense be termed the *Crustacea*, including among many others the Shrimps, Lobsters, and Crabs. But these are the most highly organised of the group. Far below them, and presenting some characters in



CRAB (CARCINUS MÆNAS).

common with the *Rotifera*, especially that afforded by the presence of jaws or teeth in the stomach, but entirely wanting the "water-vascular" system, are a number of creatures of exceedingly diversified appearance and habits. They mostly possess organs for breathing the air that is contained in water, and are provided with an apparatus for the circulation of fluids within vessels distributed throughout the body, which is made up of a variable number of more or less definite segments; while each segment may be, and

some of them always are, furnished with a single pair of jointed appendages. These appendages, as has before been stated (p. 26), serve an almost endless variety of offices, and even a summary of the different functions they perform could hardly be given within the limited space of this book. Beside the creatures just named as belonging to this group, we have here to

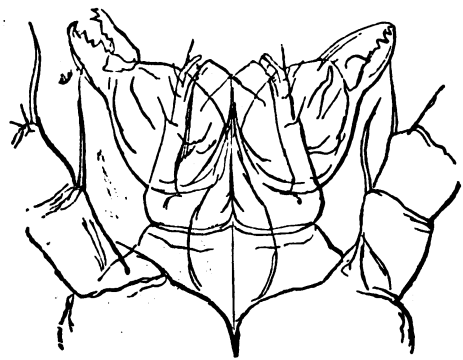


ACORN-SHELL (BALANUS).

COMMON BERNACLE (LEPAS).

include the entirely extinct forms known only from their fossil remains as Trilobites, the animals which are externally parasitic upon Fishes—Fish-Lice, the King-Crabs, the Woodlice, the Bernacles (themselves divisible into two very distinct sections—the Acorn-shells and Stalked Bernacles) and the Water-Fleas—all, excepting the Woodlice, being aquatic animals, and most of them indulging in locomotive habits for the greater part if not the whole of their life.

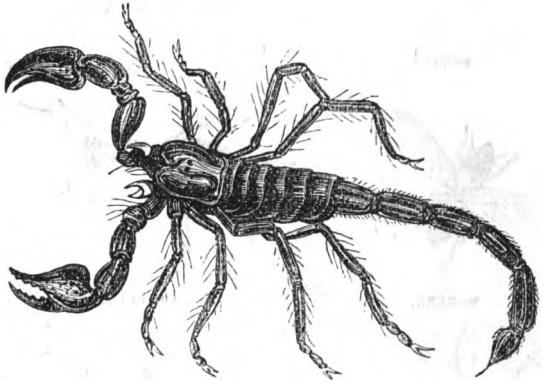
The second great division of *Arthropoda* are the *Insecta*—infinitely the most numerous of the animal world, and perhaps the most interesting. But what are commonly called Insects comprise at least three groups, and, though we may without fear of error determine that of these three the group which includes the creatures known as Centipeds or Hundred-legs (not that they have that number) is the lowest, it is not so easy to say which of the remaining two should next be



HEAD OF CHEESE-MITE MAGNIFIED.

taken. The Centipeds are most remarkable in their mode of growth; that is, if the observations made of certain kinds should on investigation prove to be applicable to all. Entering life with three pairs of legs only, other legs grow at intervals in batches of four pairs at a time, until the whole number borne by the perfect animal be complete. The true Insects (*Hexapoda*) present, as every one must know, and as we have already had occasion to remark, a wonderful example of the doctrine of the unity of plan, but diversity in its execution. They are adapted to an

infinite variety of conditions, yet, with scarcely an exception, they agree in having three segments—head, thorax, and abdomen; while to the thorax are attached three pairs of legs, and in most cases two pairs of wings or their homologues. The number of real legs never exceeds six, and their mode of growth, of which more must by-and-bye be said, differs entirely from that of the Centipeds (*Myriapoda*). The true Insects are generally separated into seven orders,* but there are some few forms which can hardly be brought within



SCORPION.

any definable limits. The *Arachnida* complete the division of *Insecta* taken in the widest sense. To them belong the Mites and Ticks, Spiders, Harvestmen and Scorpions. None of them have wings, and most of them have eight legs, with the head and thorax not separated, but forming a single segment, while

* Namely—1. *Orthoptera* (Cockroaches, Grasshoppers, Earwigs); 2. *Neuroptera* (Laceflies, Mayflies, Dragonflies, Antlions); 3. *Hemiptera* (Bugs, Lice, Cochineal-insects, Lanternflies); 4. *Diptera* (True Flies, Gnats, Fleas); 5. *Lepidoptera* (Butterflies, Moths); 6. *Coleoptera* (Beetles); and 7. *Hymenoptera* (Sawflies, Bees, Ants).

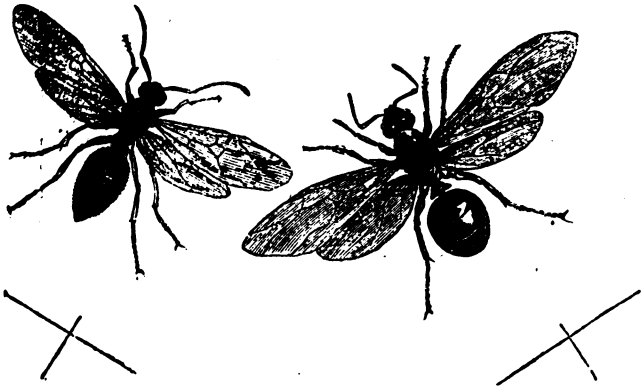
some smaller groups, as that known as the Water-Bears, have not even a distinct abdomen. In almost

FEMALE.

MALE.

WORKER.

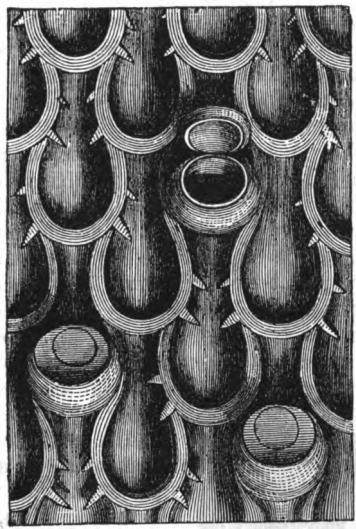
WORKER.



MALE. FEMALE.

HONEY-BEES AND RED ANTS.

all the *Insecta* (using the word broadly) respiration is effected by an elaborate system of wonderfully-constructed tubes running throughout the body and limbs from openings placed in the sides of the abdomen.* In the Scorpions the organs of breathing take almost the form of lungs, and structurally they must perhaps be regarded as the highest of the division; nevertheless they are extremely deficient in their nervous system, which seems to obtain its greatest perfection in some of the Order *Hymenoptera*, such as the Bees and Ants.

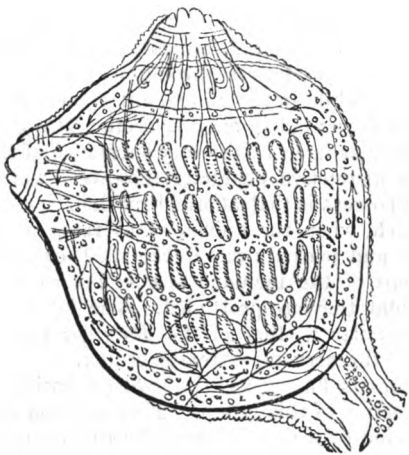


PORTION OF SEA-MAT MAGNIFIED.

Here we must again retrace our steps, and return at least as far as the great group of *Vermes*, or perhaps even lower. There is a great number of animals outwardly so much resembling the *Hydra* and its allies, that for a long time they were by all naturalists associated with the *Hydrozoa*. Of late years it has been ascertained that, notwithstanding this apparent similarity, the *Polyzoa*, as the group we now have to consider is called, exhibit a very great advance in complexity of structure. These *Polyzoa* are always compound animals, and in such a case as that of the Sea-mat (*Flustra*), which coats, as with a delicate moss-like growth, stones or shells immersed in the water, the whole surface, when examined under the microscope,

* See Gosse, as before, pp. 94—100.

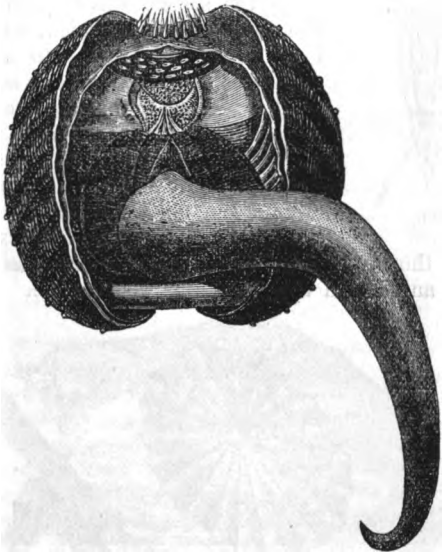
seat of the nervous system towards the main vessels which hold the circulating fluid—just the contrary to the plan which obtains in the *Brachiopods* and the *Polyzoa*. All these three groups compose what are called MOLLUSCOIDEA.



ASCIDIAN (PEROPHORA) MAGNIFIED.

Next to the *Molluscoidea* come the MOLLUSCA, or soft-bodied animals, nearly all included in a shell of great hardness, strength, and generally of beauty. This shell seems to correspond with the outer casing of the Tunicates, while the second bag of those creatures is here represented by what is spoken of as the "mantle," and, in one group at least of the Mollusks, envelopes almost the whole of the contained animal, leaving only just room for the admission of water; but in the higher groups the "mantle" becomes so much modified that its presence can only be recognized with difficulty. The first and lowest group of Mollusks is that which contains the Mussels, Cockles, Oysters and, in short, all the animals which construct shells of the

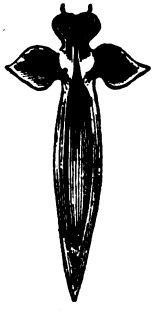
kind commonly called "bivalves," excepting, of course, the Brachiopods. They breathe by means of their flake-like gills, and are called *Lamellibranchiata*, and possess no parts that can be considered a head. The second group includes a comparatively small number of forms; but some of them make up for their paucity in this respect by their wonderful abundance as indi-



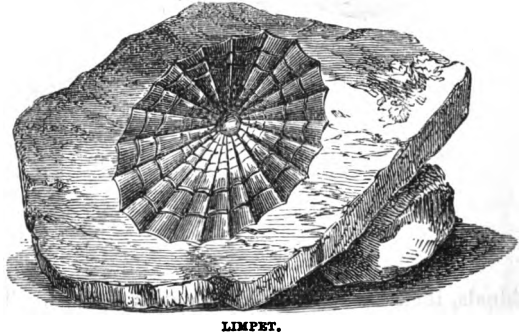
COCKLE.

viduals, their shoals often discolouring the sea. These are known as *Pteropoda*, from their swimming by means of a kind of paddle, which, though continuous in structure, extends on either side so as to look like a pair of wings. Almost all inhabit the open sea, and one of the commonest is that called by sailors "Whale's-food" (*Clio*), for upon it some of the mighty monsters of the deep feed. The Pteropods have a recognizable

head, and a mouth of singular complexity, containing among other organs a tooth-bearing tongue, which assists in grinding their food. The third is a much more extensive group, comprehending nearly all the animals which are distinguished by shells of the kind called "univalve," though in many the second valve is present in the form of a lid, which, when the creature is withdrawn into its shell, closes the opening; while in some the shell is reduced to the smallest proportions. This group is known as the *Gasteropoda*, from their manner of walking, as it were, on their belly, and the Limpet, Periwinkle, Snail and Slug, are sufficiently good examples of it, though there are many other forms as unlike those animals in appearance as well can be. It may



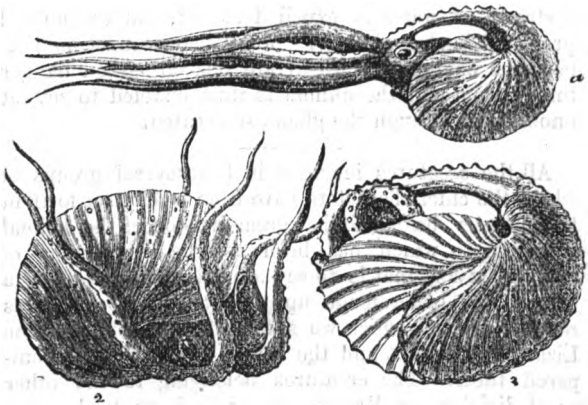
CLIO.



