AN EASY OUTLINE

OF

EVOLUTION

BY

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PREFACE

THIS book is written for those who have not yet read any connected account of Evolution. Many technical matters have, therefore, been sacrificed to the primary objects of simplicity and clearness. There are plenty of books on this important subject to be read by the more advanced student, and a list of these is given at the end of the present work.

The doctrine of Evolution does not explain everything: many things will become clearer when the investigation of the world has been carried to a sufficiently advanced stage. Still, the teaching of Evolution has done more to clear up the mysteries of life than has any previous view of the origin of things. And it is a striking fact that every new discovery in regard to plants and animals helps to show that the theory of Evolution is the true and natural account of the world and all its inhabitants.

When we try to give a popular statement of Evolution, we are met by two difficulties—first, the overwhelming number of facts which go to prove the truth of the doctrine; second, the many hard words used by scientific men.

It must always be borne in mind that in this outline I am not able to furnish one-tenth of the facts on which the doctrine of Evolution is based.

As for the words, I have explained all those of a special character which I have been compelled to use. If the student who may still have some doubts as to the meanings will carefully read three or four chapters aided by a dictionary, he will soon find his difficulties disappear.

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DENNIS HIRD.

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INTRODUCTION

In order to make our subject easier, it is well to explain some words.

We are to deal with the facts of science. Science (from the Latin *scire*, to know) is the knowledge of the order of nature, as found out by observation, experiment, and reason.

Professor Ray Lankester puts it thus: "Science is that knowledge which enables us to demonstrate, so far as our limited faculties permit, that the appearances which we recognise in the world around us are dependent in definite ways on certain properties of matter; science is that knowledge which enables, or tends to enable, us to assign to its true place in the series of events constituting the universe any and every thing we can perceive."

This may be put more briefly: Science is the knowledge of the laws governing the forces of nature. Or: Science is exact knowledge.

Substance is another word for the matter of which all things are made. It has the properties of extension, inertia, weight, motion, etc.

Law is a generalised, arranged statement of facts—a general rule, or constant mode of action of forces or phenomena

A phenomenon at first simply meant anything manifest to the senses. The plural is phenomena, and the word is used to include all the objects, and motions, and changes which make up the universe. Phenomena are the only things we can know. Anything not a phenomenon would lie outside the range of man's experience and reason, and could not, therefore, be known to him. Some philosophers divide all things into the phenomenal and the *real*. What the real is we have no means of knowing, because, if it is something different from phenomena, it is outside of human experience. Perhaps Dr. Paul Carus is right when he says "the phenomenal is real." At any rate, it is the real for us, who know and can know nothing else. By some thinkers all phenomena have been reduced to matter and motion, or matter and energy. Of the *real* nature of matter and energy we know nothing yet.

But it has been found that neither matter nor energy can ever be destroyed. So that we know that matter and energy never had a beginning and cannot have an end.

This important truth is often called the indestructibility of matter and the persistence of force. Force is another word for energy. But some writers use force for the power which drives the particles of matter together, and energy for the power which drives them apart. If we adopt this distinction, then force is said to be centripetal (making to a centre), and energy is said to be centrifugal (making *from* the centre).

As a rule, we know matter in the mass, or, as we say, in large pieces or forms. These forms are made up of very small bodies, called molecules, and the molecules are made up of atoms.

Molecule (from *molecula*, a little mass) is the smallest quantity into which the mass of any substance can be physically divided and retain its characteristic properties, or the smallest quantity that can exist in a free state. A molecule may be *chemically* separated into two or more atoms.

The integrity and properties of a substance reside in its molecules.

Molecular means that which belongs to or is made up of molecules.

Molecular motion is the movement of the molecules of a substance *within* that substance.

Atom (what cannot be divided: from *a*, not; *temno*, I cut) is the smallest unit of an element; that part of a substance incapable of further division, or the smallest part which can enter a chemical compound, or unite with another atom to form a molecule.

Atomic is of or belonging to atoms.

Atomicity is the chemical power of an atom.

Certain substances are called elements. An element (from *elementum*, a first principle) in *chemistry* is a body which cannot be decomposed into simpler substances. The recognised elements now number about seventy-three, such as hydrogen, oxygen, iron, lead, etc.

In ancient times men thought there were four elements—earth, air, fire, and water; but none of these are elements.

Now, elements have different chemical powers—that is, when they combine with one another to form molecules they have different capacities.

Hydrogen is an element with the lowest combining power, so its power is represented by one; oxygen, compared with hydrogen, has twice this power, and so is represented by two; carbon is represented by four; and so forth.

If we think of these powers acting like hands, we may understand it better. Oxygen has two hands: so, when it combines with hydrogen, one atom of oxygen joins with two atoms of hydrogen. This is how water is formed. If we have fifty atoms of oxygen and one hundred of hydrogen in a vessel, and cause them to unite, then water is formed.

The science which treats of the laws by which the molecules and atoms are governed is called chemistry. All the familiar things we use—as sugar, fats, eggs, fruit—are made up of molecules which contain atoms of the different elements arranged in many ways. This is a most important science if we wish to understand the nature and action of matter; and, with physics, it chiefly helps us to explain the basis of intelligence and the origin of life.

The word "chemistry" appears to come from the name of the Egyptian god Khem. He was the god of generation, productiveness, and vegetation. He was also the god of simple and curative herbs. The words "chemistry" and "chemist" have thus come to us from Egypt, first through the Arabic and then through the Spanish, the Arabs having adopted the word in Egypt and transmitted it through the Moors to Spain.

In biology (the science of living things, from *bios*, life) elements mean the smallest structures of a tissue which can be seen by the aid of a microscope. The word "tissue" means any web-like structure. Or the term "tissue" may be applied to a mass of similar cells. This mass may be without any well-defined form; but, if cut in any direction, it is found to be made up of a number of cells.

Atmosphere (from *atmos*, vapour; and *sphaira*, a sphere) is the mixture of gases, vapour of water, and other suspended matters surrounding the earth as an elastic fluid envelop, to the height of about two hundred miles. We commonly speak of the atmosphere as the air.

Function (from *fungor*, I perform) is the usual or special action of a tissue, organ, or parts of the body. Functional is that which belongs to the special action of an organ; for instance, it is the function of the lungs to breathe.

Physics (from *phusis*, nature) is the science that treats of the properties of matter and of the laws governing it in conditions of rest and motion, and in its solid, fluid, and gaseous states.

Physiology is the science which treats of the *functions* of organic beings.

Nature: this word is used with different meanings. It is from the Latin *natura*, which means birth, origin. Nature is the existing universe with all things that it contains, their phenomena and laws. The causes and forces that work in nature are often spoken of as one power and personified as she; and we say, She is the energy by which the many phenomena that we see are produced. Of course, nature includes the organic and the inorganic.[1]

Mechanics is the science that treats of forces and powers and their application, either directly or by the intervention of machinery. It may treat of bodies at rest (statics) or in motion (dynamics).

Metaphysics (*meta*, beyond; *phusis*, nature), the branch of philosophy which includes the investigation of the ***nature*** of mind and all things *beyond* the senses. Metaphysics, therefore, deals with the conceptions or principles behind all phenomena, including being, becoming, reality, time, space, etc. Sometimes it is called the philosophy of the ultimate nature, causes, or reason of things. It is not a science, and, as its theories can neither be proved nor disproved, it must be left to the individual judgment to decide its value.

Philosophy at first meant the love of wisdom (from *sophia*, wisdom; and *phileo*, to love). It is now used in many ways, but as a system it means "the science of principles," "perfectly unified knowledge," or "the investigation of those principles on which all knowledge and all being ultimately rest."

Now, as we do not know the ultimate nature of anything, it is clear that any philosophy must be speculative, or, in other words, rest on assumption. This accounts for the fact that one system of philosophy usually contradicts another.

Evolution is rather a science than a philosophy, though Ernst Haeckel, Herbert Spencer, and others, have done much to give us a system of "perfectly unified knowledge."

[1] All natural objects in the world may be divided into the organic and inorganic worlds; the organic world including all bodies which either are or have been alive, and the inorganic comprising all others (as sand, stones, water). Inorganic bodies are treated of in geology and mineralogy. Biology deals with organisms; it is divided into botany, the study of plants, and zoology, the study of animals. Inorganic bodies increase in size by the addition of *similar particles* to the *outside*. Organic bodies grow by receiving matter into the interior and assimilating it.

The following is a bare outline of the most important factors of Evolution :—

1. Pressure of environment. } The factors of Lamarck.
2. Use and disuse of organs. }
3. Natural selection. } The discovery of Darwin.
4. Sexual selection. }

5. Physiological selection. (Romanes and Gulick; not yet universally recognised.) "This means selection of those varieties the individuals of which are fertile among themselves, but sterile or less fertile with other varieties and the parent stock."

6. In human evolution a higher factor is present—"conscious, voluntary co-operation in the work of evolution...... This factor consists essentially in the formation and pursuit of ideals."

CHAPTER I.

LINKS IN NATURE

"Whatever may be men's speculative doctrines, it is quite certain that every intelligent person guides his life and risks his fortune upon the belief that the order of Nature is constant, and that the chain of natural causation is never broken."—HUXLEY.

WHAT is the doctrine of Evolution?

In the special sense of explaining how living things came into being, Evolution teaches that all living things, plants and animals, have come from small, simple forms, or from one earliest form.

Evolution is also termed "descent by modification." Descent is used in the sense of coming down from ancestors, as a man is said to be descended from his grandparents. Otherwise the word "ascent" would be more correct, as the higher forms of living things have really ascended from small and lowly organisms.

Modification is a word for change, and so the doctrine of Evolution may be said to signify the derivation of all living things by minute, gradual changes from some simple forms or form. Evolution shows how things have become what they are, and how they are being changed.

Evolution is sometimes called Darwinism, because Charles Darwin did so much to explain the process; but the word "Evolution" is used in a wider sense in this book.

We know now that stars and suns are made up of the same substances as our earth, and Evolution includes the history of every form of matter and force in the universe, as far as they are known.

All changes in the universe result from the nature and environment of the objects composing the universe.

Environment means everything outside myself. My nature means everything which constitutes me.

Evolution does *not* teach that all living things are constantly developing into something better. If there is no perceptible change in the environment, an organism may remain practically the same for ages. This point should be clearly understood, for many people, who do not understand what Evolution means, often make a great mistake here. Yet Darwin and Spencer, among others, have clearly pointed out that Evolution means no such thing as a universal and continuous change of all beings into something better.

Dealing with this very point, in *The Origin of Species*, Darwin says: "By this fundamental test of victory in the battle for life, as well as by the standard of the specialisation of organs, modern forms ought, on the theory of natural selection, to stand higher than ancient forms. Is this the case? A large majority of palæontologists would answer in the affirmative; and it seems that this answer must be admitted as true, though difficult of proof.

"It is no valid objection to this conclusion that certain Brachiopods have been but slightly modified from an extremely remote geological epoch, and that certain land and fresh-water shells have remained nearly the same, from the time when, as far as is known, they first appeared. It is not an insuperable difficulty that Foraminifera have not, as insisted on by Dr. Carpenter, progressed in organisation since even the Laurentian epoch; for some organisms would have to remain fitted for simple conditions of life, and what could be better fitted for this end than these lowly-organised protozoa? Such objections as the above would be fatal to my view, if it included advance in organisation as a necessary contingent. They would likewise be fatal if the above Foraminifera, for instance, could be proved to have first come into existence during the Laurentian epoch, or the above Brachiopods during the Cambrian formation; for in this case there would not have been time sufficient for the development of these organisms up to the standard which they had then reached. When advanced up to any given point, there is no necessity, on the theory of natural selection, for their further continued progress, though they will, during each successive age, have to be slightly modified, so as to hold their places in relation to slight changes in their conditions. The foregoing objections hinge on the question whether we really know how old the world is, and at what period the various forms first appeared; and this may well be disputed" (page 307).

According to Evolution, there is no break in the chain of life. Everything has come from something else. Evolution shows that all living things form one family, that the earth itself is but a small child of the large family of planets and stars, and that every known portion of matter is but a part of one universal, unbroken whole.

We will take a simple instance of a form of Evolution.

Suppose I wanted a bicycle, and that I had lived on a far-off island for thirty years, so that on returning home I inquired for the kind of machine in use when I was a boy. Imagine the astonishment I should produce in the shop of a first-class firm if I were to go and ask for the primeval bone-shaker, or for a machine the front wheel of which was fifty inches high! The firm would be unable to supply such a machine. Nay, if I insisted that I would have only this kind, and they went out in search of one, probably in the whole of Coventry or London they would be unable to find one.

Then I should be astonished. I might ask, "Has there been some terrible accident which destroyed all the original bicycles, or did a grandmotherly Government pass a law forbidding the use of such old-fashioned machines?"

The salesman would most likely think I was insane. If he were not too terrified, he would explain: "Well, you see, they discovered that a low front wheel would act as well as an enormously high one. They put india-rubber cushion tyres on; then they invented a tube, which they call a pneumatic. They have lowered the handle bar, they have corrected the gearing, they have invented the free wheel, so that you have no need to pedal on a slight incline. And, if you like, here is a machine which goes by electricity up hill and down, and you need never pedal at all!"

"Goodness, gracious!" I ejaculate. "What next?"

And I look at these magnificent machines, and I ask: "What man made all these improvements?"

"What man? Why, hundreds of men. One year there was one improvement, next year there was another, or three different firms invented three different improvements."

"Well," I say, "I can hardly believe you. Show me all the machines from the first, so that I can see every step of the improvements from the original bone-shaker."

The man would reply: "Quite impossible. Why, they would fill all the shops in this street."

"But where are they?" I ask. "I want to see them. Where can I find them?"

"Several of them you will not find, sir. There are none of them left."

"But why did you destroy them?"

"Oh, it was not done that way, sir. When the improved one came out, nobody would have the old ones, so they disappeared, and were not only superseded, but forgotten. We call it the survival of the fittest."

Now, here you have a sketch of Evolution. Mark, it has only taken thirty years to do it, and already it is impossible for the ordinary man to find any link in the short series of improvements. What wonder, then, if you begin to consider the evolution of living forms on this planet for a hundred million years, that you do not at first see half the connections between low forms and high forms? For we must remember, if thirty years can have buried many of the samples of hard, material machines, still more will millions of years have buried the soft, delicate forms of plants and animals.

The law of mere utility, backed by public fashion and sentiment, has condemned every inferior bicycle in favour of the better one. Now, in this universe of ours there is a law of relentless doom that cuts off every inferior organism, as it comes into competition with a better organism—one more adapted to its environment and of more use to its species.

This law of an unpitying world is the most terrible force that can engage our contemplation. There is no atom so small, no organism so large, as to be able to escape it when once they are brought into competition. This infinite force of an almighty environment says, "Adapt yourself or die!" Hence it is that thousands of forms, tens of thousands of small modifications, have disappeared into the furnace of progress.

But the living form has one advantage over the bicycle, for the most delicate living thing will bear some marks of its ancestry. If the remote ancestor had four feet, it will have four feet, even if they are modified. If the remote ancestor could breathe air in water, the descendant will bear some trace of a water-breathing apparatus. Everything has a pedigree. There is not an animal, a flower, an act, or a thought that cannot be traced back to a real ancestor. As a fact, nothing in this universe stands alone. No single thing is even conceivable as standing alone. And as far as the universe is known, the same laws are at work everywhere. No region has been found which has a new element, or an animal on an absolutely new and distinct principle.

If you went to visit a new country and stayed with a family which was fortunate enough to possess a family album containing the representatives of many generations, you would be able to apply the principle of descent with modifications. Suppose you noted on the newest page that the man had eyebrows, singular by six very long white hairs. As you turned back you found six generations more remote: there was a tuft of these long white hairs; six generations further back still you found half the eyebrow to be of these long white hairs; and twenty generations further back you found three brothers in whom the whole eyebrow was composed of these long white hairs. You could not doubt that this characteristic was a family mark, that it was changing, that it was gradually passing away. Again, supposing you had two hundred such albums, showing all the descendants of the original three brothers, you would find several instances in which the white, bushy hairs had entirely disappeared. You would perhaps find the more recent descendants so modified by descent, so changed by marriage and environment, that you could no longer be certain that they were all of the same original family.

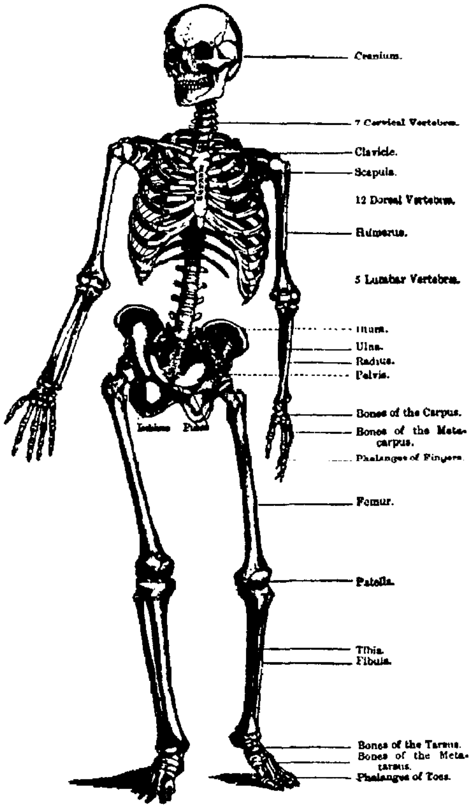
Now, such an album is Nature. It lies around you and beneath your feet.

One way of learning the doctrine of Evolution is to become familiar with the present living forms, note their likenesses and their affinities; then excavate the solid rocks, and, as you turn over their pages of stone, see how the families of life have evolved from that rude and savage ancestry which is still all too strong in us. When baldly stated, many refuse to believe the doctrine of Evolution; but, properly speaking, belief has nothing to do with this subject. We have to understand it. When we have examined the evidence, then we must determine whether the doctrine is reasonable; and if the evidence shows that this is the best explanation of living things, we are bound, as reasonable beings, to accept it.

We may take the horse as a good example of Evolution. We are familiar with the horse as an animal with only one toe. But there is much evidence that it was not always so.

From the time of Julius Cæsar until now many horses have had more than one toe. Examples could be greatly multiplied, but we will trace the pedigree of the horse backwards.

The large hoof of a horse is said to be the enlarged nail of the middle finger, the other four fingers or toes having been lost. In tracing this we cannot do better than follow Huxley's account. Let us first look at the fore limb. In most four-footed animals (called quadrupeds) the fore-arm contains two distinct bones called the radius and the ulna (*see* Fig. 1). The corresponding region of the horse at first seems to possess but one bone. Carefully looking, however, we see in this bone a part which clearly answers to the upper end of the ulna. This is closely united with the



THE SKELETON (AFTER HOLDEN).

FIGURE I.

chief mass of bone which represents the radius, and runs out into a slender shaft which may be traced for some distance downwards upon the back of the radius, and then, in most cases, it thins out and vanishes. Looking still more closely, we see that a small part of the lower end of the bone of the horse's fore-arm, which is only distinct in a very young foal, is really the lower extremity of the ulna. So that clearly the horse once had two bones in this region of the fore arm, as we have.

What is commonly called the knee of the horse is its wrist. The "cannon bone" answers to the middle bone of the five metacarpal bones which support the palm of the hand in ourselves. The "pastern," "coronary," and "coffin" bones in the horse answer to the joints of our middle fingers, while the hoof is simply a greatly enlarged and thickened nail. But if what lies beneath the horse's "knee" thus corresponds to the middle finger in ourselves, what has become of the four other fingers (often called digits)? We find in the places of the second and fourth digits only two slender splint-like bones, which taper to their lower ends and bear no finger joints. (The bones between these joints are called phalanges.)

Sometimes small bony or gristly little knots are to be found at the bases of these two splints, and it is likely that these represent what is left of the first and fifth digits. Thus the part of a horse's skeleton which corresponds with that of the human hand contains one overgrown middle digit and at least two imperfect side digits, and these answer respectively to the third, the second, and the fourth fingers in man.

The same kind of changes can be traced in the hind limb. We must omit the evidence of the teeth.

When America was first discovered, there were no traces of the existing horse to be found in that country. For some reason, in this ancient home of the horse the animal had died out. Now, America has wonderful deposits admirably suited for preserving the remains of animals, so that remains have been found well preserved, and in great numbers. Professor Marsh has carefully examined and collected these fossils, and in Yale museum are to be seen the specimens which tell the following wonderful facts.

The forms which he found carry us from the top to the bottom of the bed of rocks called tertiary. Nearest the top there is the true horse. Next we have the horse of the Pliocene rocks, the Pliohippus (hippus means horse); its limbs differ slightly from those of the ordinary horse of the present day. Then, lower down in the same rocks, comes the Protohippus, which represents the one found in Europe, called Hipparion, having one large digit and two small ones on each foot. Going still lower down, and turning up the Miocene rocks, they found the Miohippus. This corresponds pretty nearly with one found in Europe called the Anchitherium. It presents three complete toes, and higher up there is a small rudiment of that digit we call our little finger.

Lower still in the Miocene rocks is found an older form of horse, the Mesohippus. It has three toes in front with a large splint of bone, and three toes on the hind limbs. Here the radius and ulna are quite distinct bones.

But in the next bed of rocks, the Eocene, a still more important discovery was made. Here was found the Orohippus, which has four complete toes on the fore limb and three toes on the hind limb. This animal was hardly as big as an ordinary fox.

In the lowest layers of the Eocene rocks Professor Marsh found remains of the Eohippus. This is the oldest and the smallest form, the animal being about the size of a very small fox. Three species are known. The Eohippus has the feet, in the main features, very similar to the Orohippus; in each genus four well-developed toes in front and three behind, but the Eohippus has a remnant of the first digit.

These remains are from the Coryphodon bed or lower Eocene of New Mexico. This bed is below that in which the Orohippus occurs.

The oldest ancestor of the horse, as yet undiscovered, undoubtedly had five toes on each foot, and probably was not larger than a rabbit, perhaps much smaller (*American Journal of Science*, November, 1876, and April, 1892).

These discoveries of the many stages of the horse are of the highest value to science. They answer every expectation of the doctrine of Evolution; and if we can say of anything that it is proved, we certainly can say it of descent by modifications in the case of the horse.

The history of any species of animal, such as this just given, is called its phylogeny.

The history of the growth of any one individual is called ontogeny.

Now, it is an established fact that each individual organism in its ontogeny frequently repeats the history of the development of its ancestors. If an examination is made of a very young foal before its birth (called the embryo or fœtus), it is found to have five toes.

Nothing could be clearer. From the beds of the rocks has come the evidence of the slow formation of the horse from a five-toed animal. Every foal now living was also itself a a five-toed animal.

After this striking example of the unfolding and changing of one form of life, we may take quite a different attitude, and see if there is any connection, in a wide sense, between the different animal groups. We must remember always that, before we can form any opinion on such a subject, we must examine the whole known life of the animals, and we must also look beneath their skins. The history of the life before birth (which is called the life of the embryo) often reveals connections whose existence otherwise would not be suspected.

If a complete stranger to our earth, possessed of great intelligence, were to visit us, he might be struck with the number and variety of our living things. And if, further, he took a great interest in all forms of life, we can imagine his drawing up a report. In doing this he would have to note the likenesses and unlikenesses of animals. He would soon observe that thousands of animals fall into groups, such as we name cats, dogs, sheep, cows, etc. For a while he might suppose each of these groups to be entirely distinct. But, as he proceeded, he would discover more comprehensive features, which would enable him to enter hundreds of groups under the same name as vertebrates, and all other forms of life as invertebrates. Under these two orders he would naturally conclude that every living thing could be placed, and he would find them to be so separate from each other that he could usually place any living creature in one or other group. Further, he would discover features, less general, yet of sufficient comprehensiveness to include several groups each, as quadrupeds would include all four-footed animals, marsupials all pouch-bearing mammals, etc. But when this process had been carried into great detail, some new facts would arrest the inquirer's attention. He would note that certain functions were common to all living things. They are all capable of responding to their environment, of taking food, and of reproducing their kind.

Universal traits of such marvellous comprehensiveness might set the inquirer off on a new line of investigation. He might suspect that all living things were members of the same family. He would find many facts to support such a theory. All known living things begin life in the same way, by the division of a cell too small to be visible to the naked eye.

The elephant or the frog, the rabbit or the shark, make their first step in life in exactly the same way, so that the expert, by the aid of special instruments, could not discover any difference among them; the fact being that they all, in common with the rest of vertebrates, have their origin from a fertilised egg, about $\frac{1}{120}$ of an inch in diameter.

This is, indeed, one of the strongest cases of family likeness. Further, when it was seen that the more distinctive forms of the mammals passed through stages in their growth which clearly resembled stages noticed in the development of the frog, the reptile, or the fish, the expert would note these points in favour of a common ancestry. Then by slow degrees would he discover some connecting links.

Let us take any ordinary list of the various families of vertebrates, and mark their slow gradations from one to the other.

THE DIVISION CALLED VERTEBRATES.

The name vertebrate simply means jointed (Latin, *vertebra*, a joint—from *verto*, to turn; and especially a bone of the spinal column), and refers to the possession of a jointed internal axis as the main part of the skeleton. This jointed axis is the backbone. In the lowest forms this axis is not developed, and in place thereof there is a smooth elastic rod, which has received the name of *notochord* (literally back-string, Greek *notos*, back; *chordē*, string). In all members of the division this *notochord* is present at some stage of development, although, in the higher forms, it subsequently becomes surrounded and nearly obliterated by the jointed rod or vertebral column (the back bone).

Some books more correctly describe this division as chordata, instead of using the more common word, vertebrata.

Besides the possession of the notochord there are two other features by which the vertebrata are distinguished—gill-slits and the spinal cord. They all possess at some period of their lives slits in the wall of the front part of the alimentary canal (the throat). These slits in the lower forms allow the water, which is taken in at the mouth for purposes of respiration, to escape, and hence they are called gill-slits.

Further, the nervous system takes the form of a strip of sensitive skin on the back (called the medullary plate), which becomes wholly or partly enrolled to form a tube, the neural canal (spinal cord).

There are about 32,000 *known* species of vertebrata—fish, frogs, reptiles, birds, mammals. The number of species is not much more than half that of mullusca, and is not a tenth of the species called arthropoda.

Before we can study the vertebrate proper, there are three small classes of remarkable animals which we ought to consider. These are named in reference to the chord or string already referred to.

CLASS I.—HEMICHORDATA (THE ACORN-WORM).

The name of this class means half-stringed, because the notochord is very short. Sometimes they are called Enteropneusta (*enteron*, within; *pneuma*, breath), because, like all vertebrates, they use the front part of the gut for breathing.

The most primitive members of this class are worm-like in form; they live in the mud of the sea, they pass the mud through their intestines and extract food from it; thus they feed and move forwards by the same process. There are several genera with their own names, but the name Balanoglossus is used for any species of this class. The Balanoglossus is called the acorn-worm.

The body of the animal is divided into three parts (*see* Fig. 2 Balanoglossus): 1. a conical part in the front of the mouth, the *proboscis;* 3. a swollen cylindrical portion immediately behind the mouth, the *collar;* 4. a long trunk, at the end of which is an opening, the vent.

The alimentary canal runs straight from the mouth, on the anterior surface of the collar region, to the posterior end of the trunk.

The notochord is a hollow tube of cells surrounded by a tough membrane much thickened beneath. This tube opens into the alimentary canal in the collar region, and projects forward into the proboscis as a support for this organ, which is attached by a very narrow neck to the collar. The whole skin is sensitive, since there is everywhere a layer of nerve-fibrils underlying the outer-skin cells; but this layer is especially thickened along the mid dorsal and mid ventral lines of the trunk, those two regions

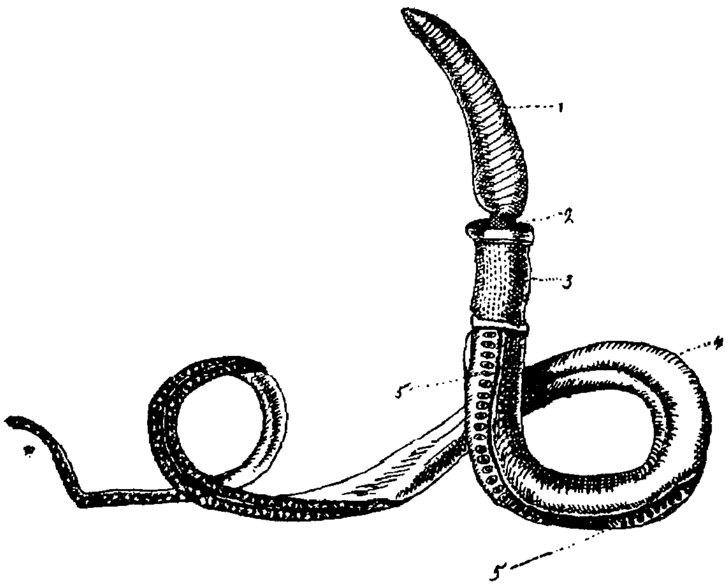


FIGURE 2.

1. Proboscis or tongue. 2. Mouth. 3. Collar. 4. Trunk. 5. Gill slits.

being connected by a ring of nervous tissue immediately behind the collar. The dorsal thickening alone is continued into the collar region, and there it becomes rolled up so as to constitute a short *neural tube.*

There are numerous gill-slit openings into the alimentary canal, in the front part of the trunk; or they may be called pouches, with small outer and large inner openings.

There are vessels corresponding to the kidneys and the heart. There is a simple sack (pericardium) the walls of which pulsate rhythmically. "One point of great interest attaching to Hemichordata is that they commence life as free swimming larvæ, resembling the larvæ of the Echinodermata and suggesting the thought that perhaps two such different groups as the Vertebrates and Echinodermata may have descended by different paths from the same simple free-swimming ancestors."

So say Messrs. Shipley and MacBride in their excellent Zoology. I have mainly followed their account of Balanoglossus, and I have treated it rather fully because it seems that we may look at this small creature and say with Job, "I have said unto the worm, thou art my mother."

In this animal we see man in the making.

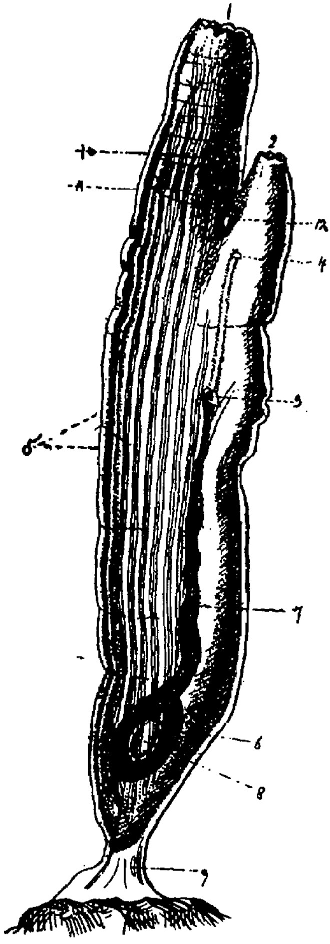


FIGURE 3.—AN ASCIDIAN.

Ciona intestinalis. The live animal seen in its test. Some of the organs can be seen, as the test is semi-transparent. 1. Mouth. 2. Atrial orifice. 3. Anus. 4. Genital pore. 5. Muscles. 6. Stomach. 7. Intestines. 8. Reproductive organs. 9. Stalk attached to rock. 10. Tentacular ring. 11. Peripharyngeal ring. 12. Brain.

CLASS II.—UROCHORDATA (ASCIDIANS).

This name means tail-stringed (from *oura*, a tail). Sometimes they are called tunicates, because they are covered with leathery skin like a mantle (*tunica*, a mantle). They are also called ascidians (from *askidion*, a small wine skin, or leather bottle, used by the Greeks). The body has two openings, a mouth and a vent. The mouth opens into a sac-like pharynx (*see* Fig. 3), and in its walls are numerous slits. The heart is in the form of a simple tube open at both ends. The sexes are united in the same individual, and the animal passes through great changes in its growth, for it begins life as a larva, and the larva has a structure corresponding to the notochord of vertebrates.

There are different classes of this animal, some being simple, some compound. The nervous system consists of a single ganglion, placed on the dorsal (back) side of the mouth. In one genus (Appendicularia) there is a second ganglion at the base of the tail, which gives off a nerve cord to the latter.

Some of them reproduce their kind by budding.

CLASS III.—CEPHALOCHORDATA.

Cephalochordata means literally "head-stringed" (from *cephalos*, head, and *chorde*, string), and in this class it shows that the notochord extends into the head.

There is only one kind of animal found in this division, the amphioxus (meaning "pointed at both ends"). Sometimes it is called the lancelet, because it is like a small lance.

The lancelet (Fig. 4) is a little, half-transparent, worm-like or fish-like animal from one to two inches long, found buried in the sand of shallow seas in various regions, with its mouth usually exposed to the water. It is described thus: "No outside skeletal structures are developed, but the skin in the middle line is developed into a continuous dorsal, caudal, and anal fold, while paired limbs are wanting. The notochord is persistent, and there are neither vertebral centres nor arches, nor is there any skull. The notochord runs along the entire length of the nerve-axis, and no differentiated brain is present. The blood is colourless, and there is no distinct heart. The pharynx is dilated and furnished with lateral clefts, the sides of which are ciliated, the whole being respiratory in function."

No fins representing limbs are present; the mouth is an opening lengthwise in the front part of the head and without jaws.

On the under surface of the body are two openings or vents, the abdominal pore and the anus. Observe that the

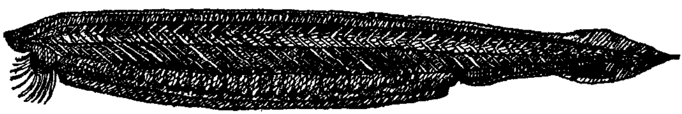


FIGURE. 4.—AMPHIOXUS OR LANCELET (after Lankester).

notochord is in the back of the body, and that it runs the whole length of the body.

The spinal cord extends along the whole body and swells out in the front part, which swelling probably represents the beginning of a brain, for it sends branches to a pigment spot and a ciliated pit. These last are supposed to represent respectively organs of vision and smell. There is a caecal sack, representing a liver, and a pair of tubes which seem to be the beginnings of the kidneys. The discovery of this animal is of the greatest possible value, as it shows, in so many ways, the simplest beginnings of organs of great importance to vertebrates.

When we come to deal with the ontogeny of man we shall see the value of these three classes of peculiar animals which are well placed at the beginning of the whole vertebrate division.

In any ordinary handbook on zoology we find the true vertebrates divided into five classes: fishes, amphibians, reptiles, birds, mammals. If we take a well-developed specimen from each class, as a herring, a frog, a tortoise, a pigeon, or a cow, there does not appear to be much connection between the classes; yet, on closer examination, each class will be seen to shade off quite gradually into the other.

A fish is provided with gills (called branchiæ) throughout the whole life, the blood is cold, a tail is present, the limbs —if they may be so called—are imperfectly developed and have the form of expansions of the skin, and are called fins. A fish usually can live only in water, and its gills enable it to breathe the air contained in the water.

An amphibian means an animal with a double life; that is, it can live in water or on land. It has proper air-breathing lungs, and, when full grown, as the frog, seems to differ in almost every point from the fish.

But there are some fish called Dipnoi—*i.e.*, double breathers—which have gills to breathe the air in the water, and an air-bladder by which they can breathe the free air. These fishes are rather rare, but they are found in South America, tropical Africa, and in Queensland.

Now, when we turn to the young frog, called the tadpole, we see how very fish-like it is. It has gills, a large tail, no limbs, and dies if left on the land. It is a water animal.

But we are able to watch its progress to full growth (*see* Fig. 5). Its gill-slits are closed with a flap of skin; first its hind legs appear, then the fore legs; it absorbs its tail (some amphibians retain the tail throughout life); it acquires lungs and breathes in the peculiar manner known as swallowing air. If its mouth were propped open, it would die of suffocation. Really, it breathes by a throat air-pump. Many other features could be named, but from these it can be seen how closely the amphibian is related to the fish. In fact, it may almost seem a waste of time to give these points of likeness, as by some scientists fishes and

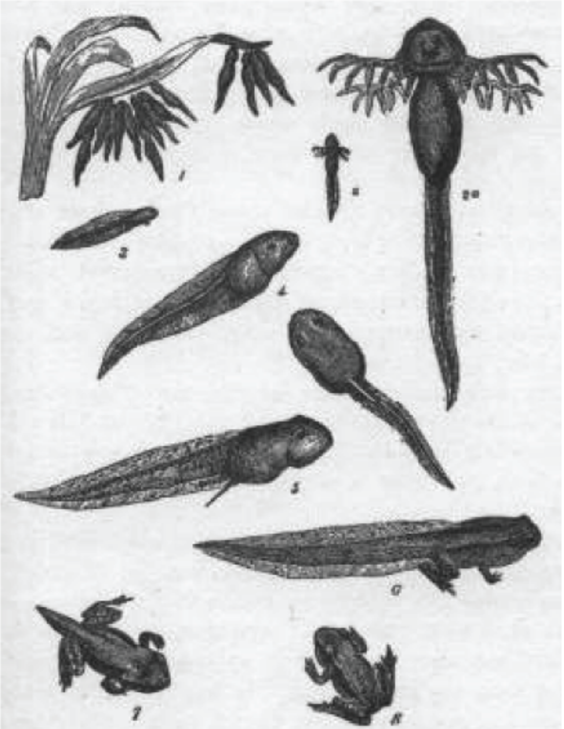


FIGURE 5.—GROWTH OF THE FROG.

1. Tadpoles just hatched. 2 and 2a show external gills. 3 to 8 show the order in which the frog developes. The hind limbs appear first because the fore limbs are concealed by skin. The tail is absorbed and does not drop off.

amphibians are classed together under the name Ichthyopsida (the fish-like).

Reptiles include tortoises, snakes, lizards, crocodiles. They are land animals, and branchial or water-breathing respiratory organs are never developed, so that in this respect they resemble in their arrangement the *adult* amphibians; they also have the three-chambered heart of the adult amphibians. The fore limbs are formed for various purposes, and in some extinct varieties they were used for flight, but they were not constructed on the type of the wings of birds. The blood of reptiles is cold. In many points they seem to begin where the amphibians left off, while on the other hand they resemble birds in many respects.

Besides their close general resemblances, there are very interesting connecting-links between reptiles and birds.

There was a flying reptile, the Pterodactyl, with five digits; the fifth or outermost digit had four joints, and was lengthened out to support the wing. It had a head shaped like a bird, but with teeth.

There was also another reptile, the Compsognathus, found in the slate quarries of Stonesfield, near Oxford. It had short fore limbs and long hind limbs. It was remarkably like a bird, and forms a very close link between birds and reptiles.

A remarkable bird, the Archæopteryx, was found in slate at Solenhofen in 1862. Its skeleton was that of a bird, and it even retained its feathers so perfect that the vanes as well as the shaft were preserved. Anatomists agree that it is a true bird, yet they find that it approaches more nearly to reptiles than any known bird. It has the tail of a reptile, composed of twenty vertebræ, though each vertebra supports a pair of quill feathers.

It is perhaps now possible to see that our birds are four-legged animals, whose fore limbs have developed into their present form for the purpose of flight.

We come lastly to the important group, mammals. This very large group is distinct enough, for they are the only animals which suckle their young. The word mammal is from the Latin *mammæ*, meaning breasts. Now at first sight it seems scarcely possible that there can be any connection between a cow and a snake. But again we must not take the most distinct forms of the two groups. We must rather begin with the lowest mammals, and see how they are related to the general class of reptiles.

Animals which bring forth their young by laying eggs are called oviparous (from *ovum*, an egg, and *pario*, to bring forth).

Animals which develop the egg and *nourish* the young in the body, bringing them forth alive, are called vivaparous (from *vivus*, living, and *pario*). Between these two there is a sort of half-and-half arrangement by which the animal retains the eggs in its body till they are hatched and the young are born more or less actively alive: these animals are called ovoviviparous. But in these cases there is no nutritive connection between parent and offspring before birth.

Mammals form the highest class of vertebrates; they have warm blood, they have hair and never feathers or scales; their young are nourished for a longer or shorter time after birth with milk, which is secreted by special glands—the mammary glands.

The lowest class of mammals are called monotremes (*monos*, single; *tremo*, to pierce), as their bodies have only *one* posterior opening. Of this class there are only two specimens, the duck-mole (ornithorhyncus) and the spiny ant-eaters (echidna) (Fig. 6, duck-mole).

The duck-mole is found only in Australia and Tasmania. It is, perhaps, the most remarkable of the mammals, and but for its discovery we might not have been able to show the close connection between reptiles and mammals. It is verily a connecting link.