LIMPET.

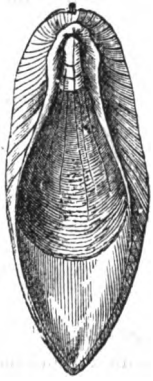
be divided into several sections, but there is some difficulty in doing this. Two such sections, however—those which live in water breathing the air therein contained, and those which live on land breathing the free air—appear to be really natural divisions, though there are many of the latter which can adapt themselves

to wet places, even so far as to inhabit fresh water. Finally, we come to the highest group of all, the




PAPER-NAUTILUS:—1, SWIMMING; 2, CREEPING; 3, WITHDRAWN INTO SHELL.

*Cephalopoda*, which, so to say, walk on their heads, and contain the Pearly Nautilus, and the many kinds of Cuttle-fishes and the Paper-Nautilus. The Pearly Nautilus is distinguished from all other existing Mollusks by having a many-chambered shell, the outer chamber of which only is occupied by the animal, the rest being empty. The shell of the Paper-Nautilus or Argonaut has no partitions, and the animal sits freely in it. The Cuttle-fishes have their shell internal, and in a few cases it is of a spiral form, but generally it is in shape somewhat like a sword, and may be composed either of an opaque earthy substance, or of a thin transparent flake-like horn. All these creatures have their mouth armed with a horny beak re-



"BONE" OF CUTTLE-FISH.

sembling a Parrot's, and surrounded by more or less numerous tentacles, generally furnished with suckers which have a powerful grasp. They have large, well-developed eyes, and a funnel or tube through which a stream of water is expelled at will, and the animal projected backwards way. Many also possess an ink-bag, the contents of which are discharged on danger threatening, and the animal is thus enabled to retreat unobserved through the gloom so created.

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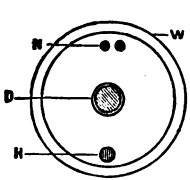
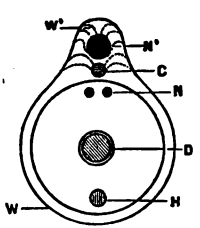
All the creatures included in the several groups of which the chief characters have been briefly set forth in this chapter, belong to that great division of the Animal Kingdom to which has been assigned the name of INVERTEBRATA, that is to say animals not possessing a jointed back-bone, made up of *vertebræ*, more or less resembling that which we saw in the skeletons of the Lizard, the Rabbit and the others with which we compared them. The creatures belonging to the other great division, or VERTEBRATA, now have to be considered, and, though the structure of a few of them is possibly simpler than that of some of those with which we have hitherto dealt, there can be no question of the higher position in the scale, as manifested by their organization, of the VERTEBRATA.




INVERTEBRATE, IDEAL TRANSVERSE SECTION.




VERTEBRATE, IDEAL TRANSVERSE SECTION.

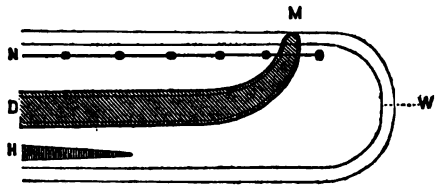
In the Invertebrates the outer wall, as we may call it, of the animal from its earliest condition, is never developed, whatever be its nature, into more than a single bag-like or tube-like covering which includes within it all the principal organs of life. So that if we were to make a transverse section of any

one of these animals endowed with a sufficiently high organization to possess a system of nerves and a heart, or arrangement of vessels for the circulation of the blood, that section might be ideally represented by such a diagram as this first, where the circle W shows the body-wall of the creature, D the digestive canal in the middle, on one side of which is H the heart, and on the other side, N the nervous system: and in none of these animals, again, is there at any period of their life any partition formed by the body-wall between the nervous system and the digestive canal.

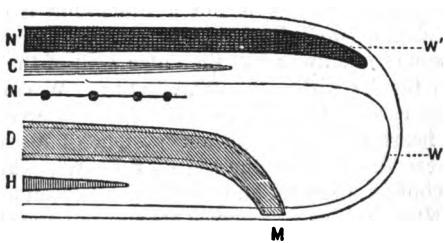
But in the Vertebrates we find at a very early stage in the development of the animal the body-wall becoming raised up into two ridges, one on either side of the middle line, so that a long groove is formed between these ridges, running as they do from one end of the animal to the other. These ridges at last unite with one another at the top, thus turning the groove into a second tube $W^1$ parallel with the first W, as in the second figure of the diagram. Hence it follows that after any Vertebrate has passed through its very earliest stages, it is not a single but a double tube, and the two tubes are separated by a partition which was originally part of the outer wall of the body, but now lies far within it. The first tube W contains, as in the case of the Invertebrate, the digestive canal D, the heart H, and a certain system of nerves N; but superadded to it is the second tube $W^1$, which we find to contain a second and much more perfect nervous system $N^1$ as well as a structure C known as the "notochord"—a feature with which we had not met before. This second tube is what is called the "cerebro-spinal" canal, because in it is seated the more perfect or "cerebro-spinal" nervous system—the brain, or *cerebrum*, with its continuation the spinal marrow.

If we were to make our imaginary sections lengthways instead of transversely, we should have the representation of the Invertebrate and Vertebrate like these diagrams, and here another very great difference between

the two divisions is remarkable. In all such Invertebrates as have a well-developed nervous system N, we find that the gullet, or upper part of the digestive canal, passes through this system, so that the mouth M is on the same side of the body as the principal nerves; but in the Vertebrate neither of the nervous systems N or N¹ is so perforated, the gullet turning away from both and the mouth M being placed on the opposite side of the body.




INVERTEBRATE, IDEAL LONGITUDINAL SECTION.




VERTEBRATE, IDEAL LONGITUDINAL SECTION.

Very many other differences between the Vertebrate and the Invertebrate animal exist, and might, if there were room, be here pointed out; but these two—the superaddition of this more perfect nervous system, the "cerebro-spinal" canal N¹, and the "notochord" C, appearing as they do at so early a stage in the formation of the animal, to say nothing of the position of the

mouth relatively to that of the less perfect nervous system N and heart H, seem to be the most essential.

One more distinction, and one which is very obvious, between Vertebrates and Invertebrates may be mentioned. Vertebrates may or may not possess jointed limbs, but when they have such limbs they never have more than two pairs; and these have an internal bony framework to which the muscles that move them are outwardly attached. On the other hand, whenever an Invertebrate has jointed limbs it has generally more than two pairs; and the framework to which the muscles are attached is external or connected with an external bony skeleton.*

Differing then in these respects from all the groups of *Invertebrata*, the *Vertebrata* present the most consistent, the most harmonious and the best-defined group in the whole Animal Kingdom. There is no one of them known—even that form which will be immediately shown to depart furthest from the rest—about the relationship of which any doubt can now-a-days be entertained; whereas, though allusion to the fact has purposely been omitted, most if not all of the groups of *Invertebrata* contain some members whose right to be included therein is more or less questionable.

It has already been declared that the "notochord" C, situated below the "cerebro-spinal canal" $N^1$, is one of the principal characters of the animals forming the great group *Vertebrata*. In fact if names were not merely names but also definitions the term *Vertebrata* would have to be rejected, since some of the lowest forms of the group so called never possess *vertebræ* at all, but only this notochord. It is present in all the *Vertebrata*, at a very early stage in a fibrous or gelatinous condition, and in some remains throughout the animal's life in that same condition. It does not undergo the process of ossification or becoming bone, but in most Vertebrates it is gradually superseded or

* Compare Huxley as before (pp. 58—61), from whom these paragraphs, with the diagrams, are by permission adapted.

will be found beset by numberless small apertures leading into little chambers, each of which lodges a creature that may be seen protruding its mouth surrounded by a crown of fringed tentacles.* But the *Polyzoa* have not merely a digestive cavity, like the *Hydra* and Sea-Anemone, they have besides a distinct gullet leading into the stomach and a distinct intestine, bent back upon itself, and leading from it to an outlet, placed, it is true, near the mouth, but always forming a second aperture. They have also a more or less well-defined nervous and a well-developed muscular system, the latter enabling them to project their mouth and its tentacles from the chamber or tube, which on occasion lodges it. The seat of the nervous system is on that side towards which the intestine is bent, and this is a point of great importance as regards the affinity of the group to that which will next come before us. On the other hand, if they possess any circulatory system, it is so obscure as not hitherto to have been discovered with certainty, so that in this respect they stand much below the Annelids. In one division of the *Polyzoa* the tentacles do not make a complete circle, but are arranged in the form of a crescent or horse-shoe, and when this is the case a flap-like organ overhangs the mouth.

BRACHIOPOD.

The next step to be taken is one that must be still considered open to doubt, for the true position of certain animals, which in former and very remote ages flourished in vast numbers, but are now comparatively speaking rare, seems to be by no means determined. These form the group called *Brachiopoda*, and comprise two divisions chiefly known by their fossil remains. One of these includes all the animals known as Lamp-shells or *Terebratulæ*, and the

* See Gosse, as before, pp. 60—62.

other *Lingula* and its allies. In all these creatures we have the body enclosed by a hard "bivalve" shell, that is, a shell composed of two pieces or valves, which can be opened at will, turning, as they generally do, on a kind of hinge. But these shells differ much from ordinary "bivalves" in that they are always equal-sided, but never equal-valved.* Most of the species which still live affix themselves to the station they occupy by a long muscular stalk, which in one division, that of the *Terebratulæ*, passes through a round hole in the deeper shell, while in the *Lingulæ* it emerges from between the valves; but in another section (*Craniidæ*) the animal attaches itself by the very substance of the shell. The most distinctive character, however, which these creatures possess is that afforded by their long fringed arms, which, when the animal is at rest, are spirally coiled up and packed away in the shell, occupying the greater part of the included space; but when food is being sought they are protruded. The intestine takes a bend, similar to that of the *Polyzoa*, towards the side where the nervous system is seated.

The animals known as *Tunicata* or Ascidians form another section of this group. They have no shell, but are protected by a thick leather-like casing in the form of a bag with two openings, within which is suspended a second bag, in appearance almost similar to the first. Many of them are compound animals, with their outer casing continuous; others are single, while there is one section of which the members are alternately compound and single—one generation being in the one condition, and the generation from which it sprang, as well as that which springs from it, being in the other. Beside the two layers enveloping the animal there is within it a third bag or chamber—the breathing organ, generally of comparatively large size, and communicating with the rest of the body by rows of apertures in its walls. In these Ascidians the intestine is bent away from the

* That is to say, that the right and left side of each valve are alike and equal, but the two valves are unequal and unlike.

encroached upon by the bony *vertebræ* as they are formed. The notochord indeed is only persistent in the lowest forms of the *Vertebrata*, certain Fishes. This is the case in the Lancelet (*Branchiostoma**), with which the series of existing Vertebrates begins, but it

LANCELET.

is also found in the Lamprey (*Petromyzon*) and some others. As we ascend in the scale we find the notochord gradually invaded by bony matter, until this last usurps nearly the whole of its space, and, in the form of segments shaped like an hour-glass, constitutes the perfectly distinct and peculiar biconcave *vertebræ* which are characteristic of the majority of Fishes.

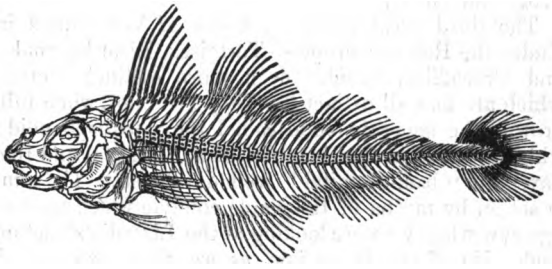
The *Vertebrata* are by almost unanimous consent separated into five groups or Classes:—i. Fishes (*Pisces*), ii. Amphibians (*Amphibia*), iii. Reptiles (*Reptilia*), iv. Birds (*Aves*), and v. Mammals (*Mammalia*).† Of these five Classes some present greater resemblance to each other than the rest, and if we care so to do, we may link together the *Pisces* and *Amphibia* under the name of *Ichthyopsida*—or Fish-like creatures, and the *Reptilia* and *Aves* under the name of *Sauropsida*—or Lizard-like creatures; but we must leave the *Mammalia* to stand alone.

The enormously varied structure of Fishes, the animals composing the first of these classes, renders their definition a matter of great difficulty. If we except the Lancelet, already mentioned, and a few others, we should have a good character in the heart, which in all other Fishes is divided into two chambers, one

* By many writers this animal is scientifically called *Amphioxus*, but *Branchiostoma*, as the oldest name, ought to be used.

† There are some naturalists who limit the number of Classes to four, not recognising the *Amphibia* as a Class distinct from the *Reptilia*.

called an "auricle" and the other a "ventricle." But this will not hold as regards the Lancelet, which is devoid of any special heart, while the Mud-fish (*Lepidosiren*), and perhaps some more, possesses two auricles. Perhaps the single positive character that can be laid down is that Fishes are the only *Vertebrata* which possess "median" fins (that is fins situated along the median or middle line of their body) supported by spikes of bone—"fin-rays" as they are called, but even then it is doubtful whether all Fishes possess such fins. As a negative character (the most unsatisfactory kind of character it must be admitted) may be added that when limbs are present they are not composed of



SKELETON OF HADDOCK, SHOWING MEDIAN FIN-RAYS.

three segments as we find to be the case in all other Vertebrates which possess limbs. Some other negative characters exist, but they are of a kind too recondite to be noticed here.

The Amphibians in many points resemble Fishes. For a longer or a shorter time they breathe by means of gills as Fishes do, and not by lungs like the higher *Vertebrata*, and a single median bone, called the "parasphenoid," is found under the base of their skull as in Fishes. Though some of them possess median fins, these fins are not supported by fin-rays, and when limbs exist they always present the three segments exhibited by the limbs of the higher Vertebrata.

Several characters distinguish them from the next Class, the Reptiles, as the (at all events temporary and in some cases perhaps permanent) possession of gills, the want of claws on the feet of those which are footed, and the fact that the skull is articulated with the *vertebræ* of the neck by means of two distinct "condyles," situated one on each side of the large hole through which the spinal marrow communicates with the brain, and there is an utter want of a certain bone at the base of the skull called the "basi-occipital," which bone in the higher Vertebrates contributes largely towards forming the articular connection between the skull and *vertebræ* of the neck. To the Amphibians belong such animals as the *Cæcilia*, Axolotl, Salamanders, Newts, Frogs and Toads.

The third great group or Class of Vertebrates includes the Reptiles proper—Tortoises, Lizards, Snakes and Crocodiles, besides even more distinct sections which are now all extinct.* They have not, when fully grown, the separate bone called the "parasphenoid" which is found in the Amphibians and Fishes, and they have the "basi-occipital" well developed. The skull is set on by means of the single condyle which we long ago saw when we were looking at the Lizard's skeleton: each side of the lower jaw, as we then also saw, is formed of more than one piece, and articulates not directly with the skull, but by means of the intervening bone called the "quadrate"—though in the Tortoises and Crocodiles this "quadrate" is fixed immovably to the walls of the skull, and in some of the Lizards, as well as in the Tortoises, the single condyle instead of being rounded is more in shape of a heart or even of a trefoil. In these respects, with many more that could be cited, especially certain important characters connected with the earliest development of the animal in the egg, Reptiles differ from Amphibians; and in the same respects the Reptiles resemble Birds, so that the

* These are *Ichthyosauria*, *Plesiosauria*, *Dicynodontia*, *Pterosauria* and *Dinosauria*.

alliance between Birds and Reptiles is a very close one.

The fourth group is that of the Birds. Some of their characteristics, as has just been said, they have in common with Reptiles—but taking only living Reptiles and living Birds, there can be no two classes outwardly more unlike, and no one can have any doubt in distinguishing between them. There is at once the great and obvious difference that Birds are clothed with feathers, and though these feathers may be as to their chemical composition the same as the scales of Reptiles or the hair of Mammals, it is needless to say that they have a structure vastly more complex. Then too, as distinguishing Birds from Reptiles, there is no living Reptile which has the fore-limbs fashioned as are the fore-limbs of Birds, and even the fore-limbs of the extinct Pterodactyls, though serving for flight, are made quite otherwise than are those of Birds. On the other hand the hind-limbs of the extinct Dinosaurs were framed very much like those of Birds, though it is not to be supposed that these gigantic Reptiles had the power of flight. There are three very well-defined sections of Birds—the *Saururi*, all extinct and indeed known but by one single specimen (*Archæopteryx*) now in the British Museum; the *Ratitæ*, wanting a keel to the breastbone and distinguished by many other characteristics as well; and the *Carinatæ*, possessing such a keel more or less well developed. To the former belong such forms as the *Apteryx*, Moa, Emeu, Cassowary, Ostrich and Rhea—all incapable of flight—and to the latter all the remainder of existing Birds.

The fifth and last group of Vertebrates is that of the Mammals, or animals which give suck to their young—a character in itself so remarkable that it separates them from all the rest of creation, and hardly requires any other to be mentioned. The Mammals include three sections, which are certainly better defined than are the three sections of Birds, and the distinctions between them are of greater importance, though perhaps

not quite so easily stated. There is first the *Ornithodelphia* or *Monotremata*, which is unquestionably the lowest and differs from the rest by three well-marked characters: they have but one outlet common to the digestive, urinary and generative organs, in the female the internal organs of reproduction greatly resemble those of a Bird and there is no nipple. The only animals belonging to this section are the *Ornithorhynchus*, or Water-Mole as it is called in Australia, and the Australian and Tasmanian Anteaters—*Echidna*. These last have no teeth at all, and the *Ornithorhynchus* has only teeth of a singular horny structure. The young are born in an exceedingly helpless and imperfect condition, and it is not yet known by what means the milk with which their parent is provided is supplied to them in the absence of a nipple. The next section is that called *Didelphia* or *Marsupialia*. Here the animals are when born almost as helpless as those of the *Ornithodelphia*, but are in nearly all cases received into a more or less complete pouch formed by a fold of the skin, in which are situated the nipples, and, the young being attached to them, the milk is at first forced into their mouth by the action of a special muscle. Nearly all these animals may be known by a singular formation of the lower jaw, the hind corner of which is, as it were, bent inwards, so that a considerable bony projection encroaches upon the space between the two branches of the jaw. They have besides two peculiar bones projecting forwards from the lower side of the pelvis and commonly known as "marsupial bones." All these animals have teeth. Except a few, which are found in America, the Marsupials now-a-days occur only within the limits of the Australian Region, but their fossil remains have been found in Europe and even in England. The third section is called *Monodelphia* and comprehends all other animals which give suck, from Whales and Porpoises to the Monkeys and Man. Here the young are not born until they are able to suck of their own accord; there are no "marsupial

bones," nor is the corner of the jaw bent inwards in the manner above described. But the variation of form presented by the Monodelphian Mammals is so great as to defy even their leading characteristics being here set forth. They may be covered with hair or be hairless: they may have a hundred teeth or none at all: they may inhabit the deepest seas, burrow in the ground or fly in the air: they may be gigantic monsters or almost as small as any known Vertebrate. Yet in all main points they agree, and once more proclaim that unity of plan and diversity in its execution, which so strongly marks creation from its lowest to its highest form—MAN himself. It is undeniably true that no absolute structural line of demarcation wider than that between the animals which immediately succeed us in the scale, can be drawn between the rest of the brutes and ourselves. Yet to borrow the words of a great writer:—

"Our reverence for the nobility of manhood will not be lessened by the knowledge that Man is in substance and in structure one with the brutes; for, he alone possesses the marvellous endowment of intelligible and rational speech, whereby, in the secular period of his existence, he has slowly accumulated and organized the experience which is almost wholly lost with the cessation of every individual life in other animals; so that now he stands raised upon it as on a mountain top, far above the level of his humble fellows, and transfigured from his proper nature by reflecting, here and there, a ray from the Infinite Source of Truth."

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## CHAPTER IV.

HAVING now taken a rapid survey of the mutual resemblances and differences between animals, and having shown, so far as was possible in that space, what they look like and how they are framed, it is time to con-

sider, according to the plan we laid down for our guidance in the opening sentence of this book, the changes they undergo and how they breed and grow. Taking one of the lowest forms of animal life—a Sponge—we find that what we must deem the regular mode of reproduction obtains there as in the very highest form. During summer certain Sponge-particles, ceasing from their food-gathering labour, assume the character of eggs, while other particles fill with granules, and, when ripe, burst, scattering their contents upon the eggs and fertilizing them as the pollen fertilizes the ovules of a flower. The eggs in consequence develop into germs, which make their way out and, being furnished with *cilia*, after swimming freely in the water for a while, settle themselves down and grow into Sponges like their parents. But besides this method of reproduction there is another. In one of these creatures towards autumn, when it may be reasonably supposed that the genial warmth of summer has infused the greatest amount of vigour into the organism, we find that the deeper layer of the Sponge becomes full of exceedingly small bodies of a more or less globular shape and having an opening at one spot. Each of them is a mass of Sponge-particles which has set itself apart. It ceases from all active functions, becomes coated over with a filmy substance and remains still. The whole Sponge dies down and these bodies thus "encisted," as it is called, remain uninjured throughout the winter. When spring returns the "encisted" particles emerging from their shelter grow up like the Sponge from which they were produced.

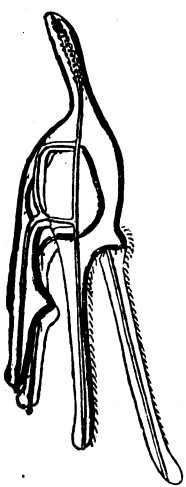
This double mode of reproduction which has its analogue in the Vegetable Kingdom is especially characteristic of the lower forms of animal life. We have it in some at least of the Hollow-bodied animals (*Cœlenterata*), of the Worms and of the Molluscoids. We have also something like it in the true Insects. In the first of the groups now named the individual constantly propagates itself by means of a process which, after the

fashion of botanists, we may call "budding;" and, what is exceedingly curious, in the case of a *Hydra*, if a wound be inflicted upon the creature its effect is to cause a new one to bud or sprout from the original stem.

As regards Worms, and especially some of those which are parasitic, facts still more wonderful have been observed, and these, as has already been promised in the last Chapter, must be here very briefly related. It is not only that some of these creatures multiply by natural "fission," as it is called—that is an apparently voluntary splitting up or division of their parts—but others regularly undergo a series of changes which is absolutely marvellous. The case of the Fluke-Worms will be enough for our consideration here. These, it is believed, are only for a part of their life-time parasitic, but it seems to be necessary for them to pass through one or more parasitic stages of existence in order to complete their career. Their final home appears to be in the body of Vertebrate animals, but in their wanderings in search of it they temporarily occupy the intestines of Invertebrates, besides for a time inhabiting either open waters or dry pasture-grounds. This however is not all. While still contained in the body of the mother, each egg develops in its interior a living being called a "nurse," which is entirely beset with *cilia*, and within that is developed another being, a "*scolex*," as different from the "nurse" which contains it as that is from its parent. This "nurse" being excluded from the egg is able to swim freely by means of its *cilia*, and for a time assumes an independent existence, but, after a while, it gives birth to the "*scolex*" it contains. This "*scolex*" becomes converted into a sluggish creature and develops in its own interior several other creatures called "tailed worms" or "*cercariæ*," which at length assume the form of Fluke-Worms like that from which the whole series of creatures has sprung. It is animals of this kind which produce in Sheep the disease known as the

rot, for the ciliated "nurses" are capable of active progression when in contact with dew or rain-drops on grass, and enter the bodies of Snails which are found in damp pastures. There the "nurses" are delivered of the "*scolex*" which each contains, and this "*scolex*" producing in its turn the "*cercariæ*," the latter are passed out from the Snail's body and are then swallowed as the Sheep grazes. Once in the digestive canal of the higher animal, the "*cercariæ*" find their way to and attack its liver, remaining there many weeks or even months, and when abundant bringing death to the "host" at whose expense they have been living.