The intestinal, the urinary, and reproductive organs, all open into one common chamber, called the cloaca, in the same way as in reptiles. Its breasts are without nipples, but their ducts open into a depressed space, which forms into

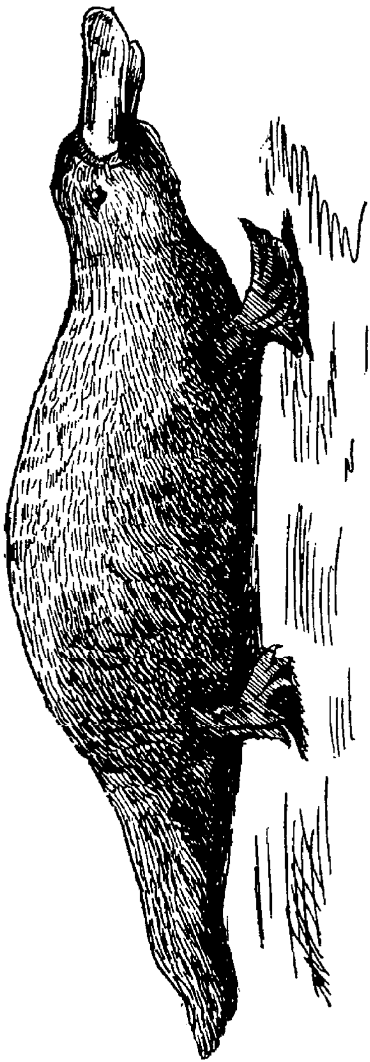


FIGURE 6.—THE DUCK-MOLD.

a sort of mammary pouch during the time when the young are being suckled. The young are produced as eggs.

The next division of mammals is called the marsupials (from *marsupium*, a pouch). Of these the kangaroo and the opossum are well-known specimens. These animals bring forth their young alive, but so imperfect that the mother carries them for some time in a pouch formed by a fold of the skin on the abdomen.

This is a distinct connecting link between the animals which lay eggs and the higher mammals which bring forth their young fully developed. There are other marks of a more perfect organism than that of the monotremes. The breasts have nipples, and there is no cloaca, the organs having separate openings. From the duck-mole upwards the mammals are easily traced till we reach man; but this requires a chapter to itself.

I have tried to show in the baldest outline that there is a close connection between the vertebrates. This connection could be shown far more clearly if there were room for detail, and if the technical words of science were commonly understood.

CHAPTER II.

MAN AND THE REST OF THE ANIMAL FAMILY

YOU may have stood under the *steep* side of a mountain and felt that no human being could ever climb it, but on wandering perhaps miles away you came to a path which by a gradual slope led you to the top of this very mountain.

So it is with the evolution of man. If you begin with your Carlyles, Ruskins, Gladstones, Darwins, Spencers, then man seems to stand forth in solitary mountain glory far above all animals. But there is another way of approaching the problem.

We must always remember that a problem wrongly stated is insoluble.

To understand a difficult language or science we must begin at the beginning and not at the end. A man can climb the highest tower if there are steps to the top, but without steps a roof ten feet high may be quite inaccessible. The mountain-glory view of man has been developed by many forces—ignorance of other animals, vanity, prejudice, preconceived notions, as in the various classical mythologies, showing that their own race sprang from the gods. These early people did not study the forms of life; they knew nothing of the influence of environment. They did not look beneath the skin, and, above all, they knew nothing of the beginning of the growth of each individual and of its gradual development before birth. So they missed many steps in the ladder.

Ancient forms, to be found only in fossilised remains, they had never seen, and thus other important steps in the ladder were missed. No wonder they said man is a mountain rising alone in his grandeur from the landscape of life.

When the discovery of Evolution was new, all sorts of prejudices arose against it. Less than fifty years ago foolish doctrines were held as the unalterable facts of all life history, and really learned men were blinded by the rude devices of early man when he sought to explain many of the problems of our common daily life.

We may well pause and inquire before we dogmatise, when we remember the infallible ignorance which poisoned the whole world less than a century ago. Take the superstitions of witchcraft and magic, which held sway through the most enlightened countries of Europe. Learned men, wise men, Christian men, humane men, sat in judgment on defenceless women who were old and ugly, or merely peculiar, and sentenced them to a hideous death by hundreds and thousands because they were accused of a thing which we now know had no existence. Lecky thinks that this is probably the darkest piece of inhuman cruelty which has stained the pathway of man.

But preconceptions or prejudices prevented them from discovering the truth. May not some such darkness have veiled man's vision when he began to note the glories of his race? We will try and ascend the mountain by its slope.

We turn to Darwin's *Descent of Man*, and we ask what evidence is there that man has come from some lower animal? Supplementing him with discoveries since his time, we can answer:—

I.—We take his bodily structure.

1. We note that man is constructed on the same general type or plan as the other mammals.

It is nothing short of a marvel that man can have lived among animals for hundreds of years without seeing that he was one of the same family. His birth, death, all the means by which he eats and lives, are so like the same things in other animals that one wonders how it was that no man realised, "I, too, am an animal." And if any one had ever seen a dead man and a dead pig, with their structures exposed to view, it must have been clear to him that the likeness between the two was so striking as to tell of near relationship.

2. All the bones of man can be compared with corresponding bones in a monkey, a bat, or a seal.

Every bone, every prominence on every bone, every marking for the attachment of muscles, is the same in man as in the higher apes.

3. All the muscles of man's body correspond with the muscles of some other animal. Not one of man's five hundred muscles is peculiar to his body; and in the animals they have been found to be connected with the same bones, the same parts of the bones, running in the same direction, having just the same function as in man.

There are four muscles in the anthropoid apes which are not *generally* present in man, but all these four have been found as varieties in the human body. Two muscles are usually present in man that are wanting in the anthropoid apes, but of these two one is sometimes, and the other frequently, absent in man. The interesting point is that the six variable muscles are variable in man and ape.

4. The nerves, the blood-vessels, and the internal viscera correspond with those of other mammals.

5. "The brain follows the same law, as shown by Huxley and other anatomists. Bischoff, who is a hostile witness, admits that every chief fissure and fold in the brain of man has its analogy in that of the orang, but he adds that at no period of their development do their brains perfectly agree, nor could perfect agreement be expected, for otherwise their mental powers would have been the same" (Darwin, *Descent of Man*, p. 6).

Just so! If man agreed perfectly with an ape, he would be an ape, and Evolution would have stopped at apes.

But we shall return to this point and deal with it more fully.

II.—We turn to disease.

"Man is liable to receive from the lower animals and to communicate to them certain diseases, such as hydrophobia, variola, glanders, cholera, ringworm."

To take the last as an example. Ringworm affects the skin of the scalp; it is due to the growth of a fungus in the skin. This disease is known to be "very catching"—*i.e.*, it is easily transferred from one human being to another.

But ringworm is common among cattle, and it is well known that those who attend cattle frequently take ringworm from them.

Darwin points out: "This proves close similarity of their tissues and blood, both in minute structure and composition, far more plainly than does their comparison under the best microscope or by the aid of the best chemical analysis."

Monkeys are liable to many of the same contagious diseases as we are. Rengger (in Paraguay) observed a monkey, the Cebus Azarae, liable to catarrh with the usual symptoms. These monkeys suffered from apoplexy, inflammation of the bowels, and cataract in the eye. The younger ones, when shedding milk teeth, often died from fever.

III.—We note the effect of drugs.

Many medicines produce the same effect on animals as on us. Many kinds of monkeys have a strong taste for tea, coffee, and spirituous liquors; they will also smoke tobacco with pleasure. "Brehm asserts that the natives of North Eastern Africa catch the wild baboons by exposing vessels filled with strong beer, by which they are made drunk." And so exactly is the nature of the nervous system like man's that alcohol has the same effect on monkeys. When they have taken it, some monkeys are rendered so bad-tempered that they want to fight everyone they meet. Others become maudlin and weep on or without the least provocation. A few are rendered "real good fellows," and become sweetly amiable and generous.

Everyone must recognise that in these cases we have a description of the different kinds of drunkenness in man. Baboons kept in confinement and made drunk were very cross and dismal next morning; they held their aching heads with both hands; when beer or wine was offered to them they turned away with disgust, but relished the juice of lemons. One American monkey, after getting drunk on brandy, would never touch it again.

"These trifling facts prove how similar the nerves of taste must be in monkeys and man, and how similarly their whole nervous system is affected."

IV.—We seek the evidence of parasites.

Parasite means one that lives on another (from *para*, by the side, and *sitos*, food); originally it meant one who eats at the table of another. Man is infested with internal parasites, all of which belong to the same genera or families as those infesting other mammals, and in the case of itch they belong to the same species.

V.—The law of periods.

Some of the important processes of life happen at fixed times; for instance, if a hen is set on eggs of her own kind, we can tell the day on which the chickens may be expected. If duck's eggs are used, we know they will take a week longer to hatch.

This law applies to the birth of mammals as well. It also applies to several diseases.

Altogether it is very mysterious; but, most wonderful of all, these different times follow the periods of the moon. Many careful observations have shown that a seven-days period is very common in Nature. Of course, it may be a period of one seven, or two sevens, or three sevens, and so on up to forty-eight sevens. Human beings are universally subject to this law in common with mammals, birds, and insects. At present there is not an absolutely clear explanation of this law; but evidently it is one of the oldest things in connection with life, extending, as it does, all the way back to insects, and, for anything we know, much farther still.

Darwin suggests that this law is due to the tides. As is well known, the tides are influenced by the moon. He says (*Descent of Man*, p. 164): "The most ancient progenitors in the kingdom of the vertebrates at which we are able to obtain an obscure glance apparently consisted of a group of marine animals, resembling the larvæ of existing Ascidians."

Then he adds this note (note 32, p. 164): "The inhabitants of the sea-shore must be greatly affected by the tides; animals living either about the mean high-water mark, or about the mean low-water mark, pass through a complete cycle of tidal changes in a fortnight. Consequently, their food supply will undergo marked changes week by week. The vital functions of such animals living under these conditions for many generations can hardly fail to run their course in regular weekly periods. Now, it is a mysterious fact that in the higher and now terrestrial vertebrata, as well as in other classes, many normal and abnormal processes have one or more whole weeks as their periods; this would be rendered intelligible if the vertebrata are descended from an animal allied to the existing tidal Ascidians. Many instances of such periodic processes might be given, as the gestation of mammals, the duration of fevers, etc. The hatching of eggs affords also a good example, for, according to Mr. Bartlett (*Land and Water*, Jan. 7th, 1871), the eggs of the pigeon are hatched in two weeks, those of the fowl in three, those of the duck in four, those of the goose in five, and those of the ostrich in seven. As far as we can judge, a recurrent period, if approximately of the right duration for any process or function, would not, when once gained, be liable to change; consequently, it might be thus transmitted through almost any number of generations. But if the function changed, the period would have to change almost abruptly by a whole week. This conclusion, if sound, is highly remarkable; for the period of gestation in each mammal and the hatching of each bird's eggs and many other vital processes thus betray to us the primordial birthplace of these animals."

If further evidence should establish this as a fact, it is certainly one of the most marvellous discoveries of man, and carries us back to the life of millions of years ago.

VI.—Healing of wounds.

The wounds of man are repaired by the same process of healing as are those of other animals. And here unexpected evidence is forthcoming of man's animal ancestry.

It is a fixed law that the lower the organism and the lower the tissue the greater is the amount of restoration possible from wounds. An injury to an animal of the less highly-developed classes is, even if it be very extensive, likely to be completely remedied by the power which the animal has to restore itself. But the removal of any considerable portion of a more highly-developed animal is not likely to be followed by restoration of the part removed. "In like manner, if even in man some low form of tissue, such as the fibrous or cartilaginous, is in part destroyed, it can again be made good. But if the tissue is a complex and excessively active one, as the muscular or nervous, there is little likelihood of its reparation."

So we see there is a close connection between the lowness and simplicity of the organism, or the part injured, and its power of restoration.

The lobster, which is a high member of its class, is able to re-form its very large forceps-bearing limb, or claw, with greater or less completeness.

In fishes this power is very marked, and they are the lowest class of vertebrates. The whole fin or limb of certain fishes has been restored after accidental removal.

In amphibia there is this same power. A salamander had its tail removed eight times in succession, but the tail always grew again. The same experiment with a leg had similar results.

In the frog this power is not so great, but in the tadpole it is as great as in a fish. A tadpole is really a fish, but the adult frog is really a reptile.

Now we turn to man. In this connection we are chiefly concerned with man at the very early stage of his life. The young of a mammal before birth is called an embryo. Now, it is scientifically known that a very young embryo may, by accident, have a limb literally cut off, and at birth it is found that a leg or arm has grown again.

VII.—Reproduction.

To reproduce its kind is clearly one of the earliest powers which must have marked any living thing. Next to sustaining itself, the power to reproduce itself is absolutely necessary, or the race would die out.

If Evolution has taken place, here we ought to find some striking facts. We know that at first there was no such thing as sex. The lowest organisms multiply by dividing in half, or by budding, and thus form new creatures of their kind.

If we might write quite plainly, the history and explanation of reproduction would of itself supply overwhelming evidence of Evolution. The whole process of reproduction of the species, says Darwin, "is strikingly the same in all mammals, from the first act of courtship by the male to the birth and nurturing of the young." Monkeys are born in almost as helpless a condition as our own infants. Some urge, as an important distinction, that with man the young arrive at maturity at a much later age; but if we look at the races of man in tropical regions, the difference is not great, for the orang is believed not to be adult till the age of ten to fifteen (Huxley).

Man differs from woman in size, bodily strength, hairiness, etc., as well as in mind, in the same manner as do the two sexes of many mammals.

VIII.—Rudiments.

Rudiments are those parts of a body which are incomplete and which never become fully developed, and in the language of Evolution they mean vestiges—relics of a past time when they used to be developed and useful in some other organism. "No one of the higher animals can be named which does not bear some part in a rudimentary condition; and man forms no exception to the rule." These organs are either absolutely useless, such as the paps of male quadrupeds, or the incisor teeth of ruminants which never cut through the gums; or they are of such slight service to their present possessors that we can hardly suppose that they were developed under the conditions which now exist."

The following are some of the rudiments found in man:—

Muscles which are present in the lower animals are occasionally detected in man—*e.g.*, those by means of which animals twitch their skin. Remnants of such are found in various parts of our bodies—*e.g.*, the muscles on the forehead by which we raise the eyebrows.

Some can contract the superficial muscles on the scalp; these muscles are variable and rudimentary. Candolle knew a family in which one, the head of the present family, could pitch books off his head by these muscles. His father, uncle, grandfather, and three children possess the same power in the same unusual degree. A distant cousin, in the seventh degree, in another part of France, can do the same thing.

"The case offers a good illustration how persistent may be the transmission of an absolutely useless faculty, probably derived from our remote semi-human progenitors; since many monkeys have, and frequently use, the power of largely moving their scalps up and down."

Extrinsic muscles which move the external ear and the intrinsic which move the different parts are in a rudimentary condition in man. They belong to the same system as the above. Men are found who can draw the whole ear forwards, others can draw it upwards, others can draw it backwards. The whole external shell of the ear is a rudiment, and is of scarcely any distinct use.

It has been observed that the ear of man alone possesses a lobule, but a rudiment of it is found in the gorilla, while it is not rarely absent in the negro.

Ears pointed on the *inward fold* of the margin are not confined to man. In baboons the upper part of the ear is slightly pointed, and very much so before birth. Sometimes the upper margin is not folded, and yet shows a point.

The third eyelid is found in some reptiles and amphibians, and in certain fishes (sharks). It is fairly well developed in the two lower divisions of mammals (monotremes and marsupials) and in a few higher mammals, as in the walrus; but in man, all the monkey family, and most other mammals it is a mere rudiment, the semilunar fold.

Smell is of the highest importance to many mammals; but it is of extremely slight service to us, or even to the dark-coloured races of men, in whom it is much more highly developed than in white and civilised races. Evolution does not show that this sense was acquired by man for his benefit; he inherits the power in an enfeebled and rudimentary condition from a progenitor to whom it was useful.

Negroes and Indians can recognise persons in the dark by smell.

Hair.—Man differs from other animals by being almost naked. The hairs he has are rudiments of the uniform hairy coat of the lower animals. Often several members of a family have a few hairs of the eyebrows much longer than the others; even these seem to be inherited, for in the chimpanzee and macacus there are scattered hairs of considerable length rising from the naked skin above the eyes, and corresponding to our eyebrows. Similar long hairs project from the covering of the superciliary ridge in some baboons. Fine woolly hair covers the human fœtus during the sixth month; but the palms of the hands and the soles of the feet are quite naked. This woolly covering probably represents the first permanent coat of hair in those mammals born hairy. Persons have been born with their bodies and faces covered with fine long hairs, and this condition is strongly inherited, and is correlated with an abnormal condition of the teeth.

Alimentary canal, vermiform appendix. This was left as a rudiment by change of diet from vegetable feeders. The orang utan has this appendix.

Supra-condyloid foramen, a hole through which the great nerve of the fore limb, and often the great artery, passes.

This passage is at the lower end of the humerus in some of the lower monkeys, lemurs, and carnivora, and in many marsupials. In the humerus of man there is often a trace of it, and sometimes it is fairly well developed. When present, the great nerve passes through it usually. This clearly indicates that it is a rudiment of the hole in the bone of the lower animals. But if the occasional development of this structure in man is, as seems probable, due to reversion, it is a return to a very ancient state of things, because in the higher monkeys it is absent.

There is another small hole in the humerus occasionally present in man—the inter condyloid. It is remarkable that this hole seems to have been present much more frequently in man during ancient times than recently. "It is an interesting fact that ancient races, in this and several other cases, more frequently present structures which resemble those of the lower animals than do the modern."

Os coccyx.—This is the name for the lower end of the backbone in man. Though it is of no use as a tail, it plainly represents this part in other vertebrates. Before birth and at an early period it is free, and *longer than the legs*. Even after birth it has been known to form a small external rudiment of a tail.

The *os coccyx* is short, usually composed of four bones joined together, and these are, except the basal one, in a rudimentary condition. They are furnished with small muscles, one of which is a rudiment of the muscle by which animals erect their tail. At the extremity has been found a small convoluted body, and, on examining the tail of a monkey and a cat, in both was found a similarly convoluted body, though not at the extremity, which seems to indicate that some bones have been lost from the original tail.

IX.—Embryonic development.

Man is developed from a small cell (called the ovum or ovule), about the 120th of an inch in diameter, which differs in no apparent respect from the ovules from which other animals grow. The embryo itself at a very early period cannot be distinguished from that of other members of the vertebrate kingdom (*See* Fig. 7). Very wonderful is the evidence in favour of Evolution furnished by the development of man from the very beginning of his life before birth. Speaking broadly, man in his development goes through a series of changes that are the same, at different stages, as the *fixed* forms of the lower animals when they are *full-grown*. In his development from cell or egg he presents structures that are precisely like those seen in the bodies of the lower and lowest animals in their adult state. In fact, they correspond with the stages of man's evolution in the almost infinite past. The detailed life-history of any one man shows the history of his race.

It is a scientific truism to say that no one can distinguish the cell which is to become a human being from the cells of those tiny forms which hover on the border line, not only between the plant and animal kingdom, but between the kingdoms of the living and the not-living.

It is impossible to give all the details, but we will notice a few.

1. To begin with the very small cell, called the ovum or germ. After impregnation the cell divides into two, four, eight, sixteen, thirty-two, and so forth, until a mass of similar cells is formed. This stage of the human animal is called the morula stage. Morus means a mulberry, and the

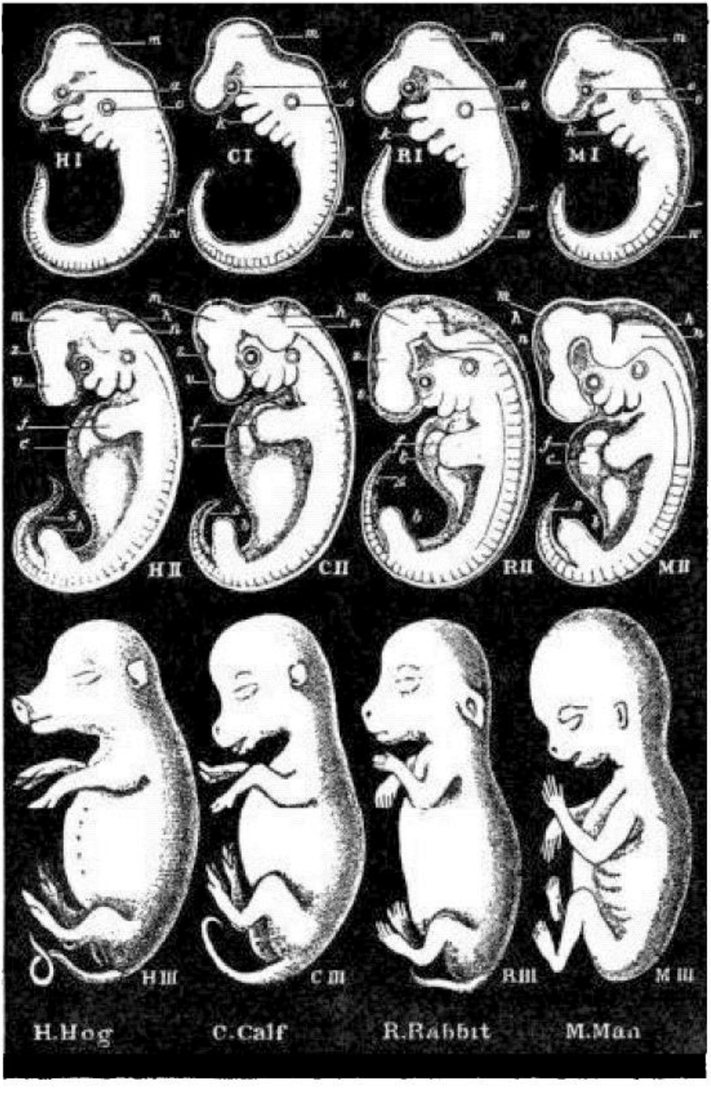


FIGURE 7. [For particulars see commencement of next page.]

FIGURE 7.—This is a reproduction (by permission) of plate vii. from Haeckel's *Evolution of Man*, vol. i.

The figures show the early stages of the growth of a hog, calf, rabbit, and man, and their likeness to each other is striking. In the earlier stages the likeness is still greater. It is striking that the nearer we go to the origin of life the more nearly are all the animals alike. The first row across (I.) shows a very early stage, with gill openings, and without limbs. The second row (II.) shows a somewhat later stage, with the first rudiments of limbs, while the gill openings are yet retained. The third (lowest row, III.) shows a still later stage, with the limbs more developed and the gill openings lost. All the figures are slightly magnified. The letters indicate the same parts: *v*, fore-brain; *z*, twixt-brain; *m*, mid-brain; *h*, hind-brain; *n*, after-brain; *r*, spinal marrow; *e*, nose; *a*, eye; *o*, ear; *k*, gill-arches; *g*, heart; *w*, vertebral column; *f*, fore-limbs; *b*, hind-limbs; *s*, tail.

collection of those cells resembles the mulberry fruit. Just such an appearance is presented by certain low forms (*see* Fig. 8) both of plants and animals.

2. A little later the inner cells have liquefied and the outer

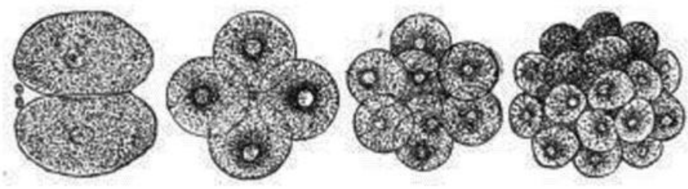


FIGURE 8a.

a to *d* shows how an ordinary mammal grows from a single cell called the egg or ovum. *a*, the single cell has divided in two, each with its nucleus or kernel; *b*, each of these has again divided; *c*, shows this process again repeated; *d*, is the mass of cells produced in the same way, and called a morula, because it is like a mulberry.

condensed into two membranes, and now our embryo is a double bag, holding the liquid contents, as some of the cœlenterata, members of the sub-kingdom that contains the hydra (the fresh water polyp) and the sea-anemone.

How does the back-bone of man make its first appearance? As a little rod of tissue running along the middle line of what is to be the back, and marking where the bones of the vertebræ will be formed. This little rod corresponds with what we have seen as the notochord in the balanoglossus and in the amphioxus, those little animals at the very bottom of the vertebrate group.

3. The circulation of the blood shows a remarkable history. The arteries at an early period rise in twelve arch-like branches in six pairs (called the aortic arches), as if to carry blood to branchiæ or gills which are not present in the higher vertebrates, though grooves on the side of the neck of the embryo still are to be seen, marking their former position.

Or to state the same thing another way: "The heart of the human being is at first only a pulsating, undivided vessel. So is that of the amphioxus. From the heart of adult man passes off the great aorta, the vessel that carries the good

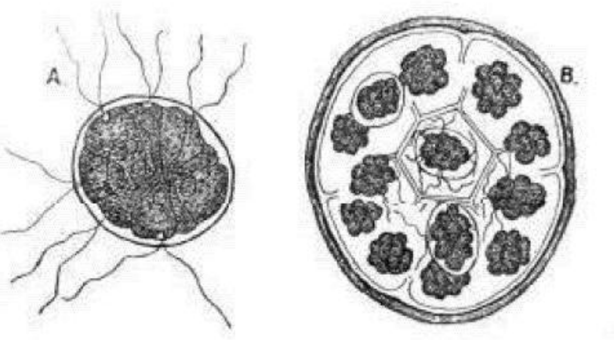


FIGURE 8b (after Headly).

A is a small animal found in ponds, called the Pandorina. It is almost like the morula of figure 8a *d*. *B* shows that the colony *A* has broken up by asexual reproduction, each cell having divided into a daughter colony.
The whole of figure 8 shows how the higher animals, in their earliest stages of growth, resemble the lower forms.

blood for distribution to the body generally. In man this large artery makes a curve to the left-hand side of the body ere it reaches the inner aspect of the vertebral column as the descending aorta. In the mammalia generally this arrangement holds. In birds the curve is to the right, not to the left. In reptiles there are two aortic arches, one over-running to the right, the other to the left, that join together on the anterior aspect of the backbone. In the amphibia, in their adult condition, the same plan as under the reptilia obtains.

"But in the larval state (the tadpole—*e.g.*, of the frog) there are twelve aortic arches, six to the right, six to the left, and this, which is the state of affairs in the larva of the amphibia, is the persistent condition in some adult members of the lowest vertebrate class, the fishes. Now, in the development of man there are at first twelve aortic arches arranged just as in fishes. By a series of changes we have at last only the one on the left-hand side. But as surely as we reason that the arrangement of the aortic arches in the adult amphibian is the result of evolution from the fish-like tadpole form, so we may reason that the present arrangement of the one aortic arch in man is the result of development from pre-existing conditions identical with those now persistent in fish. If this be not the truth, are we not entitled to cry out to the holders of the antique belief, To what purpose is this waste? Why are there to begin with six pairs of arches when only one is ultimately to remain?"

4. At a somewhat later period, when the limbs are developed, "the feet of lizards and mammals, the wings and feet of birds, no less than the hands and feet of man, all arise from the same fundamental form" (Baer).

In fact, the arms and legs, in the first stages of their development, are exactly as they are in other vertebrates; the arms and legs of man begin to develop, and continue for some time to develop, on the same plan as the fins of fish.

5. The excreta are voided through a cloacal passage—*i.e.*, there is only one passage with one vent. This is the fixed condition of the duck-mole (the lowest mammal), of all birds, reptiles, amphibians, fish, ascidians, amphioxus, and of innumerable thousands of low invertebrate animals. Here is a record of one of the most important functions of every living thing, carrying us back tens of millions of years. At one stage man has this same arrangement, and yet it disappears as he developes a more perfect system.

6. The bone at the bottom end of the backbone, called

the *os coccyx* (*see* Fig. 1), projects as a true tail, extending considerably beyond the rudimentary legs (*see* Fig. 7), showing clearly that man's ancestors had tails.

Huxley says: "It is quite in the later stages of development that the young human being presents marked differences from the young ape, while the latter departs as much from the dog in its development as does man."

At a later period are some striking resemblances between man and the lower animals.

(*a*) "Bischoff says the convolutions of the brain in a human fœtus at the end of the seventh month reach about the same stage of development as in a baboon when adult."

(*b*) "The great toe, which forms the fulcrum when standing or walking, is perhaps the most characteristic peculiarity in the human structure" (Owen); but in an embryo about an inch in length Professor Wyman found "that the great toe was shorter than the others, and, instead of being parallel to them, projected at an angle from the side of the foot, thus corresponding with the *permanent* condition of this part in the quadrumana" (monkeys and apes).

Huxley asks: "Does man originate in a different way from a dog, bird, frog, or fish?" He replies: "Without question, the mode of origin and the early stages of the development of man are identical with those of the animals immediately below; without doubt, in these respects he is nearer to apes than the apes are to the dog."

Certainly this known record of man is one of the most brilliant discoveries of the brain. These are facts, and man must explain them in the most reasonable way possible.

Darwin well says: "The homological construction of the whole frame in the members of the same class is intelligible if we admit their descent from a common progenitor, together with their subsequent adaptation to diversified conditions. On any other view the similarity of pattern between the hand of a man or monkey, the foot of a horse, the flipper of a seal, the wing of a bat, etc., is utterly inexplicable. It is no scientific explanation to assert that they have all been formed on the same ideal plan. With respect to the development, we can clearly understand, on the principle of variation supervening at a rather late embryonic period and being inherited at a corresponding period, how it is that the embryos of wonderfully different forms should still retain, more or less perfectly, the structure of their common progenitor. No other explanation has ever been given of the marvellous fact that the embryos of a man, dog, seal, bat, reptile, etc., cannot at first be distinguished from each other. In order to understand the existence of rudimentary organs, we have only to suppose that a former progenitor possessed the parts in question in a perfect state, and that under changed habits of life they became greatly reduced, either from simple disuse, or through the natural selection of those individuals which are least encumbered with a superfluous part, aided by the other means previously indicated" (*Descent of Man*, p. 24).

CHAPTER III.

WHAT IS MAN?

A LOST queen, with her baby, arrived at a shepherd's hut and took shelter. The family watched the baby being undressed, and at last their astonishment knew no bounds as they exclaimed, "Why, it is like one of ours!"

This story represents one of the series of wonders which comparative anatomy has brought to light. At each step, as the dissecting knife has laid bare the secrets of the limbs and bodies of animals, and as the microscope has revealed the forms and nature of small organs, tissues, and cells, the astonished student has been able to say, "Why, it is like ours!"

In order to determine more clearly man's relation to other animals, I will pursue the inquiry on the lines of Professor Ernst Haeckel. He has given such an amount of genius and toil to scientific inquiry as to render him distinguished throughout the civilised world. In his *Riddle of the Universe* he devotes Chapter II., which I shall here chiefly follow, to "Our Bodily Frame."

At this period it seems almost amusing that educated men a hundred years ago could think of man as a creature outside of the animal family. Thousands of those men had well-trained minds, great natural powers, and many opportunities of observation.

They failed to see man's true place among the living things of the earth chiefly for three reasons:

1. They had the erroneous views of former ages to prevent them from seeing facts. For thousands of years men had

been drugged by the false-hypothesis poison. A false hypothesis will eat up the facts of countless generations, and still cry for more.

2. The subject was not open for inquiry. Men of early times having taken one view, soon this was held to be the only possible view. The question was closed. Now, a closed question is a closed cradle, and its only use is to rock the ages to sleep.

3. They had not the means for inquiry. They had neither the instruments nor the subjects for dissection, nor the collections of natural history. Even in the fifteenth century to dissect a human corpse was a crime visited with capital punishment.

After this, darkness began to reel "from forth day's path"; human anatomy alone occupied attention. This branch of science had its martyrs: Vesalius, the great anatomist of Brussels, wrote his remarkable book on the structure of the human body in 1543 when he was twenty-three years of age. Later he was physician to the King at Madrid, where he was condemned to death by the Inquisition as a magician! He escaped by going a pilgrimage to Jerusalem. In returning, he suffered shipwreck on the Isle of Zante, and died there in misery and destitution. Thus another victim was offered to truth and another spot of earth was consecrated.

When we have been thrilled by this pathetic tragedy, there comes the gleam of irony which is seldom absent from human events. Because Vesalius saw what every schoolboy might see, self-blinded priests branded him as a magician. Those men having created a devil, put him into everything as a proof of their own versatile powers and a record of their unconscious humour.

Is man an animal?

In 1803 the great French zoologist, Cuvier, created the new science of Comparative Anatomy. He endeavoured to seek and arrange, for the first time, the definite laws of the organism both of man and beasts. He found that man did not stand alone, but fitted into a group, as other animals formed groups. In this he did more completely what Goethe and Linnæus had vaguely suggested or partially accomplished. Then followed an army of men who by toil and thought led mankind into the light. In 1859 Darwin laid bare great laws of life in his *Origin of Species*, and Huxley and Gegenbaur (1864) applied the evolution theory to comparative anatomy, and by this means proved that man is a vertebrate animal in every respect.

But anatomy was not all.

An entirely new line of inquiry was being pursued. Bichat, a French anatomist (1802), made an attempt to dissect the organs of the human body into their finer constituents by the aid of the microscope. This led to little result, because the scientist was ignorant of the one common element of all tissues. "This element was first discovered in 1838, in the shape of the cell, in the plant world, by M. Schleiden, and immediately afterwards proved to be the same in the animal world by Theodor Schwann."

This discovery, that tissues are built up of cells, is known as the cellular theory, and forms one of the revolutions of the scientific world.

Two eminent Germans, Kölliker and Virchow, "took up this theory of the cells about 1860, and the theory of tissues which is founded on it, and applied them to the human organism in all its details both in health and disease. They proved that in man, as in all other animals, every tissue is made up of the same microscopic particles, the cells; and these 'elementary organisms' are the real self-active citizens which, in combinations of millions, constitute the 'cellular state' of our body."

By the aid of the microscope we had learnt much of the finer structure of man and animals. But this discovery of the cells was "especially important in the light of their connection with the evolution of the cell and the tissue." For this confirmed the great cell theory of Siebold (1845), that the lowest animals (the infusoria and the rhizopods) are organisms made up of single cells.

Then it became possible for the first time to inquire into the origin of each individual life. That long mysterious growth before birth could now be understood.

For what is the origin of all these cells? They all spring from one simple cell, the stem cell (cytula), otherwise known as the fertilised egg (ovum), by continuous divisions. "The general structure and combination of the tissues are the same in man as in the other vertebrates." Yes, man is an animal.

Is man a vertebrate?

Man's whole frame, in its general plan and detailed structure, presents the characteristic type of the vertebrates. This group of the animal world was first recognised in its natural unity by Lamarck, in 1801. He made four groups of the higher animals of Linnæus—mammals, birds, amphibia, fishes. The lower classes of insects and worms he called invertebrates. Cuvier (1812) established the unity of the vertebrate type more firmly by comparative anatomy.

"It is quite true that all the vertebrates, from the fish up to man, agree in every essential feature; they all have a firm internal skeleton, a framework of cartilage and bone, consisting principally of a vertebral column and a skull; the advanced construction of the latter presents many variations, but, on the whole, all may be reduced to the same fundamental type. Further, in all vertebrates, the 'organ of the mind,' the central nervous system, in the shape of a spinal cord and a brain, lies at the back of this axial skeleton. Moreover, what we say of its bony environment, the skull, is also true of the brain—the instrument of consciousness and all the higher functions of the mind; its construction and size present very many variations in detail, but its general characteristic structure remains always the same" (*The Riddle of the Universe*, p. 28).

We find the same thing to be true when we compare the rest of our organs with those of the other vertebrates.

Everywhere the original plan and the relative arrangement of the organs remain the same, though the size and structure may have been modified.

"Thus we find that in all cases the blood circulates in two main blood-vessels, of which one—the aorta—passes over the intestine, and the other—the principal vein—passes underneath, and that by the broadening out of the latter in a very definite spot a heart has arisen; this 'ventral heart' is just as characteristic of all the vertebrates as is the 'dorsal heart' of all the articulata and mollusca. Equally characteristic of all vertebrates is the early division of the intestinal tube into a 'head-gut' (or gill-gut), which serves for respiration, and a 'body-gut' (or liver-gut), which co-operates with the liver in digestion" (*ibid*, p. 28).

Yes; man is a vertebrate.

Is man a quadruped?

Quadruped means four-footed. It is the Latin for the Greek *tetrapod*, which was the name Aristotle gave to the higher warm-blooded vertebrates. The meaning of the term was enlarged afterwards, when Cuvier proved that even "two-legged" birds and men are really "four-footed." "He showed that the internal skeleton of the four legs of all the higher land vertebrates, from the amphibia up to man, was originally constructed after the same pattern out of a definite number of members. The arm of man and the wing of bats and birds have the same typical skeleton as the foreleg of the animals which are conspicuously four-footed."

This point was one of great difficulty until comparative anatomy had cleared up the structure of the limbs.

So long as writers thought that man was apart from animals they looked upon all animals as being four-footed, four-handed, or two-handed. They thought the monkeys had four hands, and called them quadrumana; that men had two hands, and so called them bimana. Some old-fashioned people still think monkeys have four hands (*see* Figs. 9 and 10).

To realise the importance of this discovery, tell the man in the street that the wing of the bird is like his arm, or that a frog's leg is like his own, and watch his shock of amazement.

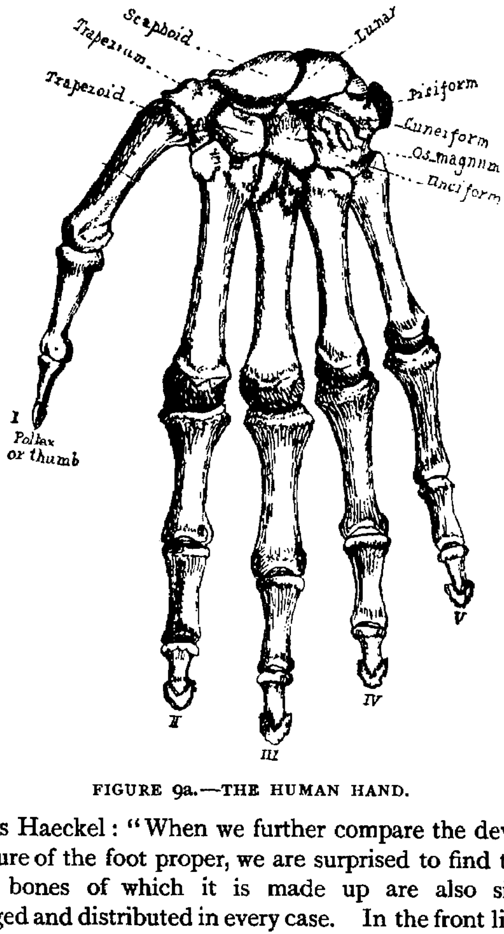


FIGURE 9a.—THE HUMAN HAND.

Says Haeckel: "When we further compare the developed structure of the foot proper, we are surprised to find that the small bones of which it is made up are also similarly arranged and distributed in every case. In the front limb the three groups of bones of the fore-foot (or 'hand') correspond in all classes of the tetrapoda: (1) the carpus,

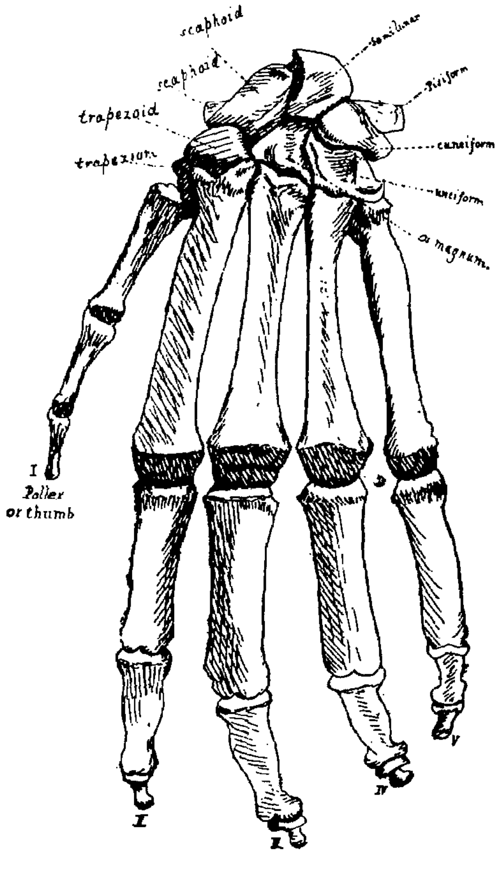


FIGURE 9b.—THE APE'S HAND.

(2) the meta-carpus, (3) the five fingers. In the rear limb, similarly, we have always the same three osseous groups of

the hind-foot: (1) the tarsus, (2) the meta-tarsus, and (3) the five toes. It was a very difficult task to reduce all these little bones to one primitive type, and to establish the equivalence (or homology) of the separate parts in all cases; they present extreme variations of form and construction in detail, sometimes being partly fused together and losing their individuality. This great task was first successfully achieved by the most eminent comparative anatomist of our day, Carl Gegenbaur. He pointed out, in his *Researches into the Comparative Anatomy of the Vertebrata* (1864), how this characteristic 'five-toed leg' of the land-tetrapods originally (not before the Carboniferous period) arose out of the radiating fin (the breast-fin, or the belly-fin) of the ancient fishes. He had also, in his famous *Researches into the Skull of the Vertebrata* (1872), deduced the younger skull of the tetrapods from the oldest cranial form among the fishes—viz., that of the shark.

"It is especially remarkable that the original number of the toes (five) on each of the four feet, which first appeared in the old amphibia of the Carboniferous period, has, in virtue of a strict heredity, been preserved even to the present day in man. Also, naturally and harmoniously, the typical construction of the joints, ligaments, muscles, and nerves of the two pairs of legs has, in the main, remained the same as in the rest of the 'four-footed.' In all these important relations man is a true tetrapod" (*ibid*, pp. 29 and 30).

Yes, man is a quadruped.

And here we must pause to consider a difficult point, for it presents one of the most remarkable links in the history of man from the lower animals.

We have seen that all the vertebrates are divided into five groups—fish, amphibians, reptiles, birds, mammals.

The fish and amphibians live either altogether or partially in water, and it is manifestly a great change to the organism to become altogether adapted to a life on land. So that it is no wonder we find new structures appearing in all those animals. One of these structures is the amnion. It is

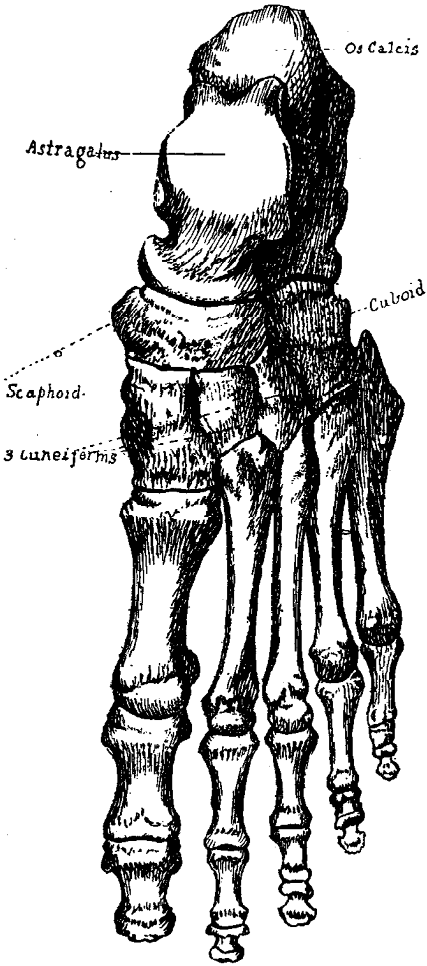


FIGURE 10a.—THE HUMAN FOOT.

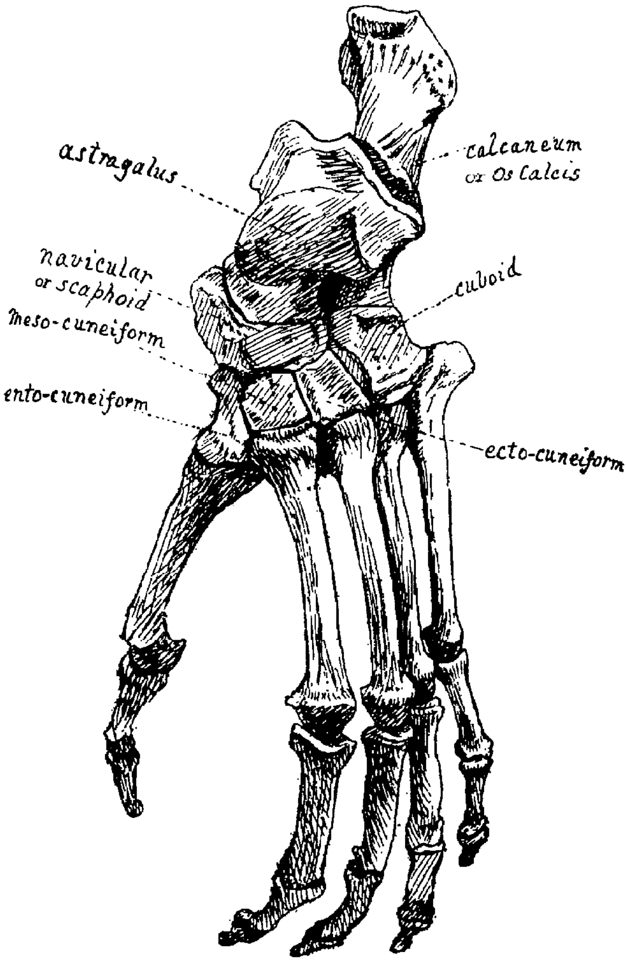


FIGURE 10b.—THE APE'S FOOT.

Note the os calcis and the astragalus. These are not in the hand. It proves the ape is not a four-handed animal.

found in reptiles, birds, and mammals, and so all these animals can be classed together as amniotes.

But Haeckel shall first tell us of this. He says, after describing the wonderful resemblance between the embryos of many vertebrates, that the same striking resemblance is seen in the membranes which protect the embryos while they are growing before birth.

"All vertebrates of the three higher classes—reptiles, birds, and mammals—are distinguished from the lower classes by the possession of certain fœtal membranes—the amnion and the serolemma. The embryo is enclosed in these membranes or bags, which are full of water, and is thus protected from pressure or shock. This provident arrangement probably arose during the Permian period, when the oldest reptiles, the proreptilia, with the common ancestors of all the amniotes (animals with an amnion), completely adapted themselves to a life on land. Their direct ancestors, the amphibia, and the fishes are devoid of these fœtal membranes; they would have been superfluous to these inhabitants of the water. With the inheritance of these protective coverings are closely connected two other changes in the amniotes—firstly, the entire disappearance of gills (while the gill arches and clefts continue to be inherited as 'rudimentary organs'); secondly, the construction of the allantois.

"This vesicular bag, filled with water, grows out of the hind gut of the embryo of all the amniotes, and is nothing else than an enlargement of the bladder of their amphibious ancestors. From its innermost and inferior section is formed subsequently the permanent bladder of the amniotes, while the larger outer part shrivels up. Usually this has an important part to play for a long time as the respiratory organ of the embryo, a number of large blood vessels spreading out over its inner surface. The formation of the membranes, the amnion and the serolemma, and of the allantois, is just the same complicated process of growth in man as in all the other amniotes; man is a true amniote" (*ibid.*, pp. 66 and 67).

Here we see that man shares with three large groups of animals four distinct points in addition to the many brief similar stages through which he passes in embryo.

That these membranes should have been developed to protect the young in so many animals so widely unlike is nothing short of a marvel, and the wonder is all the more striking when we remember that the two lower classes of vertebrates live in the water, at least when young. These membranes or bags full of water provide the old element in which the ancestors of the three higher groups had lived so long.

Is man a true mammal?

The mammals are the youngest and most advanced class of the vertebrates. They are derived from the older class of amphibia, as birds and reptiles are. Yet they are distinguished from other quadrupeds by many striking features. Externally, clothing of skin with hair, possession of two kinds of skin glands—sweat glands and sebaceous glands.

A local development of these sebaceous glands on the skin of the belly gave rise to the organ by which the mothers of these animals suckle their young, called the mammarium, from which the whole class takes its name. This organ is made up of milk glands and the "mammar pouches" (folds of the abdominal skin). In its development the teats appear, through which the young mammal is able to suck its mother's milk.

Internally, the most remarkable feature is the muscular wall which divides the hollow body into two chambers—the chest and the abdomen. This dividing wall is called the diaphragm, and is found in all mammals.

The skull and the jaws present remarkable formations. The brain, the olfactory organ (nose), the lungs, the sexual organs, the kidneys, and other parts of the body present features peculiar to mammals. All these taken together point without doubt "to an early derivation of the mammals from the older groups of reptiles and amphibia," which may have taken place at the latest in the Triassic period—say fourteen million years ago.

In all these characters man is a true mammal.

Is man a placental?

The order of mammals is divided into three great groups.

1. Monotremes.
2. Marsupials.
3. Placentals.

These three groups differ in their structure and development; they also correspond to three different historical stages in the formation of the class.

1. Monotremes correspond to the Triassic period.
2. Marsupials correspond to the Jurassic period.
3. Mammals correspond to the Cretaceous period.

Each of these groups is marked by the acquirement of some new structure for the perfection of the animal, especially in relation to producing or nourishing its young.

One of the most important of these organs is the placenta, commonly called the after-birth. This organ serves the purpose of nourishing the young before birth. At certain points it is so delicate in structure that the nutriment in the mother's blood can pass directly into the blood of the offspring. This contrivance makes its appearance late in the history of mammals, and gives the unborn offspring the opportunity of staying longer, and developing more completely, in the womb.

Now, the first two classes, the monotremes and marsupials, have not this organ, and are called implacental.

The placentals include the armadillo, the whale, dolphin, elephant, pig, cow, horse, sheep, rabbit tribe, cat, dog, mole, monkey, ape, man.

Man is a placental animal.

Does man belong to the primates?

The placentals may be divided into four groups. These can be traced to one common ancestral group, the prochoriata of the cretaceous period. This group is directly connected with the marsupial ancestors.

The placental four main groups are the rodents, the ungulata, the carnivora, the primates.

The primates include lemurs, monkeys, man; or, in other terms, half-apes, apes, man.

All three orders agree in many important features, and are at the same time distinguished by these features from every other order of placentals.

One feature is the length of their bones, which were originally adapted for living in trees; hands and feet are five-fingered, suited for grasping, provided with nails, have no claws. The order of the teeth is complete, containing incisors, canines, premolars, molars.

They are distinguished from all other placentals by important features in the skull and the brain.

Man is a truc primatc.

He has descended through ancestors of the Old-World monkeys, the catarrhine monkeys, all of which have the same teeth as man—thirty-two.

These Old-World monkeys are either tailed, the dog-like apes; or tailless, the man-like apes.

These man-like apes share certain features with man, which seem to show that man came through the family-lin of tailless apes, though not from any of the present specimens. Man has in common with them the same two hundred bones, the same five hundred muscles; the same groups of cells which build up his brain, the same four-chambered heart, the same thirty-two teeth in the same order, the same salivary, hepatic, and gastric glands, the same reproductive organs, both internal and external.

Haeckel has taken us through all the groups of vertebrates with great care, and we have seen that man as clearly belongs to these groups as does any other animal. We shall deal more fully with monkeys, but so far we have found nothing to prevent our grouping man with "the lower animals."

It is true we find certain differences in size and shape between the organs of man and the ape, but we also find differences between the higher and lower races of men. Nay, more, we find considerable differences in the size and shape of many organs among Englishmen. When carefully examined, their noses, ears, hands, and feet are by no means so exactly alike that we can suppose they have been cast in one and the same mould.

Chapter IV.

MAN AND MONKEYS

To the well-informed it must seem unnecessarily ancient to give a chapter to show man's relationship to apes and monkeys. They have already made up their minds on this point. Men have long since embalmed the brilliant wit which shone around the "missing link" and ended in the popular dogma that man had come from a tailed monkey. Prejudice may bring out this dusty mummy on feast days to give hope and amusement to the unthinking; but the serious student soon discovers that there is no missing link, and that if man had come from any living monkey it would not be evolution, but a miracle.

It is probably quite as true to say that man has come from a monkey as that he came from a mole. For men, monkeys, and moles had at one stage common ancestors.

Much amusement can be got from studying the difficulties of those to whom the word Evolution has no meaning, for they spend all their time seeking small points of difference between man and the apes. I have been seriously told that Evolution is not true because man has two nerves on the side of his head, which are not found in monkeys! Such objectors say that they would believe in the doctrine of modification by descent if man were exactly the same as the apes. In other words, they would believe in Evolution where there had been no Evolution.

In looking at the whole kingdom of animals, we divide them into large groups, in which every division of the group possesses some common character or characters—as the invertebrate and the vertebrate. The mammals may be divided into eleven orders, the highest of which is the primates. We have to inquire, therefore, whether man naturally fits into this order, or whether he demands an order to himself, as the old naturalists used to think. This method of grouping is called classification, and, if we turn to any scientific book on zoology, we find that man is regarded as a member of a single order, the Primates. I read this description of all members of this order: "The primates may be defined—

"1. By the possession of perfect clavicles which articulate with the top of the sternum, or breast bone.

"2. The radius and ulna, and tibia and fibula, are complete and are not anchylosed with one another (excepting only the odd little animal, a sort of lemur, called Tarsius, found in Borneo, etc.).

"3. The hallux (the great toe) has a flat nail, and is commonly opposable to the other toes.

"4. The pollex (the thumb) is also usually opposable to the other fingers.

"5. The typical arrangement of teeth is—

$$\text{i}\,\frac{2-2}{2-2};\ \text{c}\,\frac{1-1}{1-1};\ \text{p.m.}\ \frac{2-2}{2-2}\ \text{or}\ \frac{3-3}{3-3};\ \text{m.}\ \frac{3-3}{3-3} = 32\ \text{or}\ 36.$$[1]

"6. In no instance are there more than thirty-six teeth altogether, and the molars always have broad and tuberculate crowns.

"7. The mammary glands are typically two in number, and are almost always on the chest.

"8. The placenta is discoidal."

These eight points, which are common to hundreds of different species of animals, would be sufficient to settle the classification of those animals in one order if it

[1] The teeth exactly in front are called incisors, four above and four below; the next are called canines, one on each side above and below; next are the pre-molars, which may be two or three on each side above and below; finally, there are the molars or grinding teeth, three on each side above and below.

were not for human vanity and prejudice. No difficulty would be raised to this way of grouping if we were dealing only with birds or reptiles. The scientific man would be satisfied that animals with so many points in common *must* be placed in one group.

The order, Primates, may be divided into three families:—

1. The Lemuroids.
2. The Simioids.
3. Man.

1. Lemuroids.

This group contains the prosimii (half-apes). They are small animals, which live in trees; their fore limbs are shorter than their hind limbs; the great toe is opposable to the other toes; so also, as a rule, is the thumb to the fingers. The second digit of the foot has a curved claw; but in the typical lemuroids the other digits of both feet and hands have nails, those of the great toe and thumb being flat, while those of the other digits are more claw-like.

The nostrils are twisted and curved, with their convexities turned outwards and placed at the end of the snout. There may be two abdominal mammary glands, or there may be abdominal mammæ in addition to the two on the chest. None of the lemuroids have a prehensile tail, cheek pouches, or natal callosities.

Speaking roughly, their centre is Madagascar. The lemur itself has thirty-six teeth.

2. Simioids.

These include all the monkeys and apes—called by Owen the catarrhine and platyrrhine monkeys.

These are distinguished from the other members of the Primates by having the great toe much shorter than the other toes and always opposable. There is a space (*diastema*) between the upper canine teeth and the incisors, and between the lower canines and the first premolars, the large canine teeth being thus able to pass each other when the mouth is closed.

There is but a single pair of mammary glands, and these are on the chest. In many cases the cheeks are distended into "cheek-pouches," and there are often spaces of thickened and naked skin on the rump, called "the natal callosities."

The Simioids are divided into three groups—(1) the Arctopithecini (marmosets); (2) the Platyrrhini (spider monkeys, howling monkeys, woolly monkeys, etc.); (3) the Catarrhini (macaques, baboons, apes, gorillas, etc.).

Groups (1) and (2) are found only in America, and group (3) is confined entirely to the warmer parts of the Old World, and, except one species of macaque, is found only in Africa and Asia and its islands.

The great divisions are Platyrrhini and Catarrhini. Platyrrhine means broad or flat-nosed. The nostrils are separated by a broad division (*septum*) and open sidewards. Catarrhine means down-nosed. The nostrils are separated by a narrow division (*septum*), and so directed as to look downwards.

Platyrrhini.—This group includes all the American monkeys except group one, the marmosets. The tail is long and commonly prehensile; there are no cheek pouches or natal callosities, the fore limbs are shorter than the hind limbs, and the thumb is not opposable to the fingers. There are three molars on each side of each jaw, as in the catarrhini and in man, while there is a premolar more on each side than in these. The number of the teeth is thirty-six. These monkeys live in trees, partly on fruits and partly on insects.

Catarrhini.—These include all the monkeys and apes of the Old World. The tail may be long or short, or wanting, but is never prehensile. Cheek pouches and natal callosities are often present. The thumb (wanting in *colobus*) is opposable to the fingers. The number of molars and premolars is the same as in man, and they have thirty-two teeth, as man has. They are essentially African and Asiatic. A single species, the Barbary ape (*macacus inuus*), is found on the rock of Gibraltar, and is the only monkey which inhabits Europe. No monkeys are found in Australia, but a species of Macaque lives on the island of Timor, and thus belongs to the Australian province.

The anthropoid apes form the highest section of monkeys. They are without a tail or cheek pouches, and usually there are no natal callosities. They include the gibbons (*hylobates*), the orang-utan (*simia*), the gorilla, and the chimpanzee (*anthropopithecus*). (The gorilla and chimpanzee used to be called troglodytes, but this name is now confined to a genus of birds.)

In the anthropoid apes the fore limbs are longer than the hind limbs; the animal can progress in a semi-erect position. The cæcum has a vermiform appendix; the sternum is broad and flat as in man. The thumb is never rudimentary, and is always opposable to the fingers. The great toe is joined at an angle to the other toes, and is opposable. The spine shows a slight curve, and articulates with the back of the skull. The canine teeth are large, especially in the males; the muzzle projects to a greater or less extent; the muscular ridges of the skull are usually greatly developed.

In one species of the gibbons (the Siamang of Sumatra) there is a distinct chin.

In the gibbon and the orang the arms are excessively long, reaching considerably below the knee when the animal stands erect. The hind legs are very short, and there is no tail.

The orang stands about four feet high, never progresses by the help of a stick or walks erect at all, except along the branches of trees, or when attacked. When young, the head of the orang is not very different from that of an average European child; but as the animal grows the facial bones are very much produced, and the muzzle becomes as pronounced and well marked as in many of the carnivora. The orangs live in trees and form for themselves a sort of nest or shelter in them. The forehead is rounded, the cerebrum is greatly convoluted, and the canine teeth of the males are very large.

The chimpanzees have shorter arms than the gibbons or orangs, still they are longer than the hind limbs. They can stand erect, but their natural mode of progression is on all fours. The hands are naked to the wrist, and the face is also naked. The chimpanzee lives in society in wooded districts, and constructs a kind of nest.

The gorilla is much larger than the chimpanzee, the full-grown male being over five and a half feet high. The muzzle is prominent, the supraciliary ridges and the sagittal crest of the skull are enormously developed, and the canines are large. The fore limbs are long and extend to about the knees when the animal stands erect. The palms and soles of the feet are naked and hairless, black in colour, the fingers rendered in appearance shorter than they really are by the extension forwards of the skin between them. The cranial capacity is about thirty-one cubic inches, that of the average Australian being seventy-five cubic inches. The gorilla is essentially a tree-living animal, and the male builds a sort of nest in a tree, in which the female brings forth her young. It is found in equatorial Africa, and is a strong, ferocious animal.

Such is a bare outline of the family of the Simioids after Nicholson.

If we read this account, bearing in mind that man is not supposed to be descended from any of these, but that they may be regarded as distant cousins to man, he and they being all descended from some common ancestor or ancestral group, we cannot fail to be struck with many points of family likeness. We note that there are many indications of human features, and we must always bear in mind that an organ is not a really different organ because it is larger or smaller. An arm is an arm whether it is two feet long or three feet long.

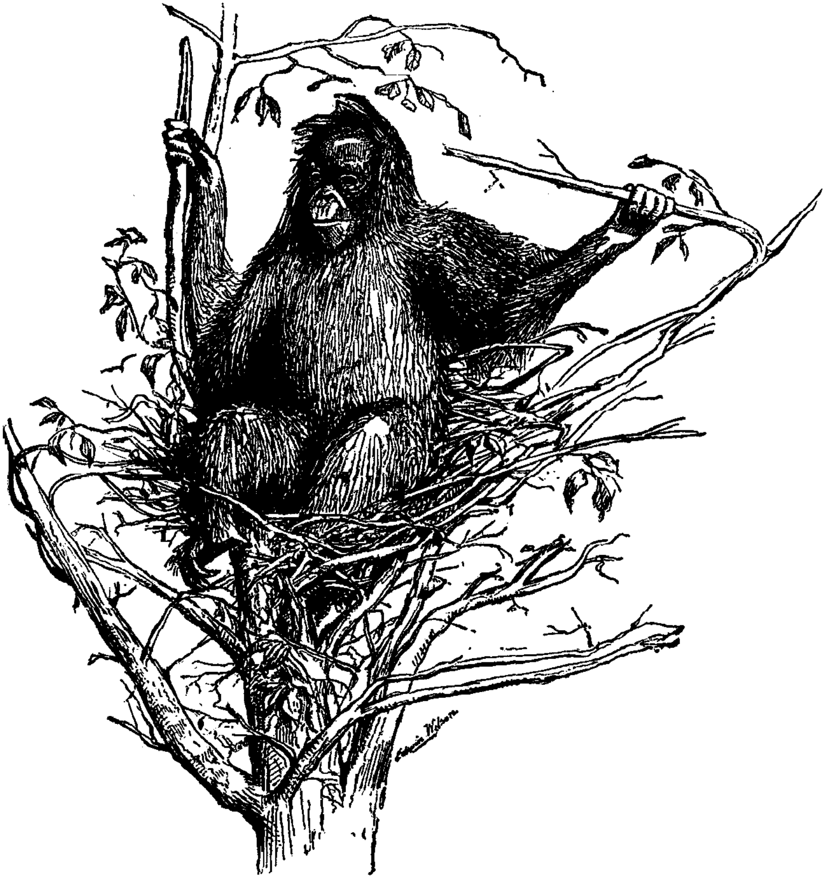


FIGURE II.—THE ORANG-UTAN (Simia Satyrus) sitting in its nest.

From a specimen in the Cambridge Museum, from Shipley and MacBride's *Zoology*. (By kind permission.)

The gorilla is nearest man in the structure of the hands and feet.

The chimpanzee is nearest man in the form of the skull.

The orang is nearest man in the development of the brain.

The gibbon is nearest man in the form of the chest.

Just as several cousins or half-cousins may resemble each other in particular features.

And we must remember that the young anthropoid ape is always more like the human child than the adult ape is like adult man.

Man (*Homo*).

Turning to Nicholson again, we find that man (*Homo*) is distinguished from the other primates by his habitually erect posture and by walking on two feet. The lower limbs are exclusively devoted to walking and to supporting the body, the foot being broad and plantigrade, with a well-developed heel. When the skeleton is studied the great toe is seen to be shorter than the second toe, with which it is placed in a line, and it is not opposable. The fore limb is shorter than the hind limb. The thumb is joined at an angle to the fingers, and is not only opposable, but is capable of being drawn to or from the fingers. The spine has a double curve. In the skull there is no sagittal crest, and the supraciliary ridges are little developed. The lower jaws are joined so as to form a well-developed chin. There are thirty-two teeth, which form a nearly even series, without any interval. The canines are not markedly larger than the incisors. The capacity of the brain case varies from about fifty to over one hundred cubic inches, and is never less than forty cubic inches. The brain averages from forty-five to sixty ounces in weight, the cerebral lobes being proportionately larger, and its surface being more abundantly and deeply convoluted than is the case with any other mammal.

Lastly, the development of hair is but partial, and man is the only terrestrial mammal in which the body is not provided, at any rate on its back, with a covering of hair.

Nicholson concludes: "At the present day it is usual to regard man, from a purely zoological point of view, as constituting a special section (Anthropidæ) of the order, Primates, or a special family (Hominidæ) of the Simioidea."

This account is not quite clear in one respect—viz., as to which are the characteristics by which man is "distinguished"; but, to be quite sure, we may take the whole list of points in this description.

I do this because some uneducated people, who have just heard of Evolution, talk loudly of "the missing link." During the last forty years this phrase has been the shield of much ignorance, and I cannot but think it has been greatly exaggerated sometimes by really scientific men.

We have seen (p. 19) that, at the beginning of the vertebrate series, there were links enough to join the vertebrates to the invertebrates. No fewer than three classes of animals were found so like invertebrates that only by the closest scrutiny had it been discovered that they possessed the one organ—the notochord—which marks the whole vertebrate class.

In the same way we found (p. 27) that at the commencement of the Order of Mammals there was no break in the series. True, there were found new structures which mark all the class of mammals, but with them appeared other structures which joined the lowest mammals in many points with birds or reptiles or amphibia or fishes. So that mammals, far from standing alone, are connected with the whole family of the back-boned by many "links."

Now we come to the last and highest order of mammals, called Primates, meaning the first order.

Do they start on some entirely new principle having no points of connection with the lower mammals? By no means.

At the bottom of this order, Primates, stands the class of lemurs which in many points are like the class next below them—the insectivora. But that there shall be no break, we find a family of insectivora so strange that it has to be classified by itself, as possessing so many marks of the insectivora and the lemurs. These little creatures are called Galeopitheci, found in Borneo, Malacca, and Sumatra. There are only two established species, and one of them possesses the power of flight, and is commonly called "the flying-lemur."

The insectivora contain the bat, the mole, the hedgehog; and the "flying-lemur" is a strong connecting-link between the insectivora and the lowest Primates. On the other hand, a little lemur, called the Aye-aye of Madagascar, looks like a large squirrel, and has teeth resembling those of a rabbit, but no canines.

But perhaps nothing will more clearly show the relationship of man to the rest of the order, Primates, than to examine separately the points given in the above account of him.

Man has habitually the erect posture and walks on two feet. But no child has the power to walk erect at birth. It acquires this by a slow and laborious process, and for a long time every mother has to allow her infant to be a quadruped. The chimpanzee can stand erect, and some of the higher apes can walk on their two feet in a half-erect position, supporting themselves by touching the ground with their knuckles. There is no lack of a connecting-link here.

In consequence of man having fully acquired the habit of walking erect, and thus bearing the weight of the body on two limbs, of course the lower limbs and the feet also become more developed, but they have not acquired any new muscles or bones.

The great toe (*hallux*) is shorter than the second toe and cannot be "opposed" to the other toes, and lies in a line with them. In some of the platyrrhine monkeys the great toe is so much smaller than the rest as to be quite a rudiment, and cannot be "opposed" to them.

The fore limb is shorter than the hind limb; so it is among the marmosets and most of the platyrrhine monkeys.

The thumb is opposable to the fingers; so it is in all the Old World monkeys.

There is no sagittal crest, and the ridges over the eyes are little developed. I am informed that the Woolly Monkey of Venezuela has no sagittal crest.

The lower jaws are joined to form a chin; so they are in the Siamang, one of the gibbons.

There are thirty-two teeth in a *nearly* even series. All the catarrhine monkeys and marmosets have only thirty-two teeth, and the fact that they are only "*nearly even*" in man shows their resemblance to those of apes which are only less even. The canines are not markedly larger, but they *are* larger, and this is all that can be needed to show that they are not even.

Man is not covered with hair, but we have seen (p. 39) that in an early stage before birth he is covered with hair, and we also know that in the chimpanzee and the gorilla the hands and feet are naked.

In all these and in many other points it can be shown that man has no physical feature which is not also possessed in some degree by other animals. If these are not "links," what can be the meaning of the word?

But, says one, there is the most important organ of all—the brain. We will, therefore, follow Huxley. (*See* Figs. 12 and 13.)

The brain of apes and man.

What really constitutes a great and what a small difference in this organ? We shall see best if we study some of the chief modifications which the brain shows in the series of vertebrate animals.

The brain of a *fish* is very small compared with the spinal cord into which it is continued, and with the nerves which come off from it; no one of its segments is so much larger than the rest as to cover them; the so-called optic lobes are frequently the largest masses of all.

In *reptiles* the mass of the brain increases in proportion to the spinal cord, and the two upper and chief divisions,

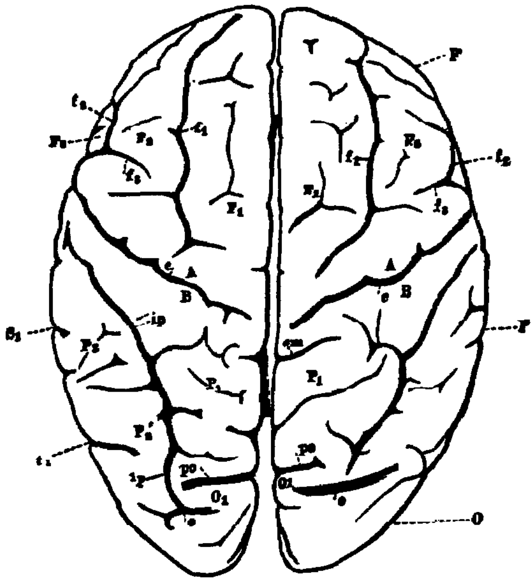


FIGURE 12.—HUMAN BRAIN.

This represents the view of the brain as seen in its place, if we looked down on its top-surface. SI shows the end of the horizontal branch of the fissure of Sylvius. The other letters refer to the same parts as in Figure 14.

called the cerebral hemispheres, begin to be much larger than in other parts; while in *birds* they are still more marked in their size.

The brain of the lowest *mammals* (platypus, opossums, and kangaroos) exhibits a still clearer advance in this direction. The cerebral hemispheres have now become so large that they more or less hide the representatives of the optic lobes, which remain comparatively small. (*See* Figs. 14 and 15.)

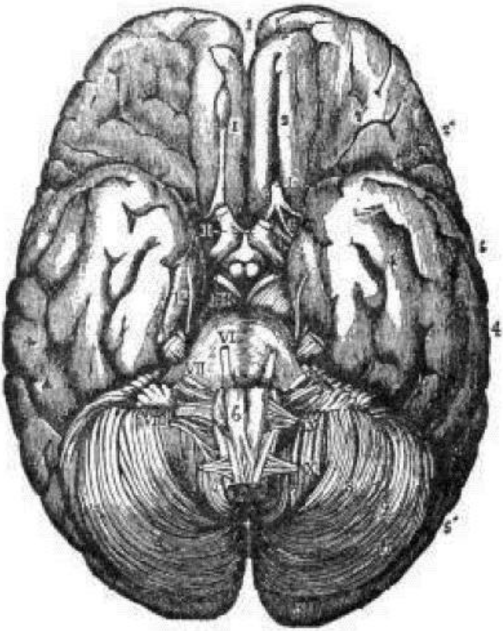


FIGURE 13.—HUMAN BRAIN.

Shows the base or under surface of the brain as we should see it from beneath. Here the brain has been turned over so that we look at its under surface. Base of the brain.—1. Superior longitudinal fissure; 2, 2′, 2″. Anterior cerebral lobe; 3. Fissure of Sylvius, between anterior and 4, 4′, 4″, middle cerebral lobe; 5, 5′. Posterior lobe; 6. Medulla oblongata (the figure is in the right anterior pyramid); 7, 8, 9, 10. The cerebellum; X, the inferior vermiform process. The figures from I. to IX. are placed against the corresponding cerebral nerves; III. is placed on the right crus cerebri; VI. and VII. on the pons Varolii; X. the first cervical or suboccipital nerve. (Allen Thomson.)

There also appears the beginning of a new structure, the "corpus callosum." The corpus callosum is often called "the great commisure," because, when fully developed, it is found between the central hemispheres, connecting them together. This structure is very small in monotremes and

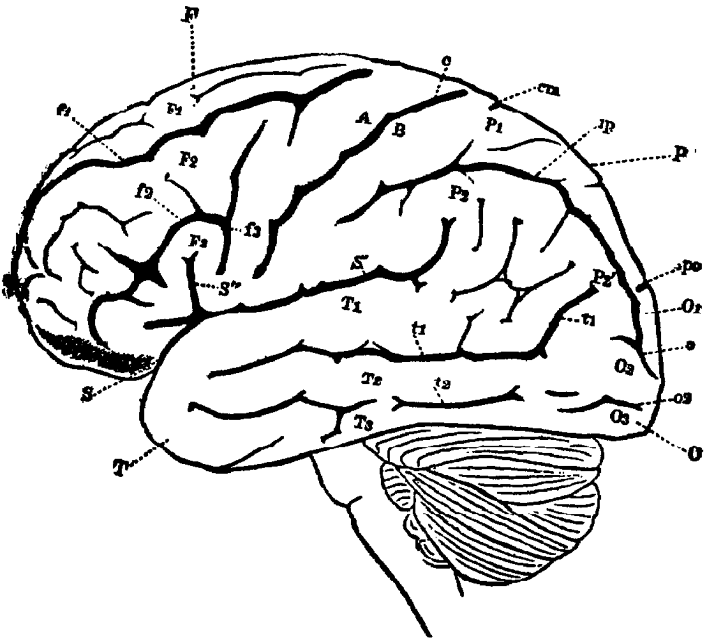


FIGURE 14.—HUMAN BRAIN.

This represents a side view of the outer brain as it would appear on the left side of the head, if the skull bone were removed. Lateral view of the brain (semi-diagrammatic). F, Frontal lobe; P, Parietal lobe; O, Occipital lobe; T, Tempore-sphenoidal lobe; S, fissure of Sylvius; S', horizontal; S'', ascending ramus of the same; c, sulcus centralis (fissure of Rolando); A, ascending frontal; B, ascending parietal convolution; F1, superior; F2, middle; F3, inferior frontal convolutions; f1 superior, f2 inferior, frontal sulcus; f3, præcentral sulcus; P1, superior parietal lobule; P2, inferior parietal lobule, consisting of P2, supramarginal gyrus, and P2', angular gyrus; ip, interparietal sulcus; cm, termination of calloso-marginal fissure: O1, first; O2, second; O3, third occipital convolutions; po, parieto-occipital fissure; o, transverse occipital fissure; o2, sulcus occipitalis inferior; T1, first; T2, second; T2, third temporo-sphenoidal convolutions; t1, first; t2, second temporo-sphenoidal fissures. (Ecker.)

marsupials. But, owing to the development of the cerebral lobes and the beginning of this connecting structure, the brain of a marsupial is extremely different from that of a bird, reptile, or fish.

A step higher in the scale, among the placental mammals, the brain seems to undergo a great change in its structure—though there is not a great change in the external view of a

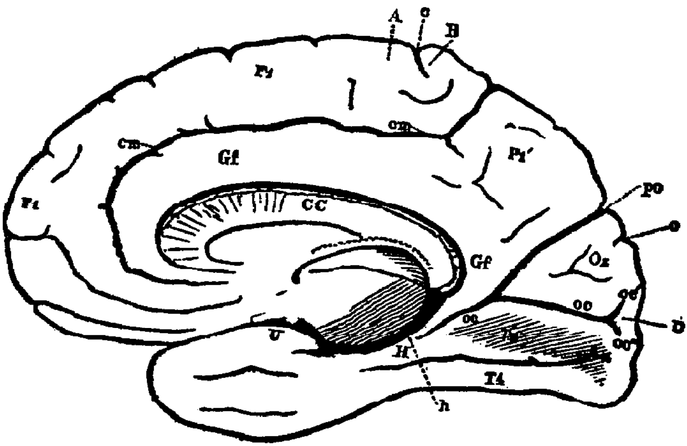


FIGURE 15.—HUMAN BRAIN.

View of the right hemisphere in the median aspect (semi-diagrammatic). CC, corpus callosum longitudinally divided; Gf, gyrus fornicatus; H, gyrus hippocampi; h, sulcus hippocampi; U, uncinate gyrus; cm, calloso-marginal fissure; F1, median aspect of first frontal convolution; c, terminal portion of sulcus centralis (fissure of Rolando); A, ascending frontal; B, ascending parietal convolution; P′, præcuneus; Oz, cuneus; po, parieto-occipital fissure; o, sulcus occipitalis transversus; oc, calcarine fissure; oc′, superior; oc″, inferior ramus of the same; D, gyrus descendens; T4, gyrus occipito-temporalis lateralis; T5, gyrus occipito-temporalis medialis.

rat or rabbit as compared with a marsupial, neither are the proportions of its parts much changed; but the new structure (the corpus callosum) has developed to what is known as a true corpus callosum, so as to have a definite function.

This seems to be the most sudden modification shown by the brain in the whole series of vertebrate animals—it is the greatest leap anywhere made by Nature in brain development.

For the two halves of the brain being thus once knit together, the progress of the brain's complexity can be traced through a complete series of steps from the rabbit or the mole to man. This complexity consists chiefly in the disproportionate development of the cerebral hemispheres, and of the lower and back portion of the brain called the cerebellum, but especially of the former.

In the *lower* placental mammals the cerebral hemispheres leave a large part of the cerebellum visible at the back of the brain when we look at it from above, but in the higher mammals the hinder part of each hemisphere inclines backwards and downwards, and grows out so as to overlap and hide the cerebellum.

In *all mammals* each cerebral hemisphere contains a cavity (the ventricle), and as this cavity is prolonged on the one hand forward and on the other downward, into the brain substance, the cavity is said to have two horns (the cornua). Later there appears a third prolongation of the cavity, extending into that part of the brain called the posterior lobe. This hollow is called the posterior horn.

In the lower and smaller orders of placental mammals the surface of the cerebral hemispheres is either smooth or evenly rounded, or shows a very few grooves (the sulci) and separating ridges (the convolutions) of the substance of the brain; and the smaller kinds of *all* orders tend to a similar smoothness of brain.

But in the *higher orders* the grooves become very numerous, and the ridges between are much more complicated in their twisted lines, until, in the elephant, the porpoise, the higher apes, and man, the surface of the brain appears a perfect network of twisted foldings.

At the back part of the brain, where the hollow called the posterior horn appears, there is commonly a particular groove upon the inner and under surface of the lobe, beneath the floor of the posterior horn, which is, as it were, arched over the roof of the groove. It is as if the floor of the posterior horn had risen as a convex eminence. This eminence is called "Hippocampus minor": the function of this structure is not known.

Now, omitting a great deal, we will fix our attention on the three points which have been declared again and again to be peculiar to, and characteristic of, man. These three points are:—

The posterior lobe;

The posterior horn;

The hippocampus minor.

It has been demonstrated without doubt that these three portions are among the most distinctly ape-like peculiarities which the human body shows!

As to the ridges (convolutions), the brains of apes show every stage of progress from the almost smooth brain of the marmoset to the orang and the chimpanzee, which fall but little below man. (*See* Fig. 16.)

"And it is most remarkable that, as soon as all the principal grooves appear, the pattern according to which they are arranged *is identical* with that of the corresponding grooves of man. The surface of the brain of a monkey exhibits a sort of skeleton map of man's, and in the man-like apes the details become more and more filled in, until it is only in smaller characters, such as the greater depth of the front lobes, the constant presence of fissures usually absent in man, and the different arrangement and proportions of some of the convolutions, that the chimpanzee's or orang's brain can be structurally distinguished from man's."

"So far as the brain is concerned, therefore, it is clear that man differs less from the chimpanzee or the orang than these do even from monkeys, and that the difference between the brains of the chimpanzee and of man is almost insignificant when compared with that between the chimpanzee brain and that of a lemur!"

As far as man is concerned, there is clearly no "missing link" in the development and structure of his brain.

Those who wish to pursue this inquiry must read *Man's Place in Nature*, by Professor Huxley.

After an exhaustive examination, he thus sums up: "Thus, whatever system of organs be studied, the comparison of their modifications in the ape series leads to one and the

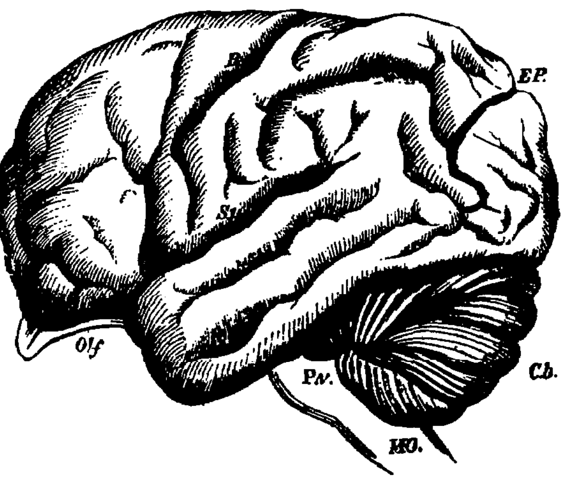


FIGURE 16.—MONKEY'S BRAIN.

Brain of the Orang, showing the arrangement of the convolutions. *Sy*, fissure of Sylvius; *R*, fissure of Rolando; *E P*, external perpendicular fissure; *Olf*, olfactory lobe; *Cb*, cerebellum; *P V*, pons Varolii; *M O*, medulla oblongata. As contrasted with the human brain, the frontal lobe is short and small relatively, the fissure of Sylvius is oblique, the temporo-sphenoidal lobe very prominent, and the external perpendicular fissure very well-marked. (Gratiolet.)

same result—that the structural differences which separate man from the gorilla and the chimpanzee are not so great as those which separate the gorilla from the lower apes."

Still he emphasises the fact that the differences between man and the highest apes are not small and insignificant. He adds: "Let me take this opportunity, then, of distinctly asserting, on the contrary, that they are great and significant."

He points out that there is no existing link or intermediate form between man and the gorilla; but in the same way there is no existing link between the gorilla and the orang or the orang and the gibbon. Yet no one doubts that these latter are all of one and the same order.

One further line of inquiry is left. Are there any fossil remains of man which would help to bring existing men into closer relationship with the ape family?

We know that, so far, scarcely any portion of the rocks of the earth has been explored in comparison with the unexcavated part. The marvel, therefore, is not that we have found so few remains of primates, but rather that we have found so many. In two cases remains were found which caused considerable excitement. Skulls were found in the cave of Engis, in the valley of the Meuse, in Belgium, and in the cave of Neanderthal, near Düsseldorf. It is agreed that these skulls are those of human beings, and the one found at Neanderthal seems to offer features which show a low savage type, and in two or three points it is more ape-like than the skull of the average savage of to-day.