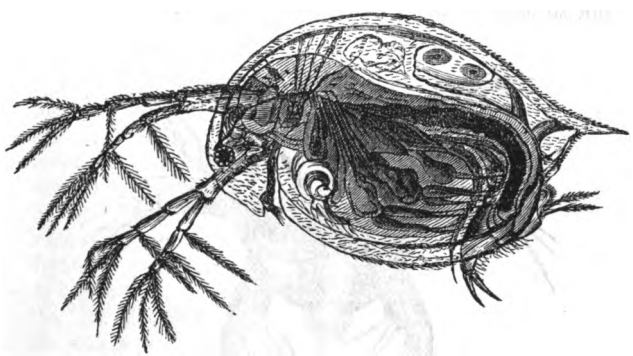
Hardly less astonishing are the changes through which some of the *Echinodermata* pass. For a long time there had been known the existence of certain strange and minute creatures, which from their singular appearance were called "Easel-Animalcules," and received the scientific name of *Pluteus*, since they called to mind the form of a painter's easel, having long rod-like projections sticking out of a body, wide at the base but somewhat pointed at the top. At length it was discovered that the contents of this body became developed into a young Echinoderm—Sea-Urchin or *Ophiura*—but the curious part is that this development is accomplished as though independent of the strange easel-like frame of the "*pluteus*," which is cast off when there is no further use for it. It is also to be remarked that this mode of development is by no means common to all the Echinoderms, since the true Star-fishes and the Sea-Cucumbers are developed in a compara-



"PLUTEUS" OF SEA-URCHIN MAGNIFIED.

tively simple manner which calls for no particular remark here.

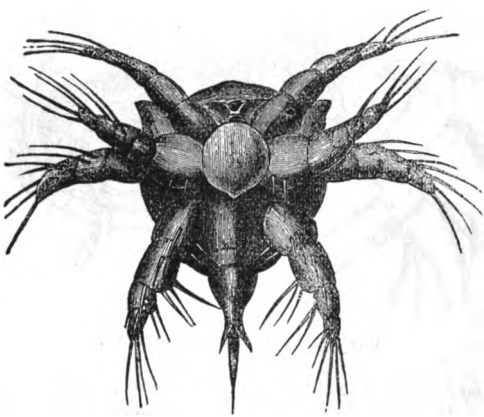
Another but more instructive state of things occurs in the *Crustacea*. The form in which the young Bernacle makes its first appearance is not only entirely unlike that of the adult, but in its second stage it can hardly be said more to resemble its original than its final condition. For convenience sake it may here be stated that, following the practice which has so long obtained among those who make Insects their study, the first stage is called the "*larva*," and the second the



WATER-FLEA (DAPHNIA) MAGNIFIED.

"*pupa*," while the third and final stage is the "*imago*." Now a Bernacle in its larval condition has none of the segments which characterize its *imago*. We have a triangularly-shaped body, prolonged in front into two horn-like projections, and a fringed tail. From the body proceed three pairs of jointed legs, whereof the two hinder pairs are forked. Now so far this description is equally applicable to the adults of a small group of animals, the Lernæans or Fish-Lice, which seem to be the lowest among the *Crustacea*. The second stage of the Bernacle presents several changes, the first pair

of legs become forked like the rest, and three posterior pairs grow, the head is definitely visible, and the single plate which covered the body is split as it were along the middle of the back into two flaps united by a kind of hinge, and each flap is drawn towards the other. The motive power of the little creature lies in its newly-assumed hind-legs, and by their means its progress in the water consists of a series of jerks. In this last peculiarity, as in others here mentioned, the animal agrees essentially with the section of *Crustacea* called Water-Fleas—a section higher than the Fish-Lice, but not so high as the Bernacles or Cirripeds.



LARVAL BALANUS MAGNIFIED.*

Now from these facts a lesson is to be learned—not only does the young Water-Flea resemble the full-grown Fish-Louse, but the larval or first stage of the Bernacle corresponds with the Fish-Louse, while the pupal or second stage of the Bernacle corresponds with the old Water-Flea. Consequently we see that in the progress

* This is the young of the animal of which a portion is figured at page 69.

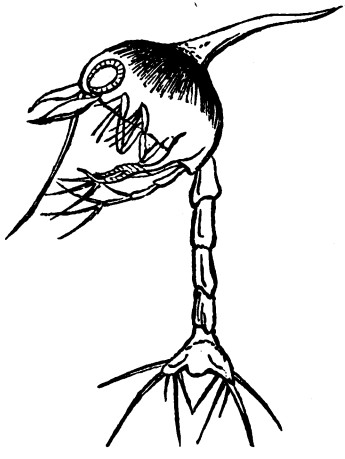
towards maturity the higher animal passes through the stages at which the lower one of the same essential structure stops. We may perhaps put the matter more plainly. Taking the number of legs as a guide, we have:—

| Three pairs of legs only— | Three pairs of legs added— |
|---|---|
| Larval Bernacle. | Pupal Bernacle. |
| Young Water-Flea. | Old Water-Flea. |
| Fish-Louse. | |

Or, taking the character of the body-plate we have the same result:—

| Body-plate undivided— | Body-plate divided— |
|---|---|
| Larval Bernacle. | Pupal Bernacle. |
| Young Water-Flea. | Old Water-Flea. |
| Fish-Louse. | |

We shall find many other instances which abide by the same conditions. In this same group of *Crustacea*, the Crabs are admittedly the highest form. Much below them come such creatures as the Lobsters, Shrimps and Prawns. But the larval Crab is so unlike the mature animal that it was for a long time thought to be an entirely distinct thing, and was, as such, described and known under the name of *Zoea*. Now this "*zoea*" is proved to be nothing but a young Crab, and its resemblance to the long-tailed *Crustacea*, such as Lobsters and the like, is unmistakable.



"ZOEA" OF CRAB MAGNIFIED.*

* This represents the young of the animal figured at page 68.

The changes which certain Insects—such as Moths and Butterflies—undergo, is known to almost everybody. Nothing is easier than to keep such an animal alive for a few days in a muslin cage, allow her to lay her eggs, and leave the eggs to be hatched in due course of time, which may be days, weeks, or months. From the eggs are produced "caterpillars," or to speak scientifically "*larvæ*." These it is necessary to supply with their proper food (and almost every such Insect feeds solely on some particular plant, without which it cannot live), and we find them to grow as fast as they feed. At last we perceive that they refuse their hitherto greedily-devoured food, some kinds grow sluggish, others show a disposition to wander—but in either case it is plain that an entire change of habit is impending or indeed has occurred. Some kinds begin to discharge a glutinous secretion, which in meeting the air rapidly hardens in the form of a fine thread, and continue to spin this thread until they completely enroll themselves in it, forming an elongated ball or "coccoon"—and this is especially the case with the Silk-worm. Others seek to bury themselves in the ground, where removed from view they form a somewhat similar though less elaborate covering. But whichever mode be adopted the result is the same—the hidden animal undergoes an entire change of form, and if after a few days we open the "coccoon" we shall find its contents to be something entirely unlike the caterpillar we saw ensconcing itself in its silken chamber, something which more resembles the seed of a plant than an animal. This is the "pupa"—a baby in swaddling clothes. It is enclosed in a hard crust, it takes no food and only occasionally shows signs of vitality by a wriggling motion of its hinder parts, which are made up of slightly movable segments. All outward legs are gone. The fore-part, which had possessed eyes, jaws and perhaps other organs, is encased in continuous shell. Leaving this for some time, looking at it occasionally only, we shall perceive that a

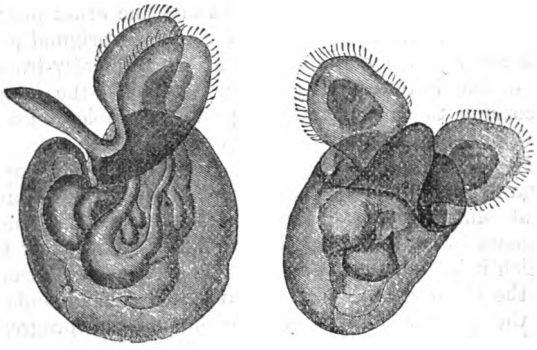
slight change is progressing, and we begin by degrees to see traced out upon its surface certain lines indicative of legs, wings and so forth. At last the crust bursts and the animal emerges in the form of the original perfect Insect whence it sprang, with its brilliantly-traced or delicately-tinted wings—the "*imago*"—the image according to so many pleasing and venerable fables of the Soul freed from its mortal bonds.

Now it is hardly possible to assert that the pupal form of such an Insect as we have just been describing is absolutely higher in the scale than its larva. There appears to be here a kind of retrograde movement for which it is difficult to account, and even among certain of the *Crustacea* (though we have cited other members of the group as examples of regular onward progress, which they undoubtedly are) a similar retrogression is known to exist. We may, however, rely upon it that a satisfactory explanation of these facts will in time be afforded, and even now some kind of explanation has been put forth which may or may not be deemed sufficient.* But cases like these stand in the way of our declaring it to be an universal law in Zoology that in the progress towards maturity the higher animals pass through stages at which the lower ones of the same essential structure stop.

Yet there is much to induce the belief that such is the general rule, though we are compelled to confess our inability to account for such exceptions as have just been cited. Among the Mollusks the *Gasteropoda* stand higher than the *Pteropoda*, and it is a known fact that the larval condition of certain Gasteropods corresponds more or less exactly with the mature condition of the Pteropods. Here is a representation of a larval *Æolis* (a Gasteropod) which may be compared with that of the adult *Clio* (a Pteropod) before given, and the essential resemblance between the two is great. But

* Compare Darwin 'On the Origin of Species,' chap. xiii. "Embryology and Development."

other Gasteropods—such as Snails—are born with their



LARVAL ÆOLIS MAGNIFIED.

proper forms. Yet to take the case of the Vertebrates, the "tadpole" or *larva* of the Frog in its original condition is hardly to be distinguished from that of the Newt, and both *larvæ* undergo the same changes until at last that of the Frog declares its superiority by losing its tail and assuming such a form as enables it to pass the greater part of its time on land. To come higher in the scale even, among *Mammalia* it is notorious that most of the different kinds of the Cat-tribe are striped or spotted in lines, but in the highest and most intelligent members of this section, such as the Puma and the Lion, these markings are only found in the whelps and are entirely lost as the animal approaches maturity.

We must accordingly put up with the exceptions we find, and, for the present, content ourselves by declaring this important law of progressive "Metamorphosis" to be, though perhaps generally, yet only partially and not universally established.