A fossil ape-man found in Java has seemed to some to give the lowest form of a human being yet discovered. This ape-man has been named the pithecanthropus erectus (the erect ape-like man).

Mr. A. H. Keane, F.R.G.S., late Vice-President of the Anthropological Institute, has written a valuable book on *Man, Past and Present* (1899). In dealing with ancient skulls and the ape-like man of Java he says: "It must be obvious that if man is specifically one, though not necessarily sprung of a single pair, he must have had a single cradle-land."

"It follows, further, and this point is all-important, that, since the world was peopled by pleistocene man, it was peopled by a generalised proto-human form, prior to all later racial differences."

"No doubt Dr. R. Munro is right in suggesting that during the larger portion of the quaternary (pleistocene) period, if not, indeed, from its very commencement, man had acquired his human characters—that is, the more general qualities by which man is distinguished from the other anthropoid groups."

This statement "acquires a large degree of probability, if not absolute certainty, by the remains of pithecanthropus erectus, found in 1891 by Dr. Eugene Dubois in the pliocene beds of East Java—that is, in the very region which more than one eminent naturalist had pointed to as the probable original home of mankind."

The human character of these remains has been placed beyond reasonable doubt.

"Nobody now denies that they at least represent a form intermediate between man and the higher apes, or, rather, between man and the generalised Simian prototype, which is practically the same thing. They do not bridge over the impassable gap between man and the gorilla or chimpanzee; but they form, none the less, a true link, which brings man much nearer than before to the common stem from which all have diverged."

"No one has studied this question more carefully than Mr. L. Manouvrier, who concludes that Homo Javanensis walked erect, was about the medium height, and a true precursor, possibly a direct ancestor, of man."

He handles Virchow severely.

He points out that the cranial capacity decreases with the antiquity of all the skulls hitherto brought to light, and that this skull has a capacity of from 900–1000 cubic centimetres—that is, "stands at the level of the smallest which have been occasionally found among the reputedly lower savage peoples."

Manouvrier adds, "that it may perhaps be more directly connected with the Australian race. The differentiation of the human races having probably been but slightly developed in the pliocene epoch, I may be permitted to suggest that the race of Trinil (Java) was the common ancestor of many human races, if not of all those which have been subsequently specialised."

"Dr. D. Hepburn says the femur is distinctly human, and antedates all other human remains hitherto discovered; and that of living races the nearest akin are the Australians, Andamanese, Bushmen, thereby lending support to the view that these low races spring from a common primeval stock, which originally inhabited the now vanished Indo-African Continent."

The pliocene inhabitant of Java may thus in a sense be taken as the long-sought-for "First Man," and the Indo-Malagasian inter-tropical lands may also be, with some confidence, regarded as the cradle of the human family.

In that truly great work, *The Cambridge Natural History*, vol. x. is devoted to mammals. This work is edited by Mr. Frank E. Beddard, M.A., of Oxford, F.R.S,, Vice-Secretary and Prosector of the Zoological Society, London, and this volume was published in 1902. Pithecanthropus erectus is here placed under man-like apes; but, when dealing with man, we read: "Pithecanthropus, perhaps, is a member of this family; but its remains permit us to leave it among the Simiidæ, at least for the present. The skull in its profile outline stands roughly midway between that of a young chimpanzee and the lowest human skull—that of Neanderthal man. This creature is truly, as Professor Haeckel put it, 'the long-searched-for "missing-link"'; in other words, it represents 'the commencement of humanity.'"

Of the fossil pithecanthropus erectus, discovered, as already mentioned, in Java, in 1891, by Dr. Eugene Dubois, Professor Haeckel says:—

"The remains are scanty—the skull cap, a femur, and two teeth. It is obviously impossible to form from these scanty remains a complete reconstruction."

The more important points are the following:—

"The remains rested upon a conglomerate which lies upon a bed of marine marl and sand of the pliocene age. Together with the bones of the pithecanthropus, were found those of the stegodon, leptobos, rhinoceros, pig, cat, hyæna, hippopotamus, etc.

"It is remarkable that the first two of these genera are now extinct, and that neither hippopotamus nor hyæna exists any longer in the Oriental region. If we may judge from these fossil remains, the bones of the pithecanthropus are not younger than the oldest pleistocene, and probably belong to the upper pliocene. The teeth are like those of a man. The femur also is very human, but shows some resemblances to that of the gibbon. Its size, however, indicates an animal which stood, when erect, not less than five feet six inches high. The skull-cap also is very human, but with prominent eyebrow ridges, like those of the Neanderthal cranium.

"The final result of the long discussion at Leyden was that, of twelve experts present, three held that the fossil remains belonged to a low race of man; three declared them to be those of a man-like ape of great size; the rest maintained that they belonged to an intermediate form which directly connected primitive man with the anthropoid apes. This last view is the right one, and accords with the laws of logical inference. The pithecanthropus erectus of Dubois is truly a pliocene remainder of that famous group of highest catarrhines which were the intermediate pithecoid ancestors of man. He is, indeed, the long-searched-for missing link."

At the Leyden congress this view was attacked by Professor Virchow. This eminent "pathologist cannot allow himself to think of man 'as a descendant of apes.'"

He first said the skull and thigh bone did *not* belong to the same animal. This the expert palæontologists refuted.

He then explained that certain growths on the thigh bone proved its human nature, for the patient could never have been healed of its original injury, except under careful treatment. Professor Marsh showed a number of thigh bones of wild monkeys which had similar growths on them, and which had healed without hospital treatment.

"Then," said Virchow, "the deep constriction behind the upper margin of the orbits proved that the skull was that of an ape, as such never occurred in man. It happened that a few weeks later Professor Nehring, of Berlin, demonstrated exactly the same formation on a human prehistoric skull received by him from Santos, in Brazil."

Poor Virchow, like all men who, through prejudice, oppose the truth, had shifted and shifted in vain! I give these facts because he is by far the greatest scientist who opposed Evolution, and because he showed so clearly the methods to which these opponents are all reduced.

Haeckel continues: "It is established that the oldest mammalia 'were small insectivorous mammals with a very primitive organisation. Probably they were monotremes, and may be derived directly from Permian Sauromammalia, an ill-defined mixture of mammalia and reptilia.' This generalised characteristic supports our view that the whole class of mammalia is monophyletic, and that all its members, from the oldest monotremes upwards to man, have descended from one common ancestor living in the older triassic, or perhaps permian, age. To acquire full conviction of this important conception, we have only to think of the hair and the glands of our human skin, of our diaphragm, the heart, and the blood corpuscles without a nucleus, our skull, with its squamoso-mandibular articulation. All these singular and striking modifications of the vertebrate organisation are common to mammals, and distinguish them clearly from other Craniota. This characteristic combination and correlation proves that they have been developed only *once* in the history of the vertebrate stem, and that they have been transferred by heredity from one common ancestor to all the members of the class Mammalia."

In summing up his lecture on "The Last Link," given at Cambridge, August 26th, 1898, the learned Professor says: "Four results stand out clearly: (1) The primates, as the highest order of mammals, form one natural, monophyletic group. All the Lemures, Simiæ, and Homines descend from one common ancestral form, from a hypothetical 'Archiprimas.' (2) The Lemures are the older and the lower of the natural groups of the primates; they stand between the oldest Placentalia (Prochoriata) and the true Simiæ. (3) All the Catarrhinal, or Eastern Simiæ, form one natural monophyletic group. Their hypothetical common ancestor, the Archipithecus, may have descended directly or indirectly from a branch of the Lemures. (4) Man is descended directly from one series of extinct Catarrhine ancestors. The more recent ancestors of this series were tailless anthropoids (similar to the Anthropopithecus), with five sacral vertebræ. The remote ancestors were tailed (Cercopitheci), with three or four sacral vertebræ. These four theses possess, in my opinion, absolute certainty. They are independent of all future anatomical, embryological, and palæontological discoveries which may possibly throw more light upon the details."

He further adds: "Man alone combines the four following features: (1) Erect walk. (2) Extremities differentiated accordingly. (3) Articulate speech. (4) Higher reasoning power. Speech and reason are obviously relative distinctions only—the direct result of more brains and more brain-power, the so-called mental faculties. The erect walk is not an absolutely distinguishing characteristic. The larger apes likewise walk on their feet only, supporting their bodies by touching the ground with the backs of their hands—in fact, with their knuckles; and this is a mode of progression very different from that of the tailed monkeys, which walk upon the *palms* of their hands."

CHAPTER V.

THE FOUNDATION OF ALL LIFE

WHEN man began to take an interest in the world around him, he tried to understand its workings. Unfortunately, it was necessary to ask questions long before he had enough knowledge or reason to answer them. The child is satisfied with a child's answers to all its questions. So early man, with the mind of a child, accepted explanations which were no true explanations. And, just as a child has to grow out of its ready-made child-world, so the human race has been for centuries growing out of its childish notions of life and the problems of life.

Few men have grasped the fact that the universe is one —one in its component parts, in the laws which govern it, in the elements that compose it, unless indeed it is formed of one element, which seems likely.

Nothing shows this more clearly than the common notion that there is a great gulf fixed between animals and plants. The greater number of men think that there is nothing in common between animals and plants. They rather hold that these two forms of life are entirely different, both in their natures and their actions. No wonder, then, that such people are quite clear that there is a yawning abyss between living things and lifeless matter, or, as it is usually called, between the organic and the inorganic.

Yet this view greatly exaggerates the facts. There is no such absolute and impassable gulf between animals and vegetables, or between living stuff and not-living stuff.

To understand this, we must lay aside our common notions, and we must no longer begin the great search for truth by taking the hardest things first. The secrets of the

Universe are only to be discovered by beginning at the beginning and by learning her grand old A B C.

If we take some living substance, say a part of a growing root, a green leaf, or some of the fresh tissue of an animal, and if an exceedingly thin slice or shred of such living material be placed in water and examined under a microscope, it may be seen to be composed of closely-packed, distinct pieces. These pieces are called *cells*. Sometimes they show clear *cell-walls*, and a spot in the centre, a sort of thickening, called the *nucleus*. (But some cells have no wall and no nucleus.) "What is more important to notice is that these cells, when taken alive from fresh tissues, and preferably from young growing tissues, are composed of a semi-transparent, greyish material, looking like thin gum, into which small transparent granules have been stirred. *The substance which has this appearance is protoplasm, and is the living part of the cells of all animals and plants.*"

It is a pity that this substance has been called by such a hard Greek name, for the substance itself is perhaps the most wonderful thing in the world, and we must learn much about it.

The name itself is from the Greek *protos*, *first*, and *plasma*, *anything moulded.* Huxley called it "the physical basis of life," because life is never found apart from it. Perhaps we might be allowed to speak of it as *life-substance;* this certainly would be far nearer the truth than the old way of speaking of life as something separate from matter.

The name "protoplasm" was first given to the matter in vegetable cells in 1846, but soon after it was discovered that this matter was the same as that in animal cells: this brought the animal and vegetable world into close union. Later, the many discoveries about protoplasm led some to suppose that the only difference between living and not-living substance was simply a difference of the complexity of the chemical constitution.

The mere suggestion of the point is enough to show of what vast importance this substance is. Let us, therefore, try and understand it. "Animals and plants are alive and growing; their protoplasm is alive and growing; *we know protoplasm only as a living substance.* Chemical analysis kills it, and dead material is not protoplasm."

We know that protoplasm is a mixture, not a single chemical substance.

It is alive, and, therefore, constantly building up food materials into itself; constantly breaking down part of itself in the process of doing the work of living; constantly forming substances like cell-walls, like enamel, or wax, or horn, which are derived from protoplasm.

"This protoplasm, as we look at it under the microscope, and as we must think of it, is a flux of chemical materials, some of them food in various stages of the process of building up into living substance, some of them broken down, waste products from the living material which has been used up, and some of them substances manufactured by the living material."

To see protoplasm it is best to choose young growing cells, for in older cells the living material is frequently obscured by the various substances it has made.

Protoplasm, then, is not a definite chemical compound, but a jelly-like substance one can see with the microscope; still, we know much of its chemical composition, for we know it is mainly made up of compounds called proteids, and they contain the five following substances:—

Oxygen from 20.9 to 23.5 per cent.
Hydrogen from 6.9 to 7.3 per cent.
Nitrogen from 15.2 to 17.0 per cent.
Carbon from 15.5 to 54.5 per cent.
Sulphur from 0.3 to 2.0 per cent.

One of these proteids, called albumen, is the chief part of the white of egg. If you break a fresh egg, the fluid mass, which is almost colourless, will give you a good, rough notion of what a proteid is. And remember, this most marvellous substance, protoplasm, is a compound formed of several other compounds called proteids, and, besides these, protoplasm always contains a large amount of *water*, small quantities of *carbo-hydrates* (such as glucose) and *fats*, and traces of *iron* and of *phosphates* and *sulphates* of potassium, calcium, and magnesium; so that, if there is in protoplasm any special compound, the molecules of this compound are probably much more complex than the molecules of proteids.

Now, turning away from this rather difficult subject of chemistry, let us see what protoplasm can do.

First, *it has the power of movement.*

To see this we may examine under a microscope the cells, which form the hairs of many plants, as nettles or the Virginian spiderwort (*Tradescantia*). The hairs are seen to be made up of long, barrel-shaped cells placed in single rows. The inner wall of each cell is seen to be lined with a layer of protoplasm (*see* Fig. 17a). In or near the middle of the cell is seen the *nucleus*, a rounded, dark, solid-looking mass. The *nucleus* is embedded in another mass of protoplasm, and from this to the layer round the cell-wall there pass strands, branching and running into each other. In this network of protoplasm may be seen granules of different shapes and sizes.

When the eye has become accustomed to this nearly clear protoplasm, it may be seen that constant streaming movements take place, especially in the fine strands to and from the nucleus.

Another kind of movement can be seen in white blood-corpuscles. If we watch one of these white corpuscles, we see that the shape slowly changes (*see* Fig. 17b). At first it may appear covered with fine prickles, which are really extensions of the protoplasm of the cell. These prickles are often called *processes*. Sometimes these processes lengthen, become thicker, and even bend on themselves. The shape of the whole cell is constantly altering, and the cell itself slowly moves through the liquid in which it is floating by putting out processes on one side and by drawing them in on the other.

This second kind of movement is called *amœboid.* The

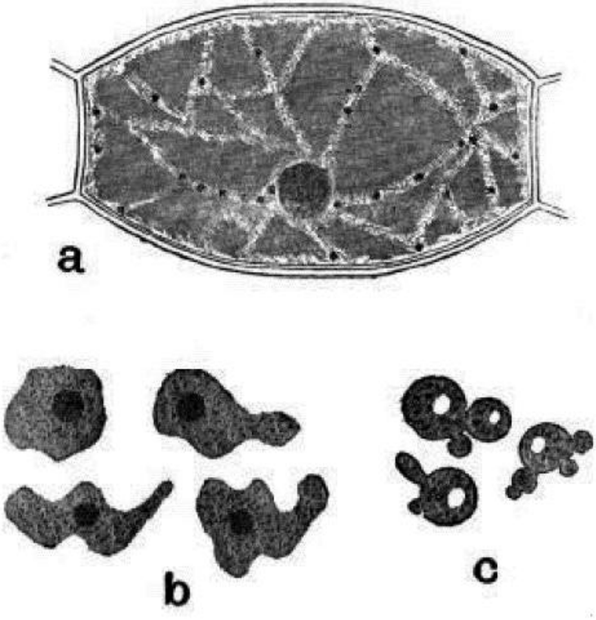


FIGURE 17 (after Mitchell).

a. Cell from staminal filament of plant, Tradescantia. The protoplasmic threads are light, aud in them are contained the nucleus and chlorophyll granules. The spaces between the threads are filled with coloured cell sap. *b.* A white or amœboid corpuscle from the blood of a frog, showing changes of shape undergone during five minutes. *c.* Group of yeast-cells exhibiting active budding.

processes which are pushed out or drawn in are called *pseudopodia.*

There are other forms of movement, but these are sufficient to show that *living protoplasm moves.*

Second, *protoplasm is irritable.*

We must be careful to learn the exact meaning of this word "irritable" or "irritability."

All education, all progress, depends on the fact that protoplasm is irritable.

Irritability means that the substance can be affected by something outside of it. This something outside is called a stimulus, and if more than one outside object acts upon the substance, they are called *stimuli* (the plural of stimulus). Any substance which shows it is acted upon by a stimulus is said to *respond* to the stimulus.

The shock of the removal of protoplasm from a plant or animal may have stopped its motion. But gentle warmth or an electric shock may cause it to move again. This proves that protoplasm responds to stimuli.

The stimulus may take many forms—light, food, variations in the fluids. Purity or impurity of the fluids in which the organisms are living serve to increase or lessen the activity of protoplasm. Another word for many of these stimuli is environment. We see, therefore, that protoplasm is greatly influenced by environment, just as plants and animals are.

Protoplasm is irritable.

Third, *protoplasm absorbs food.*

Sometimes, as with animals, the food consists of the bodies of other animals and of plants; sometimes, as in most plants, the food is purely "dead matter" (inorganic).

Fourth, *protoplasm has the power of respiration.*

Protoplasm is constantly exchanging gases with the surrounding air, or with water; this is called *respiration.*

Fifth, *protoplasm grows as the result of feeding.*

Sixth, *protoplasm has the power of reproduction.*

The separate cells do not grow indefinitely large. After having reached a certain size, a cell on the point of overgrowth gives off a bud, which grows into another cell, or which divides into two daughter cells. This method of reproducing is called budding (*see* Fig. 17c) or gemmation.

It is the simplest kind of reproduction, and is really a form of growth.

Seventh, *protoplasm excretes, or turns out waste products.*

In the processes of life substances generally coming from broken-down protoplasm are pushed out by the protoplasm. Many of these substances are soluble in water, and are turned out in a watery fluid.

This can be seen under a microscope in small, single-celled animals, which are found in pond or ditch water. The protoplasm is clear and granular, and there is a small nucleus; but the most striking thing is a round spot that looks empty (*see* Fig. 18a). As one looks at it, this spot suddenly disappears; the round disc of the cell becomes shrivelled, and in the water a little whirlpool is seen, as if an oily liquid had been squeezed out (*see* Fig. 18b). Slowly the spot reappears, gets larger and larger, and bursts again, and in a few minutes it may be seen to fill and empty several times. This spot is called *the contractile vacuole*, and it is the most visible form of protoplasmic excretion.

In most cells the process of excretion (like the process of eating or digesting) goes on slowly throughout the cell at any part, and no special vacuole is seen.

Eighth, *protoplasm has the power of contracting.*

Ninth, *protoplasm has the power of conductibility.*

If we apply a stimulus to one part of the cell, it produces an effect on the other parts. This shows that not only are the parts connected, but that a shock applied at one point passes through the protoplasm to the other parts. This power of conveying the effect of a stimulus is called conductibility.

We have now learnt much of this lowest form of living matter. We know fairly well what appearance protoplasm must have, of what it is composed, and we know that it possesses the properties of—

Movement,	Irritability,	Contractibility
Feeding,	Respiration,	Growth,
Reproduction,	Excretion,	Conductibility.

The student who wishes to understand all life from the lowest moss to the brain of man will not think it a waste of time to learn all that can be known about protoplasm.

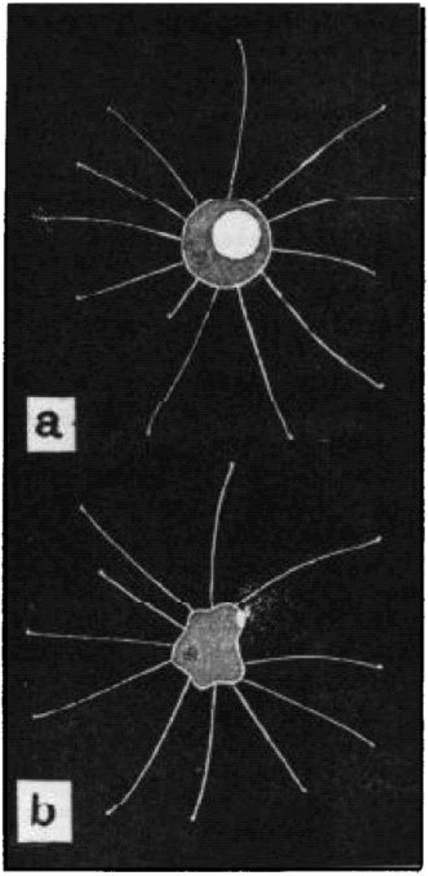


FIGURE 18 (after Mitchell).

a. A single-celled animal (belonging to suctorial Protozoa) with delicate spherica cell-wall, and long-knobbed pseudo-podia: within the protoplasm lies a small nucleus and a large contractile vacuole. *b.* The same; the contractile vacuolel has disappeared, the contents being extruded; the shrivelling of the cell-wall shows the loss of bulk undergone.

Practically, the living world is protoplasm. Such a plain basis of the unity of life offers a key to all life, and to the workings of all that we mean by the mind of man. It writes in capital letters this one fact—that all life, from the lowest to the highest, is one. And, further, it helps us to see that there is but one short, easy step from the not-living to the living.

Those who study Professor Loeb's great work, *The Physiology of the Brain*, will be rewarded for many weeks of toil on the lower forms of life, because only by knowing these lower forms can we understand the higher.

There are millions of small animals, called protozoa, which are but one cell of protoplasm. All forms of animals begin life as a single cell, and grow as single cells grow. This stands as one of the most marvellous revelations of science, proving beyond doubt that life is one not only in its structure, but in the mode of its growth and the laws of its being. The nine characters which we have found in protoplasm are the common characters of every living animal.

The greatest genius could produce nothing if one of these powers were completely to fail. The human race, with all its glories, would vanish if one of the laws of protoplasm were to lose its power of action. Such a thought is well nigh overwhelming. In the presence of this fact, all vain theories of man's isolated splendour crumble to the dead dust, which they are. Everything in the grandest life depends upon the power of this lowest form of living matter, which is common to animals and to plants.

It will repay us, therefore, to try and understand more of this life-substance. Let us see how protoplasm is built up.

"Protoplasm and substances formed by it are the material of the tissues of all animals and plants; and all animals and plants in consequence of this have the powers of *Movement*, *Irritability, Feeding, Respiration, Growth, Reproduction, Excretion, Contractibility, and Conductibility.* The individual cells of the animal or plant bodies may be built up into complicated tissues and organs which serve special purposes, and in the elaborate systems of higher animals and plants these tissues and organs may assist, or regulate, or interfere with each other's work. But in every case the actual work done is done by individual cells present in the organs. For instance, the hands may take food to the mouth, the teeth chew it, the muscles of the tongue and mouth and gullet force it down; but it is at last the individual cells lining the intestines that absorb and really eat the meal. Similarly, all the powers of animals and plants can be traced down to individual cells—down to protoplasm itself."

In the process of life protoplasm is constantly being used up. When an animal or plant dies and decays, protoplasm is destroyed. How, then, is this substance built up from the inorganic materials in the world? The world-need is protoplasm; how, then, can we obtain it?

"If we consider the food supply of the land, it is clear that flesh-eating animals practically only turn the protoplasm of their prey into their own protoplasm, and that their life is dependent on the life of other animals." Some animals live partly on animal protoplasm and partly on the tissues of plants. Others live entirely on plants.

In seeking an answer to this question, How is life-substance built up? if we turn to plants, we can dismiss many which, like moulds and fungi, live on living or decaying matter, and we are left with *the green vegetation of the earth.*

The food supply of the sea is less easy to understand. Most of the lower forms of life are carnivorous; fish live on fish, or on small swimming animals. Others live on the shell-fish, or on worms and anemones and coral polyps.

The floating sea-mud is not enough to replace the vegetation of the land. It is true that waste matters and sewage supply food, but even this is not enough.

If, however, we examine a bucket of surface water, there we find vast numbers of microscopic plants, and these, like the green vegetation of the earth, form the first stage in the building up of protoplasm, and, like most land plants, they have a green colour.

"The starting-point of the food supply of land and sea is green vegetation."

The formation of protoplasm from inorganic matter depends on the substance to which this green colouring is due, and which is called chlorophyll (green of leaf). If some green leaves are soaked in alcohol, the green colouring matter is dissolved and forms a clear solution, bright green in colour.

Every living cell containing chlorophyll in the presence of sunlight performs chemical work. It absorbs carbonic acid from the air, tears apart the carbon and oxygen, and the oxygen is returned to the air, while the carbon becomes associated with hydrogen and oxygen in the plant.

"This leads to another striking fact. Carbon combines readily with oxygen, and in the process sets free energy in the form of heat. What, then, takes place in plants, by the agency of chlorophyll, is a turning of the radiant energy of sunlight into potential energy; the radiant energy is stored up in the form of a chemical compound of such a kind that, by union with free oxygen, it will liberate the energy again.

"From our point of view, plants and animals, or the protoplasm of which they consist, may be regarded as centres of force, as things capable of doing work; and here, as the secret of their food-supply (as the first stage in the building up of protoplasm), is to be found a supply of energy, a means by which the radiant energy of sunlight is stored up in a form which can be used. The plants which possess chlorophyll store up the energy; the animals which feed upon plants use this store of energy for their own lives, but retain enough in their own bodies to serve for the carnivorous animals which eat them."

The chemical details of the processes of life are very complicated, yet we may say generally that protoplasm takes in oxygen, performs the work of life, and gives out carbonic acid; and that it is enabled to do this by the capacity chlorophyll has for absorbing the energy of sunlight and storing it up in the form of carbon compounds with less oxygen than the proportion in carbonic acid (CO_2).

Many attempts have been made to draw a distinction between plants and animals, and in most cases this can be clearly done.

Plants have a power, scarcely possessed by animals, even if they have it at all—viz., by some chemical process they can produce living substance out of not-living salts and gases.

Still, Mr. Mitchell sums up thus: "No complete separation exists between the two kingdoms. It is most probable that animals and plants have a common origin, and that some of the lower existing forms of life retain characters that afterwards became the marks of separate kingdoms."

This important conclusion of science may yet receive expansion and be flooded with new light; but for our purpose it is sufficient, for no stronger proof of the unity of life can be desired than the confession of all scientists that they are unable to separate absolutely the two great kingdoms of plants and animals.

If we could but discover the common ancestor of plants and animals, we should probably understand how, by a process of chemistry, inorganic matter first became living substance, and we should know the origin of life.

NOTE.—In dealing with protoplasm, I have chiefly followed the account in *Outlines of Biology* by Mr. P. Chalmers Mitchell, which is a good handbook written for medical students.

CHAPTER VI.

VARIATIONS IN ANIMALS

IF you were to speak to some uneducated man of the doctrine of Evolution for the first time, he would probably laugh with all the vigour of ignorant infallibility. Tell him that all the animals he sees daily may have come from one simpler form of life, and he thinks you are only making sport of his verdant ignorance.

This is not altogether due to the mere fact that he does not understand the first principles of Evolution, or to the novelty of the explanation. It arises chiefly from a false view of the life around him. He is familiar with common objects, as cats, dogs, pigs, cows; and he knows that these distinct families remain fixed, and never cross so as to become mixed and cause confusion. He might not put it into these words, but he means that species are distinct, fixed, unalterable, and, he would probably add, have no connection whatever with each other. It is this last point especially which rouses his laughter.

So that, in examining the teaching of Evolution, we soon come face to face with this difficulty, and we cannot do better than say at once that there is abundant evidence to show that species can be modified and become extinct, and that new ones can arise. This knowledge is no longer new, but it appears new to those who have had the misfortune to read only the books of the earlier geologists, for they held that species never change, and they arrived at this conclusion from the lack of sufficient records or of careful study of those records. Sir Charles Lyell at first held that species are immutable, but after fifteen years of careful study he changed his opinion.

Geologists are now agreed that the extinct forms can be grouped under existing families, but they also agree that the old forms are not the same as the present forms. The old belong to the same general plan, but the new have been specialised in many structures. Here is a plain fact which all can see for themselves if they compare the bones of animals which are extinct with the bones of their living representatives. Species do change.

Now, the great principles upon which Darwin and Wallace founded the discovery of Evolution rest upon common, plain facts, which all may see and know.

Mr. Wallace has given a summary of these facts (*Essays on Natural Selection*, p. 265) :—

1. *The law of multiplication in geometrical progression.*—A simple instance of geometrical progression is thus represented—2, 4, 8, 16, 32, etc., or 3, 9, 27, 81, etc. All organised beings multiply very rapidly. Man multiplies more slowly than most animals, yet he could double his numbers every fifteen years, and increase a hundredfold in a century. Many animals and plants could increase their numbers from ten to a thousandfold every year.

2. *The law of limited populations.*—The number of living individuals of each species in any country, or in the whole globe, is practically stationary. From this we see that the whole of this enormous increase must die off almost as fast as produced, except only those individuals for whom room is made by the death of parents. For instance, an oak may drop annually hundreds of acorns, but till an old tree falls scarcely one of these acorns can grow up into an oak. They must die at various stages of growth.

3. *The law of heredity, or likeness of offspring to their parents.*—This is a universal, but not an absolute, law. All creatures resemble their parents in a high degree, so that even individual peculiarities of the parents are almost always transmitted to some of the offspring.

4. *The law of variation.*—Offspring resemble their parents

very much, but not wholly; each being possesses its individuality. This "variation" itself varies in amount, but it is always present, not only in the whole being, but in every part of every being. To understand this degree of variation, think of any large family you know well, and note the wide differences between the brothers and sisters. It is quite common to find families in which the children vary so much that one could not be sure from their appearance that they were all members of the same family.

Or, again, let any farmer or fancier destroy all the offspring which are not exactly like one of the parents, and you know he would ruin his business.

5. *The law of unceasing change of physical conditions upon the surface of the earth.*—"Geology shows us that this change has always gone on in times past, and we also know that it is now everywhere going on." (For details of this law see chapter xiii.)

6. *The equilibrium or harmony of nature.*—When a species is well suited to the conditions which surround it, this species flourishes; when imperfectly suited, it decays; quite unsuited, it becomes extinct. Now, these general facts or laws are mere statements of what is the condition of nature. Some people are angry, as if the evolutionist had *created* them for his own purpose. Here they are; here they have always been. The evolutionist merely tries to explain them.

We will first deal more fully with the law of Variations. And it should be borne in mind that it makes no difference with regard to the doctrine of Natural Selection whether we can fully explain the *causes* of these variations or not. Tens of thousands of variations occur, and this suffices.

We know that one of the great causes of this variation is environment. Mr. Spencer says (*Principles of Biology*, vol. i., sect. 96): "Were it not that individuals are ever being made unlike each other by their unlike conditions, there would not arise among them those contrasts of molecular constitution which we have seen to be needful for producing the fertilised germs of new individuals."

And again: "Besides owing to the external world those energies which, from moment to moment, keep up the lives of its individual members, every species owes to a certain more indirect action of the external world those energies which enable it to perpetuate itself in successive generations."

In the same book (sect. 82) Mr. Spencer brings out clearly the influence of outward conditions, thus: "But the best examples of inherited modifications produced by modifications of function occur in the human race. To no other cause can be ascribed the rapid metamorphoses undergone by British races when placed in new conditions. It is notorious that in the United States the descendants of the emigrant Irish lose their Celtic aspect, and become Americans. This cannot be ascribed to inter-marriage with Americans, since the feeling with which Irish are regarded by Americans prevents any considerable amount of inter-marriage.

"Equally marked is the case of the immigrant Germans, who, though they keep themselves very much apart, rapidly assume the prevailing type. To say that 'spontaneous variation,' increased by natural selection, can have produced this effect is going too far.

"Races so numerous cannot have been supplanted in the course of two or three generations by varieties springing from them. Hence there is no escape from the conclusion that physical and social conditions have here wrought modifications of function and structure which offspring have inherited and increased. Similarly with special cases. In the *Cyclopædia of Practical Medicine*, vol. ii., p. 419, Dr. Brown states that he has in many instances observed in the case of individuals, whose complexion and general appearance have been modified by residence in hot climates, that children born to them subsequently to such residence have resembled them rather in their acquired than primary mien."

This and much more which Mr. Spencer says to the same effect, supported by many clear instances, seems to prove that *acquired* characteristics may be hereditary. The cases could easily be multiplied a hundredfold, and they establish beyond controversy the fact that one powerful source of variation is outward conditions.

Still, we must not lose sight of Darwin's great utterance on causes of variability. In the first chapter of the *Origin of Species* he says: "As far as I am able to judge, after long attending to the subject, the conditions of life appear to act in two ways—directly, on the whole organisation or on certain parts alone, and indirectly, by affecting the reproductive system. With respect to the direct action, we must bear in mind that in every case, as Professor Weismann has lately insisted, and as I have incidentally shown in my work on *Variation under Domestication*, there are two factors—namely, *the nature of the organism and the nature of the conditions.* The former seems to be much the more important; for nearly similar variations sometimes arise under, as far as we can judge, dissimilar conditions; and, on the other hand, dissimilar variations arise under conditions which appear to be nearly uniform."

No words can emphasise this passage too strongly if we are to comprehend and apply the theory of Evolution. We must remember these *two forces* which no man can measure, either in their strength or variety.

Darwin continues: "Changed habits produce an inherited effect, as in the period of the flowering of plants when transported from one climate to another.

"With animals the increased use or disuse of parts has had a more marked influence; thus I find in the domestic duck that the bones of the wing weigh less and the bones of the leg more, in proportion to the whole skeleton, than do the same bones in the wild duck, and this change may be safely attributed to the domestic duck flying much less and walking more than its wild parents......Not one of our domestic animals can be named which has not in some country drooping ears; and the view which has been suggested that the drooping is due to the disuse of the muscles of the ear from the animals being seldom much alarmed seems probable."

By the law of heredity, any peculiarity or power of remote ancestors may re-appear in their descendants. The two parents of any mammal had sixteen great grandparents, and these again had thousands of ancestors. Further, by this same law of heredity, any peculiarity of a parent, to whatever cause it may be due, may become a fixed characteristic of its descendants.

Here, then, we see in outline some of the forces which cause variations and modifications of species and individuals.

But, to be quite clear, let us deal with one case in greater detail, and we cannot do better than to take the example given by the great master himself on pigeons. Darwin says:—

"Believing that it is always best to study some special group, I have, after deliberation, taken up domestic pigeons. I have kept every breed which I could purchase or obtain, and have been most kindly favoured with skins from several quarters of the world, more especially by the Hon. W. Elliot, from India, and by the Hon. C. Murray, from Persia. Many treatises, in different languages, have been published on pigeons, and some of them are very important, as being of considerable antiquity. I have associated with several eminent fanciers, and have been permitted to join two of the London pigeon clubs. The diversity of the breeds is something astonishing." (Fig. 19.) "Compare the English carrier and the short-faced tumbler, and see the wonderful differences in their beaks, entailing corresponding differences in their skulls. The carrier, more especially the male bird, is also remarkable from the wonderful development of the carunculated skin about the

FIGURE 19.—PIGEONS.

1. Homing pigeon. 2. Tumbler. 3. Carrier. 4. Barb. 5. Pouter. 6. Fantail. 7. Salinette. 8. Turbiteen. 9. Jacobin. 10. Trumpeter.

head, and this is accompanied by greatly elongated eyelids, very large external orifices to the nostrils, and a wide gape of mouth. The short-faced tumbler has a beak in outline almost like that of a finch, and the common tumbler has the singular inherited habit of flying at a great height in a compact flock, and tumbling in the air head over heels. The runt is a bird of great size, with long, massive beak and large feet; some of the sub-breeds of runts have very long necks, others very long wings and tails, others singularly short tails. The barb is allied to the carrier, but, instead of a long beak, has a very short and broad one. The pouter has a much elongated body, wings, and legs, and its enormously developed crop, which it glories in inflating, may well excite astonishment and even laughter. The turbit has a short and conical beak, with a line of reversed feathers down the breast, and it has the habit of continually expanding slightly the upper part of the œsophagus. The Jacobin has the feathers so much reversed along the back of the neck that they form a hood, and it has, proportionally to its size, elongated wing and tail feathers. The trumpeter and laugher, as their names express, utter a very different coo from the other breeds. The fantail has thirty, or even forty, tail feathers, instead of twelve or fourteen, the normal number in all the members of the great pigeon family; these feathers are kept expanded, and are carried so erect that in good birds the head and tail touch; the oil-gland is quite aborted. Several other less distinct breeds might be specified.

"In the skeletons of the several breeds, the development of the bones of the face in length and breadth and curvature differs enormously. The shape, as well as the breadth and length, of the ramus of the lower jaw varies in a highly remarkable manner. The caudal and sacral vertebræ vary in number; as does the number of the ribs, together with their relative breadth and the presence of processes. The size and shape of the apertures in the sternum are highly variable; so is the degree of divergence and relative size of the two arms of the furcula. The proportional width of the gape of the mouth, the proportional width of the eyelids, of the orifice of the nostrils, of the tongue (not always in strict correlation with the length of the beak), the size of the crop and of the upper part of the œsophagus; the development and abortion of the oil-gland; the number of the primary wing and caudal feathers; the relative length of the wing and tail to each other and to the body; the relative length of the leg and foot; the number of scutellæ on the toes, the development of skin between the toes, are all points of structure which are variable. The period at which the plumage is acquired varies, as does the state of the down with which the nestling birds are clothed when hatched. The shape and size of the eggs vary. The manner of flight, and in some breeds the voice and disposition, differ remarkably. Lastly, in certain breeds, the males and females have come to differ in a slight degree from each other.

"Altogether at least a score of pigeons might be chosen which, if shown to an ornithologist, and he were told that they were wild birds, would certainly be ranked by him as well-defined species. Moreover, I do not believe that any ornithologist would in this case place the English carrier, the short-faced tumbler, the runt, the barb, pouter, and fantail, in the same genus; more especially as in each of these breeds several truly-inherited sub-breeds, or species, as he would call them, could be shown him.

"Great as are the differences between the breeds of the pigeon, I am fully convinced that the common opinion of naturalists is correct—namely, that all are descended from the rock-pigeon (*Columba livia*), including under this term several geographical races or sub-species, which differ from each other in the most trifling respects" (*Origin of Species*, pp. 15, 16, 17).

We can further summarise Darwin: If we consider the steps by which domestic races have been produced either from one or several allied species, we shall discover one most remarkable fact. For, though much may be attributed to the action of external conditions of life, and something to habit, this is not all. This would hardly serve to explain the difference between a dray-horse and a race-horse. There is this remarkable fact, that we see in our domestic races adaptation, not to the good of the animal or plant, but to man's use or fancy. "We cannot suppose that all the breeds suddenly appeared as perfect and as useful as we now have them; in fact, we know that in many cases this has not been their history. The key is man's power of accumulative selection; nature gives successive variations; man adds them up in certain directions useful to him. In this sense he may be said to have made for himself useful breeds."

Now, is this a mere supposition? By no means. As Spencer says: "There are no inductions so trustworthy as those which have undergone the mercantile test." Now, this law of producing special kinds, according to the will of man, by the accumulation of small variations has stood the mercantile test, both in plants and animals.

To take animals only, Darwin says: "It is certain that several of our eminent breeders have, even within a single lifetime, modified to a large extent their breeds of cattle and sheep. In order to fully realise what they have done, it is almost necessary to read several of the many treatises devoted to this subject, and to inspect the animals. Breeders habitually speak of an animal's organisation as something plastic, which they can model almost as they please. If I had space, I could quote numerous passages to this effect from highly competent authorities. Youatt, who was probably better acquainted with the works of agriculturists than almost any other individual, and who was himself a very good judge of animals, speaks of the principle of selection as 'that which enables the agriculturist not only to modify the character of his flock, but to change it altogether. It is the magician's wand, by means of which he may summon into life whatever form and mould he pleases.' Lord Somerville, speaking of what breeders have done for sheep, says: 'It would seem as if they had chalked out upon a wall a form perfect in itself, and then had given it existence.' In Saxony the importance of the principle of selection in regard to merino sheep is so fully recognised that men follow it as a trade: the sheep are placed on a table and are studied, like a picture by a connoisseur; this is done three times at intervals of months, and the sheep are each time marked and classed, so that the very best may ultimately be selected for breeding" (*Origin of Species*, pp. 22 and 23).

These are marvels of *conscious* selection operating in a very short time. To the average man of town habits a flock of sheep consists of animals all alike, but we see the facts are quite the contrary. Nature supplies variations, which, when guided in any one definite way, yield amazing results. No less striking is the case given under *unconscious* selection.

"Youatt gives an excellent illustration of the effects of a course of selection, which may be considered as unconscious in so far that the breeders could never have expected, or even wished, to produce the result which ensued—namely, the production of two distinct strains. The two flocks of Leicester sheep kept by Mr. Buckley and Mr. Burgess, as Mr. Youatt remarks, 'have been purely bred from the original stock of Mr. Bakewell for upwards of fifty years. There is not a suspicion existing in the mind of anyone at all acquainted with the subject that the owner of either of them has deviated in any one instance from the pure blood of Mr. Bakewell's flock, and yet the difference between the sheep possessed by those two gentlemen is so great that they have the appearance of being quite different varieties.'"

It remains but to notice some circumstances favourable to man's power of selection. Clearly a high degree of variability is favourable, as this furnishes the materials for selection to work upon.

Next, largeness of numbers is of the highest importance. "On this principle, Marshall formerly remarked, with respect to the sheep of parts of Yorkshire, as they generally belong to poor people, and are mostly *in small lots*, they never can be improved."

"Probably the most important element is that the animal or plant should be so highly valued by man that the closest attention is paid to even the slightest deviations in its qualities or structure."

Facility in preventing crosses is an important element in the formation of new races.

We now begin to see how species may have arisen, and, perhaps, we may nearly be ready for the astounding truth that in nature nothing is fixed. Our infant notions of immutability are among the many errors of a defective intelligence. We may look upon species or suns, and reverently note the mystery of the old Greek philosopher's great saying, "All things are in unceasing change."

We know more—that all things *live* by unceasing change. Life's highest splendours are literally but the pageantry of death and decay.

CHAPTER VII.

THE STRUGGLE FOR LIFE

THE presence of variation in infinite forms and numbers is manifest to the most ordinary observer, and the causes of this variation are recognised, upon a little reflection, to be in ceaseless action as well as to be of practically almighty power. No scheme, no system, no organisation, can in any serious way interfere with these causes. There is no evidence that they ever had a beginning; there is no evidence that they ever can have an end. When life is viewed in its widest aspect, our most ancient institutions or immemorial customs are seen to possess scarcely more fixity than the running brook or the floating mist. Nay, even the orbits of planets and the activity of suns are known to change like spring fashions, and to grow old like a garment. Rest, equilibrium, peace, stability, are the figments of a dreamy, drowsy imagination.

If, then, we can discover some equally universal power which can utilise these infinite variations, we begin to see something of the laws which shape the destiny of atoms and the doom of nations.

We must, therefore, inquire whether these countless variations have each free play, without let or hindrance from each other or from equally powerful forces and laws which compete with them for a share of the universe.

If we are able to get away from the haunts of men and the din of machinery, and visit the lonely sea-shore, or lie on the quiet moorland, tented by the blue sky and draped with the horizon, or sit in the silent glade of an extensive forest, we are ready to think here, at any rate, is peace.

Yet we are assured that in every one of these sacred temples of life there are to be seen the blood-red footprints of a murderous competition.

Perhaps, if we begin nearer home, we shall more completely grasp the truth.

We have but to fix our attention upon a small village or sleepy market town to be conscious of this competition. If any family is allowed twelve loaves a week, and you double the number of the family, clearly each member, then, can only receive half the quantity of bread. This operation is too well known to be disputed. Again, if in some village there is a carpenter who follows his trade with great success and is able to supply all the needs of his family in comfort, should a second carpenter be introduced into that village, while all the other circumstances remain practically unchanged, either one carpenter will die of starvation, or both will struggle on with the greatest difficulty, and their families will not obtain a due share of life's common necessaries. The children will grow up weaker, less developed, and not so well equipped for their duties as citizens, or a higher percentage of them will die. This tragedy you can see in nearly every village and town on earth.

Or you can turn to a separate family for an illustration of the same law. You may find a tradesman who, by extreme toil, foresight, and carefulness, is able to educate his *two* sons, to give them all the advantages which are derived by being brought up in comfort; but, had there been six sons instead of two, all the family history would have been revolutionised; all the sons would have received less food, clothing, and education; they would have been less physically fit, less mentally developed, and probably their weakened condition would have exposed them to disease, so that, after a brief, defective life, one or more would have filled a nameless grave; or, owing to the struggle, one or both parents might have died, and all the children might have drifted to the workhouse, and thus have become waste products of civilisation.

All this is familiar enough, and has filled the lives of loving parents with unspeakable terror. But it is only a fraction of a general law. Thus examined, the whole universe is but a country village, and the human race is but one overgrown family. Your largest planet can be measured, and there is a limit to its area. Nay, more, the whole universe is found to contain matter which is fixed in quantity, and energy which is also fixed in quantity. So that, by whatever processes matter and energy are used up, the more one carpenter gets the less there is left for the other.

With regard to life on our earth, the problem is reduced into a much smaller compass. The area of the earth, the productive power of the earth, its food supply, its fresh air, are all limited. It is only recently that men have begun to speculate upon the failure of our coal supply, upon the period when the earth shall float as a barren ice-globe, unless it has fallen into the furnace of the sun, and when the sun himself shall drift as a ball of ashes, unless he shall have collided with some other sun to pass through a cycle of nebular regeneration. These speculations are less unreal than many of our most cherished convictions, yet they seem very far away to those who waste life in one incessant struggle for bread. But it is well to pause, either amid the pomp of wealth or the squalor of pauperism, and to remember that bands of iron girdle the races of men, and that the scales of the leper share in the same universal laws with the glory of the setting sun.

This struggle for existence is universal in nature. In steady murder it surpasses the invention of man. Yet without it there could have been no man. As in the individual life it is the struggle that developes the man, so in the widest sense the various species owe their existence and their development to this struggle. We owe a debt to Charles Darwin and Alfred Russel Wallace for unfolding this truth.

Darwin says: "Nothing is easier than to admit in words the truth of the universal struggle for life, or more difficult—at least I have found it so—than constantly to bear this conclusion in mind. Yet, unless it be thoroughly engrained in the mind, the whole economy of nature, with every fact on distribution, rarity, abundance, extinction, and variation, will be dimly seen or quite misunderstood" (*Origin of Species*, p. 49).

"I should premise that I use this term ["struggle for existence"] in a large and metaphorical sense, including dependence of one being on another, and including (which is more important) not only the life of the individual, but success in leaving progeny. Two canine animals, in a time of dearth, may be truly said to struggle with each other as to which shall get food and live. But a plant on the edge of a desert is said to struggle for life against the drought, though more properly it should be said to be dependent on the moisture. A plant which annually produces a thousand seeds, of which only one on an average comes to maturity, may be more truly said to struggle with the plants of the same and other kinds which already clothe the ground. The mistletoe is dependent on the apple and a few other trees, but can only in a far-fetched sense be said to struggle with these trees, for, if too many of these parasites grow on the same tree, it languishes and dies. But several seedling mistletoes, growing close together on the same branch, may more truly be said to struggle with each other. As the mistletoe is disseminated by birds, its existence depends on them; and it may metaphorically be said to struggle with other fruit-bearing plants in tempting the birds to devour and thus disseminate its seeds. In these several senses, which pass into each other, I use for convenience sake the general term of 'struggle for existence.'

"A struggle for existence inevitably follows from the high rate at which all organic beings tend to increase. Every being which during its natural lifetime produces several eggs or seeds must suffer destruction during some period of its life, and during some season or occasional year; otherwise, on the principle of geometrical increase, its numbers would quickly become so inordinately great that no country could support the product. Hence, as more individuals are produced than can possibly survive, there must in every case be a struggle for existence, either one individual with another of the same species, or with the individuals of distinct species, or with the physical conditions of life" (p. 50).

"There is no exception to the rule that every organic being naturally increases at so high a rate that, if not destroyed, the earth would soon be covered by the progeny of a single pair. Even slow-breeding man has doubled in twenty-five years, and at this rate, in less than a thousand years, there would literally not be standing-room for his progeny.

"Linnæus has calculated that if an annual plant produced only two seeds—and there is no plant so unproductive as this—and their seedlings next year produced two, and so on, then in twenty years there would be a million plants. The elephant is reckoned the slowest breeder of all known animals, and I have taken some pains to estimate its probable minimum rate of natural increase. It will be safest to assume that it begins breeding when it is thirty years old, and goes on breeding till ninety years old, bringing forth six young in the interval, and surviving till one hundred years old. If this be so, after a period of from 740 to 750 years there would be nearly nineteen million elephants alive, descended from the first pair.

"Still more striking is the evidence from our domestic animals of many kinds which have run wild in several parts of the world. If the statements of the rate of increase of slow-breeding cattle and horses in South America, and latterly in Australia, had not been well authenticated, they would have been incredible. So it is with plants: cases could be given of introduced plants which have become common throughout whole islands in a period of less than ten years. Several of the plants, such as the cardoon and a tall thistle, which are now the commonest over the wide plains of La Plata, clothing square leagues of surface almost to the exclusion of every other plant, have been introduced from Europe; and there are plants which now range in India, as I hear from Dr. Falconer, from Cape Comorin to the Himalaya, which have been imported from America since its discovery" (p. 51).

The only difference between organisms which annually produce eggs or seeds by the thousand and those which produce extremely few is, that the slow-breeders would require a few more years to people, under favourable conditions, a whole district, let it be ever so large. The condor lays a couple of eggs and the ostrich a score, and yet in the same country the condor may be the more numerous of the two; the fulmar petrel lays but one egg, yet it is believed to be the most numerous bird in the world.

In looking at nature, it is most necessary to keep the foregoing considerations always in mind—never to forget that every single organic being may be said to be striving to the utmost to increase in numbers; that each lives by a struggle at some period of its life; that heavy destruction inevitably falls either on the young or old during each generation or at recurrent intervals.

"Seedlings, also, are destroyed in vast numbers by various enemies; for instance, on a piece of ground three feet long and two wide, dug and cleared, and where there could be no choking from other plants, I marked all the seedlings of our native weeds as they came up, and out of three hundred and fifty seven no less than two hundred and ninety five were destroyed, chiefly by slugs and insects. If turf which has long been mown—and the case would be the same with turf closely browsed by quadrupeds—be let to grow, the more vigorous plants kill the less vigorous, though fully grown, plants; thus out of twenty species growing on a little plot of mown turf (three feet by four) nine species perished, from the other species being allowed to grow up freely.

"The amount of food for each species of course gives the extreme limit to which each can increase; but very frequently it is not the obtaining food, but the serving as prey to other animals, which determines the average numbers of a species. Thus, there seems to be little doubt that the stock of partridges, grouse, and hares on any large estate depends chiefly on the destruction of vermin. If not one head of game were shot during the next twenty years in England, and, at the same time, if no vermin were destroyed, there would, in all probability, be less game than at present, although hundreds of thousands of game animals are now annually shot" (p. 53).

"Climate plays an important part in determining the average numbers of a species, and periodical seasons of extreme cold or drought seem to be the most effective of all checks. I estimated (chiefly from the greatly reduced numbers of nests in the spring) that the winter of 1854–5 destroyed four-fifths of the birds in my own grounds; and this is a tremendous destruction when we remember that ten per cent. is an extraordinarily severe mortality from epidemics with men. The action of climate seems at first sight to be quite independent of the struggle for existence; but in so far as climate chiefly acts in reducing food, it brings on the most severe struggle between the individuals, whether of the same or distinct species, which subsist on the same kind of food" (p. 54).

When a species, owing to highly favourable circumstances, increases inordinately in numbers in a small tract, epidemics —at least, this seems generally to occur with our game animals—often ensue; and here we have a limiting check independent of the struggle for life. But even some of these so-called epidemics appear to be due to parasitic worms, which have from some cause, possibly in part through facility of diffusion among the crowded animals, been disproportionately favoured; and here comes in a sort of struggle between the parasite and its prey.

"Many cases are on record showing how complex and unexpected are the checks and relations between organic beings which have to struggle together in the same country. I will give only a single instance, which, though a simple one, interested me. In Staffordshire, on the estate of a relation, where I had ample means of investigation, there was a large and extremely barren heath, which had never been touched by the hand of man; but several hundred acres of exactly the same nature had been enclosed twenty-five years previously and planted with Scotch fir. The change in the native vegetation of the planted part of the heath was most remarkable, more than is generally seen in passing from one quite different soil to another; not only the proportional numbers of the heath-plants were wholly changed, but twelve species of plants (not counting grasses and carices) flourished in the plantations which could not be found on the heath. The effect on the insects must have been still greater, for six insectivorous birds were very common in the plantations which were not to be seen on the heath; and the heath was visited by two or three distinct insectivorous birds. Here we see how potent has been the effect of the introduction of a single tree, nothing whatever else having been done, with the exception of the land having been enclosed, so that cattle could not enter. But how important an element enclosure is I plainly saw near Farnham, in Surrey. Here there are extensive heaths, with a few clumps of old Scotch firs on the distant hill-tops; within the last ten years large spaces have been enclosed, and self-sown firs are now springing up in multitudes, so close together that all cannot live. When I ascertained that these young trees had not been sown or planted, I was so much surprised at their numbers that I went to several points of view, whence I could examine hundreds of acres of unenclosed heath, and literally I could not see a single

Scotch fir, except the old planted clumps. But, on looking closely between the stems of the heath, I found a multitude of seedlings and small trees which had been perpetually browsed down by the cattle. In one square yard, at a point some hundred yards distant from one of the old clumps, I counted thirty-two little trees; and one of them, with twenty-six rings of growth, had, during many years, tried to raise its head above the stems of the heath, and had failed. No wonder that, as soon as the land was enclosed, it became thickly clothed with vigorously growing young firs. Yet the heath was so extremely barren and so extensive that no one would ever have imagined that cattle would have so closely and effectually searched it for food.

"Here we see that cattle absolutely determine the existence of the Scotch fir; but in several parts of the world insects determine the existence of cattle.

"I find from experiments that humble-bees are almost indispensable to the fertilisation of the heartsease (*viola tricolor*), for other bees do not visit this flower. I have also found that the visits of bees are necessary for the fertilisation of some kinds of clover; for instance, twenty heads of Dutch clover (*trifolium repens*) yielded 2,290 seeds, but twenty other heads, protected from bees, produced not one. Again, 100 heads of red clover (*T. pratense*) produced 2,700 seeds, but the same number of protected heads produced not a single seed. Humble-bees alone visit red clover, as other bees cannot reach the nectar. It has been suggested that moths may fertilise the clovers; but I doubt whether they could do so in the case of the red clover, from their weight not being sufficient to depress the wing-petals. Hence we may infer as highly probable that, if the whole genus of humble-bees became extinct, or very rare, in England, the heartsease and red clover would become very rare or wholly disappear. The number of humble-bees in any district depends in a great measure on the number of field-mice, which destroy their combs and nests; and

Colonel Newman, who has long attended to the habits of humble-bees, believes that 'more than two-thirds of them are thus destroyed all over England.' Now, the number of mice is largely dependent, as everyone knows, on the number of cats; and Colonel Newman says: 'Near villages and small towns I have found the nests of humble-bees more numerous than elsewhere, which I attribute to the number of cats that destroy the mice.' Hence it is quite credible that the presence of a feline animal in large numbers in a district might determine, through the intervention first of mice and then of bees, the frequency of certain flowers in that district.

"When we look at the plants and bushes clothing an entangled bank, we are tempted to attribute their proportional numbers and kinds to what we call chance. But how false a view is this! Everyone has heard that, when an American forest is cut down, a very different vegetation springs up; but it has been observed that ancient Indian ruins in the Southern United States, which must formerly have been cleared of trees, now display the same beautiful diversity and proportion of kinds as in the surrounding virgin forest. What a struggle must have gone on during long centuries between the several kinds of trees, each annually scattering its seeds by the thousand! What war between insect and insect—between insects, snails, and other animals with birds and beasts of prey—all striving to increase, all feeding on each other, or on the trees, their seeds and seedlings, or on the other plants which first clothed the ground, and thus checked the growth of the trees! Throw up a handful of feathers, and all fall to the ground according to definite laws; but how simple is the problem where each shall fall compared to that of the action and reaction of the innumerable plants and animals which have determined, in the course of centuries, the proportional numbers and kinds of trees now growing on the old Indian ruins!

"But the struggle will almost invariably be most severe between the individuals of the same species, for they frequent the same districts, require the same food, and are exposed to the same dangers......To keep up a mixed stock of even such extremely close varieties as the variously coloured sweet-peas, they must be each year harvested separately, and the seeds then mixed in due proportion, otherwise the weaker kinds will steadily decrease in number and disappear. So, again, with the varieties of sheep: it has been asserted that certain mountain-varieties will starve out other mountain-varieties, so that they cannot be kept together.

"We see this in the recent extension over parts of the United States of one species of swallow having caused the decrease of another species. The recent increase of the missel-thrush in some parts of Scotland has caused the decrease of the song-thrush. How frequently we hear of one species of rat taking the place of another species under the most different climates! In Russia the small Asiatic cockroach has everywhere driven before it its great congener. In Australia the imported hive-bee is rapidly exterminating the small, stingless native bee" (pp. 54, 55, 56, 57, 58).

"A corollary of the highest importance may be deduced from the foregoing remarks—namely, that the structure of every organic being is related, in the most essential yet often hidden manner, to that of all the other organic beings with which it comes into competition for food or residence, or from which it has to escape, or on which it preys" (p. 60).

"It is good to try in imagination to give to any one species an advantage over another. Probably in no single instance should we know what to do. This ought to convince us of our ignorance on the mutual relations of all organic beings; a conviction as necessary as it is difficult to acquire. All that we can do is to keep steadily in mind that each organic being is striving to increase in a geometrical ratio; that each at some period of its life, during some season of the year, during each generation or at intervals, has to struggle for life and to suffer great destruction. When we reflect on this struggle, we may console ourselves with the full belief that the war of nature is not incessant, that no fear is felt, that death is generally prompt, and that the vigorous, the healthy, and the happy survive and multiply."

CHAPTER VIII.

NATURAL SELECTION

THE lowest forms of life are so simple that it may well seem hard to understand how the more perfect forms have arisen from them. We find bits of floating jelly-like substance called protoplasm; they are without any organs or structure; they take in food by closing round it at any part of their small bodies; they have no hollow cavity in which they digest it, no nerves, no heart, no blood; they are so simple that they produce offspring by dividing in two, and each part lives as a separate being.

We turn from this simplest form to the highest orders of mammals with separate organs for all the chief functions of life; with a heart to pump the blood through a vast network of arteries, veins, and capillaries; with a brain and nerves of the most complex order, acting with such rapidity that it seems instantaneous, receiving thousands of impressions from the outer world, storing them up for years, forming out of them new combinations, weaving them together into intellectual classifications and inferences, or forming the beautiful pictures of imaginative art.

No wonder that men who have been trained to believe that mind is something independent of matter find a difficulty in understanding how the higher has evolved from the lower. Those accustomed to look on nature as partitioned off into independent classes by insurmountable barriers are not fitted to grasp easily the idea of the unity of nature and the oneness of the universe.

We have seen that variations occur, not in every individual, but in thousands of cases, due mainly to changes of environment. We also know that no power can reduce the environment of living things on the earth to one of sameness and fixity. No criticism, no blindness, can deny this great law of variation in the world in which we live.

Further, for any one form that can survive we see that a thousand forms come into existence, and that living organisms are capable of producing millions more forms than can possibly live. The chances of survival are limited; the power to multiply new forms is unlimited. So, clearly, of the millions of living things myriads must perish. Now, is there any law or order in which they perish? Of a thousand offspring, where only a hundred can live, do the other nine hundred die by chance, or by predestination, or is there some regulating force which surely and methodically picks out the nine hundred which perish?

To begin with familiar cases capable of easy demonstration—we know that when a man enters business in a new neighbourhood, if he fails to adapt himself to the needs of that neighbourhood, his business comes to ruin. For instance, in a small market town, where the farmers are Church people and vote Conservative, if a saddler were to open a shop and proclaim himself a Mohammedan and a Socialist, he would die of starvation. He must adapt himself or die.

Again, if the younger son of a peer by any chance found himself in a mining region in the far West of America, without a friend, without a penny, we know well he would perish of hunger if he kept up the attitude and manners which he had found quite successful in the University or a West End club. He must adapt himself or die.

Further, take any domestic animal and carry him away to some new region, unlike in many respects to his old home, if he cannot assimilate the food or bear the climate of the new region, death will soon overtake him. He must adapt himself or die.

Yet again, a number of animals may be living together in a pond or lake. If by any means many of them are driven on land, only those will live which have developed air-breathing organs. Among them the fish may be larger, more beautiful, more useful to man, but they will all perish in the new conditions to which they *cannot* adapt themselves, while the frog, with his newly-acquired structures, will live and prosper.

These examples are sufficient to show the law. Outside of any organism is an environment, usually more powerful than the organism, and every animal that will live must bend to the almighty power of environment.

In nature there is no morality, no sympathy. Mercy is unknown. The same oxygen which would support living things, if they are organised to use it in the form then and there offered, will, under a slight change of circumstances, prey upon them and dissolve their beauty into a putrid mass by one and the same unalterable law.

Now, out of the millions of varieties in organisms it is clear that some would be better suited to the environment than others, and the better suited would flourish and multiply, while the unsuitable would become inferior and slowly die out. This is what is meant by Mr. Spencer's "Survival of the Fittest" and by Darwin's "Natural Selection."

Be it remembered, the fittest does not mean the best or noblest, according to any of our notions, but the organism most suited to the environment, for nature produces murderers and poets by the same rule. Neither does natural selection imply *conscious* selection, as we understand this term. It would be equally true to call it natural murder or natural weeding out.

Now, have we in this combination of forces the power necessary for creating higher individuals and new species? With variations which are practically infinite, with an environment whose power is practically almighty and against whose law there is no appeal, with periods of time compared with which the oldest civilisation is but a mushroom grown this morning, we have a delicate and mighty organisation such as the mind of man can scarcely comprehend. These inevitable forces work with ceaseless energy, with ruthless rigour, and seize with unerring skill upon any point for the advantage of the individual or the race.

Could we imagine a machine of almost infinite extension, of the most delicate sensitiveness, to respond to the slightest changes, and capable of automatic action in every response to variations, we might form some idea of the comprehensive system of life and environment which we suggest by the term "adaptation." Still, the process is too delicate, too powerful, too vital, to be imaged under the figure of any known machine.

To such few elements are reduced the forces of almighty power which bind life into one, and mould living beings out of inorganic elements. And the more familiar we become with the working of this process, the more clearly we see that the universe, by the very nature of its components, lies swathed in the law of universal and inherent necessity.

We have seen (p. 104) that man, by selecting the points in pigeons or sheep which he desires to increase, can, in a few years, greatly change the breed; if, therefore, nature, acting for millions of years, can exert a power which works like man's selection, how vastly greater must be the result. Man can "neither originate varieties nor prevent their occurrence; he can only preserve and accumulate such as do occur."

Man selects the variations useful to himself; nature selects those useful in some way to each being in the battle of life. We must admit that individuals having any advantage, however slight, would have the best chance of surviving and of leaving offspring. On the other hand, we are sure that any variation in the least degree injurious would be rigidly destroyed. Variations neither useful nor injurious would not be affected by Natural Selection; *they might at last become fixed*, "owing to the nature of the organism and the nature of the conditions."

Darwin says: "It is difficult to avoid personifying the word Nature; but I mean by Nature only the aggregate action and product of many natural laws, and by laws the sequence of events as ascertained by us."

"We shall best understand the probable course of Natural Selection by taking the case of a country undergoing some slight physical change—for instance, of climate. The proportional numbers of its inhabitants will almost immediately undergo a change, and some species will probably become extinct. We may conclude from what we have seen of the intimate and complex manner in which the inhabitants of each country are bound together that any change in the numerical proportions of the inhabitants, independently of the change of climate itself, would seriously affect the others. If the country were open on its borders, new forms would certainly immigrate, and this would likewise seriously disturb the relations of some of the former inhabitants. Let it be remembered how powerful the influence of a single introduced tree or mammal has been shown to be. But in the case of an island, or of a country partly surrounded by barriers, into which new and better adapted forms could not freely enter, we should then have places in the economy of nature which would assuredly be better filled up if some of the original inhabitants were in some manner modified; for, had the area been open to immigration, these same places would have been seized on by intruders. In such cases slight modifications which in any way favoured the individuals of any species by better adapting them to their altered conditions would tend to be preserved, and Natural Selection would have free scope for the work of improvement.

"We have good reason to believe that changes in the conditions of life give a tendency to increased variability; and, in the foregoing case, the conditions have changed, and this would manifestly be favourable to Natural Selection by affording a better chance of the occurrence of profitable variations. Unless such occur, Natural Selection can do nothing. Under the term of 'variations,' it must never be forgotten that mere individual differences are included" (p. 63).

"Nature cares nothing for appearances, except in so far as they are useful to any being. She can act on every internal organ, on every shade of constitutional difference, on the whole machinery of life. Man selects only for his own good—Nature only for that of the being which she tends."

"Under nature, the slightest differences of structure or constitution may well turn the nicely-balanced scale in the struggle for life, and so be preserved."

We may say "that Natural Selection is daily and hourly scrutinising, throughout the world, the slightest variations; rejecting those that are bad and adding up all that are good; silently and insensibly working, *whenever and wherever opportunity offers*, at the improvement of each organic being in relation to its organic and inorganic conditions of life."

"When we see leaf-eating insects green and bark-feeders mottled gray, the alpine ptarmigan white in winter, the red-grouse the colour of heather, we must believe that these tints are of service to these birds and insects in preserving them from danger." We know that the colour of the hogs which feed on the "paint-root" in Virginia determines whether they shall live or die. "In plants the down on the fruit and the colour of the flesh are considered by botanists as characters of the most trifling importance; yet we hear from Downing that in the United States smooth-skinned fruits suffer far more from a beetle, the Curculio, than those with down; that purple plums suffer far more from certain diseases than yellow plums; whereas another disease attacks yellow-fleshed peaches far more than those with other coloured flesh."

These seem but slight differences, yet "assuredly in a state of nature, where the trees would have to struggle with other trees, and with a host of enemies, such differences would effectually settle which variety, whether a smooth or downy, a yellow or purple fruit, should succeed."

These examples could be vastly multiplied, and they must be taken as indicating the method by which Natural Selection can be affected.

"Natural Selection will modify the structure of the young in relation to the parent, and of the parent in relation to the young. In social animals it will adapt the structure of each individual for the benefit of the whole community, if the community profit by the selected change. What Natural Selection cannot do is to modify the structure of one species, without giving it any advantage, for the good of another species; and though statements to this effect may be found in works of natural history, I cannot find one case which will bear investigation. A structure used only once in an animal's life, if of high importance to it, might be modified to any extent by Natural Selection: for instance, the great jaws possessed by certain insects, used exclusively for opening the cocoon; or the hard tip to the beak of unhatched birds, used for breaking the egg. It has been asserted that of the best short-beaked tumbler pigeons a greater number perish in the egg than are able to get out of it, so that fanciers assist in the act of hatching. Now, if nature had to make the beak of a full-grown pigeon very short for the bird's own advantage, the process of modification would be very slow, and there would be simultaneously the most rigorous selection of all the young birds within the egg which had the most powerful and hardest beaks, for all with weak beaks would inevitably perish; or more delicate and more easily broken shells might be selected, the thickness of the shell being known to vary like every other structure" (pp. 67 and 68).

Probably Natural Selection has worked most frequently by seizing upon slight and oft-recurring variations rather than by a few exceptional variations.

"There can also be little doubt that the tendency to vary in the same manner has often been so strong that all the individuals of the same species have been similarly modified without the aid of any form of selection. Or only a third, fifth, or tenth part of the individuals may have been thus affected, of which fact several instances could be given. Thus Graba estimates that about one fifth of the guillemots in the Faroe Islands consists of a variety so well marked that it was formerly ranked as a distinct species under the name of Uria lacrymans. In cases of this kind, if the variation were of a beneficial nature, the original form would soon be supplanted by the modified form, through the survival of the fittest" (p. 72).

In order to avoid any misunderstanding of this doctrine of "Natural Selection," I give a summary of Mr. Alfred Russel Wallace's outline of it:—

"The grand feature in the increase of living things is that close *general* resemblance is combined with more or less individual variation. The child resembles its parents or ancestors more or less closely in all its peculiarities, deformities, or beauties; it resembles them in general more than it does any other individuals. This is what we mean when we say of children that they have a 'family likeness.' Yet children of the same parents are not all alike, and it often happens that they differ very considerably from their parents and from each other. This is equally true of man, of all animals, and of plants. They differ from them and from each other in every particular: in form, in size, in colour; in the structure of internal as well as of external organs; in those subtle peculiarities which produce differences of constitution, as well as in those still more subtle ones which lead to modifications of mind and character. In other words, in every possible way, in every organ, and in every function, individuals of the same stock vary.

"Now, health, strength, and long life are the results of a harmony between the individual and the universe that surrounds it. Let us suppose that at any given moment this harmony is perfect. A certain animal is exactly fitted to secure its prey, to escape from its enemies, to resist the inclemencies of the seasons, and to rear a numerous and healthy offspring. But a change now takes place. A series of cold winters, for instance, come on, making food scarce, and bringing an immigration of some other animals to compete with the former inhabitants of the district. The new immigrant is swift of foot, and surpasses its rivals in the pursuit of game; the winter nights are colder, and require a thicker fur as protection, and more nourishing food to keep up the heat of the system. Our supposed perfect animal is no longer in harmony with the universe; it is in danger of dying of cold or starvation. But the animal varies in its offspring. Some of these are swifter than others—they still manage to catch food enough; some are hardier and more thickly furred—they manage in the cold nights to keep warm enough; the slow, the weak, and the thinly clad soon die off. Again and again, in each succeeding generation, the same thing takes place. By this natural process, which is so inevitable that it cannot be conceived not to act, those best adapted to live, live; those least adapted, die. It must be so; for as all wild animals increase in a geometrical ratio, while their actual numbers remain on an average stationary, it follows that as many die annually as are born. If, therefore, we deny Natural Selection, it can only be by asserting that, in such a case as I have supposed, the strong, the healthy, the swift, the well-clad, the well-organised animals in every respect have no advantage over—do not on the average live longer than—the weak, the unhealthy, the slow, the ill-clad, and the imperfectly organised individuals; and this no sane man has been found hardy enough to assert. But this is not all; for the offspring, on the average, resemble their parents, and the selected portion of each succeeding generation will, therefore, be stronger, swifter, and more thickly furred than the last; and if this process goes on for thousands of generations, our animal will have again become thoroughly in harmony with the new conditions in which it is placed. But it will now be a different creature. It will be not only swifter and stronger and more furry, it will also probably have changed in colour, in form—perhaps have acquired a longer tail or differently shaped ears; for it is an ascertained fact that, when one part of an animal is modified, some other parts almost always change, as it were, in sympathy with it. Mr. Darwin calls this 'correlation of growth,' and gives as instances that hairless dogs have imperfect teeth; while cats, when blue-eyed, are deaf; small feet accompany short beaks in pigeons; and other equally interesting cases.

"Grant, therefore, the premises:—1st. That peculiarities of every kind are more or less hereditary. 2nd. That the offspring of every animal vary more or less in all parts of their organisation. 3rd. That the universe in which these animals live is not absolutely invariable: none of which propositions can be denied; and then consider that the animals in any country (those, at least, which are not dying out) must at each successive period be brought into harmony with the surrounding conditions, and we have all the elements for a change of form and structure in the animals, keeping exact pace with changes of whatever nature in the surrounding universe.

"This is, briefly, the theory of 'Natural Selection,' which explains the changes in the organic world as being parallel with, and in part dependent on, those in the inorganic" (*Essays on Natural Selection*, pp. 307–311).

"It may be worth while to give another and more complex illustration of the action of Natural Selection. Certain plants excrete sweet juice, apparently for the sake of eliminating something injurious from the sap. This is effected, for instance, by glands at the base of the stipules in some

Leguminosæ, and at the backs of the leaves of the common laurel. This juice, though small in quantity, is greedily sought by insects; but their visits do not in any way benefit the plant. Now, let us suppose that the juice or nectar was excreted from the inside of the flowers of a certain number of plants of any species. Insects, in seeking the nectar, would get dusted with pollen, and would often transport it from one flower to another. The flowers of two distinct individuals of the same species would thus get crossed; and the act of crossing, as can be fully proved, gives rise to vigorous seedlings, which consequently would have the best chance of flourishing and surviving. The plants which produced flowers with the largest glands or nectaries, excreting most nectar, would oftenest be visited by insects, and would oftenest be crossed; and so, in the long run, would gain the upper hand and form a local variety. The flowers, also, which had their stamens and pistils placed, in relation to the size and habits of the particular insect which visited them, so as to favour in any degree the transport of the pollen, would likewise be favoured. We might have taken the case of insects visiting flowers for the sake of collecting pollen instead of nectar; and as pollen is formed for the sole purpose of fertilisation, its destruction appears to be a simple loss to the plant; yet if a little pollen were carried, at first occasionally and then habitually, by the pollen-devouring insect from flower to flower, and a cross thus effected, although nine-tenths of the pollen were destroyed, it might still be a great gain to the plant to be thus robbed; and the individuals which produced more and more pollen, and had larger anthers, would be selected.

"When our plant, by the above process long continued, had been rendered highly attractive to insects, they would, unintentionally on their part, regularly carry pollen from flower to flower; and that they do this effectually I could easily show by many striking facts. I will give only one, as likewise illustrating one step in the separation of the sexes of the plants. Some holly-trees bear only male flowers, which have four stamens producing a rather small quantity of pollen, and a rudimentary pistil; other holly-trees bear only female flowers; these have a full-sized pistil, and four stamens with shrivelled anthers, in which not a grain of pollen can be detected. Having found a female tree exactly sixty yards from a male tree, I put the stigmas of twenty flowers, taken from different branches, under the microscope, and on all, without exception, there were a few pollen-grains, and on some a profusion. As the wind had set for several days from the female to the male tree, the pollen could not thus have been carried. The weather had been cold and boisterous, and therefore not favourable to bees; nevertheless, every female flower that I examined had been effectually fertilised by the bees, which had flown from tree to tree in search of nectar. But to return to our imaginary case. As soon as the plant had been rendered so highly attractive to insects that pollen was regularly carried from flower to flower another process might commence. No naturalist doubts the advantage of what has been called the 'physiological division of labour'; hence we may believe that it would be advantageous to a plant to produce stamens alone in one flower or on one whole plant, and pistils alone in another flower or on another plant. In plants during culture, and placed under new conditions of life, sometimes the male organs and sometimes the female organs become more or less impotent. Now, if we suppose this to occur in ever so slight a degree under nature, then, as pollen is already carried regularly from flower to flower, and as a more complete separation of the sexes of our plant would be advantageous on the principle of the division of labour, individuals, with this tendency more and more increased, would be continually favoured and selected, until at last a complete separation of the sexes might be effected. It would take up too much space to show the various steps, through dimorphism and other means, by which the separation of the sexes in plants of various kinds is apparently now in progress; but I may add that some of the species of holly in North America are, according to Asa Gray, in an exactly intermediate condition, or, as he expresses it, are more or less dioeciously polygamous.

"Let us now turn to the nectar-feeding insects. We may suppose the plant, of which we have been slowly increasing the nectar by continued selection, to be a common plant, and that certain insects depended in main part on its nectar for food. I could give many facts showing how anxious bees are to save time; for instance, their habit of cutting holes and sucking the nectar at the bases of certain flowers, which, with a very little more trouble, they can enter by the mouth. Bearing such facts in mind, it may be believed that, under certain circumstances, individual differences in the curvature or length of the proboscis, etc., too slight to be appreciated by us, might profit a bee or other insect, so that certain individuals would be able to obtain their food more quickly than others; and thus the communities to which they belong would flourish and throw off many swarms inheriting the same peculiarities. The tubes of the corolla of the common red and incarnate clovers (*trifolium pratense* and *incarnatum*) do not, on a hasty glance, appear to differ in length, yet the hive-bee can easily suck the nectar out of the incarnate clover, but not out of the common red clover, which is visited by the humble-bees alone, so that whole fields of the red clover offer in vain an abundant supply of precious nectar to the hive-bee. That this nectar is much liked by the hive-bee is certain, for I have repeatedly seen, but only in the autumn, many hive-bees sucking the flowers through holes bitten in the base of the tubes by humble-bees. The difference in the length of the corolla in the two kinds of clover, which determines the visits of the hive-bee, must be very trifling; for I have been assured that, when red clover has been mown, the flowers of the second crop are smaller, and that these are visited by many hive-bees. I do not know whether this statement is accurate, nor whether another published statement can be trusted—namely, that the Ligurian bee, which is generally considered a mere variety of the common hive-bee, and which freely crosses with it, is able to reach and suck the nectar of the red clover. Thus, in a country where this kind of clover abounded it might be a great advantage to the hive-bee to have a slightly longer or differently constructed proboscis. On the other hand, as the fertility of this clover absolutely depends on bees visiting the flowers, if humble bees were to become rare in any country, it might be a great advantage to the plant to have a shorter or more deeply-divided corolla, so that the hive-bees should be enabled to suck its flowers. Thus I can understand how a flower and a bee might slowly become, either simultaneously or one after the other, modified and adapted to each other in the most perfect manner by the continued preservation of all the individuals which presented slight deviations of structure mutually favourable to each other" (*Ibid*, pp. 73, 74, and 75).

Circumstances favourable for the production of new forms through Natural Selection.

"This is an extremely intricate subject. A great amount of variability, under which term individual differences are always included, will evidently be favourable. A large number of individuals, by giving a better chance within any given period for the appearance of profitable variations, will compensate for a lesser amount of variability in each individual, and is, I believe, a highly important element of success. Though Nature grants long periods of time for the work of Natural Selection, she does not grant an indefinite period; for as all organic beings are striving to seize on each place in the economy of nature, if any one species does not become modified and improved in a corresponding degree with its competitors, it will be exterminated. Unless favourable variations be inherited by some at least of the offspring, nothing can be effected by Natural Selection. The tendency to reversion may often check or prevent the work; but as this tendency has not prevented man from forming by selection numerous domestic races, why should it prevail against Natural Selection?" (*Ibid*, p. 80).

But when man selects for some definite object, if the individuals be allowed freely to inter-cross, his work will fail.

"Inter-crossing plays a very important part in nature by keeping the individuals of the same species, or of the same variety, true and uniform in character."

But isolation modifies this very greatly. If the animals live in a confined area, say an island, "the organic and inorganic conditions of life will generally be almost uniform, so that Natural Selection will tend to modify all the varying individuals of the same species in the same manner. Inter-crossing with the inhabitants of the surrounding districts will also be prevented."

"Although isolation is of great importance in the reproduction of new species, on the whole I am inclined to believe that largeness of area is still more important, especially for the reproduction of species which shall prove capable of enduring for a long period, and of spreading widely. Throughout a great and open area not only will there be a better chance of favourable variations arising from the large number of individuals of the same species there supported, but the conditions of life are much more complex from the large number of already existing species; and if some of these many species become modified and improved, others will have to be improved in a corresponding degree, or they will be exterminated. Each new form also, as soon as it has been much improved, will be able to spread over the open and continuous area, and will thus come into competition with many other forms. Moreover, great areas, though now continuous, will often, owing to former oscillations of level, have existed in a broken condition, so that the good effects of isolation will generally, to a certain extent, have concurred. Finally, I conclude that, although small isolated areas have been in some respects highly favourable for the production of new species, yet that the course of modification will generally have been more rapid on large areas; and, what is more important, that the new forms produced on large areas, which already have been victorious over many competitors, will be those that will spread most widely, and will give rise to the greatest number of new varieties and species. They will thus play a more important part in the changing history of the organic world" (*Ibid*, pp. 82 and 83).

This may help us to understand how it is that the productions of a smaller continent like Australia disappear before those of the larger continents. Continental productions seem to have taken refuge on islands because on them the race for life will have been less severe, and there will have been less modification and less extermination. Hence we can understand how it is that the flora of Madeira resembles to a certain extent the extinct tertiary flora of Europe.

The same thing happens in fresh-water basins which are comparatively small: the competition has been less severe, and new forms have been more slowly produced, old forms more slowly exterminated.

It is in fresh-water basins that we find seven kinds of ganoid fishes, remnants of a once preponderant order; in fresh water we find some of the most irregular forms now known in the world, as the ornithorhyncus (*see* Fig. 6) and lepidosiren, which, like fossils, connect to a certain extent orders at present widely severed. "These anomalous forms may be called living fossils; they have endured to the present day, from having inhabited a confined area, and from having been exposed to less varied, and therefore less severe, competition."

"To sum up, as far as the extreme intricacy of the subject permits, the circumstances favourable and unfavourable for the production of new species through Natural Selection. I conclude that for terrestrial productions a large continental area, which has undergone many oscillations of level, will have been the most favourable for the production of many new forms of life, fitted to endure for a long time and to spread widely. While the area existed as a continent, the inhabitants will have been numerous in individuals and in kinds, and will have been subjected to severe competition. When converted by subsidence into large separate islands, there will still have existed many individuals of the same species on each island; inter-crossing on the confines of the range of each new species will have been checked; after physical changes of any kind, immigration will have been prevented, so that new places in the polity of each island will have had to be filled up by the modification of the old inhabitants; and time will have been allowed for the varieties in each to become well modified and perfect. When, by renewed elevation, the islands were reconverted into a continental area, there will again have been very severe competition; the most favoured or improved varieties will have been enabled to spread; there will have been much extinction of the less improved forms, and the relatively proportional numbers of the various inhabitants of the re-united continent will again have been changed; and again there will have been a fair field for Natural Selection to improve the inhabitants, and thus to produce new species.

"That Natural Selection generally acts with extreme slowness I fully admit. It can act only when there are places in the natural polity of a district which can be better occupied by the modification of some of its existing inhabitants. The occurrence of such places will often depend on physical changes, which generally take place very slowly, and on the immigration of better adapted forms being prevented. As some few of the old inhabitants become modified, the mutual relations of others will often be disturbed, and this will create new places, ready to be filled up by better adapted forms. But all this will take place very slowly. Although all the individuals of the same species differ in some slight degree from each other, it would often be long before differences of the right nature in various parts of the organisation might occur. The result would often be greatly retarded by the free inter-crossing. Many will exclaim that these several causes are amply sufficient to neutralise the power of Natural Selection. I do not believe so. But I do believe that Natural Selection will generally act very slowly, only at long intervals of time, and only on a few inhabitants of the same region. I further believe that these slow, intermittent results accord well with what geology tells us of the rate and manner at which the inhabitants of the world have changed.