Now returning to the case of Insect-Metamorphosis, we may thence derive another weighty generalization. It has already been stated as regards the development

of some of the Centipeds,* that when they are hatched from the egg they possess but three pairs of legs, and in this respect as in others, they closely resemble the *larvæ* of most true or Hexapod (*i.e.*, six-legged) Insects. But this is just at the stage when they are about to show that they are no such thing. A batch of six new segments suddenly begins to grow near the extremity of the body—between the penultimate and antepenultimate segments, and in due time from these segments are developed four new pairs of legs. Thus the creature at this stage possesses seven pairs of legs, and presents in this respect the same character as does the caterpillar (or *larva*) of any ordinary Moth or Butterfly —for in such a caterpillar, seven pairs of legs are always to be observed, the first three pairs, growing from the anterior rings of the body, remain as the legs of the *imago* or perfect Insect; while behind them are seen four pairs of legs which only exist in the larval conditions, and, after temporarily serving the animal in that stage, altogether disappear before its final transformation. These temporary limbs of the caterpillar are called "pro-legs," and the four pairs of legs which are first developed from the newly-hatched Centiped may be fairly regarded as their homologues. But here all likeness ends, for these legs of the Centiped are permanent, nay more—new pairs are successively added to them as new segments of the body are developed and come to their full growth, until at last the animal possesses not indeed, according to the literal meaning of its name, an "hundred legs," but incomparably more than the Butterfly, which, as has been said, at its Metamorphosis loses all but its original three pairs.

We thus see that animals which eventually become altogether diverse both in structure and appearance, at an earlier period of life closely resemble each other.

* By some writers this term is restricted to the animals of one division only of the group. It is here used, in accordance with common practice, so as to include those of the division known in many places as "Gally-worms."

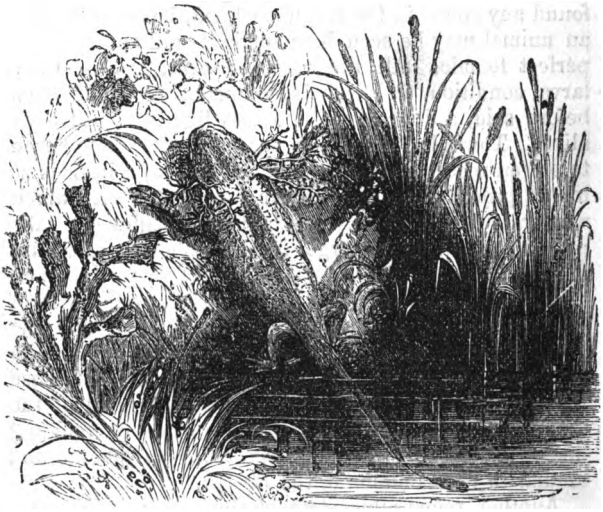
The Butterfly presents a manifest advance in the scale of organization beyond the Centiped, but it arrives at that degree of superiority not directly from the mature Centiped, but by starting earlier in its development from a common point of similarity whence each diverges —the one to become the light-shunning, creeping thing, the other to flaunt its gaudy pinions in the brightest sunshine. This is only one of the innumerable proofs that the scale of animal life is no continuous chain of links successively superior to one another, but that, united as all animals are by a common bond, this bond is far more deeply seated than would at first sight appear.

But some Insects possess a mode of reproduction almost exactly similar in its results to that which has been described as being the case among the Fluke-Worms. The curious creatures, known to gardeners as Smother-Flies or Plant-Lice, and to naturalists as *Aphides*, afford the best illustration of this mode which has obtained the name of "Parthenogenesis." In autumn the mature males and females of these animals, which in that condition are winged, may be commonly found, and often in great numbers, on very many different kinds of plants, the juices of which supply them with food. After a little while the females, like those of any other Insects, lay eggs, choosing some sheltered place on the stalk of the plant on which the animals have been feeding, or on that of some adjoining plant, and the parents die. These eggs remain unhatched during winter, but with the warmth of returning spring they hatch, and among the progeny thus hatched there are no males found. Moreover the progeny are in what may be considered a larval condition, and are easily distinguished from their parents by not possessing wings. Now so far there is not much difference between this mode of reproduction and that which commonly obtains, except the absence of any males in the progeny. But the wonderful thing is to follow. Each of these larval animals is like the rest and produces a brood of eight other *larvæ* like itself except that they

are not hatched from eggs, but are born alive. The original *larvæ* may go on repeating this remarkable process, but what is much more astounding is that from each of the *larvæ* of the second batch, or "litter" we may call it, springs a third litter exactly like the second and endowed with the same properties. This operation may continue throughout the greater part of the summer without the appearance of a single male; indeed at that season not a single perfect male is to be found anywhere in the neighbourhood, but occasionally an animal may be seen having wings and apparently a perfect female. All the rest, however, are in their larval condition, and each is competent to produce, as before said, a litter of eight others like itself, all born alive. Towards the close of summer, after from seven to eleven recurrences of this phænomenon, a litter is at length produced in which, from some cause with which we are unacquainted, development begins to take place, and these undergo Metamorphosis, becoming perfect Insects with wings, and are of opposite sexes. The females lay their eggs, as did their progenitors of the former year, both males and females die, and the offspring of these eggs carry on the succession of life as before. It is believed that the production of these living *Aphides* within the body of each animal of the preceding batch is effected by a process of budding analogous to that which takes place in plants and similar to what obtains in the *Hydra*.

Another remarkable state of things, to which allusion has already been made, occurs in the propagation of the curious animals called *Salpæ*, belonging to the group of *Molluscoidea*. These *Salpæ* are individually composed of a thin transparent membrane, through which their various organs may be plainly seen, and are generally found swimming in the form of a long chain, each individual after the leader adhering to the one which precedes it; but other *Salpæ* of a somewhat different outward form occur solitarily, and it has been ascertained that the solitary *Salpæ* are the parents of

the chained *Salpæ*, while in their turn the chained *Salpæ* produce solitary *Salpæ*. Consequently, as it has been quaintly put, "a *Salpa* mother is not like its daughter or its own mother, but resembles its sister, its granddaughter and its grandmother." This state of things is commonly known by the name of "Alternate Generation"—in the sense that each generation of beings alternates in appearance with the foregoing and the following generation.



AXOLOTL WITH EXTERNAL GILLS.

Such great exceptions from the ordinary rule of reproduction as have just been cited are limited to the lower forms of animal life. Yet there is perhaps a trace of them in a few of the higher forms. For instance the Axolotl, one of the *Amphibia*, in its final and complete condition loses the external gills which are characteristic of its immature stage; but yet it is said that by far the greater number of Axolotls possess external gills all their life long, and, though laying

eggs from which are hatched young that in time undergo Metamorphosis, the majority of the parents appear not to change. Further observation, however, is required to substantiate this statement, or at all events to acquaint us with the law, if any law exist, which governs this occasional departure from the ordinary rule that the higher animals should be perfect to perpetuate their kind.

It has been already represented that the Fluke-Worms, beside undergoing several Metamorphoses and propagating themselves by "Parthenogenesis," change their place of abode in the course of their life—at one time inhabiting the bodies of Invertebrate and at another time the bodies of Vertebrate animals. Perhaps in the whole range of Zoology no example of "Migration," as it is called, can be cited to match this. Yet Migration, though by no means universal in the animal kingdom, is in one form or another so often displayed as to be sufficiently important to deserve notice here. We have instances of what may be considered one phase of it in the lowest groups, where we find young Sponge-animals, after exclusion from the egg, swimming freely in the water prior to taking upon themselves the fixed position and sedentary mode of life in which they pass the remainder of their days. The same is the case with nearly all the creatures allied to the *Hydra*. We find it also in the Bernacles and in a very large number of *Molluscoidea* and *Mollusca*, and perhaps in all the animals that when mature are rooted, as it were, to one fixed spot. But in all these cases, including that of the Fluke-Worms, the act of Migration seems to be dependent on the stage of existence which the particular animal has reached, and it is only when we arrive at the higher forms that other causes appear to come into play and affect the movement so that it shall be more or less periodical. It is true that in many Insects external causes of some kind or other, and what they are we do not know and can hardly guess, often produce Migration, but such

Migration is for the most part uncertain. To this sort of Migration belongs the irregular visitation of Locusts, which from to time afflict whole nations in such marvellous hordes, when "the land is as the garden of Eden before them, and behind them a desolate wilderness; yea and nothing shall escape them." Butterflies also have been described by travellers in foreign countries as streaming onward for days together in numbers innumerable, all holding one course and without any assignable purpose. Here in England occasionally flights of Ladybirds (*Coccinella*) appear as unaccountably, swarming over a district perhaps one hundred miles long and fifty miles wide. The same thing is observed in the northern parts of Europe with animals far higher in the scale. In Lapland in some years, small Rodents, more or less nearly akin to our Meadow-Vole or Short-tailed Field-Mouse,* swarm in the mountains and thence descend to the valleys doing incalculable damage to the crops of the inhabitants—while perhaps a year after scarcely a single living example of the host can be seen, though the bones of the invaders lie scattered in profusion on the ground.

It is among the Fishes and the Birds that Migration at stated periods chiefly prevails. In the former case the state of our markets sufficiently proves it. Every one knows that certain kinds are "in season," to use the fishmonger's phrase, at certain times and not at others. This, in his mouth, simply means that during one part of the year they come into the way of the fishermen's nets and during another part of the year they do not. Thus is it especially with Mackerels and Herrings, though it is now known that the latter do not perform the extensive Migrations which they were once thought to do. Still their habits in some degree change with the season, notwithstanding that they do not altogether leave our shores. But a more

* Of these the best known is that called the Lemming, but generally when Lemmings thus abound, several kinds of Vole also become extraordinarily numerous.

striking instance is that of the Salmon. No Fish makes a more decided Migration than this—at one time living in the sea and at another in fresh water. Yearly the Salmon ascends such of our rivers as are suitable for its purpose, deposits its spawn and returns to the briny deep. Its habits also appear to be singularly modified during this Migration. When an adult Salmon killed in fresh water is examined it is rarely found to have lately swallowed any food, so that there is good ground for thinking that while on its inland excursions it keeps an almost perpetual fast, and the angler to obtain the coveted prize is compelled to use his utmost ingenuity in preparing "flies" to tempt its appetite.*

The case of the Salmon periodically changing its haunt for the purpose of breeding, and that to a place of quite another character, is almost exactly like what happens with a vast number of Birds. The regular Migration of these animals has attracted attention from the earliest writers. "Yea the Stork in the heavens knoweth her appointed times; and the Turtle and the Crane and the Swallow observe the time of their coming." Yet with all the light that science has been able to shed upon zoology in general, and with all the innumerable facts in reference to this point that have been accumulated, we are as regards the Migration of Birds little wiser than the ancients, and as to the means whereby it is effected we absolutely know nothing. So marvellous indeed did some of our forefathers deem the disappearance and re-appearance of certain Birds, that it was seriously supposed that they passed the winter in a torpid state, hidden in caves of the earth or plunged beneath the waters. This notion, it needs hardly to be said, is now utterly exploded and never rested on a particle of evidence that could withstand investigation. Our best known Birds-of-passage—the Cuckow, the

* In like manner the Fur-Seals are said neither to eat nor drink during the time, some three months, that they frequent their breeding stations.

Nightingale and the Swallow—have been followed to their winter retreats in the heart of Africa; while such Birds as the Fieldfare and the Woodcock, which come to us in autumn, are in like manner known to resort to more northern lands in summer. Whatever may be the case in the southern hemisphere, in our own it is certain that the periodical movement of Birds is mainly from north to south in autumn, and from south to north in spring; but that goes very little towards solving the greatest mystery of all. By what infallible means certain Birds find their way year after year from the torrid to the arctic zone and back again has never been explained and perhaps never will be. Year after year the migratory Water-Wagtail will build its nest in the accustomed spot, and year after year the migratory Cuckow will deposit her eggs in that nest, and yet in each interval of time the former may have passed some months on the sunny shores of the Mediterranean Sea, and the latter, absent for a still longer period, may have wandered beyond the Equator.* Yet it must not be supposed that Birds indulge in no irregular movements which are still to be called migratory. Investigation shews that, though nearly all are affected by what for want of a better name is termed the periodic impulse of Migration, instances are not so very uncommon of occasional irruptions as unaccountable as are the invasions of Ladybirds or of Lemmings before mentioned. As a rule, however, migratory Birds are wonderfully regular in the time of their arrival and departure, and with many of the Sea-fowls each event can be truly predicted almost to a day.