"Slow though the process of selection may be, if feeble man can do much by artificial selection, I can see no limit to the amount of change, to the beauty and complexity of the co-adaptations between all organic beings, one with another and with their physical conditions of life, which may have been effected in the long course of time through nature's power of selection; that is, by the survival of the fittest" (*Ibid*, pp. 84 and 85).

Extinction caused by Natural Selection.

"Natural Selection acts solely through the preservation of variations in some way advantageous, which consequently endure. Owing to the high geometrical rate of increase of all organic beings, each area is already fully stocked with inhabitants; and it follows from this that, as the favoured forms increase in number, so generally will the less favoured decrease and become rare. Rarity, as geology tells us, is the precursor of extinction." Any form which is represented by few individuals will run a good chance of utter extinction. Nay, more, as new forms are produced, many old forms must become extinct.

Species which are most numerous in individuals have the best chance of producing favourable variations within any given period. It is the common and diffused species which offer the greatest number of recorded varieties. It inevitably follows that, as new species in the course of time are formed, others become rarer and rarer, and finally extinct. Each new variety will press hardest on its nearest kindred and tend to exterminate them.

"We see the same process of extermination among our domesticated productions through the selection of improved forms by man. Many curious instances could be given showing how quickly new breeds of cattle, sheep, and other animals, and varieties of flowers, take the place of older and inferior kinds. In Yorkshire it is historically known that the ancient black cattle were displaced by the long-horns, and that these 'were swept away by the short-horns' (I quote the words of an agricultural writer) 'as if by some murderous pestilence'" (*Ibid*, p. 86).

Divergence of character.

This principle is of high importance, and explains several important facts. In the first place, varieties differ far less from each other than do distinct species. Varieties are species in the process of making. How, then, do varieties become species?

A variety might arise, in the natural course, differing from its parents; and the offspring of this variety might again differ from its parents in a greater degree, but this would never account for so habitual and large a degree of difference as that between the species of the same genus.

Turning to our domestic animals, it will be admitted that races so widely different as the race and cart horses could never be effected by the mere chance accumulation of similar variations during many successive generations.

"Again, we may suppose that at an early period of history the men of one nation or district required swifter horses in the one case and stronger ones in the other, the differences would become greater, and would be noted as forming two sub-breeds. Ultimately, after the lapse of centuries, these sub-breeds would become converted into two well-established and distinct breeds. As the differences became greater, the inferior animals with intermediate characters, being neither very swift nor very strong, would not have been used for breeding, and will thus have tended to disappear. Here, then, we see in man's productions the action of what may be called the principle of divergence, causing differences, at first barely appreciable, steadily to increase, and the breeds to diverge in character, both from each other and from their common parent" (*Ibid*, p. 87).

Does anything like this apply in nature? So it seems, "from the simple circumstance that the more diversified the descendants from any one species become in structure, constitution, and habits, by so much will they be better enabled to seize on many and widely diversified places, and so to increase in numbers."

It has been proved that a greater weight of hay will be got from a patch of ground sown with several distinct grasses than can be got if sown with only one kind of grass. So that nature favours divergence. This has been proved in many ways, and may be taken as demonstrated. We may form a general rule that the more diversified in structure the descendants from any one species can be rendered, the more places they will be able to seize upon, and the more their modified progeny will increase.

Chapter IX.

DIFFICULTIES OF THE THEORY OF EVOLUTION

No one supposes that the theory of Evolution has cleared up every point with regard to the wonderful varieties of living things. The theory as presented by Darwin is new, and a vast part of nature is yet unexplored.

There are many objections to the theory which are not difficulties. These are merely created by ignorance or prejudice.

Those who find a difficulty in the theory because men have not tails, or because a substance found in the eocene rocks is thought by some to be a foraminifer, require more knowledge. For instance, Eozoon Canadense is the name applied to remains found in the eocene rocks. Some maintain that they are the remains of an animal like the existing foraminifera, and then they exultingly cry, "Here is a case which knocks down your evolution theory, for in this animal there has been no evolution!"

Now, to the Evolutionist it does not matter whether the remains are those of an animal or vegetable; neither does it make the slightest difference if they could photograph these remains and any existing animal or vegetable and find the old and the new exactly alike—for this simple reason, that the doctrine of Evolution never demanded that *every* animal and plant should go on in one unbroken line of development. To have development there must be a favourable variation in the organism and a suitable environment to develop that variation. If, on the other hand, the conditions remain almost the same for a million years, the organism is likely to remain almost the same for a million years.

I cannot do better than quote Mr. Huxley's strong words on this fictitious difficulty. In his second lecture on Evolution he says:—

"Facts of this kind are undoubtedly fatal to any form of the doctrine of Evolution which postulates the supposition that there is an intrinsic necessity, on the part of animal forms which have once come into existence, to undergo continual modification; and they are as distinctly opposed to any view which involves the belief that such modification as may occur must take place, at the same rate, in all the different types of animal or vegetable life. The facts, as I have placed them before you, obviously directly contradict any form of the hypothesis of Evolution which stands in need of these two postulates.

"But one great service that has been rendered by Mr. Darwin to the doctrine of Evolution in general is this: he has shown that there are two chief factors in the process of evolution—one of them is the tendency to vary, the existence of which in all living forms may be proved by observation; the other is the influence of surrounding conditions upon what I may call the parent form and the variations which are thus evolved from it. The cause of the production of variations is a matter not at all properly understood at present. Whether variation depends upon some intricate machinery—if I may use the phrase—of the living organism itself, or whether it arises through the influence of conditions upon that form, is not certain, and the question may, for the present, be left open. But the important point is that, granting the existence of the tendency to the production of variations, then, whether the variations which are produced shall survive and supplant the parent, or whether the parent form shall survive and supplant the variations, is a matter which depends entirely on those conditions which give rise to the struggle for existence. If the surrounding conditions are such that the parent form is more competent to deal with them and flourish in them than the derived forms, then, in the struggle for existence, the parent form will maintain itself and the derived forms will be exterminated. But if, on the contrary, the conditions are such as to be more favourable to a derived than to the parent form, the parent form will be extirpated and the derived form will take its place. In the first case there will be no progression, no change of structure, through any imaginable series of ages; in the second place there will be modification of change and form" (*Lectures and Essays*, p. 24).

We must patiently smile at such objections, just as we do when some lady of seventeen summers seriously informs us that she has never seen any gill slits in *her* neck, though she has often looked for them! Still more hopeless is it when the objector creates an impossible theory of his own, and then begins to smash it up, under the fond delusion that he is answering the difficulties of Evolution. Scarcely less humorous is the position of those who cannot accept the teachings of science, because they would interfere with the cherished convictions of their grandparents. This is as rational as would be the conduct of one who refused to have his house drained because his grandmother died in it at the age of eighty, and what was good enough for her was good enough for him.

Such objections as these there must be, and we can only recognise that they enliven life and furnish valuable evidence of the truth of Evolution, for some at least have evolved beyond this stage.

It would be untrue not to admit that there are some real difficulties. Darwin himself felt many of them.

Two facts we must always bear in mind: first, our ignorance of many things in the life-history of the world; second, that the thousands of discoveries made during the last half-century have removed many old difficulties, and have not created new ones.

So that now the difficulties are really much less than when Darwin wrote his sixth edition in 1872, and even then he said, "To the best of my judgment the greater number are only apparent, and those that are real are not, I think, fatal to the theory."

"These difficulties and objections may be classed under the following heads:—First, why, if species have descended from other species by fine gradations, do we not everywhere see innumerable transitional forms? Why is not all nature in confusion, instead of the species being, as we see them, well defined?

"Secondly, is it possible that an animal having, for instance, the structure and habits of a bat could have been formed by the modification of some other animal with widely different habits and structure? Can we believe that Natural Selection could produce, on the one hand, an organ of trifling importance, such as the tail of a giraffe, which serves as a fly flapper, and, on the other hand, an organ so wonderful as the eye?

"Thirdly, can instincts be acquired and modified through Natural Selection? What shall we say to the instinct which leads the bee to make cells, and which has practically anticipated the discoveries of profound mathematicians?

"Fourthly, how can we account for species, when crossed, being sterile or producing sterile offspring, whereas, when varieties are crossed, their fertility is unimpaired?" (*Origin of Species*, p. 133).

To take them in order, we will follow Darwin briefly in dealing with these difficulties.

I. The absence or rarity of transitional forms.

Natural Selection only preserves that which is profitable in the various modified forms which arise. In a well-stocked country each new form will tend to take the place of, or finally to exterminate, its own less improved parent form and the other less favoured forms. Extinction and Natural Selection go hand in hand. We cannot too often repeat this truth, for this alone banishes defective and intermediate forms with amazing rapidity.

"Hence, if we look at each species as descended from some unknown form, both the parent and all the transitional varieties will generally have been exterminated by the very process of the formation and perfection of the new form."

We must grasp this and ponder over it, till we are familiar with the law, for, if it is not true, evolution by Natural Selection has no ground to stand upon.

Still, by the demands of the theory, there must have been transitional forms—that is, forms between the lower and the more perfect: the most perfect beings, we see, have only developed by constant changes and through many varieties. Why, then, do we not find more of these imperfect forms in countless numbers embedded in the crust of the earth?

There are two clear answers to this. First, we have not yet sufficiently explored the rocks which form the earth's crust. When we consider the extent of the surface of our globe, and the vast area which is under water, we see how small is the part which has been explored.

The second answer is that only certain classes of organic beings have been largely preserved in a fossil state; that the number both of specimens and species in our museums is absolutely as nothing compared with the number of generations which must have passed away even during a single formation.

It is clear that, in any case, creatures composed of soft or delicate substance could hardly be expected to survive in the conditions necessary for the formation of rocks. For instance, it seems well established that a subsidence of the earth is almost necessary for the storing up of deposits rich in fossil species of many kinds and thick enough to outlast the wear and tear of our ever-changing globe; therefore, great intervals of time must have elapsed between most of the successive formations. Yet there has been probably greater extinction during the periods of subsidence, so that the fewest specimens were present just where they might have been preserved.

On the other hand, during periods of elevation of the land there was more variation, but here their chance of preservation was small.

If these two laws can be proved by geologists, they do much to account for the imperfect record in the earth's crust.

When the great geologist, Sir Charles Lyell, was convinced, against his wish, of the truth of Darwin's theory of the origin of species, he emphasised this imperfection of the earth's record clearly and beautifully by comparing the crust of the earth to a book of which we have but a few pages. And Darwin said later :—

"Those who believe that the geological record is in any degree perfect will undoubtedly at once reject the theory. For my part, following out Lyell's metaphor, I look at the geological record as a history of the world imperfectly kept, and written in a changing dialect; of this history we possess the last volume alone, relating only to two or three countries. Of this volume, only here and there a short chapter has been preserved; and of each page, only here and there a few lines. Each word of the slowly changing language, more or less different in the successive chapters, may represent the forms of life which are entombed in our consecutive formations, and which falsely appear to us to have been abruptly introduced. On this view the difficulties above discussed are greatly diminished, or even disappear" (*Origin of Species*, p. 289).

This difficulty has indeed vanished. When Professor Huxley was in America, Professor Marsh took him to Connecticut to see the great beds of sandstone there, which extend for several square miles, having once formed part of an ancient sea-shore, or lake-shore. He says: "For a certain period of time after their deposition these beds remained sufficiently soft to receive the impressions of the feet of whatever animals walked over them, and to preserve them afterwards, in exactly the same way as such impressions are at this hour preserved on the shores of the Bay of Fundy and elsewhere. In these rocks are found footprints that represent the track of some gigantic animal, which walked on its hind legs. You see the series of marks made alternately by the right and by the left foot; so that from one impression to the other of the three-toed foot on the same side is one stride, and that stride, as we measured it, is six feet nine inches. I leave you, therefore, to form an impression of the magnitude of the creature which, as it walked along the ancient shore, made those impressions.

"Of such impressions there are untold thousands upon these sandstones. Fifty or sixty different kinds have been discovered, and they cover vast areas. But, up to the present time, not a bone, not a fragment, of any one of the animals which left these great foot marks has been found; in fact the only animal remains which have been met with in all these deposits, from the time of their discovery to the present day—though they have been carefully hunted over—is a fragmentary skeleton of one of the smaller forms. What has become of the bones of all these animals? You see, we are not dealing with little creatures, but with animals which made a step of six feet nine inches; and their remains must have been left somewhere. The probability is that they have been dissolved away and completely lost.

"I have had occasion to work out the nature of fossil remains, of which there was nothing left except casts of the bones, the solid material of the skeleton having been dissolved out by percolating water. It was a chance, in this case, that the sandstone happened to be of such a constitution as to set, and to allow the bones afterwards to be dissolved out, leaving cavities of the exact shape of the bones. Had the constitution been other than it was, the bones would have been dissolved, the layers of sandstone would have fallen together into one mass, and not the slightest indication that the animal had existed would have been discoverable.

"I know of no more striking evidence than these facts afford of the caution which should be used in drawing the conclusion, from the absence of organic remains in a deposit, that animals or plants did not exist at the time it was formed" (*Lectures and Essays*, 6d. ed., p. 26).

Leaving, then, the strict geological record, we ask how it is that, if distinct species are formed by slight changes in succeeding generations, the whole world of life is not a chaos of varying and intermediate links?

Darwin points out that there are many reasons which would prevent this confusion.

1. Because new varieties are very slowly formed, for variation is a slow process, and Natural Selection can do nothing till the favourable variation occurs.

2. Areas now connected must often have been divided asunder. In this case many forms may be separately rendered distinct species. And the intermediate varieties which existed on the separate pieces of land will have been supplanted and destroyed, so that they are no longer found living.

3. In a continuous area intermediate varieties will have been formed in intermediate zones, and these varieties would be of short duration, for they would exist in fewer numbers than the varieties they tend to connect. The fact of their being fewer would expose them to a severe struggle for life with the more fixed forms, and this would lead to their being destroyed.

4. Looking not to any one time, but to all time, if Darwin's theory is true, there must have existed numberless intermediate varieties, linking closely together all the species of the same group; but we must again repeat that the very process of Natural Selection tends always to kill off the parent forms and the intermediate links, and therefore we could only expect to find them in fossil remains, and of these we have just seen that there is but an imperfect record in the earth's crust, and this record is not yet half read.

Much of this may be made clearer by examples.

Darwin says: "I may illustrate what I mean by supposing three varieties of sheep to be kept, one adapted to an extensive mountainous region; a second to a comparatively narrow, hilly tract; and a third to the wide plains at the base; and that the inhabitants are all trying with equal steadiness and skill to improve their stocks by selection; the chances in this case will be strongly in favour of the great holders on the mountains or on the plains improving their breeds more quickly than the small holders on the intermediate narrow, hilly tract; and consequently the improved mountain or plain breed will soon take the place of the less improved hill breed; and thus the two breeds, which originally existed in great numbers, will come into close contact with each other, without the interposition of the supplanted intermediate hill-variety" (p. 137).

"If about a dozen genera of birds were to become extinct, who would have ventured to surmise that birds might have existed which used their wings solely as flappers, like the logger-headed duck (micropterus of Eyton); as fins in the water and as front-legs on the land, like the penguin; as sails, like the ostrich; and functionally for no purpose, like the apteryx? Yet the structure of each of these birds is good for it, under the conditions of life to which it is exposed, for each has to live by struggle; but it is not necessarily the best possible under all possible conditions. It must not be inferred from these remarks that any of the grades of wing-structure here alluded to, which perhaps may all be the result of disuse, indicate the steps by which birds actually acquired their perfect flight; but they serve to show what diversified means of transition are at least possible" (p. 140).

II. We must now turn to Darwin's second difficulty—namely, the development of organs of extreme perfection and complexity.

He himself says: "To suppose that the eye, with all its inimitable contrivances for adjusting the focus to different distances, for admitting different amounts of light, and for the correcting of spherical and chromatic aberration, could have been formed by natural selection, seems, I freely confess, absurd in the highest degree."

Still, this could hardly be considered more wonderful than a first-rate printing press. No man could have invented such a press at once. Its wonderful devices for picking up the paper, printing upon it, and then throwing it off, give it the appearance almost of some living intelligent animal. By slow degrees, by many attempts, by making many and small improvements, such mechanical wonders have become the servants of man. Probably we could no more show all the steps in the evolution of such a machine than we can produce all the steps in the evolution of man from the lowest vertebrate animal.

In such cases we should fix our attention on the steps. To ask a man to jump from the ground to a third story window seems absurd enough, yet by a little contrivance called a ladder, with steps a foot apart, the average man could reach the third story easily. It is, therefore, quite unfair to take some well-developed organ, such as the eye, and begin to stumble around its wonders in blind adoration as if it had grown in a single night, and was therefore a marvel bathed in mystery. We must begin with the simplest form of an eye which we can find, or with the simplest order of organism which can be affected by light.

Darwin says: "Reason tells me that, if numerous gradations from a simple and imperfect eye to one complex and perfect can be shown to exist, each grade being useful to its possessor, as is certainly the case; if, further, the eye varies and the variations ever be inherited, as is likewise certainly the case; and if such variations should be useful to any animal under changing conditions of life, then the difficulty of believing that a perfect and complex eye could be formed by Natural Selection, though insuperable by our *imagination*, should not be considered as subversive of the theory. How a nerve comes to be sensitive to light hardly concerns us more than how life itself originated; but I may remark that, as some of the lowest organisms in which nerves cannot be detected are capable of perceiving light, it does not seem impossible that certain sensitive elements in their sarcode should become aggregated and developed into nerves endowed with this special sensibility.

"In searching for the gradations through which an organ in any species has been perfected, we ought to look exclusively to its lineal progenitors; but this is scarcely ever possible, and we are forced to look to other species and genera of the same group; that is, to the collateral descendants from the same parent form, in order to see what gradations are possible, and for the chance of some gradations having been transmitted in an unaltered or little altered condition. But the state of the same organ in distinct classes may incidentally throw light on the steps by which it has been perfected.

"The simplest organ which can be called an eye consists of an optic nerve surrounded by pigment-cells and covered by translucent skin, but without any lens or other refractive body. We may, however, according to M. Jourdain, descend even a step lower, and find aggregates of pigment-cells, apparently serving as organs of vision, without any nerves, and resting merely on sarcodic tissue. Eyes of the above simple nature are not capable of distinct vision, and serve only to distinguish light from darkness. In certain star-fishes small depressions in the layer of pigment which surrounds the nerve are filled, as described by the author just quoted, with transparent gelatinous matter, projecting with a convex surface, like the cornea in the higher animals. He suggests that this serves not to form an image, but only to concentrate the luminous rays and render their perception more easy. In this concentration of the rays we gain the first and by far the most important step towards the formation of a true, picture-forming eye; for we have only to place the naked extremity of the optic nerve, which in some of the lower animals lies deeply buried in the body and in some near the surface, at the right distance from the concentrating apparatus, and an image will be found on it.

"In the great class of the articulata (arthropoda), we may start from an optic nerve simply coated with pigment, the latter sometimes forming a sort of pupil, but destitute of a lens or other optical contrivance. With insects it is now known that the numerous facets on the cornea of their great compound eyes form true lenses, and that the cones include curiously modified nervous filaments. But these organs in the articulata are so much diversified that Müller formerly made three main classes with seven subdivisions, besides a fourth main class of aggregate simple eyes.

"When we reflect on these facts, here given much too briefly, with respect to *the wide, diversified, and graduated range of structure* in the eyes of the lower animals, and when we bear in mind how small the number of all living forms must be in comparison with those which have become extinct, the difficulty ceases to be very great in believing that Natural Selection may have converted the simple apparatus of an optic nerve, coated with pigment and invested by transparent membrane, into an optical instrument as perfect as is possessed by any member of the articulate class.

"He who will go thus far ought not to hesitate to go one step further, if he finds, on finishing this volume, that large bodies of facts, otherwise inexplicable, can be explained by the theory of modification through Natural Selection; he ought to admit that a structure even as perfect as an eagle's eye might thus be formed, although in this case he does not know the transitional stages. It has been objected that, in order to modify the eye and still preserve it as a perfect instrument, many changes would have to be effected simultaneously, which, it is assumed, could not be done through Natural Selection; but, as I have attempted to show in my work on the variation of domestic animals, it is not necessary to suppose that the modifications were all simultaneous, if they were extremely slight and gradual. Different kinds of modification would also serve for the same general purpose. As Mr. Wallace has remarked, 'if a lens has too short or too long a focus, it may be amended either by an alteration of curvature or an alteration of density; if the curvature be irregular and the rays do not converge to a point, then any increased regularity of curvature will be an improvement. So the contraction of the iris and the muscular movements of the eye are neither of them essential to vision, but only improvements which might have been added and perfected at any stage of the construction of the instrument.' Within the highest division of the animal kingdom—namely, the vertebrata—we can start from an eye so simple that it consists, as in the lancelet, of a little sack of transparent skin, furnished with a nerve and lined with pigment, but destitute of any other apparatus. In fishes and reptiles, as Owen has remarked, 'the range of gradations of dioptric structures is very great.' It is a significant fact that even in man, according to the high authority of Virchow, the beautiful crystalline lens is formed in the embryo by an accumulation of epidermic cells, lying in a sack-like fold of the skin; and the vitreous body is formed from embryonic subcutaneous tissue. To arrive, however, at a just conclusion regarding the formation of the eye, with all its marvellous yet not absolutely perfect characters, it is indispensable that the reason should conquer the imagination; but I have felt the difficulty far too keenly to be surprised at others hesitating to extend the principle of Natural Selection to so startling a length" (*Origin of Species*, pp. 143–146).

While dealing with the eye it may be well to refer to another sort of difficulty. I have met with this kind of objection. The cuttle-fish is a low order of animal, and yet it has an eye almost as well developed as the vertebrate. How can this be if man has come through the lower forms?

Or again, Mr. Mivart raised a great difficulty of this sort from another point of view, for he maintained that, where organs are wonderfully alike in groups widely separated, the resemblance between the organs cannot be due to descent from a common ancestor.

The answer to both these difficulties is that organs may be alike in general appearance and function, yet there may be fundamental differences between them. Besides, it is not suggested that man came through the cuttle-fish.

"An organ for vision must be formed of transparent tissue, and must include some sort of lens for throwing an image at the back of a darkened chamber. Beyond this superficial resemblance there is hardly any real similarity between the eyes of cuttle-fish and vertebrates, as may be seen by consulting Hensen's admirable memoir on these organs in the cephalopoda. It is impossible for me here to enter on details, but I may specify a few of the points of difference. The crystalline lens in the higher cuttle-fish consists of two parts, placed one behind the other like two lenses, both having a very different structure and disposition to what occurs in the vertebrata. The retina is wholly different, with an actual inversion of the elemental parts, and with a large nervous ganglion included within the membranes of the eye. The relations of the muscles are as different as it is possible to conceive, and so in other points. Hence it is not a little difficult to decide how far even the same terms ought to be employed in describing the eyes of the cephalopoda and vertebrata. It is, of course, open to any one to deny that the eye in either case could have been developed through the Natural Selection of successive slight variations; but if this be admitted in the one case, it is clearly possible in the other; and fundamental differences of structure in the visual organs of two groups might have been anticipated, in accordance with this view of their manner of formation. As two men have sometimes independently hit on the same invention, so in the several foregoing cases it appears that Natural Selection, working for the good of each being and taking advantage of all favourable variations, has produced similar organs, as far as function is concerned, in distinct organic beings, which owe none of their structure in common to inheritance from a common progenitor" (pp. 151 and 152).

As a fine illustration of the way in which one organ may be formed by modification from another, I quote:—

"Again, two distinct organs, or the same organ under two very different forms, may simultaneously perform in the same individual the same function, and this is an extremely important means of transition: to give one instance—there are fish with gills or branchiæ that breathe the air dissolved in the water, at the same time that they breathe free air in their swimbladders, this latter organ being divided by highly vascular partitions, and having a ductus pneumaticus for the supply of air. To give another instance from the vegetable kingdom: plants climb by three distinct means, by spirally twining, by clasping a support with their sensitive tendrils, and by the emission of ærial rootlets; these three means are usually found in distinct groups, but some few species exhibit two of the means, or even all three, combined in the same individual. In all such cases one of the two organs might readily be modified and perfected so as to perform all the work, being aided during the progress of modification by the other organ; and then this other organ might be modified for some other and quite distinct purpose, or be wholly obliterated.

"The illustration of the swimbladder in fishes is a good one, because it shows us clearly the highly important fact that an organ originally constructed for one purpose—namely, flotation—may be converted into one for a widely different purpose—namely, respiration. The swimbladder has also been worked in as an accessory to the auditory organs of certain fishes. All physiologists admit that the swimbladder is homologous, or 'ideally similar' in position and structure with the lungs of the higher vertebrate animals; hence there is no reason to doubt that the swimbladder has actually been converted into lungs, or an organ used exclusively for respiration.

"According to this view, it may be inferred that all vertebrate animals with true lungs are descended by ordinary generation from an ancient and unknown prototype, which was furnished with a floating apparatus or swimbladder. We can thus, as I infer from Owen's interesting description of these parts, understand the strange fact that every particle of food and drink which we swallow has to pass over the orifice of the trachea, with some risk of falling into the lungs, notwithstanding the beautiful contrivance by which the glottis is closed. In the higher vertebrata the branchiæ have wholly disappeared; but in the embryo the slits on the sides of the neck and the loop-like course of the arteries still mark their former position. But it is conceivable that the now utterly lost branchiæ might have been gradually worked in by Natural Selection for some distinct purpose; for instance, Landois has shown that the wings of insects are developed from the tracheæ; it is therefore highly probable that in this great class organs which once served for respiration have been actually converted into organs for flight" (pp. 147 and 148).

We next consider Darwin's third difficulty.

III. Instinct.

Nothing could show more clearly Darwin's power of self-criticism, and of fairly judging difficulties against his own theory, than the amount of pains he has taken in dealing with instinct. He introduces *Origin of Species*, chapter viii., thus:—

"Many instincts are so wonderful that their development will probably appear to the reader a difficulty sufficient to overthrow my whole theory. I may here premise that I have nothing to do with the origin of the mental powers, any more than I have with that of life itself. We are concerned only with the diversities of instinct and of the other mental faculties in animals of the same class.

"I will not attempt any definition of instinct. It would be easy to show that several distinct mental actions are commonly embraced by this term; but everyone understands what is meant when it is said that instinct impels the cuckoo to migrate and to lay her eggs in other birds' nests. An action which we ourselves require experience to enable us to perform, when performed by an animal, more especially by a young one, without experience, and when performed by many individuals in the same way, without their knowing for what purpose it is performed, is usually said to be instinctive. But I could show that none of these characters are universal. A little dose of judgment or reason, as Pierre Huber expresses it, often comes into play, even with animals low in the scale of nature.

"Frederick Cuvier and several of the older metaphysicians have compared instinct with habit. This comparison gives, I think, an accurate notion of the frame of mind under which an instinctive action is performed, but not necessarily of its origin. How unconsciously many habitual actions are performed, indeed not rarely in direct opposition to our conscious will! Yet they may be modified by the will or reason. Habits easily become associated with other habits, with certain periods of time, and states of the body. When once acquired, they often remain constant through life" (p. 205).

"If we suppose any habitual action to become inherited—and it can be shown that this does sometimes happen—then the resemblance between what originally was a habit and an instinct becomes so close as not to be distinguished. If Mozart, instead of playing the pianoforte at three years old with wonderfully little practice, had played a tune with no practice at all, he might truly be said to have done so instinctively. But it would be a serious error to suppose that the greater number of instincts have been acquired by habit in one generation, and then transmitted by inheritance to succeeding generations. It can be clearly shown that the most wonderful instincts with which we are acquainted—namely, those of the hive-bee and of many ants—could not possibly have been acquired by habit" (p. 206).

These passages have a great historical interest quite apart from the doctrine of Evolution. They show the cloudy metaphysics which then hung around the whole question of instinct. In consequence of this metaphysical puzzle, Darwin's task of dealing with instinct was rendered vastly harder than it really is.

He has, however, given many wonderful instances of the instincts of bees and ants, and concluded that they do not present any difficulty fatal to the theory of Natural Selection.

We need not now follow all these details, as much light has been thrown on the whole question by investigation since, and notably by Professor Loeb. This eminent discoverer in other realms of biology has simplified the whole question of instinct to a remarkable degree. He has shown that many instincts are no longer to be classified with "mental powers," and that their origin is in no way connected with habit.

He has established the fact that many instincts are merely cases of simple reflex action, and are to be explained by chemistry and physics.

The Professor shall explain himself (I quote from his book, *Physiology of the Brain*) :—

"The discrimination between reflex action and instinctive action is chiefly conventional. In both cases we have to deal with reactions to external stimuli or conditions. But while we speak of reflex actions when only a single organ or a group of organs react to an external stimulus, we generally speak of instincts when the animal as a whole reacts. In such cases the reactions of the animal, although unconscious, seem often to be directed towards a certain end" (p. 177).

"The reader knows that certain plants, when exposed to the light on one side—for instance, when cultivated at a window—

bend their tip towards the window until the tip of the stem is in the direction of the rays of light. The tip then continues to grow in the direction of the rays. We call this dependence of orientation on light, heliotropism. We speak of positive heliotropism when the organ bends towards the source of light, of negative heliotropism when the organ bends away from it. It is generally assumed that the light has a chemical effect in these cases."

"It has been known for a long time that many animals are attracted by the light and fly into the flame. This was considered a special instinct. It was said that these animals loved the light, that curiosity drove them into it. I have shown in a series of articles, the first of which appeared in January, 1888, that all these actions are only instances of those phenomena which were known in plants as heliotropism. It was possible to show that the heliotropism of animals agreed in every point with that of plants. If a moth be struck by the light on one side, those muscles which turn the head toward the light become more active than those of the opposite side, and correspondingly the head of the animal is turned toward the source of light. As soon as the head of the animal has this orientation and the median-plane (or plane of symmetry) comes into the direction of the rays of light, the symmetrical points of the surface of the body are struck by the rays of light at the same angle. The intensity of light is the same on both sides, and there is no more reason why the animal should turn to the right or left, away from the direction of the rays of light. Thus it is led to the source of the light. Animals that move rapidly (like the moth) get into the flame before the heat of the flame has time to check them in their flight. Animals that move slowly are affected by the increasing heat as they approach the flame; the high temperature checks their progressive movement, and they walk or fly slowly about the flame. The more refractive rays are the most effective in animals just as in plants."

Hence the "instinct" that drives animals into the light is nothing more than the chemical—and, indirectly, the mechanical—effect of light, an effect similar to that which forces the stem of the plant at the window to bend toward the source of light. The moth does not fly into the flame out of "curiosity," neither is it "attracted" by the light; it is only oriented by it, and in such a manner that its median-plane is brought into the direction of the rays, and its head directed toward the source of light. In consequence of this orientation, its progressive movements must lead it to the source of light.

"We now come to the most important question in this chapter—namely, the relation of the central nervous system to the instincts. As long as such apparently complex things as the instincts are not analysed, but treated as entities, it is easy to believe that they are based upon very mysterious nervous structures. It would harmonise with the centre theory to assume for the moth a 'flying-into-the-flame centre,' and to seek for its localisation in the central nervous system. The fact that the flying of the moth into the flame is nothing but positive heliotropism, and the fact that the positive heliotropism of animals is identical with the positive heliotropism of plants, proves that this reaction must depend upon conditions which are *common to animals and plants.* Plants, however, possess no central nervous system, therefore I believe that it is impossible for the heliotropic reactions of animals to depend upon specific structures of the central nervous system. It is much more probable that they are determined by properties which are common to animals and plants" (pp. 179–183).

These cases are only samples of Professor Loeb's method, and hardly do him justice; but if these explanations prove to be final, and if they can be extended to all animal instincts (as seems likely), then the whole question of instinct, in its relation to Natural Selection, will require examination, and we can only hope that Professor Loeb will undertake this. In any case, it is clear that some of the greatest difficulties with which Darwin dealt have been explained now in such a way that they can call for no explanation with regard to Natural Selection.

And it is not impossible that even Darwin's greatest difficulty of "neuters or sterile females in insect communities" may receive a much simpler explanation than the one he has given.

In fact, much has already been done in this direction. It has been shown in the case of bees that the differences between queens, workers, and drones are largely, if not altogether, due to differences in food. This is only another way of saying it is a chemical difference.

Geddes and Thompson, in their remarkable book on *The Evolution of Sex*, p. 43, say :—

"Nor are there many facts more significant than this simple and well-known one, that within the first eight days of larval life the addition of a little food will determine the striking structural and functional differences between worker and queen.

"Eimer has drawn attention to the interesting correlation exhibited in the fact that a larva destined to become a worker, but converted into a queen, attains, with the increased sexuality, all the little structural and psychological differences which otherwise distinguish a queen. Regarding fertilisation as a sort of nutrition, he considers drones, workers, and queens as three terms of a series; and the same view is suggested by Rolph. Eimer recalls some interesting corroborations from humble-bees. There the queen-mother, awakened from her winter sleep by the spring sun, makes a nest, collects food, and lays her first brood. These are not too abundantly supplied with nourishment, the queen having much upon her shoulders; they develop into small females, workers in a sense, but yet fertile, though only to the extent of producing drones. By-and-by a second brood of workers is born. These have the advantage of elder sisters, and are more abundantly nourished and develop into large females. Still, like the first brood, they produce drones, though occasionally females. Finally, with the advantage of two previous broods of small and large females, the future queens are born. The above facts not only afford an interesting corroboration of the influence of nutrition upon sexuality, but are of importance as suggesting the origin of the more highly-specialised society of the hive-bee."

IV. Darwin's fourth great difficulty was hybridism.

This difficulty has acquired all the more importance because of Professor Huxley's extreme caution on the matter. He was justly afraid of over-stating the case, and he may have erred on the other side.

In *Man's Place in Nature* he says:—

"In addition to these structural distinctions, the species of animals and plants, or at least a great number of them, exhibit physiological characters—what are known as distinct species, structurally, being for the most part either altogether incompetent to breed one with another; or, if they breed, the resulting mule, or hybrid, is unable to perpetuate its race with another hybrid of the same kind.

"A true physical cause is, however, admitted to be such only on one condition, that it shall account for all the phenomena which come within the range of its operation. If it is inconsistent with any one phenomenon, it must be rejected; if it fails to explain any one phenomenon, it is so far weak, so far to be suspected, though it may have a perfect right to claim provisional acceptance......

"Our acceptance of the Darwinian hypothesis must be provisional, so long as one link in the chain of evidence is wanting; and so long as all the animals and plants, certainly produced by selective breeding from a common stock, are fertile, and their progeny are fertile with one another, that link will be wanting. For, so long, selective breeding will not be proved to be competent to do all that is required of it to produce natural species" (pp. 148 and 149).

"In justice to Mr. Darwin, however, it must be admitted that the conditions of fertility and sterility are very ill understood, and that every day's advance in knowledge leads us to regard the hiatus in his evidence as of less and less importance when set against the multitude of facts which harmonise with, or receive an explanation from, his doctrines" (p. 150).

But, lest this caution of Huxley's should be quoted unfairly against him, I add that he was one of the most thorough-going Evolutionists England has had, as this passage, in the book quoted, clearly shows:—

"But even leaving Mr. Darwin's views aside, the whole analogy of natural operations furnishes so complete and crushing an argument against the intervention of any but what are termed secondary causes in the production of all the phenomena of the universe that, in view of the intimate relations between man and the rest of the living world, and between the forces exerted by the latter and all other forces, I can see no excuse for doubting that all are co-ordinated terms of nature's great progression from the formless to the formed—from the inorganic to the organic—from blind force to conscious intellect and will" (p. 151).

Now let us squarely face this difficulty.

Huxley himself has answered one half of it in the above quotations: "The conditions of fertility and sterility are very ill understood, and every day's advance in knowledge leads us to regard the hiatus in Darwin's evidence as of less and less importance."

Now, if the cause of sterility in hybrids is the result of *merely crossing* two different species, then in every case where two distinct species are crossed there should either be no offspring or these offspring should be sterile.

But such is not the case.

I find, on inquiry of one of the greatest authorities, "there are plenty of species that will cross, but, as you say, the offspring is often unfertile."

This clearly shows that crossing of species is not always impossible, and that their offspring are not always sterile.

So we must look for some other cause of sterile offspring besides the mere fact of crossing species, as this does not always produce that result.

Truly the hiatus in "Darwin's evidence is of less and less importance."

The second half of the difficulty emphasised by Huxley is that "animals and plants certainly produced by selective breeding, from a common stock, are fertile, and their progeny are fertile, with one another."

In considering this point, there is one element alone which may go far to explain it; that is, the enormous time which it has taken to produce our old, clearly-marked species. Compared with this, the selective power of man during a few generations is but an act of yesterday.

Before we can determine whether the selective power of man is able to produce varieties which shall become distinct species in the sense now under consideration, it would be necessary for the selection to be in operation, probably for some thousands of years. So we can only say that no opportunity has yet been given for man's selective power to be tried by this test.

Even under these few general considerations the difficulty does not seem serious, and those who wish to pursue the subject further can find much information in *The Origin of Species*, and in a memoir in the *Entomologist*, 1900–1901, entitled "Synopsis of Experiments on Hybridisation," etc., by Dr. Standfuss.

CHAPTER X.

FACTS WHICH ONLY EVOLUTION CAN EXPLAIN

IN this chapter I must depart from a strictly scientific examination, and state the case from a more aggressive point of view. As I have considered some of the chief difficulties in the way of accepting the doctrine of Evolution and of Natural Selection, it is only right to point out the difficulties by which we are met if we do not accept this doctrine. To do so it will be necessary to cover again some of the ground over which we have already travelled. But if this method brings out more clearly the evidence in favour of Evolution, it will not be time lost.

According to the great doctrine that all existing forms of life have come, by slow and gradual changes, from simpler forms, we should expect the present forms to yield unmistakeable evidence of their kinship with older and simpler forms—those still existing and those which are extinct.

If, on the other hand, species were separately created, there appears to be no necessary reason why they should have been connected in structure.

Nay, more, it would then be impossible to imagine why the higher and the more perfect forms of life should have so many points in common with the lower living things.

It is well known that all living things, both vegetable and animal, fall into groups. Now, if these groups or species were entirely severed from each other, then we might suppose that they originated separately. Or, if any one group of creatures suddenly showed an absolutely new plan of arrangement in form, or mode of life, or method of reproduction, this group would present a difficulty fatal to the doctrine of Evolution.

Again, if species were separately created, there must have been many manifestations of this creative energy, for many species have become extinct and new species have taken their places. But here we find another marvel, for the new species show a striking likeness to the extinct species. Are we to suppose that the power to create requires practice in order to produce superior species, and that the earliest species were failures, and therefore destroyed, when there had been discovered a method of making new and better ones?

I doubt if anyone could imagine a disjointed world—a world the inhabitants of which would not fall into groups. It would be a state of confusion worse than the nightmare of a savage. We are so familiar with the different groups of plants and animals that we forget the great lesson which they teach, for from them we get the first indication that the families of the earth have a common parentage.

As Darwin observes (*Origin of Species*, p. 305): "On the theory of descent with modification, the main facts with respect to themutual affinities of the extinct forms of life to each other and to living forms are explained in a satisfactory manner. And they are wholly inexplicable on any other view."

If we think of it, it surely is a great marvel that all living things, plants and animals, are chiefly made up of small cells of the same substance—protoplasm. They all fall into two large groups, for they consist either of a single cell or of many cells. Those low forms of a single cell are called unicellular; those forms of more than one cell are called multicellular. Now, if there is no connection between all these groups, why should they all be built up of the same substance, protoplasm, and why should they all be formed of small cells of protoplasm?

Still greater is the difficulty presented by the fact that in their simplest forms it is sometimes impossible to tell whether these single cells are vegetable or animal. Had there been a design in nature to prevent proud Ignorance from wrapping itself in a cloak of self-conceit, I can imagine no surer way of doing this than that all life should so blend into one that it is impossible sometimes to tell a plant from an animal.

These connections cry aloud for an answer to the man who denies that Evolution is the explanation of life as we see it.

The same thing is manifest when we look at those animals which belong to two different groups, either at one and the same time or at different periods of their existence.

Why should there be double-breathing fishes (the dipnoi), animals with gills to breathe the air in the water, and also with lungs to breathe "our common air"? Why should the frog, a land animal, begin life in the water as a fish? Why should the lancelet, the acorn-worm, and the ascidian seem, to the untrained observer, like invertebrates and yet possess a structure (the notochord) which is only found in the vertebrates?

And why should these three groups of animals possess *not* a fully-developed notochord, but only a beginning of one, if it does not clearly show that the notochord slowly developed, as the Evolutionist would expect of this or any other organ?

If the vertebrates were separately created, why do these three lowest forms of this family possess every invertebrate character but one? Why should the world have been full of creeping things, without a backbone, for millions of years, before a vertebrate appeared, unless it be a fact that slowly and gradually the invertebrates developed into the higher order of vertebrates?