There is another subject which demands the attention of the zoologist and may perhaps be as well noticed in this place as in any other. This is a consideration of the effects produced by animals on the world at large,

* Absolute proof of the identity of the particular bird may be wanting, but if that objection be raised, the circumstance becomes still more puzzling, for then we have to account for some intelligent mode of communication between individual birds.

and, combined therewith, of the mutual relations between animals and plants, all of which it is as much the business of the zoologist to know as of the geologist or botanist. First as to the effects on the world. These are vast, though it happens that the mightiest of them are due to some of the very humblest forms of animal life. If we put a little of the dust that we can scrape off a white-washed wall or ceiling under a good microscope we shall be nearly sure of finding it to contain shells or parts of the shells of small creatures belonging to the group of Rhizopods called *Foraminifera*. These come from the chalk of which the whiting is composed, and in like manner if we wash away the finer portions of a piece of chalk, we shall find the sediment to consist almost entirely of such shells—in fact it is hardly an exaggeration to say that chalk is altogether made up of them. Now if we look at a geological map of England we shall see that pretty well half the kingdom is founded on chalk. Let us draw a slanting line across the country from the coast of Dorset to that of Yorkshire, a distance of nearly 300 miles, and to the south-east of that line, chalk, with some slight exceptions, forms the substratum of the whole land. In many other countries chalk is found as widely spread, and it has been calculated that the extent of the whole chalk-formation covers an area as large as Europe. Further, this chalk is in many places of great thickness: we may bore many hundreds of feet before we get through it. It forms, therefore, no insignificant portion of the earth's crust, and here in England where the surface soil imposed upon it is thin, as is very often the case, it gives a peculiar character to the country, affecting alike its flora and its fauna. But more even than this: creatures, just like those which ages ago formed the chalk we now see high and dry, are still engaged in making chalk at the bottom of the sea. So far as we can judge from recent surveys the whole bed of the North-Atlantic Ocean consists of fine mud, which when dried is like very soft, greyish chalk, and if examined

under the microscope presents innumerable shells of *Foraminifera* and especially of one kind, called *Globigerina*, which cannot be distinguished from the similar shells found in the ancient chalk of England. They occur too in rocks of the Lower Silurian epoch of immense antiquity, and even in hard limestones and marbles, the same shells—occasionally, so far as can be ascertained, specifically identical with living forms are to be detected by the microscope. It is thus obvious that the effects of these minute animals in modifying the surface of the earth have been and are stupendous.

GLOBIGERINA.

We may take another case. In the various oceans of the world—particularly in the Pacific, there are countless groups of islands, fertile beyond expression, teeming to the very top with vegetable and animal life, and affording a home to a large human population. These entirely owe their origin to the little-appreciated efforts of innumerable generations of coral-building Polyps, belonging to the group of *Cœlenterata* called *Actinozoa*. Not that these efforts have been mechanical or that the masses of coral-rock have been heaped up by laborious toil. The animals that are their cause can no more help forming these stony structures, than we can help having bones in our bodies or than the *Foraminifera* can help having shells. The coral-rock is a secretion of earthy matter from the aliment which the animal receives, produced by the parts of the animal fitted for the secreting process. These masses of rock founded in the depths of the ocean and built up to the height of hundreds of feet are undoubtedly caused by a sinking of the sea-bed. Why the sea-bed sinks is a matter for the geologist.* But the zoologist knows it to be a peculiarity of the animals which form coral

* See Bonney, 'Manuals of Elementary Science. Geology.' Society for Promoting Christian Knowledge, pp. 74—76.

that they cannot live at a greater depth than twenty or thirty fathoms beneath the surface. Below this the stimulus of light and heat becomes too feeble to maintain their vital powers. On the other hand a very short exposure to the sun's rays kills them, and unless they are constantly immersed in water, or washed over by the surf they cannot live. Some kinds indeed seem only to thrive and attain their full growth when they are so placed that the waves break over them with their fullest force. Thus in whatsoever situation the coral of such an animal is found, it is certain that it must have been formed within thirty fathoms or thereabouts of the surface. If it be found at the top of some hill, and it occurs in the Ladrones at the height of 600 feet above the sea, we may be sure that it has been lifted up by the elevation of the base upon which it was originally deposited. If it be dredged from the depth of 200 or 300 fathoms, as at Keeling Island, it must have been dragged down so far by the subsidence of its foundation, and thus the geologist is helped in his arduous investigations by the observations of the zoologist—but the zoologist must equally stand amazed if he compares the results of man's handiwork with those of the unintelligent coral-making Polyp. To protect his shipping man builds a breakwater like that at Plymouth, at Alderney, at Cherbourg or many other places. He embanks a portion of a river like the Thames or the Seine. Such achievements are justly accounted among the triumphs of engineering skill, but what are they to building whole groups of islands such as the Bermudas and the innumerable clusters that stud the Pacific? or what to running an embankment along a coast for a thousand miles? Yet such feats as these are among those which the coral-animals have done. The north-eastern coast of the great island-continent of Australia is fringed throughout its entire length by what is called the Great Barrier Reef, and every inch of it is the work of these simply-formed Polyps—animals among the lowest in creation. One cannot but

be struck with admiration at the huge consequences produced by these humble agents of the Creator!

Having thus seen some of the effects of the existence of certain animals on the crust of the globe, let us glance at those which other animals cause upon plants, and in so doing we shall become aware of the marvellously complex relations between the animal and the vegetable world. It had long been known that many plants were benefited by the visits of Insects to their blossoms for the sake of the honey there to be had—the Insects brushing off the pollen and so fertilizing the ovules, but it has lately been proved that a very large number of plants absolutely require such visits to fertilize them, and that without the agency of Insects the seed of these plants never "sets." Certain plants introduced to one country from another, and unaccompanied by the necessary Insects are altogether barren. Mr. Darwin has given some remarkable instances of this kind. He found that an hundred heads of red clover to which Bees had access produced 2,700 seeds, but the same number of heads purposely protected against the visits of Bees produced not a single seed. Moreover Humble Bees alone visit red clover, as other Bees cannot reach the nectar, and hence we may infer that if the entire race of Humble Bees were to become extinct or very rare in England, the red clover would likewise become very rare or wholly disappear. Now the number of Humble Bees in any one district seems to depend in a great degree on the number of Field-Mice, which destroy the Bees' combs and nests; but the number of Mice, as every one knows, is largely dependent on the number of Cats. Hence it is quite credible that the presence of Cat-like animals in large numbers might determine, through the intervention first of Mice and then of Humble Bees, the frequency of certain flowers in that district.*

Conversely the presence of certain plants enormously affects the animal life of a district. We cannot per-

* 'Origin of Species,' chap. iii, "Struggle for Existence."

haps point to any case in which a plant has of itself extended the limits of its geographical range,* but wherever the agency of man (whether intentionally or not) has introduced to a district a plant hitherto unknown there, and that plant has overrun the country, as has been the case in many of our colonies, the former balance between the animal and vegetable kingdoms is altogether disarranged. Even as the eminent naturalist just named has said, the mere fact of planting Scotch firs on a heath, not only materially alters the character of the surrounding flora, but it has a much greater effect on the fauna. In such a case, as is within the knowledge of the present writer, certain Insects speedily begin to swarm, wood-haunting Birds and even Mammals (the Squirrel for example) begin to abound, while those kinds of animals which formerly inhabited the spot are banished.

Thus it will be seen that the mutual relations of Animals and Plants are, as has been asserted, marvellously complex; and some idea may be formed of the changes which have been brought about by the introduction of Oxen, Sheep and Horses—many of which have run wild and are now found in vast herds—to America and Australia. First they affect the herbage and the herbage reacts upon some of the aboriginal fauna, these again upon others of the flora and so on indefinitely. But we cannot here pursue this subject of Man's interference further. Though his wilful efforts when backed by all the appliances of science and art are but as nothing, compared with the effects produced by the puny Polyps and Rhizopods already noticed, yet it must be allowed that unconsciously he is the great disturber of creation. If the materials for such a history could be collected, it would probably be plain that he has revolutionized the globe in a way that few people suspect. There is good reason for supposing

* One of the Ants (*Atta barbara*) is supposed to be an agent in extending the growth of certain plants. See J. Traherne Moggridge, 'Harvesting Ants and Trapdoor Spiders,' p. 55,

that the number of different kinds of animals which by his means, within the last two or three centuries alone, have become extinct is very large, and the number of those which will shortly share the same fate is likely to be larger. He is not even aware how literally true it is that the dominion over all living things has been put under his feet.

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## CHAPTER V.

To say much on the subjects of where and by what means animals live and what food they eat would be here impossible. A library of books might be written on these topics alone without in any way exhausting the interesting and wondrous series of facts that would be disclosed. What can be more extraordinary than the habit of a certain small Crustacean, called the "Brine-Worm" (*Artemia*) because it lives in the very strongest brine of salt-pans (only appearing to thrive where the water is so highly saturated as to give ¼lb. of salt to the pint), and, so far as is known, there alone? What can be more singular than that another Crustacean (*Birgus*) allied to our Soldier-Crab, should feed upon the contents of fallen cocoa-nuts? "It begins", Mr. Darwin tells us,* "by tearing the husk, fibre by fibre, and always from that end under which the three eye-holes are situated; when this is completed the Crab commences hammering with its heavy claws on one of the eye-holes till an opening is made. Then turning round its body, by the aid of its posterior and narrow pair of pincers, it extracts the white albuminous substance. I think", he adds, "this is as curious a case of instinct as ever I heard of, and likewise of adaptation in structure between two objects apparently so remote from each other in the scheme of nature as a Crab and a cocoa-nut tree."

* 'Journal of Researches.' Ed. 1852, p. 463.

Volumes have been devoted to the habits and instincts of Insects. To take the various kinds of Ants alone, the details of their economy have an almost endless interest. Those which are found in England offer the observer who will take the trouble to think as well as to look sufficient to occupy his attention,* but some of those which are peculiar to tropical countries present still more remarkable features in their manner of life. Here is an account of the habits of one of the Foraging Ants (*Eciton*) condensed from that given by Mr. Bates.† These creatures range in large armies throughout the densest parts of the forests of Brazil. The principal column, from four to six abreast, marches forward, clearing the ground of all animal matter, dead or alive, throwing off here and there a thinner column to forage for a short time on the flanks of the main body, and reenter it again after their task is accomplished. On meeting with a place rich in spoil, such as a mass of rotten wood abounding with insect *larvæ*, a delay takes place, and a strong force is concentrated upon it. Then the excited creatures rush in, search every cranny and tear in pieces all the large grubs they can drag to light. To them even Wasps' nests are no impregnable fortresses; the Ants escalade the low shrubs on which the nests are built, gnaw away the papery covering to get at the *larvæ* and *pupæ*, and, regardless of the infuriated owners, cut everything to tatters. These Foraging Ants never march far on a beaten path, but prefer the tangled thickets where it is seldom possible to follow them. Whenever they are on the march and wherever they move the whole animal world is set in commotion and every creature tries to get out of their way. Yet they are not always marauding. In sunny glades the hosts sometimes halt, and, while the columns preserve their relative position, the ranks are broken and the plun-

* Some very interesting facts as regards the economy of South-European Ants and Spiders will be found in Mr. Moggridge's book before cited.

† 'The Naturalist on the River Amazons,' ii., pp. 358—365.

derers walk about slowly, busying themselves with brushing their own or their neighbours' antennæ. Here and there an Ant may be seen, stretching forth first one leg and then another to be washed by a comrade who performs the task by passing the limbs between his jaws and tongue, finishing the process by giving the antennæ a friendly wipe. Other kinds of *Eciton* there are which are blind, and these are great engineers moving wholly under covered ways, of the length of from 100 to 200 yards, which they construct rapidly as they advance, and, thereby protected, push on till they reach a hunting-ground in the shape of a rotting log into the crevices of which they pour in search of booty.

Indeed there are Ants which as engineers put men's skill to the blush even as much as do the Coral-Polyps. When we think of the time and the human lives that were lost in making the Thames Tunnel or the Metropolitan Railways we cannot but be amazed at finding that Ants of another group (*Œcodoma*) have been known, in the pursuit of their living, to pierce a tunnel under a river, at Rio de Janeiro, where it is as broad as the Thames at London Bridge. The chief visible occupation of Ants of this group is the cutting out of portions of leaves in a circular form and then making away homeward with them, bearing them in an upright position between the jaws to their underground nest. It used to be supposed that the animals either ate the leaves or thatched the entrances to their dwelling with them, but a recent traveller, Mr. Belt,* gives us a very different explanation of the practice which is as extraordinary as it was unexpected. According to this observer the Ants use these leaves as a manure or matrix, to promote the growth of a small kind of fungus on which the animals feed. He tells us that he found their underground dwellings to consist of numerous rounded chambers, almost as large as a man's head, communicating with one another by tunnels. Though

* 'The Naturalist in Nicaragua,' pp. 79—81.

the Ants were continually carrying in the cut leaves, no quantity of them was ever to be found in the burrows, and it was evident that they were used in some way as soon as they were brought in. The chambers were always about three parts filled with a flocculent, spongy-looking mass of light and loosely-connected substance, which on examination proved to be composed of minutely-subdivided pieces of withered leaves, overgrown with and lightly-united by a small fungus which ramified throughout it. In the chambers of another kind of Ant belonging to the same group he found similar masses of vegetable matter overgrown with fungus, amongst which were the Ants that act as nurses together with their charges. When a nest was disturbed the animals would be at great pains to carry off every morsel of this mass and store it again under shelter, even digging out such as was buried by the operation; while, when they migrate, they also carry it from their old habitations leaving the refuse particles of leaves, that had been exhausted, as manure for the fungus, to serve as food for the *larvæ* of Beetles.

But this is by no means all that is wonderful, not to say worthy of notice, in the economy of these Ants. In one kind, according to Mr. Bates,* the workers are of three classes, varying in size. The true working-class is formed by the smallest of these—the worker-minors, as he calls them. The other two classes, whose office is not yet properly understood, have enormously massive heads. He once thought that they exercised a sort of superintendence over the rest, but this is unnecessary when all work regularly and precisely like a piece of machinery. They cannot however be useless, and it seems to Mr. Bates as though they might serve, in some sort, as passive instruments of protection to the real workers, by becoming with their enormous, hard and indestructible heads a foil, as it were, against onslaughts made by insectivorous animals on the main body of workers.

* 'The Naturalist on the River Amazons,' i., pp. 23—33.

We have dwelt at some length on these interesting creatures, but it must not be supposed that the habits of other animals are less worth studying for the sake of the information they afford. In every group whose economy has been examined we shall find examples in endless variety of the most instructive kind. The careful out-door observer, if he will but try to understand what Nature offers to his view, will entertain a far truer and clearer idea of creation than the man who works only in the library, the museum and the dissecting-room. Not at all that such home-work—and there are some who have opportunities for no other kind of study—should be neglected; but it is the combination of the two methods which gives some of the zoologists of the present day so great an advantage over their predecessors, and it may be confidently asserted that the most glorious gains of the future will be owing to a happy intermingling of closet- and field-work.

In proof of this anticipation may be cited an instance of a most curious character, and one which, from the many wonderful instincts therein involved and revealed, is especially worthy of notice from several points of view. There is a certain bird in California—a Woodpecker, called by naturalists *Melanerpes formicivorus*, which had long been known to be in the habit, towards autumn, of making stores of acorns. But its object in yearly performing this act was by no means clear, for all admitted that it was a migratory bird, so that, when winter came and its stores would seem to be most needed, it was miles away to the southward, enjoying a milder climate. Again, all who had examined the digestive organs of Woodpeckers declared, and with truth, that they were insectivorous and only most exceptionally frugivorous birds. Thus the provident habit remained unaccounted for until one day an intelligent observer, Dr. Jackson, solved the mystery:—

"On the 4th of June", he writes,* "I made an examination of the acorns which the Californian

* 'Proc. Boston Soc. Nat. Hist.' x. p. 227.

Red-headed Woodpecker so abundantly inserts into holes made in the bark of trees. Knowing that the bird is insectivorous, I did not believe the common opinion that the acorns were eaten by Woodpeckers. The acorns are always driven into the holes made to fit them, cup-end foremost, so that the pointed end only is exposed to view. They are packed in so tightly that it is difficult to extract them without the aid of a knife. On getting out some of these acorns I found in them only the worm which had eaten up the kernel of the nut. Thus it would appear that the Woodpecker is able to select the infested acorn in which there is a minute and almost invisible egg, and puts the acorn into a hole in such a manner as to prevent the escape of the worm when it comes to maturity: as the worm can only cut through the softer portion of the shell at its base and not through the hard pointed end, so it is securely imprisoned until the Woodpecker calls for it. Since there must be a limit in time as to the procuring of the infested acorns and to the existence of the worms in the nuts, and a sudden harvest of the worms would be obtained at a particular time in the year, it seems probable that these birds lay up this store of food for their young, which must require a large supply of animal food; . . . . . Every year millions of acorns are nicely packed into holes in the bark of trees, and even in the wooden ceilings of the porticoes of houses, where a crack enlarged is made capable of receiving an acorn."

A similar instance of provident instinct is hardly to be found, and its explanation is due to an out-door observer who thought as well as saw.

One of the most remarkable generalizations in Zoology that have been established is the fact of the benefit conferred upon some animals by the resemblance of their coloration to that of surrounding objects. The discovery of this could in many cases have been hardly made and certainly not proved but by observant field-naturalists. That such a resemblance existed

among animals which permanently inhabit alpine districts or arctic lands has long been known. The greater number of the denizens of such localities, it is true, migrate to more favoured climes on the approach of winter; but of those which are resident and are exposed to the rigours of a season that for half a year overwhelms the earth's surface with snow, there are hardly any which are not arrayed in a vestment of more or less pure white. Among Mammals the Alpine Hare, the Ermine, the Arctic Fox and the Polar Bear are examples sufficient to prove the truth of this statement; and among Birds the Ivory Gull, the different kinds of Ptarmigan, the Snowy Owl and the Greenland Falcon. Of Amphibians and Reptiles it is notorious that none occur in such dreary regions. Fishes and marine animals generally do not come under the conditions required, and none of the terrestrial Invertebrates are abroad during the period of cold. The Bear, the Gull, the Owl and the Falcon, just named, preserve indeed their white clothing during the whole year; but the change of colour which takes place in the Hare, the Ermine, the Fox and the various Ptarmigans is enormous. That this change is mainly in correlation with the climate is shewn by the fact that in temperate England the Ermine only exceptionally becomes white in winter, ordinarily keeping the brown pelt in which it is commonly known as the Stoat, while in countries where the snow lies for many months it invariably becomes white. So also in still more temperate Ireland the Alpine Hare usually retains its coloured coat all the year round, but in the Highlands of Scotland it puts on a white winter-dress. Again, too, the Arctic Fox in Iceland, where the ground is comparatively seldom covered with snow for any great length of time, is more often found in its "blue" coat than elsewhere, though in other countries where it occurs an example thus clothed in winter is so rare that its skin is eagerly sought by the furriers. The Red Grouse of the British Islands, which is so nearly related

to the Willow-Ptarmigan of other parts of the northern hemisphere that some of the best authorities refuse it recognition as a distinct species, chiefly differs from its more widely-spread congener in that it does not assume a white plumage in winter; and such zoologists as maintain the former to be but a local race of the latter justly point out that its almost only distinctive character lies in this peculiarity which, taken in connexion with the less severe weather it has to endure, goes for nothing. Whatever be the causes which in all these animals induce the prevalence of white clothing, and of these causes there is here no need to say anything, it is certain that its adoption by assimilating the wearer to the prevailing snowy landscape must contribute greatly to its advantage, for thus it escapes the attacks of its foes and is left to pass its time in peace.

But this protective assimilation of hue is not confined to the animals which dwell under inclement skies. We have instances of it at home, and notably in the coloration of Birds which make their nests upon the ground, such as the Partridge, the Goatsucker and the Lark. The assimilation also not only extends to the young of such animals but even to the eggs. On the other hand, it often happens that while exemption from danger is thus accorded to the females of certain species, the males, which do not incur the same risk, are often conspicuously or even brilliantly coloured, as in the Blackcock and Pheasant. There is scarcely a group of animals, Vertebrate or Invertebrate, where we cannot find this shield of comparative invisibility thrown over such as require it. Some of the Fishes possess it in an extraordinary degree, as, for instance, certain species of the genus *Phyllopteryx*, allied to those commonly known as Seahorses (*Hippocampus*), which are ornamented with filmy streamers, in shape and colour so much resembling the fronds of seaweeds, to the stems of which they attach themselves by their prehensile tails, that there is no doubt of their thus easily escaping the observation of their natural ene-

mies.* Numbers of Insects, too, are so like surrounding objects as almost to defy the sharp eye of the trained collector and the no less sharp-eyed Birds that would prey upon them. A common South American Beetle (*Onychocercus*), which frequents only trees with a rough bark, so exactly resembles in colour and rugosity the surface to which it clings fast that, until it moves, it is absolutely invisible. Still more curious is the fact, that other Beetles there are (*Buprestidæ*) which generally rest on the midrib of a leaf, and the naturalist often hesitates before picking them off so closely do they resemble the dung of birds; while there is another (*Chlamys*) which is indistinguishable to the eye from the dung of caterpillars, and some Insects (*Cassidæ*), from their hemispherical form and pearly-golden colour, resemble glittering dewdrops on the leaves.† In almost every museum may be seen specimens of some of the various Stick- or Leaf-Insects, as they are commonly called, according as they resemble the twigs or foliage of trees, which belong to the Orthopterous group *Mantidæ*, and the larval stage of another kind (*Phasma*) is not, until shaken out, to be distinguished from the moss in which it conceals itself.‡ Even in England we have a Moth (*Gastropacha quercifolia*) that looks like a little heap of withered oak-leaves.

Leaving these very remarkable and to some extent exceptional examples of protective resemblance, we may turn to countries which, though the very opposite from those snowy regions in reference to which we introduced the subject, are as well characterized by the uniformity of coloration exhibited by their denizens. And the case is perhaps the more instructive, for we may compare the animals which inhabit equally the borders of a burning, sandy desert and the desert itself. Whether it be Mammal, Bird or Reptile, Mol-

* Compare Günther, 'Proceedings of the Zoological Society,' 1865, p. 327, pls. xiv. xv.

† Wallace, 'Contributions to the theory of Natural Selection,' pp. 56—58.

‡ Belt, 'Naturalist in Nicaragua,' p. 382.

lusk or Insect, the dweller in the desert may resemble that dwelling on its borders in everything but tint. Of the Great African Desert writes Canon Tristram* (and nearly the same may be said of all the deserts of the Old World): "Where neither trees, brushwood, nor even undulation of surface afford the slightest protection from its foes, a modification of colour, which shall be assimilated to that of the surrounding country is absolutely necessary. Hence without exception, the upper plumage of every bird, whether Lark, Chat, Sylvian, or Sandgrouse, and also the fur of all the small mammals, and the skin of all the Snakes and Lizards, is of one uniform isabelline or sand colour."