To the man who believes in a special creation of each group of animals perhaps a still greater difficulty is presented by those parts, found in most animals, which are called rudiments. By rudiments we mean parts which, though they resemble well-known parts of other animals, yet never become developed so as to be of any use to the animals in which they are found. The man who holds that all the wonderful forms were specially created must surely believe in the wisdom of the creator; but what wisdom can there be in giving an animal some organ which always remains imperfect, and which is of no use to the animal?

For instance, certain snakes have hind legs *under* their skins, so that they can never be well grown or used.

Smooth-skinned amphibians have scales *buried* in their skin.

The seal, which is a mammal considerably modified to suit its life in the water, and which uses its feet mainly as paddles, has toes that still bear nails; but the manatee, which is a much more changed mammal, has nailless paddles, which, when the skin is removed, are said by Humboldt to display rudimentary nails at the ends of the imbedded digits.

Nearly all birds are covered with developed feathers, severally composed of shaft-bearing fibres, each of which again bears a fringe of down. But in some birds, as in the ostrich, various stages may be traced which show that the growth of the feathers has been stopped, beginning with feathers usually elaborate at the tail, and ending with those about the beak, which are reduced to single hairs. In the Apteryx we see the whole of the feathers reduced to a hair-like form.

This list might be greatly enlarged, for, as Darwin says, "We have plenty of cases of rudimentary organs in our domestic productions, as the stump of a tail in tailless breeds, the vestige of an ear in earless breeds, the reappearance of minute dangling horns in hornless breeds of cattle."

These and many such rudiments remain an unanswerable difficulty to any man who maintains that species were separately created, and that they are unalterably fixed.

The Evolutionist can not only easily explain them, but they are exactly what he would expect. If different species have their origin in one and the same family group, he would expect that thousands of years after they had separated species widely differing from each other in their main characters would yet retain some marks of the old family from which they had sprung. Now, will any person who denies the truth of Evolution give us a clear explanation of the presence of these useless rudiments?

But the Evolutionist has, if possible, a still stronger witness to call—nay, rather a "cloud of witnesses," for their number is vast.

We have striking evidence, if we consider the likeness between the different organs of the same animal, as well as between the same organ in different animals.

One of the most instructive instances is furnished by the back-bone (the vertebral column). Snakes, which move in a winding fashion through and over plants and stones, clearly need the back-bone to be jointed from end to end, and, as the same kind of movement is required throughout the whole length of the body, there is an advantage in all the joints being fairly alike; the creature's movements would be hindered if, instead of a chain of bones varying but little in their lengths, there existed in the middle of the series some long bony mass that would not bend.

But in most of the higher vertebrates the mechanical actions and reactions demand that, while some parts of the back-bone shall easily bend, other parts shall not. At the lower part of this back-bone is a portion called the sacrum, to which the hind limbs are joined, and it is necessary that this part shall not yield, in mammals and birds, because it is the fulcrum which bears the greatest strain to which the skeleton is exposed.

Now, in both mammals and birds this rigid part of the back-bone is *not* made of one long segment or vertebra, but of several segments fused together; and in the ostrich tribe they number from seventeen to twenty. Why is this? Why, if the skeleton of each species was separately contrived, was this bony mass made by fusing together a number of joints like those forming the rest of the back-bone, instead of being made out of one single piece? "Oh," says one, "it was to preserve the same type or plan in all skeletons."

Then why does the number of these joints which are fused together *vary* within the same order of birds? Why, too, should the development of the sacrum take place by this roundabout process, first making the joints separate and then destroying the separateness?

In the development of a bird or mammal, along the line of the back there is, at the outset, a kind of soft, continuous rod (the notochord). The segments which are to become vertebræ arise gradually around this rod, at first joined on each side; they afterwards become separate pieces of bone forming the jointed back-bone, and that part of the spine which is to form the sacrum, having passed out of a state of unity into one of disunity by separating itself into segments, passes again into unity by joining these segments together. Why this process of doing and undoing and doing again?

If, originally, the spine in vertebrate animals consisted from head to tail of separate moveable segments, as it does still in fishes and some reptiles—if, in the evolution of the higher vertebrates, certain of these moveable segments were rendered less moveable with respect to each other by the mechanical conditions to which they are exposed, and at length became relatively immoveable—one can understand why the sacrum, formed out of them, should continue ever after to show more or less clearly its originally-segmented structure. But, on any other theory, this structure cannot be explained.

"We see the same law in comparing the wonderfully complex jaws and legs in crustaceans," says Darwin, referring to the well-known fact that the many appendages on the sides, which in lower crustaceans usually serve as legs and have like shapes, are, in the higher crustaceans, some of them represented by enormously developed claws, and others by variously modified foot-jaws. (Crustaceans are a division of anthropoda with jointed legs, as crabs, lobsters, shrimps, wood lice, etc.)

Why should one crustacean, which has an extremely complex mouth formed of many parts, consequently always have fewer legs; or, conversely, those with many legs have simpler mouths?

To these and countless similar questions the theory of Evolution furnishes the only rational answer.

We will take other facts which admit of no dispute, for they are independent of all opinion and all prejudice. I refer to the facts furnished by the growth of every animal before birth. The branch of science dealing with these facts is known as embryology. Eminent men of science in every civilised country have made careful inquiries on this subject. Every sort of animal, in all stages of its growth, has been examined, and an army of observers has given us the life-history of all the stages through which an average mammal passes in its gradual growth from a single cell of $\frac{1}{120}$ of an inch in diameter.

We know the two great laws which govern the growth of all animals. They are called the law of heredity and the law of variation. By heredity there is a tendency for any peculiarity of either parent to be reproduced in the offspring, and this peculiarity may be so fixed by ages of repetition that, in spite of hundreds of other changes, it will remain for thousands of generations, and show a man that he is descended from some ancestor which has been buried in the rocks millions of years.

Just as the size, the form, the deeds of a young child tell the parent what he himself was once, so the forms of structure, the arrangements of parts, the stages of growth through which we all passed before birth, reveal what our parents were in the childhood of the world.

So, in tracing the history of any animal from its beginning as a single cell, we see in the changes of that cell the various forms which our early ancestors had as they struggled up to a more perfect organism.

Every vertebrate animal begins in the same way, as a single cell which divides into two, four, eight, sixteen, thirty-two, etc., as the first stages of its growth. Now, we have evidence that the simplest forms of animal life begin as a single cell and divide into two. These two become two separate living creatures. And this process of the growth of vertebrate animals takes us back to a time which may be counted by millions of years. The imagination of man fails to grasp it. Few can even dimly realise that distant dawn of life when a speck of jelly, which no eye saw or could have seen, lay floating on the water of some warm sea. This cell rocked on the waves till it divided to form two lives. Such was the beginning. Such *is the beginning now* of the animals we see around us. Here is a life-history running through past ages of the earth, and binding into one all the forms of beauty and power which fill the world with the pride of life. I consider this a fact of such immense grandeur that I know of no other which can rival it as a revelation of time and of the unity of life.

In the growth of an ordinary mammal we have seen that the cell divides into two, four, eight, sixteen, thirty-two, and so on, till there is a mass of cells forming a small solid body, like a mulberry, called at this stage the *morula*. This *morula* stage, found in the sponge and all animals above it in rank, is very like a pandorina (*see* Fig. 8) which is found in pond water. Next, this *morula* passes into a hollow sphere, surrounded by a single layer of cells, which afterwards becomes double.

But soon we come upon unmistakeable traces of a more definite early history of man's ancestors. In the growth of every mammal, as of every human being, there appear five marks on each side of the neck. These are the same as in a fish, and are called gill-slits, or, better, gill-clefts. They soon disappear, and no trace of them is left even in a new-born babe. Connected with them are five pairs of arches, called the aortic arches. In the fish these small blood vessels carry the blood to the gills in order to receive the oxygen which the fish breathes in the water through its gills. Now, if man does not come from an ancestor which was once a fish, or which passed through the fish stage, how can we account for these aortic arches and these traces of gill-clefts appearing in every man as well as in every mammal? The arches disappear, the gill-clefts disappear. If each species of mammal and the human race was created separately, why do they all pass through this stage? It is perfectly simple to understand it on the theory of Evolution, and we boldly challenge the world for any other sane explanation.

In the lancelet, the small animal at the bottom of the vertebrate series, the eye consists of a little sack of transparent skin, furnished with a nerve and lined with pigment, but destitute of any other apparatus. Now, it is a wonderfully significant fact that, on the high authority of Virchow, the beautiful crystalline lens of man is formed in the embryo by an accumulation of epidermic cells, lying in a sack-like fold of the skin. Those who think there is any difficulty in the evolution of the eye should ponder this fact, and explain these few cells in a sack by some other means than evolution.

There is also another remarkable fact about the eye which they might explain at the same time. It is well known that we all see objects wrong side up, or, in more correct words, an inverted image of every object is thrown on the retina, owing to the refraction of the light caused by its passing through the lens of the eye. We do not notice that the image is wrong side up, because the brain corrects this automatically.

Now, if the eye was specially made for man to see the beauties of this wonderful world, how is it that it is so constructed as to see them all wrong side up?

Many other facts in the life before birth are equally important—for instance, that the tail is longer than the legs at one time; that there is a period when the young human being is covered with hair; that the heart is at first only a small simple tube; that the great toe projects at an angle from the side of the foot; that it is impossible to tell, for a long time, which sex the child is; that the excreta are voided through a cloacal passage with only one vent, as in birds and reptiles. In all these and other points, why is man first made in the image of whole families of the lower animals if his ancestor did not share in the parentage of these lower animals?

We next turn to that wonderful law of periods. Some diseases of man, the time required to hatch eggs or develop the young of mammals ready for birth, and other functions, obey a strange law of time which is somehow connected with periods of the moon.

The eggs of a pigeon are hatched in two weeks, those of a fowl in three, of a duck in four, of a goose in five, of an ostrich in seven. And mammals obey the same law.

Now, the size of the egg may have something to do with the length of time required; but this does not affect our point, and cannot apply to mammals.

We wish to discover why these periods were fixed at all, and why they should obey the same law of seven days or some multiple of seven. We know that nothing more completely corresponds to periods of the moon than the tides, and if for tens of thousands of years man's ancestors lived in tidal waters, this would account for the fact that the law is still in force. And as Darwin points out: "If the function changes, the period would have to change almost abruptly by a whole week" (*Origin of Species*, p. 165). Again the Evolutionist can offer an explanation of the difficulty; but what other explanation is there?

Perhaps, on the whole, man boasts more broadly of his intelligence than of aught else; though, as a rule, he has the most vague and misty notions of what it is which makes him intelligent. Now, throughout living forms it is the outer layer of cells, or the skin, which forms the nervous system, including the brain. Quite early in the life of the unborn animal a fold of the outer layer is enveloped by the other cells, and this becomes the spinal cord and the brain. Of this there is not a shadow of a doubt. There is also no doubt that intelligence varies with the development of the nervous system. Even those who talk vaguely of a something which they call "mind" must admit the close relationship between intelligence and brain development.

Now, if intelligence depends upon some special endowment of man, such as mind, or soul, or spirit, there is no explanation of this connection between intelligence and the nervous system; still less can it be explained why an outer portion of the body should be taken to form the delicate structure of the brain.

But the Evolutionist can give a fair explanation. The outer layer was that portion of the small animals which came into contact with the outside world. It was, in fact, the only means of communication between the animal and its environment. For these early animals had no ears, no eyes, no hands, no nerves. They had to feel by means of the whole outer layer. Again, we must remember that this state of things may have lasted for countless centuries. So that when, by the principle of division of labour, organs were slowly developed, the chief organ of intelligence began to arise by the enfolding of the outer part, which so long had served for all our organs of intelligence. During those long centuries the outer layer had become sensitive to outward impressions. It had acquired the power of responding to those outside forces which are named stimuli. How many ages were given to develop this marvellous power we cannot even imagine. But, after its long schooltime, the outer part had powers in which the inner portion had no share. It had developed that most marvellous property called irritability, upon which all intelligence and all possibility of education depend.

So that once more to the Evolutionist there is no dark mystery either in the power of intelligence or in the origin of that power. But without Evolution it is a miracle of mystery.

Will the man who denies Evolution tell us why intelligence should depend, at least for its *manifestation*, upon the enfolding of a bit of skin?

There are many points of interest in the development of the brain which offer unanswerable difficulties to the rejector of Evolution. To take two at random: Professor Wiedersheim, in his great book, *The Comparative Anatomy of Vertebrates*, points out that the corpus callosum, one of the most important structures of the brain, is very small in those mammals which are the lowest of that class—viz., the duckmole (monotremes) and the kangaroo (marsupials). In fact, this great organ, which joins the two halves of the brain (the cerebral hemispheres), is only just beginning to form in these two groups of animals, and it cannot be called a corpus callosum proper, for it has not the full development or the function of a true corpus callosum. In these lower mammals only the part corresponding to the anterior portion of a full corpus callosum is present. But note the important and interesting light which this throws on the acquirement of this great organ. When we come to study the growth and development of the corpus callosum in man and the higher mammals generally, we find that the part which appears first is just this portion which the duckmole and kangaroo have. Now, if the ancestor of man has not come through the monotremes and marsupials, why does this part of the brain develop in the same way as among them, and why should this part develop sooner than the rest?

Again, the brain of an unborn child closely resembles that of a grown-up gorilla. Why should this be, unless it is true that man's ancestor and the gorilla's ancestor were at some remote period the same? Closely akin to this last point is the fact that extinct and ancient animals resemble the embryos of the more perfect living animals. What earthly reason can be given for this, unless the living species are changed and improved forms of those ancient and extinct species of millions of years ago?

CHAPTER XI.

THE EVOLUTION OF THE WORLD

MR. HERBERT SPENCER, in *First Principles*, p. 30, says: "Respecting the origin of the universe three verbally intelligible suppositions may be made. We may assert that it is self-existent; or that it is self-created; or that it is created by an external agency."

By the aid of Dean Mansel, he proves that each of these suppositions is inconceivable.

The Very Reverend Dean says: "The conception of the Absolute and the Infinite, from whatever side we view it, appears encompassed with *contradiction*," among other reasons because we can do nothing "towards explaining how the absolute can give rise to the relative, the infinite to the finite."

Those who wish to see all this worked out with much subtlety must go to *First Principles*. We only refer to it here to show that none of the three suppositions named above stand in the way of scientific inquiry or help us in this inquiry. If they are all alike unthinkable, then they are of equal value or no value in helping us to a knowledge of causation.

For clearly science can only deal with what can be known.

To say "that the power which the universe manifests to us is utterly inscrutable" might be a fitting burial service for much metaphysical dust, and, in addition to this, it opens a free highway to the searcher after truth.

But we do not proceed far on this path of inquiry before we meet two monsters which, in more senses than one, have devoured the sons of men—I mean, Space and Time.

Mr. Spencer asks: "What are space and time? Two hypotheses are current respecting them: the one that they are objective, and the other that they are subjective—the one that they are external to, and independent of, ourselves; the other that they are internal and appertain to our own consciousness."

He examines the statement that space and time are entities, and the contention that they are forms of thought, and arrives at the conclusion "that space and time are wholly incomprehensible."

He next examines matter, and says: "In its ultimate nature it is as absolutely incomprehensible as space and time."

Motion and force he finds equally incomprehensible in their ultimate natures.

The position of the man of science is thus summed up:—

"Supposing him, in every case, able to resolve the appearances, properties, and movements of things into manifestations of force in space and time, he still finds that force, space, and time pass all understanding. Similarly, though the analysis of mental actions may finally bring him down to sensations, as the original materials out of which all thought is woven, yet he is little forwarder; for he can give no account either of sensations themselves or of that something which is conscious of sensations. Objective and subjective things he thus ascertains to be alike inscrutable in their substance and genesis. In all directions his investigations eventually bring him face to face with an insoluble enigma; he learns at once the greatness and the littleness of the human intellect; its power in dealing with all that comes within the range of experience; its impotence in dealing with all that transcends experience. He realises with a special vividness the utter incomprehensibleness of the simplest fact considered in itself. He, more than any other, truly knows that *in its ultimate essence nothing can be known*" (pp. 66 and 67).

Of course, some readers will note that this last sentence begs the whole question as to whether there is such a thing as ultimate essence or not, just as the former conclusion begged the question as to whether the universe manifests one Power which is inscrutable.

Mr. Spencer next deals with the relativity of all knowledge, and thinks he proves that the relative and the absolute stand or fall together. But many hold that in this he fails, for one may be real and the other may not.

Now, all notions which deal with suppositions outside human experience are properly called transcendental. The transcendental is of no value to science, for it does not admit of being known or verified.

Returning, then, to things which we experience, Mr. Spencer points out that "relations are of two orders: relations of sequence and relations of co-existence, of which the one is original and the other derivative." "The abstract of all sequences is time; the abstract of all co-existences is space."

"Space and time, therefore, are relative realities."

"Our conception of matter, reduced to its simplest shape, is that of co-existent positions that offer resistance." "Hence the necessity we are under of representing to ourselves the ultimate elements of matter as being at once extended and resistant." Our experience of force is that out of which the idea of matter is built.

Matter is another relative reality.

"Our conception of motion as presented or represented in the developed consciousness involves the conceptions of space, of time, and of matter. A something that moves; a series of positions occupied in succession; and a group of co-existent positions united in thought with the successive ones—these are the constituents of the idea."

"Motion, as we know it, is thus traceable, in common with the other ultimate scientific ideas, *to experiences of force.*"

"We come down, then, finally to force as the ultimate of ultimates." Space, time, matter, motion, as we know them, are all either built up of, or abstracted from, experiences of force.

These scrappy quotations from *First Principles* are not given as representing Mr. Spencer's argument, but merely to clear the way for our inquiry into the Evolution of the World.

Perhaps it would be of help to some readers to refer to Professor Karl Pearson's newer setting of this doctrine.

Many great minds have pondered over this question in different generations. Descartes said: "Give me extension and motion, and I will construct the world."

Mr. Pearson says: "'Give me motion and space capable of changing its shape, and I will explain the universe to you, is far more rational than Kant's 'Give me matter, and I will create the world,' for matter being granted not much universe is left to be explained."

Again: "Force is not, then, a *real cause* of change in motion. It is merely a description of change in motion. But force, being the how of a motion, may naturally suggest that matter is that which moves."

"The sensible existence of matter is entirely dependent on the existence of motion—that is, change of position and change of shape."

"If we bring any two bodies together, we notice that they change each other's motions. Everything in the universe is changing the motion of every other thing."

"Science has reduced the universe, not to those unintelligible concepts, matter and force, but to the very intelligible concept, MOTION. All that we know of mass is its measurement in motion" (lecture on "Matter and Soul," 1886).

Extension and motion may be the necessary properties of matter. At least, we know that where there is motion there is matter. And, whether we use the terms

"Matter and Force" or "Matter and Motion," we recognise the accepted conclusions of science that both are indestructible. This greatest of discoveries teaches us that neither can be destroyed, so that it is almost certain as they can have no end that they had no beginning.

Add to this that heat, light, colour, magnetism, and electricity are all of them only modes of motion, and then we shall be prepared to admit that the same force may show itself in different forms at different times. This is called the transformation and equivalence of forces. That is, just as the same particles of matter may at one time form parts of a rose and at another time parts of a mushroom, so the same force may at one time strike a church as lightning, and at another time may be the mother-love which rocks the cradle.

This will not be deemed fanciful by the reader who masters the following: "The transformations of electricity into other modes of force are still more clearly demonstrable. Produced by the motion of heterogeneous bodies in contact, electricity generates magnetism in a bar of soft iron; and now the rotation of a permanent magnet generates currents of electricity. Here we have a battery in which, from the play of chemical affinities, an electric current results; and there, in the adjacent cell, we have an electric current effecting chemical decomposition. In the conducting wire we witness the transformation of electricity into heat; while in electric sparks and in the voltaic arc we see light produced. Atomic arrangement, too, is changed by electricity: as instance the transfer of matter from pole to pole of a battery; the fractures caused by the disruptive discharge; the formation of crystals under the influence of electric currents. And whether, conversely, electricity be or be not directly generated by re-arrangement of the atoms of matter, it is at any rate indirectly so generated through the intermediation of magnetism.

"How from magnetism the other physical forces result must be next briefly noted—briefly, because in each successive case the illustrations become in great part the obverse forms of those before given. That magnetism produces motion is the ordinary evidence we have of its existence. In the magneto-electric machine we see a rotating magnet evolving electricity. And the electricity so evolved may immediately after exhibit itself as heat, light, or chemical affinity. Faraday's discovery of the effect of magnetism on polarised light, as well as the discovery that change of magnetic state is accompanied by heat, point to further like connections. Lastly, various experiments show that the magnetisation of a body alters its internal structure; and that, conversely, the alteration of its internal structure, as by mechanical strain, alters its magnetic condition.

"Improbable as it seemed, it is now proved that from light also may proceed the like variety of agencies. The solar rays change the atomic arrangements of particular crystals. Certain mixed gases, which do not otherwise combine, combine in the sunshine. In some compounds light produces decomposition. Since the inquiries of photographers have drawn attention to the subject, it has been shown that 'a vast number of substances, both elementary and compound, are notably affected by this agent, even those apparently the most unalterable in character, such as metals.' And when a daguerreotype plate is connected with a proper apparatus, 'we get chemical action on the plate, electricity circulating through the wires, magnetism in the coil, heat in the helix, and motion in the needles.'

"The genesis of all other modes of force from chemical action scarcely needs pointing out. The ordinary accompaniment of chemical combination is heat; and when the affinities are intense, light also is, under fit conditions, produced. Chemical changes involving alteration of bulk cause motion, both in the combining elements and in adjacent masses of matter: witness the propulsion of a bullet by the explosion of gunpowder. In the galvanic battery we see electricity resulting from chemical composition and decomposition. While, through the medium of this electricity, chemical action produces magnetism" (*First Principles*, pp. 200 and 201).

The earnest student should think for some months on these facts:—

(1) The genesis of *all* other modes of force is from chemical action.

(2) "*Everywhere* throughout the cosmos this truth must *invariably* hold. Every successive change, or group of changes, going on in it must be due to forces affiliable on the like or unlike forces previously existing"—*i.e.*, all forces manifested at any time must link on to those which went before. This shows one of the necessary conditions of all evolution—viz., *continuity*.

(3) There is no such thing as matter at rest, absolutely. The molecules of matter are in incessant motion, even in those masses which we think are quite fixed.

(4) There is no such thing as *empty* space. Matter is everywhere, and is either ponderable or imponderable as ether. This imponderable ether it is which fills up any spaces, whether between the sun and our earth or between the molecules and atoms of which masses of matter are composed.

Recognising always that matter and motion are eternal, we no longer look for a *beginning*, neither do we look for an *end* to the universe.

All that we can hope to discover is some hypothesis to account for its changes of form. And this brings us at once to the nebular hypothesis (*nebulæ* is the plural of *nebula*, meaning mist or vapour).

Nebulæ are bright patches seen in the sky, consisting either of far-distant stars or of matter in a less condensed state.

"Observations on nebulæ caused Kant and Laplace to suggest a theory—now known as the nebular theory—as to the formation of worlds. They considered that the solar system, for example, originally existed as uncondensed nebulous matter. This gradually condensed towards the centre, forming the nucleus of the sun, and later the outer portions separated into distinct parts, each part condensing into a planet. The different forms of nebulæ observed in the heavens were then supposed to be systems in different stages of development. Although instruments, such as Lord Rosse's telescope, have shown that so many nebulæ can be resolved into star clusters, yet, on the other hand, the spectroscope has shown us that many nebulæ do really consist of uncondensed matter."

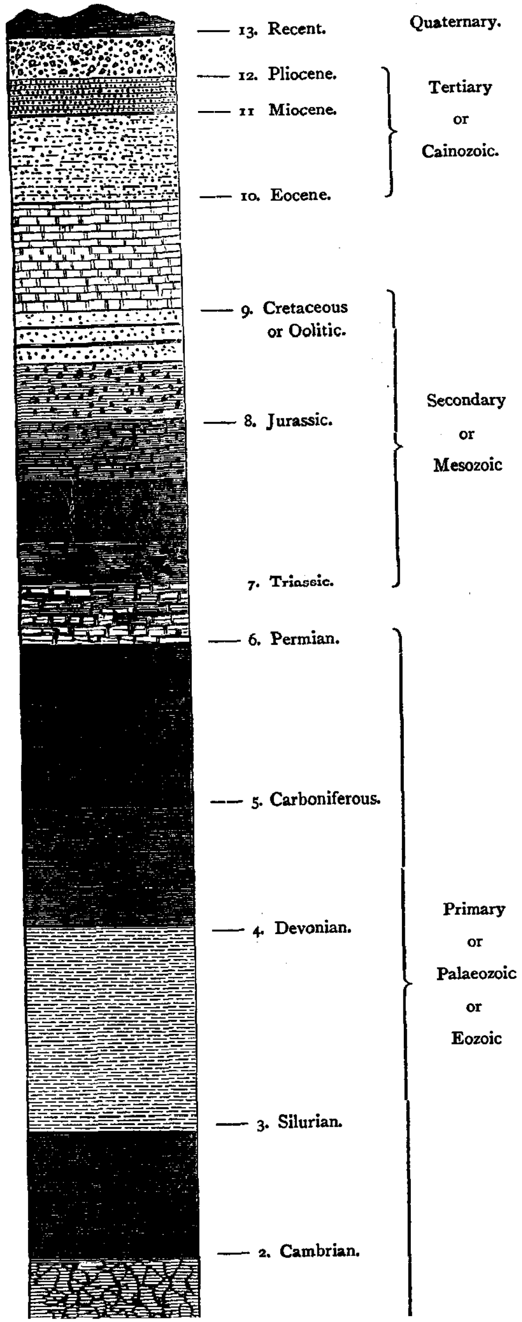
The theory may also be stated thus: "The solar system existed originally in the form of a nebula, which, by cooling, condensing, and revolving, was formed into the sun and rings of matter, which latter were consolidated into the planetary bodies; the same is applied also to all the heavenly bodies."

If we assume that matter composing the solar system once existed in a diffused state, we have, in the gravitation of its parts, a force adequate to produce the motions now going on.

Even those familiar with chemical action cannot imagine the heat which would result from such enormous motions as the theory implies, so that these masses became more than "red-hot" and were in the condition we call molten.

"If it is asked what has become of all that motion which brought about the aggregation of the diffused matter into solid bodies, the answer is that it has been radiated in the form of heat and light."

Geologists conclude that the heat of the earth's still molten centre is but a remnant of the heat which once made molten the entire earth. As the crust of the earth cooled it contracted, and this contraction gave it an uneven surface. The same condition has been observed in the surfaces of the moon and the planet Venus. "In the sun we have a still continued production of heat and light,


13. Recent.
Quaternary.
12. Pliocene.
11 Miocene.
10. Eocene.
Tertiary or Cainozoic.
9. Cretaceous or Oolitic.
8. Jurassic.
7. Triassic.
Secondary or Mesozoic
6. Permian.
5. Carboniferous.
4. Devonian.
3. Silurian.
2. Cambrian.
Primary or Palaeozoic or Eozoic

which must result from the arrest of diffused matter moving towards a common centre of gravity."

Smaller bodies have lost nearly all the produced heat; but the sun, a thousand times as great in mass as the largest planet, is still radiating with great intensity.

Thus all the changes in the earth are either direct or indirect results of the unexpended heat caused by nebular condensation. These changes are usually divided into igneous and aqueous :—

Igneous.—All those disturbances we call earthquakes, the risings and fallings which they produce in the crust of the earth; all those accumulated effects of many such risings and fallings seen in ocean-basins, islands, continents, table-lands, mountain-chains; and all those formations distinguished as volcanic—geologists regard as modifications of the earth's crust produced by the still molten matter occupying its interior.

Aqueous.—The effects of rain, of rivers, of winds, of waves, of marine currents, have a common origin. The river current, bearing its sediment down to the sea, is due to the gravitation of water. The water is there because it fell in the shape of rain.

The rain came to be in the position whence it fell because the vapour from which it condensed was drifted there by winds.

The vapour was raised to this height by the sun's heat. To the same source are due atmospheric currents and ocean currents.

When, by all these secondary agencies, the crust of the earth has been fitted to be the abode of living things, we find that the forces seen in vital actions, vegetable and animal, are also derived from the sun's heat.

"Plant life is dependent, directly or indirectly, on the sun. Each plant owes the carbon and hydrogen of which it mainly consists to the carbonic acid and water contained in the surrounding air and earth. The carbonic acid and water must be decomposed before their carbon and hydrogen can be assimilated. To overcome the powerful affinities which hold their elements together, requires the expenditure of force; this force is supplied by the sun.

"Animal life is dependent on vegetable life. The power absorbed by the plant under the shape of light and heat reappears in the movements, internal and external, of the animal.

"The forces which we distinguish as *mental* come within the same generalisation, for these depend on the nervous system, on the proportion of phosphorus in the brain, and on the supply of blood to the brain. The modes of force which we call motion, heat, light, chemical affinity, can not only be transformed into each other, but they can also be transformed into sensation, emotion, thought."

Those who desire to see proofs of this are referred to Mr. Spencer's *First Principles*. Here we can only give a few of the leading conclusions to show that the world and all that therein is are one.

So far, the examples used have been of an analytical character; but no number of analytical truths can give us that synthesis (combination) of thought which alone can be an interpretation of the synthesis of things. We need a law which will unite every process that takes place in the universe. In science it is necessary to consider certain processes separately, as in astronomy, geology, biology, sociology. But we cannot imagine that these are really separate. The processes as wholes cannot be unrelated to one another. So the question is, What is the common element in the histories of all concrete processes?

Clearly it must be one that specifies the course of the changes undergone by both the matter and the motion; or, in other words, it must be the *law of continuous redistribution of matter and motion.*

An entire history of anything must include its appearance out of the imperceptible and its disappearance into the imperceptible.

This general law of the redistribution of matter and motion must also be one which unifies the successive changes which sensible existences, separately and together, pass through. The formula must be one comprehending the two opposite processes of concentration and diffusion.

"The change from a diffused imperceptible state to a concentrated perceptible state is an integration of matter and concomitant dissipation of motion; the change from a concentrated perceptible state is an absorption of motion and concomitant disintegration of matter. These are truisms."

These two opposite processes, taken together, give us the history of every sensible existence, for everything is in progress either towards integration or disintegration.

Evolution is the integration of matter and the dissipation of motion.

Dissolution is the absorption of motion and the disintegration of matter.

Now, the total history of every sensible existence is included in its evolution and its dissolution.

Mr. Spencer gives many proofs of the law that existences of all orders *do* exhibit a progressive integration of matter and loss of motion, and shows that the components of the mass, while they become integrated, also become differentiated.

In its early stages the condition of matter was simple—as Mr. Spencer styles it, homogeneous. From this simple state it integrates and differentiates, till it has many parts—it proceeds "from the homogeneous to the heterogeneous."

In planets, in organisms, in societies, this law holds good.

After working out, in many forms, the law of integration of matter and dissipation of motion, he is able to reduce the law of the whole cosmos to this formula:

"Evolution is an integration of matter and concomitant dissipation of motion; during which the matter passes from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity, and during which the retained motion undergoes a parallel transformation."

I hope I have said enough to make clear this all-embracing law.

But as Mr. Spencer is not easy to translate into brief, popular language, I will give a summary of Professor Haeckel's chapter on the evolution of the world from his great book, *The Riddle of the Universe.* This subject is so important that it is worth running the risk of a little repetition to make it clearer.

Professor Haeckel has placed the world under an immense debt of gratitude by his profound researches into the laws of biology.

He calls the conservation of matter and the conservation of energy "The Law of Substance."

Lavoisier, in 1789, stated the conservation of matter thus: "The sum of matter which fills infinite space is unchangeable."

Mayer established the conservation of energy (the persistence of force) in 1842, which may be thus stated: "The sum of force, which is at work in infinite space and produces all phenomena, is unchangeable."

These two laws are fundamentally one; hence Haeckel calls them the law of substance.

J. C. Vogt, in 1891, put forward a theory that "the primitive force of the world is not the vibration of particles in empty space, but the condensation of a simple primitive substance, which fills the infinity of space in an unbroken continuity."

This theory is called the pyknotic theory—from *pyknosis*, condensation.

He holds that atoms do not float in empty space, but in the continuous, extremely attenuated, intermediate substance, which represents the uncondensed portion of primitive matter.

He credits these atoms with sensation and inclination in the lowest form, because some agree to condense and some do not.

The condensed portion forms the positive ponderable matter of bodies; the uncondensed portion, the negative imponderable matter—the ether. Between the positive and negative there is a constant struggle.

Whether this theory turns out to be true or not, many of the highest authorities hold that there is but one substance in the universe; and we may conceive the *elements* as having evolved from this simple primitive substance.

Ether has probably no chemical quality, and is not composed of atoms. It is called imponderable because we have no means of weighing it yet. It is boundless and immeasurable and in eternal motion. The specific movement of ether (vibration, or strain, or condensation) in reciprocal action with mass movement (or gravitation) is the ultimate cause of all phenomena. So we may divide the most general phenomena of nature into two groups: they may be regarded as the function of ether or the function of ponderable matter. This may be called the first division of labour in the development of matter.

After this very bald outline, we may follow Haeckel in his monistic view of the evolution of the world. He holds that the nebular hypothesis "is still the best of all the attempts to explain the origin of the world, etc., on monistic and mechanical lines. It has recently been strongly confirmed and enlarged by the theory that this cosmogonic process did not simply take place once, but is periodically repeated. While new cosmic bodies arise and develop out of rotating masses of nebulæ in some parts of the universe, in other parts old, extinct, frigid suns come into collision, and are once more reduced by the heat generated to the condition of nebulæ" (*The Riddle of the Universe*, p. 245).

He warns us against supposing that the universe had a beginning, and emphasises the fact that "movement is as innate and original a property of substance as is sensation."

"By spectral analysis we have found, not only that the millions of bodies which fill the infinity of space are of the same material as our own sun and earth, but also that they are in various stages of evolution.......We know that the paths of the millions of heavenly bodies are changeable, and to some extent irregular.......We know that the law of substance rules unconditionally in the most distant reaches of space. Through all eternity the universe has been, and is, subject to this law."

From the great progress of the sciences of astronomy and physics we can draw a series of most important conclusions.

"1. The extent of the universe is infinite and unbounded; it is empty in no part, but everywhere filled with substance.

"2. The duration of the world is equally infinite and unbounded; it has no beginning and no end—it is eternity.

"3. Substance is everywhere and always in uninterrupted movement and transformation; nowhere is there perfect repose and rigidity; yet the infinite quantity of matter and of eternally-changing force remains constant.

"4. The universal movement of substance in space takes the form of an eternal cycle or of a periodical process of evolution.

"5. The phases of the evolution consist in a periodic change of consistency, of which the first outcome is the primary division into mass and ether—the ergonomy of ponderable and imponderable matter.

"6. This division is effected by a progressive condensation of matter as the formation of countless infinitesimal 'centres of condensation,' in which the inherent primitive properties of substance, feeling, and inclination are the active causes.

"7. While minute and then larger bodies are being formed by this pyknotic process in one part of space, and the intermediate ether increases its strain, the opposite process—the destruction of cosmic bodies by collision—is taking place in another quarter.

"8. The immense quantity of heat which is generated in this mechanical process of the collision of swiftly-moving bodies represents the new kinetic energy which effects the movement of the resultant nebulæ and the construction of new rotating bodies. The eternal drama begins afresh. Even our mother earth, which was formed of part of the gyrating solar system millions of ages ago, will grow cold and lifeless after the lapse of further millions, and, gradually narrowing its orbit, will fall eventually into the sun.

"It seems to me that these modern discoveries as to the periodic decay and re-birth of cosmic bodies, which we owe to the most recent advance of physics and astronomy, associated with the law of substance, are especially important in giving us a clear insight into the universal cosmic process of evolution" (*The Riddle of the Universe*, pp. 247–249).

CHAPTER XII.

HOW IS ORGANIC EVOLUTION CAUSED?

HERE it is especially necessary to repeat earnestly the warning that we must begin with the lowest forms of life and the surrounding forces of the universe if we are to understand the doctrine of Evolution.

Many attempts have been made to define life, and, perhaps, none are completely successful; but it is generally admitted that Mr. Spencer has enriched thought and the scientific literature of the world by his definition of life.

He says (*Principles of Biology*, vol. i.): "Choosing assimilation, then, for our example of bodily life, and reasoning for our example of that life known as intelligence, it is first to be observed that they are both processes of change. Without change food cannot be taken into the blood or transformed into tissue; without change there can be no getting from premisses to conclusion. Life, then, consists of simultaneous and successive changes."

These changes, either in viscera or brain, are not homogeneous (*i.e.*, have not the same character). Changes in the inorganic world, on the other hand, have a remarkable likeness (homogeneity).

The next great point in the changes of living things is "that they are distinguished by *combination* subsisting among their constituent changes."

"Thus we have growth, decay, changes of temperature, of excretion, all going on in *connection*."

Again we find that they manifest a remarkable *definiteness*.

So that we arrive at the definition that "Life is the definite combination of heterogeneous changes, both simultaneous and successive; but this fails to call up an adequate conception of life."

"We habitually distinguish between a live object and a dead one by observing whether a change which we make in the surrounding conditions, or one which nature makes in them, is or is not followed by some perceptible change in the object."

"Adding this all-important characteristic, our conception of life becomes the definite combination of heterogeneous changes, both simultaneous and successive, in correspondence with external co-existences and sequences."

Or, more briefly: "Life is the continuous adjustment of internal relations to external relations"—*i.e.*, life is a correspondence between the internal and the external, and the degree of life varies as the degree of correspondence (§§ 25–30).

Now, as we have already considered sufficiently the chief arguments in favour of Evolution, we can trace the leading facts of organic evolution from the same first principles to which Evolution at large conforms.

Many attempts have been made to find the key to organic evolution. At first, the theory that plants and animals of all kinds were gradually evolved seems to have been accompanied by scarcely any conception of a cause.

De Maillet (1735) was one of the earliest who contended that organisms are indefinitely modifiable, and that, through their modifications, they have become adapted to various modes of existence. Yet, though he considered that all living things have arisen by a natural, continuous process, he does not appear to have had any definite idea of that which determines the process.

In 1794 Dr. Darwin (the grandfather of Charles Darwin), in his *Zoonomia*, gave reasons for believing that organised beings of every kind have descended from one or a few original germs. He suggests the possibility "that all warm-blooded animals have arisen from one living filament."

In some of his points he anticipated Lamarck; but Lamarck worked out his theory more precisely. Dr. Darwin named external conditions as causes of modifications in organisms, as did also Lamarck. These early suggestions, even though somewhat crudely expressed, showed great insight and did good service, for in the age when they were suggested they were a marked advance as contrasted with the dogmas of that age. Lamarck proved himself profounder than his contemporaries by seeing that evolution, however caused, has been going on.

The importance of this is very great; for, "before it can be ascertained how organised beings have been gradually evolved, there must be reached the conviction that they *have* been gradually evolved."

Dr. Darwin and Lamarck assign one actual factor as accounting for some of the phenomena—viz., "that functional adaptation to conditions produces either evolution in general or the irregularities of evolution." But this only raises the further question, "Why is there a functional adaptation to conditions? Why do use and disuse generate appropriate changes sf structure? Neither this nor any other interpretation of biologic evolution, which rests simply on the basis of biologic induction, is an ultimate interpretation. Biologic induction must itself be interpreted. Only when the process of evolution of organisms is affiliated to the process of evolution in general can it be truly said to be explained. The thing required is to show that its various results are corollaries from first principles. We have to reconcile the facts with the universal laws of the redistribution of matter and motion" (*Principles of Biology*, vol. i., §§ 144–147).

We know that, besides the daily and annual alternations in the quantities of light and heat which any portion of the earth's surface receives from the sun, there are alternations which require immensely greater periods to complete. "Every planet, during a certain long period, presents more of its northern than of its southern hemisphere to the sun at the time of its nearest approach to him; and then, again, during a like period, presents more of its southern hemisphere than its northern." This change recurs at regular periods, and, though it causes no sensible alterations of climate in some planets, yet in the case of the earth there is "an epoch of 21,000 years during which each hemisphere goes through a cycle of temperate seasons, and seasons that are extreme in their heat and cold." There is also a variation of this variation. The slow rhythm of temperate and intemperate climates which takes 21,000 years to complete is itself sometimes greater and sometimes less during epochs far longer than 21,000 years.

"The earth's orbit slowly alters in form; sometimes it is nearly a circle, sometimes it is more eccentric. During the period at which the earth's orbit is most nearly a circle, the temperate and intemperate climates, which repeat their cycle in 21,000 years, are severally less temperate and less intemperate than when, some one or two million years later, the earth's orbit has departed as far as it can from the circular.