But more than this, some animals most curiously resemble other animals to which they are not nearly related, and this is especially observable among certain groups of Insects. The fact was long ago known, and, though it was to the great entomologists Kirby and Spence that the idea first occurred that the resemblance might be a real advantage to one of the two animals, it is Mr. Bates who deserves the credit of having shown how important a character this resemblance is in the economy of Nature. In particular certain Insects of various groups are so exceedingly like certain others belonging to a group of Butterflies (the *Heliconii*) that the latter may metaphorically be said to be mimicked by the former, and hence the term "Mimicry"† has since been extensively used to indicate resemblance of this kind. Struck with the circumstance, Mr. Bates was led to investigate the matter, and, induced by the consideration of such examples as we have cited, wherein it is clear that many animals obtain a deliverance from their foes owing to their protective coloration, he judged that some such explanation might be afforded of the facts which had been so pro-

* 'Ibis,' 1859, p. 430.

† A misleading word unless prefixed by "unconscious," or something of that sort; for it might be supposed to signify that one animal voluntarily imitated the other, which of course it does not.

minently brought to his notice. Nor was he herein mistaken. Though these *Heliconii* are adorned with beautiful, brilliant and varied colours, and are thus rendered exceedingly conspicuous in the South-American forests they frequent, they are generally seen there more abundantly than any other kinds of Butterflies; while, unlike many of such animals, they possess none of that protective colouring often seen in the lower side of the wings, which is exposed when those members are folded—a colouring that serves to conceal its wearers when at rest. They fly slowly and weakly, and would certainly be caught by Birds more frequently than any other Insects, but their great abundance shows that they do not suffer from any such persecution; and, as a matter of fact, a careful observer like Mr. Bates never saw them pursued by any predaceous animals. But they are characterized by having a very strong and offensive odour, with which is probably combined a nauseous flavour, and in these two properties lies almost unquestionably the hitherto unexplained secret of the immunity from attack which they enjoy. If this be so, it follows that a similar immunity should be enjoyed by the other Insects which are, as it were, disguised so as to be commonly mistaken for them by Birds, though such other Insects do not possess either of the disagreeable attributes mentioned.*

From what has been advanced in the last paragraph but one it will be seen that some animals vary in appearance according to the physical features of the district they inhabit. It was there stated that dwellers on the borders of a desert differ but in tint from those inhabiting the desert itself. The same kind of thing may, to a greater or less extent, be observed in numerous other cases. It seems certain that animals haunting shady woodlands have a darker coloration than those which, though otherwise like them, inhabit open districts more exposed to the influence of light. At present we cannot pretend to account for the fact,

* 'Transactions of the Linnean Society,' xxiii. pp. 495—566.

but fact it appears to be. So also animals belonging to countries in which the rainfall is great seem to be more dingily coloured than those of countries where the rainfall is less, or, at any rate, less incessant. The British Islands, it is known, receive more continuous rain than most parts of continental Europe, and, as a rule, the colouring of our indigenous animals is more dull than those of France or Germany, so that a practised eye can often at once tell the locality whence comes any specimen. The Squirrel and the Common Fox are examples among Mammals, and the Yellow Bunting and Blue Titmouse among Birds, while among Insects the difference between British and foreign examples is in many cases notoriously obvious. But the variation thus dependent on locality is not always confined to colour; it is very often sufficiently remarkable in size, and occasionally in the form of certain organs. Mr. Wallace has pointed out* that almost any Butterfly of the genus *Papilio* inhabiting the island of Celebes has the wings of a peculiar shape, distinguishing it at a glance from the allied Butterflies of every other island. This peculiarity lies in the upper wings being longer and more falcate and having the anterior margin much more curved, while in most instances the same margin exhibits near the base an abrupt bend, which in some cases is very conspicuous. Of this fact no explanation which is not conjectural can yet be given, but the fact remains.

Just as worthy of remark are the distinctive features offered by the animal inhabitants of islands more or less separated by great distance or by continual adverse winds from other lands. It is well known that what are commonly called "Oceanic Islands"—or islands situated in mid-ocean, and thus far removed from any mainland, are, with some exceedingly rare exceptions, devoid of all Mammals and Amphibians; while Reptiles, save those like the Sea-Snakes and some Tortoises, which can traverse a great expanse of salt water, are

* 'Transactions of the Linnean Society,' xxv. p. 16.

only less scarce. The peculiar fauna of such islands has not met with so much attention as it ought to have done, and it is only in a few of them that any groups have been at all well worked out. In what have been termed the Atlantic Islands, namely the Madeiras, Azores and Canaries, this, however, has been well effected by Mr. Wollaston as regards the Beetles, and by Mr. Godman as regards the Birds, while the same groups of animals have been to some extent treated of in certain other isolated spots. Now, the majority of the Beetles of the Madeiras show an unmistakable affinity to those of the African portion of the Palæarctic Region, while others have their nearest allies in Spain and Portugal; but nearly all the Insects found in the Madeiras differ from their continental representatives in one of two ways—either their wings are so much reduced in size that the animals are incapable of flight (and this happens in most cases), or their wings are so much developed that their volant power becomes much greater.* It may therefore be surmised, and not without reason, though proof of course is wanting, that the Beetle-population of the Madeiras is of the same origin as that of the nearest continents, and that in the process of time the ordinary type of Beetle has been eliminated, through the individuals possessing wings of moderate size running the greatest chance of being blown out to sea and perishing, while the Beetles with the smallest wings, taking shorter flights, have been spared that risk, until finally those in which the wings were scarcely or not at all developed have become the most numerous. But, on the other hand, Beetles having a tendency to grow larger and larger wings have overcome the same danger by possessing the power of regaining the land when caught by a furious blast.

As regards the Birds of these Atlantic Islands, Mr. Godman has shown that many of the resident species invariably possess a thicker bill and stouter legs than

* Wollaston 'On the Variation of Species,' pp. 81, 99.

do their continental brethren, but no indication of an altered wing-development has been noticed.* Yet if we turn to other islands, we shall find that, while the same tendency to variation in the bill and legs is observable, it is also coupled with a shortening of the wings. Two illustrations of this assertion may be sufficient. The preeminently "Oceanic" island of Tristan d'Acunha is inhabited by a Moor-hen (*Gallinula*) in general appearance so like that of Europe that for a long time no one discovered the difference between them; but, while our own familiar bird can take very long flights, the wings of the other are on examination found to be so short that there is reason to think that it cannot fly at all, and for purposes of locomotion depends entirely on its largely-developed legs.† In like manner one of the Seychelle Islands has a peculiar Turtle-Dove (*Turtur*), differing only from a widely-spread Turtle-Dove, found on the neighbouring islands, in its stronger bill and legs and in its shorter wings.‡

Here there is not room for more instances of the kind. Our only object is to show the existence of local variation, of which thousands of examples might be brought forward, and, except in the case of the Madeiran Insects, it is not now advisable to hazard any possible explanation of the means by which such variation has been effected. It is enough for us to be sure that it exists, and that it is not the work of chance, but has been brought about by the operation of some law, whether that law may ever be made known to us or not. One other result, however, follows from the consideration of local varieties or "Races." That is the impossibility of defining in any but an arbitrary way the difference between such Races and what naturalists have long been accustomed to call "Species"—attaching to that term some hidden meaning, some mystic

* 'Ibis,' 1866, pp. 88—109; 1872, pp. 158—177, 209—224.
† 'Proceedings of the Zoological Society,' 1861, pp. 260, 261.
‡ 'Ibis,' 1867, pp. 354, 355.

virtue, about which nevertheless hardly any two men are agreed. Whatever signification be given to it, the word "Species" is a convenient one, and at present few naturalists would be able to get on without it, but though its use may be trusted in the mouth or from the pen of a true naturalist, there is scarcely a word which by the quasi-naturalist is more abused.

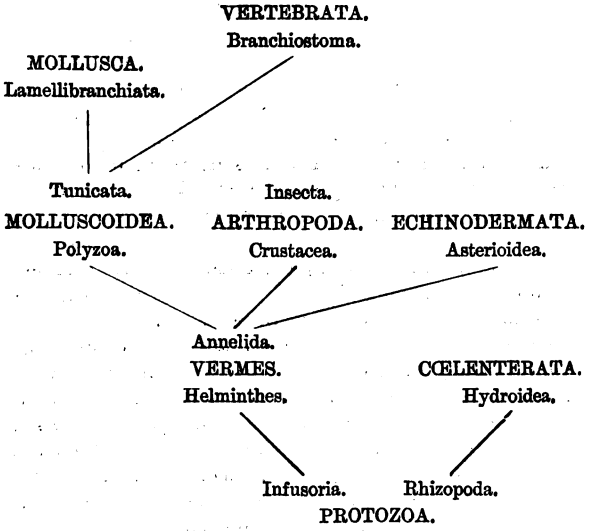
What after all if it should turn out that a Species was but an idea? One can hardly say that such is impossible. Everybody who uses the word ought, one would think, to be able to give it a precise meaning. There is no need to recapitulate the various definitions of the word which have been set forth: there is scarcely one which does not imply some presumption incapable of proof or some postulate which a logician would hesitate to grant. Perhaps the most reasonable explanation of a Species is that, when a difference is discernible between any two beings which is greater than an individual difference, one is entitled to call that difference *specific*. But anybody acquainted with the subject must know that people—even those best qualified to judge—will not agree even as to the limits to be set to individual differences. Thus any definition of a Species seems as far from our reach as ever. We must face the difficulty that the boundaries between a Race (that is a local variety, which may be of the slightest) and a Species are at present indeterminable. But if this be so it follows naturally that the differences between what forms a Species and a Genus, a Genus and a Family, a Family and an Order, an Order and a Class are just as vague and arbitrary. We may admit that the difference between a Species and a Genus is greater than that between a Race and a Species, that the difference between a Genus and a Family is greater than that between a Species and a Genus, and so on with regard to Orders and Classes, but the upshot is still the same—no one can draw a hard and fast line between any two of these groups—the character that we rely upon in one, two or many cases breaks down in the next, and the

result would seem to be hopeless confusion. Yet we need not despair of evolving something like order therefrom. Granted that a Species be but an idea and that if Species go all higher groups are equally ideal and must go too. Every one will allow that the source is distinct from the brook, the brook from the river, the river from the estuary and the estuary from the sea—yet who will venture to lay down the exact boundaries between sea, estuary, river, brook and source. The one merges insensibly in the other, just as do the Race, the Species, the Genus and so on. There was a time, and that not long since, when each of these groups was looked upon as a concrete entity having an independent existence, and some men there are who still so regard them; but whether that belief is destined to be perpetuated or restored may well be questioned. It would seem rather that each of these groups exists, as a group, but in the abstract—connected so intimately as they are and that most of all by the common bond of life—the life which is the cause and not the effect of organization and is itself the gift of the Creator.

Should we wish to express more clearly how this common bond of life unites the whole animal world, we cannot do so better than by adopting the form of a genealogical tree with its various branches, nearly as it has been drawn by Professor Allman.* Starting from the PROTOZOA as the root, we are led on one side through the Rhizopods to the Hydra-like animals of the group CŒLENTERATA, and there that line soon comes to an end; but from the Infusories, which may be regarded as on a level with the Rhizopods, we pass to the lowest group of the VERMES, namely the Helminthes, and thence to the Annelids or highest. Here we find our tree sending forth three branches, two of which, the ECHINODERMATA and ARTHROPODA, are connected with the stock by the Starfishes and Crustaceans respectively, while the third, through the *Polyzoa*, shoots upwards to

* Address delivered to the Biological Section of the British Association at Bradford, 1873, p. 5.

the Tunicates, the highest group of the MOLLUSCOIDEA. Thence again arise two branches, one not extending very far and ending in the MOLLUSCA, while the other points to the Lancelet (*Branchiostoma*), the lowest member of the great group of VERTEBRATA. Arrived there the general sequence, as it has been already given in this book, is plain, and the series of creatures culminates in Man.




But then this common bond of life; is it indeed more than a mere phrase, or is it as many now think a reality? and if it be a reality how is it caused? Those questions relate to matters too great and too obscure to be here considered. Reality or not, caused in one way or another, it is enough that we should read and believe:—"As for our God He is in heaven; He hath done whatsoever pleased Him."

LONDON: Printed by Jas. Truscott & Son, Suffolk Lane, E.C.

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