"Thus, besides these daily variations in the quantities of light and heat received by organisms, and responded to by variations in their functions; and besides the annual variations in the quantities of light and heat which organisms receive, and similarly respond to by variations in their functions; there are variations that severally complete themselves in 21,000 years and in some millions of years—variations to which there must be a response in the changed functions of organisms. The whole vegetable and animal kingdoms are subject to a quadruply-compounded rhythm in the incidence of the forces on which life primarily depends —a rhythm so involved in its slow working round that at no time during one of these vast epochs can the incidence of these forces be exactly the same as at any other time. To the direct effects so produced on organisms have to be added much more important indirect effects. Changes of distribution must result. Certain redistributions are occasioned even by the annual variations in the quantities of the solar rays received by each part of the earth's surface. The migrations of birds thus caused are familiar. So, too, are the migrations of certain fishes: in some cases, from one part of the sea to another; and, in some cases, from salt water to fresh water. Now, just as the yearly changes in the amounts of light and heat falling on each locality yearly extend and restrict the habitats of many organisms that are able to move about with some rapidity, so must these alternations of temperate and intemperate climates produce extensions and restrictions of habitats. These extensions and restrictions, though slow, will be universal—will effect the habitats of stationary organisms as well as those of locomotive ones. For if during an astronomic era there is going on at any limit to a plant's habitat a diminution of the winter's cold or summer's heat, which had before stopped its spread at that limit, then, though the individual plants are fixed, yet the species will move: the seeds of plants living at the limit will produce individuals that survive beyond the limit. The gradual spreading so effected having gone on for some ten thousand years, the opposite change of climate will begin to cause retreat; the tide of each species will, during the one half of a long epoch, slowly flow into new regions, and then will slowly ebb away from them. Further, this rise and fall in the tide of each species will, during far longer intervals, undergo increasing rises and falls, and then decreasing rises and falls. There will be an alternation of spring tides and neap tides, answering in its period to the changing eccentricity of the earth's orbit.

"These astronomical rhythms, therefore, entail on organisms unceasing changes in the incidence of forces in two ways. They directly subject them to variations of solar influences in such a manner that each generation is somewhat differently affected in its functions; and they indirectly bring about complicated alterations in the environing agencies by carrying each species into the presence of new physical conditions" (*Ibid*, § 148).

I have quoted Mr. Spencer thus fully because the action of these forces is so often forgotten by many who wish to think of the doctrine of Evolution. But these changes, important as they are, by no means complete the list of forces which are constantly acting to modify living things.

For instance, if we turn to geology, we find another set of actions which everywhere modify the circumstances of plants and animals.

1. There is a process called denudation, by which part of the crust of the earth is worn away, and this changes the deposit or soil.

2. Alluvial beds are being formed, and thus changes are effected in the natures and proportions of the strata denuded.

3. The inclinations of surfaces and their directions with respect to the sun are at the same time altered.

4. Igneous action works many great changes, as by volcanoes and earthquakes, though others are gradual.

5. Alterations in the earth's crust are ever subjecting the inhabitants of the ocean to new conditions.

6. The mineral character of ocean beds occasionally changes.

7. Changes are caused by changes in the movement of the water of the ocean.

8. Local temperature is from time to time raised or lowered, because some rearrangement of the earth's crust has wrought a difference in those circulating currents of warm and cold water which pervade the ocean.

Turning from these powerful agencies to meteorological conditions, we find another set of changes at work:

1. We know that land is sometimes rising, sometimes sinking, producing a continent where it used to be ocean,

or causing wide seas where there used to be snow-capped mountains. These alterations produce great changes in the atmosphere.

2. While the highest parts are emerging, they exist first as islands, and the plants and animals which migrate to these islands have climates peculiar to small tracts of land which are surrounded by large tracts of water.

3. As, by upheavals, greater areas are exposed, the state of the outside portions differs from that of those in the centre.

4. The winds, which were comparatively uniform so long as only small islands existed, grow widely different in different parts of a large continent.

5. The quantity of rain varies everywhere, according to the nearness to the sea and according to the special character of the surface of the land.

We see that climatic variations that are geologically produced are compounded with those which result from slow astronomical changes, and, as there is no correspondence between the geologic and astronomic rhythms, this astounding result follows, that the same combination of actions never recurs. Hence the incidental forces, to which living things are exposed, are ever passing into unparalleled combinations.

Further, besides changes which inorganic forces cause, there are equally continuous and still more involved changes in the incidence of forces which organisms exercise on one another.

We have partly seen this in considering Variation (Chapter VI.).

"The plants and animals inhabiting each locality are held together in so entangled a web of relations that any considerable modification which one species undergoes acts indirectly on many other species, and eventually changes, in some degree, the circumstances of all the rest. If an increase of heat, or modification of soil, or decrease of humidity, causes a particular kind of plant either to thrive or to dwindle, an unfavourable or favourable effect is wrought on all such competing kinds of plants as are not immediately influenced in the same way. The animals which eat the seeds or browse on the leaves either of the plant primarily affected or those of its competitors are severally altered in their states of nutrition and in their numbers; and this change presently tells on various predatory animals and parasites. And since each of these secondary and tertiary changes becomes itself a centre of others, the increase or decrease of each species produces waves of influence which spread and reverberate and re-reverberate throughout the whole flora and fauna of the locality" (*Ibid*, § 151).

Considering all these forces and changes, we see that throughout all time organisms have been exposed to an endless succession of modifying causes so complex that we can scarcely think of them all. We must also remember that, even if everything else remained the same, every new faculty by which an organism is brought into relation with external objects, as well as every improvement in such faculty, becomes the means of subjecting an organism to new *stimuli*.

Also, every increase in the locomotive power of animals increases the various actions of things upon them and of their reactions upon things.

By compounding the actions of all these several orders, there is produced a progression of changes increasing with immense rapidity, till the mind is lost in wonder at the complex web of forces and changes which in their subtle power enfold and alter the life of man.

We turn from these striking marvels of external factors to the internal factors—*i.e.*, the composition of the organism itself.

We must try and grasp in merest outline what is the kind of thing we call a living being, upon which these very powerful forces are continually acting in various degrees. Our ordinary notions of fixity and solidity are so contrary to fact that nothing can be more important than to correct these notions.

"Of the four chief elements which, in various combinations, make up living bodies, three are gaseous under all ordinary conditions, and the fourth is a solid."

The three elements usually gaseous are oxygen, hydrogen, and nitrogen. The solid is carbon.

When we remember how those re-distributions of matter and motion which constitute evolution, structural and functional, imply motions in the units that are re-distributed, we shall see a probable meaning in the fact that organic bodies, which exhibit the phenomena of evolution in so high a degree, are mainly composed of ultimate units having extreme mobility. The properties of substances, though destroyed to sense by combination, are not destroyed in reality; it follows from the persistence of force that the properties of a compound are *resultants* of the properties of its components—*resultants* in which the properties of the components are severally in full action, though greatly obscured by each other. One of the leading properties of each substance is its degree of molecular mobility; and its degree of molecular mobility more or less sensibly affects the molecular mobilities of the various compounds into which it enters.

Those who wish to go more fully into details must consult Mr. Spencer's *Biology*, chapter i., vol. i. We have said enough to show that a living body is not a hard, fixed, resisting mass, but, on the contrary, a delicate organism, ready to yield in some degree to any small subtle forces which play upon it.

It may be needful to say that these four elements, by chemical affinity, combine with other elements to form solids, liquids, or gases. Hydrogen combines with but few elements, but it has well-known combinations. It combines with oxygen to form water, which is the largest part of any living body. It combines with sulphur to form the compound which gives rotten eggs their unpleasant odour.

Oxygen displays the greatest chemical energy, and is the gas we inhale from fresh air; in fact, it is the gas which makes all the difference between fresh air and foul.

Nitrogen has the least chemical energy, and, though it abounds in the air, we are not able to absorb it direct from the air: we must have nitrogen; but, in order to assimilate it, we have to eat compounds of nitrogen in various forms of food.

Carbon is found in three forms—diamond, graphite, and charcoal. But it unites with oxygen in various degrees to form gases; one of its compounds, carbonic acid (CO_2), is the poisonous gas which animals give out in breathing.

Only by giving much thought to these delicate compounds can we partly understand how living things are built up from not-living.

Of course, other elements besides these four enter into the formation of living bodies; but these may suffice to show the connection between the living and the not-living, and also to show that every living thing is undergoing constant changes, and thus is largely affected by the forces of the outside world.

Mr. Spencer says "the wonderful relationship in the same continent between the dead and the living" was one of the first facts that so greatly struck Darwin on his memorable voyage. Mr. Spencer points out how instructive this fact is; and he adds: "It cannot be said that, the marsupials imbedded in recent Australian strata having become extinct because of unfitness to some new external condition, the existing marsupials were then specially created to fit the modified environment; since sundry animals found elsewhere are so much more completely in harmony with these new Australian conditions that, when taken to Australia, they rapidly extrude the marsupials. While, therefore, the similarity between the existing Australian fauna and the fauna which immediately precede it over the same area is just that which the belief in Evolution leads us to expect, it is a similarity which cannot be otherwise accounted for. And so it is with parallel relations in New Zealand, in South America, and in Europe" (*Principles of Biology*, vol. i., pp. 400 and 401).

If we consider this passage carefully, it is difficult to see how we can deny its statements. And we may here call attention to a point which some people magnify into a difficulty against Evolution. When it is found that an organism has lived for millions of years, without showing any modification of change, some ask: "What has become of Evolution?"

Now, it cannot be re-iterated too often that the doctrine of Evolution nowhere claims that all species are constantly evolving. In order to produce Evolution, there must be the force of favourable conditions acting on the favourable structure of an organism. Far from being surprised, therefore, that some low forms remain apparently the same as they were ages ago, the Evolutionist would expect this. For if the organism itself is simple, and the conditions are such as to remain nearly always the same, what force is there to produce those changes which are favourable to Evolution?

Some find an extraordinary difficulty in the fact that the human hand or nose does not show continued signs of evolution to some other form. All such difficulties are answered by the preceding case. The hand has practically been used in the same way and in the same conditions for thousands of years. Besides, there is the law of fixity of form, known as heredity, upon the force of which I have already insisted.

No organ which has developed through many ages from a simple (homogeneous) state to one of great complexity can be regarded as being in that unstable condition which we saw in the preceding chapter is the first necessity for further development.

Hence also it is that man is evolving far more in his brain than in any other part of his body, because the brain is far less rigid than the other organs.

If we have instability of an organ, we know that the complex forces acting upon it will produce great variety of structure in the organ, and that all parts of the organism will be more or less affected in consequence.

"Suppose that the head of a bison becomes much heavier—what must be the indirect results? The muscles of the neck are put to greater exertions; and its vertebræ have to bear additional tensions and pressures, caused both by the increased weight of the head and the stronger contractions of the muscles that support and move it. These muscles also affect their special attachments; several of the dorsal spines have augmented strains; and the vertebræ to which they are fixed are more severely taxed. Further, this heavier head, and the more massive neck it necessitates, require a stronger fulcrum: the whole thoracic arch, and the fore limbs which support it, are subject to greater continuous stress and more violent occasional shocks. And the required strengthening of the fore-quarters cannot take place without the centre of gravity being changed and the hind limbs being differently reacted upon during locomotion. Anyone who compares the outline of the bison with that of its congener, the ox, will see how profoundly a heavier head affects the entire osseous and muscular systems. Besides this multiplication of mechanical effects, there is a multiplication of physiological effects. The vascular apparatus is modified throughout its whole structure by each considerable modification in the proportions of the body. Increase in the size of any organ implies a quantitative, and often a qualitative, reaction on the blood, and thus alters the nutrition of all other organs. Such physiological correlations are exemplified in the many differences that accompany difference of sex. That the minor sexual peculiarities are brought about by the physiological actions and reactions is shown both by the fact that they are commonly but faintly marked until the fundamentally distinct organs are developed, and that, when the development of these is prevented, the minor sexual peculiarities do not arise. No further proof is, I think, needed that in any individual organism or its descendants a new external action must, besides the primary internal change which it works, work sundry secondary changes as well as tertiary changes still more multiplied" (*Ibid*, § 155).

Thus we realise that these changes, which would go on to a comparatively small extent were organisms exposed to constant external conditions, are kept up by the continual changes in external conditions produced by astronomic, geologic, meteorologic, and organic agencies. So the result is that, to previous complications of structure caused by previous forces, new complications are continually being added by new forces. Hence there arises greater and greater variety in the structures of individuals and in the structures of species, both of plants and of animals.

Had the whole of the universe been designed as one factory for the sole purpose of trying every possible experiment, in order that natural selection should have the widest possible chance of determining which forms were best suited for the several environments, no surer method could be imagined than this which we see in operation in the world, with its ever-changing organisms.

Hence it is that we find progression to result, "not from a special inherent tendency in living bodies, but from a general average effect of their relations to surrounding agencies."

This outline is far too incomplete; but it shows, at any rate, that there is no lack of number and variety in forces to produce organic evolution. And when some ill-informed opponent says that he cannot believe that "man came from monkeys," or that "man came from clods," he but tells us that he has neither grasped the principles of Evolution nor once realised that millions of ever-changing influences have been at work on millions of plastic forms through a period of time of practically infinite duration. Here, however, reason may rest. Whatever are the difficulties in the way of accepting Evolution, the absence of sufficient forces and of efficient causes is not one of them.

CHAPTER XIII.

LIFE AND HOPE

MANKIND is rightly afraid of being bereft of hope. The unavoidable miseries of life are so terrible that men have sought out many inventions in order to deaden the anguish of sorrow, or to paint a mask on the grim features of coming doom.

And not unnaturally some ask—How does the doctrine of Evolution help us? Is life darker or brighter for its teaching? We must carefully consider our answer.

It is agreed that the teachings of Evolution deal with subjects of the deepest interest—the relation of man to the universe, and the relation of the present universe to a practically infinite past and future. Few can deny that the message of Evolution has revolutionised every department of knowledge and thought in less than fifty years.

Naturally many cannot understand the doctrine. The words are new, the thoughts are new, and, above all, the attitude of mind demanded is new. Coming to people who have never studied science, falling upon ears plugged with many superstitions, unfolded before eyes which have never been trained to see facts, there can be no wonder that this message of immortal Nature to her latest child plunges him into a whirlpool of difficulties.

Early man formed false notions of the world and his relationship to it. These notions have been taught with the highest sanction of authority and the persistence of constant reiteration, till inquiry has been paralysed and reason poisoned.

For instance, all men learn that the sun rises and sets.

This has long since been demonstrated to be a false account of the matter; but how few men, in the most civilised countries, habitually think of the facts as they are?

In face of this fact, one dimly realises that thousands of generations may have to pass away before the average man will think correctly of the other and more complicated relationships between himself and the universe.

Even to men who recognise that Evolution affords the only reasonable explanation of facts as we see them, there are points which cause them to stumble.

Thousands of men fall into a slough of error because they look for the beginning, in a cycle of events which has no beginning. They cannot grasp the grandest and most revolutionary discovery of the last century—namely, that matter and motion are without beginning and without end. To such the phenomena of the universe must remain an insoluble problem.

Others are bewildered by time. These could grant that Evolution has done all which is claimed for it, but it would require such an infinite period of time. Yet the eternity of matter and motion removes this difficulty.

No man knows what is meant by a million years, and when we speak of twenty or a hundred million years we might as well speak of eternity. Probably it is more than a hundred million years since our little earth was thrown from the sun as a belt of vapour, and who shall calculate the millions of years which have elapsed since the first tiniest cell began that marvellous development which has resulted in the body of man with its thinking brain? This difficulty with regard to the duration of time is as utterly erroneous as the self-made difficulty about a beginning where there is no beginning.

Others who can easily surmount both of these difficulties are haunted by a nightmare which they call "the missing link." At this time of day to speak of "the missing link" is to show that the speaker has not clearly grasped the principles of Evolution. No Evolutionist supposes that man has come from any species of existing monkeys. He merely says that the apes and man must somewhere have had a common ancestor. But there is nothing startling in this statement compared with many other statements which pass unchallenged by the objector. Man and fish had, then, a common ancestor; man and the oyster had a common ancestor; nay, man and the thistle had a common ancestor. For all forms of living things, animal and vegetable, arose from that first crude vegetable cell which hovered on the border line of inorganic matter. This cell was simpler and smaller than any form of cell we know, and probably our most delicate instruments could not have determined that it was a living organism.

To grant all these earlier stages of development which have been so well established, and then to raise a question about "the missing link" between monkeys and men, is to miss the whole point of Evolution. As well might we ask for the missing link between an oak and an ash. By the whole theory of Evolution, the highest ape can only be a far distant cousin of the human family, and cousins far removed do not look for any connecting link except ancestry, and this link we have already abundantly furnished.

Read the words of the master on this subject. In *The Origin of Species*, page 265, Charles Darwin says:—

"In the first place, it should always be borne in mind what sort of intermediate forms must, on the theory, have formerly existed. I have found it difficult, when looking at any two species, to avoid picturing to myself forms directly intermediate between them. But *this is a wholly false view;* we should always look for forms intermediate between each species and a common but unknown progenitor; and the progenitor will generally have differed in some respects from all its modified descendants. To give a simple illustration, the fantail and pouter pigeons are both descended from the rock-pigeon; if we possessed all the intermediate varieties which have ever existed, we should have an extremely close series between both and the rock-pigeon; but we should have no varieties directly intermediate between the fantail and the pouter; none, for instance, combining a tail somewhat expanded with a crop somewhat enlarged, the characteristic features of these two breeds. These two breeds, moreover, have become so modified that, if we had no historical or direct evidence regarding their origin, it would not have been possible to have determined, from a mere comparison of their structure with that of the rock-pigeon, Columba livia, whether they had descended from this species or from some other allied form, such as Columba oenas.

"So with natural species, if we look to forms very distinct—for instance, to the horse and tapir—we have no reason to suppose that links directly intermediate between them ever existed, but between them and an unknown common parent. The common parent will have had in its whole organisation much general resemblance to the tapir and to the horse; but in some points of structure may have differed considerably from both, even perhaps more than they differ from each other. Hence, in all such cases we should be unable to recognise the parent form of any two or more species, even if we closely compared the structure of the parent with that of its modified descendants, unless at the same time we had a nearly perfect chain of the intermediate links."

Finally, with another set of men these difficulties have not much weight. They have a different difficulty—the origin of life. This difficulty is one of a large group of difficulties which have been created by stating the problem wrongly. If we begin by saying that Time, Space, Motion, Consciousness, and Life are things in themselves *apart from matter*, then we have created a difficulty which the brain of man cannot solve. But note, this kind of difficulty is caused by a pure assumption.

Time and Space are not things; they cannot be caught or measured; they have no separate existence independent of phenomena.

Motion is not a thing in itself; it has nowhere ever been known except as a property of matter; to have motion there must be matter capable of changing its form or position.

Consciousness is not a thing in itself; it is a state of brain action; it has never been found apart from matter.

The whole of this class of difficulties has been created by man, and Life, like the rest, is not a thing in itself. Is it likely that, in the long history of tens of thousands of years, man would never have discovered life, if such a thing existed? There is no thing which we can call life, if we think accurately. We ought to say there are living bodies, living things, for what people mean by life is a state or condition found in certain arrangements of matter. Life, apart from matter, is as inconceivable as motion apart from matter.

Recently much evidence has been given that life and thought (including consciousness) are, as Spencer defined them, but *processes* of change.

Professor Bose, in his great book (1902), *Response in the Living and Non-living*, has proved beyond doubt that the same electrical response can be obtained by the same means from animals, vegetables, and metals.

He says (p. 181): "The irritability of tissue, as shown in its capacity for response, electrical or mechanical, was found to depend on its physiological activity. Under certain conditions it could be converted from the responsive to an irresponsive state, either temporarily as by anæsthetics, or permanently as by poisons. When thus made permanently irresponsive by any means, the tissue was said to have been killed. We have seen further that from this observed fact —that a tissue when killed passes out of a state of responsiveness into that of irresponsiveness; and from a confusion of 'dead' things with inanimate matter, it has been tacitly assumed that inorganic substances, like dead animal tissues, must necessarily be irresponsive, or incapable of being excited by stimulus—an assumption which has been shown to be gratuitous."

To explain the irritability of tissue some physiologists had recourse to a super-mechanical power, which they called "vital force." This was a mystical explanation, which was no explanation, and introduced the notion of duality. But Mr. Bose proves "that not the fact of response alone, but all those modifications in response which occur under various conditions, take place in plants and metals just as in animal tissues" (p. 182).

There is therefore no need to maintain the notion of duality.

He has proved that animal tissues, plants, and metals, all alike respond, grow tired, can be poisoned, and thus killed.

"Thus living response in all its diverse manifestation is found to be only a repetition of responses seen in the *inorganic*. There is in it no element of mystery or caprice, such as we must admit to be applied in the assumption of a hyper-mechanical force, acting in contradiction or defiance of those physical laws that govern the world of matter" (p. 189). The phenomena of response "are physico-chemical phenomena, susceptible of a physical inquiry as definite as any other in inorganic regions" (p. 190). He shows that these laws, which know no change, act "equally and uniformly throughout the organic and the inorganic worlds" (p. 191).

It is too early yet to realise how vastly this great demonstration of uniformity must revolutionise our notions of life, but we must recognise that our artificial divisions between the living and the not-living are rapidly "vanishing into thin air."

We now see that the difficulty, called the origin of life, rests on two flagrant assumptions—(1) that there is a thing called life, apart from all other things; and (2) that this thing had a beginning at some distinct point in the world's history.

It is hardly necessary to point out that, in all his experience, man has never found warrant for either of these assumptions in the land of fact.

In classifying the phenomena of the universe, there are certain states which we call living. Now, many are afflicted with horror at the mere thought that it could have been possible for the living condition to be evolved from the not-living condition. Such a development is often called "spontaneous generation." The term is a bad one, though, as it is well known, we retain it.

But we must be careful to understand the stage to which we apply it. A few years ago experiments were made by sealing up boiling water in large vessels, and keeping it for a long time; then the vessels were opened, and nothing had grown in the water! Clear proof this, said the wiseacres, that every living thing comes from a germ!

Of course, it is a waste of time to point out to such people that the Evolutionist, when he looks for the first living forms, looks for something smaller and simpler than infusoria. To expect *advanced* or *organised* beings to appear straightway out of the inorganic is not evolution, but that miracle called the John Milton creation:—

> "The grassy clods now calved; now half appears
> The tawny lion, pawing to get free
> His hinder parts."

There can be nothing more comic than this notion of Milton's, except the fact that many people now living in Britain believe it.

Again, I emphasise, we are not looking for a beginning which *started* with full-blown maturity.

We might remember also that the conditions suitable for living things never have been those of boiling water stored in air-tight jars.

The inquirers who seek the beginning of living forms under these conditions would act more rationally if they began to study the laws of their own health when they had made their own mouths air-tight.

The phrase "spontaneous generation" describes no phase of Evolution, for as far as nature is known there is no event or act which is spontaneous in the strict sense of that word.

In order to attempt to understand how living forms arose, we will first read Mr. Herbert Spencer's letter on the subject (at the end of *Principles of Biology*, vol. i.).

"I conceive that the moulding of such organic matter into the simplest types must have commenced with portions of protoplasm more minute, more indefinite, and more inconstant in their characters than the lowest rhizopods—less distinguishable from a mere fragment of albumen than even the protogenes of Professor Haeckel. The evolution of specific shapes must, like all other organic evolution, have resulted from the actions and reactions between such incipient types and their environments, and the continued survival of those which happened to have specialities best fitted to the specialities of their environments. To reach by this process the comparatively well-specialised forms of ordinary infusoria must, I conceive, have taken an *enormous period of time.*"

The conception of a first organism in anything like the correct sense of the words is wholly at variance with the conception of Evolution, and is scarcely less at variance with the facts revealed by the microscope. The lowest things are not, properly speaking, organisms at all; they have no distinct parts—no traces of organisation.

This vagueness, inconstancy, want of structure, seen in the simplest of living things, must have been still more decided when, as at first, no forms, no types, no specific shapes, had been moulded. "I distinctly deny the 'absolute commencement of organic life on the globe.' The affirmation of universal evolution is in itself the negation of an 'absolute commencement' of anything."

Every kind of being is conceived as a product of modifications, either of a pre-existing being or of pre-existing inorganic compounds.

"That organic matter was not produced all at once, but was reached through steps, we are well warranted in believing by the experiences of chemists. Organic matters are produced in the laboratory by what we may literally call *artificial evolution.* Chemists find themselves unable to form these complex combinations *directly* from their elements; but they succeed in forming them indirectly, by successive modifications of simpler combinations."

A compound containing two elements is called a binary compound; one containing three elements is called a ternary compound.

For instance, beginning with a binary compound, as ammonia, $N H_3$, a higher form is obtained by replacing one of the atoms of hydrogen, H, by an atom of methyl, so producing methyl-amine, N (C H H); then, under the further action of methyl, is produced the still more compound substance, dimethyl-amine, N (CH) (CH) H. In this way highly complex substances are at last built up.

Without confusing the reader by a mass of chemical signs, three things are clear:—

1. Organic forms can be made out of inorganic elements.
2. These forms can only be made gradually.
3. One compound substance can act upon another to produce a still higher compound.

It is in such a stage as this that the origin of the lowest living forms is to be looked for; then, at any rate, we shall begin to see what we mean when we talk of the origin of life. We are not looking for organisms, however small, but for bits of living protoplasm which have no distinction of parts, and which are so small and simple that only by scientific instruments can they be discovered at all.

It should hardly be necessary to point out that, when these low first living forms were evolved, the conditions of the earth were widely different from those now prevailing.

We should also bear in mind that no one can prove or disprove whether such living forms are still coming into existence.

If we turn from Mr. Herbert Spencer's account to Haeckel's *History of Creation*, we find that this great thinker takes practically the same view.

Beginning at page 327, he thus states the case :—

"As the terrestrial ball cooled, water formed. This was most important, as all animals and plants are largely made up of it.

"We know, therefore, that at one stage of the world's history there was no living thing or organism.

"How are we to conceive the origin of the first organisms?

"We must first form a clear conception of the principal properties of the two chief groups of natural bodies—the inorganic and the organic.

"The three fundamental properties of every natural body are matter, form, force.

"1. *Matter.*—Every element found in animal and vegetable bodies is also found outside them in the inorganic. So the difference is not in the material which composes them.

"2. *Form.*—In Monera the whole body—a semi-fluid, formless, and simple lump of albumen—consists, in fact, of only a single chemical combination, and is as perfectly simple in its structure as any crystal which consists of a single inorganic combination.

"Among Radiolaria and other Protista, the body, *in the same way as crystals*, may be traced to a mathematically determinable fundamental form, and the form in its whole, as well as in its parts, is bounded by definite geometrically determinable planes and angles." ("Details and Proofs," *Morphology*, pp. 375-574).

"Moreover, there are perfectly amorphous organisms, like the Monera, Amœba, etc., which change their forms every moment, so that we are as little able to point out any definite fundamental form as in the case of the shapeless masses we term inorganic.

"3. *Forces or phenomena of motion.*

"Here we meet with the greatest difficulties. When we take the simplest forms, we learn that all vital phenomena, and, above all, the two fundamental phenomena of nutrition and propagation, are purely physico-chemical processes, dependent on the material nature of the organism, just as all the physical and chemical qualities of every crystal are determined solely by its material composition.

"The most influential force in organisms is carbon. We are driven to the conclusion that there is a unity of organic and inorganic nature; an essential agreement between the inorganic and organic in matter, form, force.

"Now, we ask, is there such a thing as autogeny, or 'spontaneous generation'; that is, can a living organism arise naturally out of the inorganic?

"We have seen that Monera are so nearly allied to the inorganic that they may be termed 'organisms without organs.' In a perfectly-developed and a freely motile state, they present nothing but a simple lump of an albuminous combination of carbon.

"Now, the discovery of these low organisms has made the 'origin of life' comparatively easy to understand. We have found these living things on the very border line of the inorganic. *Organic compounds* of carbon, as alcohol, acetic acid, formic acid, can now be made by chemists. And there is every likelihood that complicated albuminous combinations will be produced artificially."

There is no longer a deep chasm between the inorganic and the organic. And since Professor Loeb has succeeded in fertilising the eggs of the Sea-urchin by chemistry, the chasm is at least half-bridged over already. Haeckel continues:—

"We have seen that these tiny lumps of jelly (protoplasm) which are living animals (Monera) are without any organs or parts, without kernel (nucleus) or covering (cell wall), so that they lie on the border line of the inorganic.

"By developing a nucleus, one part becomes separate from the rest, and the moneron becomes a cell. Every animal and plant at the beginning of its life is such a cell—a simple lump of mucous containing a kernel.

"This kernel arose, probably, by condensation of the innermost central part of the albumen; this made a separation of parts. In the same way a further separation was effected when the first cell membrane was found on its surface, either as a chemical deposit or as a physical condensation of the outermost mass, or as a secretion.

"The elementary organisms are also called form-units or plastids. There are two main groups, the cytods and the cells.

"Cytods are like Monera, pieces of protoplasm without a kernel.

"Cells, on the other hand, are pieces of protoplasm with a kernel.

"Each of these two groups is again divided into two, according as they possess or do not possess an external covering (skin, shell, or membrane). So we have four grades of plastids.

"1. Simple cytods.

"2. Encased cytods.

"3. Simple cells.

"4. Encased cells.

"Probably group 1, the simple cytods, naked pieces of protoplasm without kernel, like living Monera, are the only plastids which directly come into existence by spontaneous generation—*i.e.*, arise out of inorganic matter. 2, 3, and 4 arose out of 1, by Natural Selection. We thus obtain a simple and natural connection in the whole series of the development of nature."

We must either accept some such origin of living organisms, or believe in a miracle, and say that Evolution only partly applies to the development of living things.

Since Haeckel wrote this, other discoveries have been made, especially that on the voyage of the *Challenger*, when peculiar little bodies were found largely diffused over the bottom of the deep sea. These very small bodies are known as Coccoliths. Their size ranges in *length* from $\frac{1}{2700}$ to $\frac{1}{11000}$ of an inch.

The man who can form any idea of the minuteness of bodies, eleven thousand of which are required to make an inch, will no longer look for organised animals in boiled water which has been kept in air-tight jars.

Many great names could be added to Spencer and Haeckel in support of this common-sense view of the origin of living forms; but, fortunately, science does not rest on authority: it rests on observed facts and the application of reason to those facts.

We will, however, give two other important presentations of this view. First we turn to that truly great book, *The Grammar of Science*, by Professor Karl Pearson (second edition, 1900).

On page 357 he says: "There are two elements in Natural Selection—environment, which may be either organic or inorganic, and death, as a process of eliminating those less fitted to this environment."

All sorts of chemical products may have first arisen in the azöic period. "Scientifically we might describe these products as the complex dances of corpuscular groups."

As group met group some would retain their individuality (be stable), others would not. This may be called *physical selection*, where the environment is more inorganic than organic.

Still it is perfectly true, "As a matter of fact, 'Natural Selection' in its true meaning covers inorganic just as much as organic selection."

On page 346 Professor Pearson states the case clearly: "Those who accept the evolution of all forms of life from some simple unit, a protoplasmic drop or grain—and this scientific formula is so powerful as a means of classification and description that no rational mind is likely to discard it—will hardly feel satisfied to stop at this stage. They will demand some still more wide-embracing formula, which will bring under one statement their perceptual experience of both the living and the lifeless.

"Here the physicist comes in with some very definite conclusions. He tells us that, in order to classify his perceptions with regard to the earth, he is compelled to postulate a period, distant, it is true, many millions of years back, in which, owing to conditions of fluidity and temperature, no life, *such as we now know life*, not even the protoplasmic grain, could have existed on the earth. This period has been termed the azöic or lifeless period, but we must be careful that we mean by lifeless only '*without life as we now know it.*'

"There are three hypotheses which say how living things have arisen:—

"(*a*) Life may be conceived as based upon an organic corpuscle which is immortal—that is to say, it will, with suitable environment, continue to exist for ever. This hypothesis may be termed the *perpetuity of life.*

"(*b*) Life may be conceived as generated from a special union of inorganic corpuscles, which union may take place under favourable environment. This hypothesis is termed the *spontaneous generation of life.*

"(*c*) Life may have arisen from the operation in time of some ultra-scientific cause. This is the hypothesis of a *special creation of life.*"

Now, hypothesis (*a*) contradicts the fact of the azöic condition of the earth. So two great men, Von Helmholtz and Lord Kelvin, suggest that a meteorite may have brought the protoplasmic drop to our earth!

But meteorites travel through such extremes of heat and cold that to believe in the possibility of any living thing enduring them would require more imagination than is possessed by ordinary mortals.

Hypothesis (*c*), which starts with an ultra-scientific cause, evidently lies outside scientific inquiry, for man possesses no means of discovering such a cause.

With regard to hypothesis (*b*), Professor Pearson says: "In the first place, this formula involves the conception of forms of protoplasm anterior to those with which we are at present acquainted, but it does not suppose these like forms to have existed in unlike conditions. It postulates that, if we were to go backwards, the organic would have disappeared into the inorganic, before we reached the azöic age. After the azöic age the physical conditions must be conceived as such that the various chemical compounds were evolved which ultimately culminated in the first protoplasmic unit."

Professor Lankester (article "Protozoa") points out the same thing, with this important addition: "It seems, therefore, likely enough that the first protoplasm fed upon these antecedent steps in its own evolution, just as animals feed on organic compounds at the present day."

Professor Pearson continues: "These words suffice to indicate the long ages of development that probably lie behind protoplasm as we know it. Let us for a moment consider that there is possibly as long an evolution from the chemical *substance* to the protoplasm we now know as from protoplasm to conscious animal life. On the hypothesis of spontaneous generation we must conceive life as reappearing when and wherever the physical conditions are suitable."

Again, I can call a remarkable witness.

Professor A. E. Dolbear has written a book on *Matter, Ether, and Motion* (1899). The English edition is edited by Professor Alfred Lodge. Further, the book is published by the Society for the Promotion of Christian Knowledge, so it has the unique authority of the highest science and the most respectable orthodoxy. The following extracts speak with no uncertain sound:—

Professor Dolbear shows the difficulty of defining life, and that an analogous difficulty is met in the attempt to define other of the so-called physical forces. "Light was supposed to be a created something"; "heat was supposed to be a kind of imponderable matter," and "therefore was supposed to be an entity." "Electricity and magnetism were supposed to be fluids." "The regular movements of the planets were thought to require intelligent directive power to keep them in their orbits; but now the gravitative property of matter itself is held to be quite sufficient to account for all the observed facts, and the extra material directive force is held to be an entirely unnecessary assumption" (p. 278).

"The discovery of the conservation of energy, covering every field that has been investigated, led to the growing conviction that there are no special forces of any kind needed to explain any phenomena." Vital force used to be supposed to be an entity, but "vital force as an entity has no existence." So with the entities above named, one after another they have disappeared (p. 278).

"Let it be granted that atoms are in the neighbourhood of the fifty-millionth of an inch in diameter; then, if a thousand of them are organised into a molecule, its diameter would be about the five-millionth of an inch. A speck of protoplasm, one ten-thousandth of an inch in diameter, would require not less than five hundred such molecules in a row to span it, and there would be no less than 125 millions of such molecules in the small mass" (p. 281).

"There is no longer any question that the qualities of protoplasm are chemical and physical, and belong to it simply as a chemical substance. Chemists have synthetically formed out of the various elements a vast number of substances that were not long ago believed to be *formed only by living things;* and there is but little reason to doubt that, when they shall be able to form the substance protoplasm, it will possess all the properties it is now known to have, including what is called life; and one ought not to be surprised at its announcement any day" (p. 282).

"The energy available for all the purposes of an animal, including man, exists in the material of the body" (p. 290).

"Life is a process rather than a condition" (p. 292).

"If there are any that would still hold that life is a something *sui generis*, that may be considered apart from some material structure and not as a *transformation process*, it will be well for such to inquire what can become of such life as a grain of corn or an egg has, when it is cooked, or when either of them is left for months or years, and they rot. At first it is in the grain of corn or egg. If it be an entity of any sort, it must be somewhere else after leaving either the one or the other......The properties of a mass of matter are, by general agreement, the result of the *arrangement* of the matter" (p. 294).

"It may be said, and often has been, that every living thing has an ancestry of living things; and in human experience it is true. It is sometimes said that one cannot get out of a mass of matter what is not in it, which in this case might imply that matter itself is alive, though I have never heard anyone so conclude. If anyone would apply this dictum, let him settle with himself before turning a new electrical machine whether the electricity he is to get from it is or is not in the machine, and how, if it be in the machine, he can get an infinite amount from it by simply turning the crank. He may reach the conclusion that what can be got out of a mass of matter *depends upon its composition and structure*" (p. 296).

In conclusion, one perhaps can do no better than to quote the words of Sir Michael Foster, Professor of Physiology in the University of Cambridge, as to the properties of protoplasm:

"The more these molecular problems of physiology are studied, the stronger becomes the conviction that the consideration of what we call structure and composition must ......be approached under the dominant *conception of modes of motion.*

"If such be the case, it is clear that the solution of every *ultimate* question in biology is to be found *only in physics*, for it is the province of physics to discover the antecedents as well as the consequents of all modes of motion.

"At the same time, it is well to remember that some of the properties of matter are inherent, like gravitation and magnetism; while some are contingent, like opacity and temperature. Inherent qualities are not to be explained like contingent qualities, as depending upon kinds and rates of motion, but rather as depending upon the *nature of the ether* out of which the matter is formed. Such qualities may properly be called physical, even though ordinary mechanical laws are not applicable to them. If life be an inherent quality, it would be as inexplicable as the nature of the ether. Molecular arrangement might determine its manifestation, but not its existence" (p. 297).

At the end of Professor Dolbear's book are notes from seventeen distinguished men of science. Among them is Sir John Burdon-Sanderson, Regius Professor of Medicine at Oxford, whose fame is known to the world as that of an exact scientific observer and discoverer. He says: "In physiology the word life is understood to mean the chemical and physical activities of the parts of which the organism consists."

All the other notes support this view, and they are from the works of W. K. Clifford, C. S. Peirce, George Chrystal, John Fiske, Haeckel, Höffding, Helmholtz, Claus and Sedgwick, Wundt, Huxley, Ray Lankester, G. Stanley Hall, Professor E. L. Mark, Lang, O. Hertwig, and Professor J. S. Kingsley.

Perhaps a stronger agreement on any scientific point could not be found than this, which proclaims that the only reasonable account of living things is that by chemical and physical laws they have originated from those atoms which form inorganic matter.

Mr. J. Arthur Thomson, in his book, *The Science of Life* (pub. 1899), says :—

"In his presidential address to the British Association, 1870, Huxley expressed his *opinion* that, if he could have been a witness of the beginning of organic evolution, he would have seen the origin of protoplasm from not-living matter" (p. 99).

"The *opinion* towards which the majority seem to swing round is that which was expressed with great clearness by Haeckel in 1866, that analogy points to an erstwhile origin of living matter from not-living matter. The botanist C. Von Nägeli, the zoologist Ray Lankester, the physiologist Pflüger, may be mentioned as prominent workers who have more or less fully accepted Haeckel's position" (p. 100).

This evidence, in fact, brings us to a former conclusion, that life is the function of matter, when matter is combined in a certain way and under certain conditions.

So when Mr. F. Wollaston Hutton, F.R.S., says, "Now, in the origin of living substance on this planet we have a case which is *generally recognised* as a break in continuity," he either unconsciously or wilfully misrepresents the case, as do many others who make the same statement.

Opinion may long remain divided on this point, but the Evolutionist has no room for "a break in continuity," and if living things did not evolve in some such way as Spencer, Haeckel, and Pearson have shown, then Evolution would be a broken system and of little value.

"He that hath eyes to see, let him see."

The earnest student will find thousands of other facts and reasons, besides those given in this book, to enable him to see the length and breadth of the unifying doctrine of Evolution. And by degrees the world will be clothed in new grandeur, and human life will show the possibilities of new beauty and a higher achievement.

To fully grasp the teaching of Evolution is to pass from a condition of helpless isolation to one of universal brotherhood with the universe. Man is no longer to be treated as a solitary, maimed lodger in a world of dust and ashes. But by learning the laws of the universe, and by knowing that he, too, must conform to those laws, he is enabled to march unerringly to the highest goal.

It may be that the dreams of childhood will perish and the idols of youth crumble to dust; but the living truth abides.

Learning that environment is little short of an almighty power, man will also learn to seek the best environment and to shun the worst, and his feeling of brotherhood will prevent him from offering pictures of the ideal to men who are cursed with the squalor of slums and starvation.

Every system of art, of morals, of education, and of religion will have to rise to the plane of the highest—the loftiness of known facts and laws understood, and therefore capable of application.

In this redemption of mankind from the necessary but hideous ghouls of a savage past lies the surest hope of man. At present no man can imagine what human life might become if men were free and reasonable, so that they could pursue truth and righteousness with open eyes and an unterrified conscience.

Our methods of education might become true and scientific, so that instead of wasting the energy of every new generation in learning a few fragments of Greek and Latin, or in asking metaphysical conundrums in the fruitless endeavour to turn ancient assumptions into living facts, we might train an army of men and women to see the laws of the universe, and to reach the highest life in obedience to those laws. This would give us a true Sociology.

Psychology can only be understood when based on Evolution. Only by a knowledge of the lower organisms and by tracing intelligence to its first manifestation can we hope to understand the working of the human brain. The old psychologies are bags of wind anchored to a few assumptions, not one of which can be shown to represent a real existence. And until we have a sound, workable psychology, we look in vain for any great development of intelligence and for any practical system of education.

But perhaps Evolution will confer the greatest benefit on man in the science of ethics. False morals, referred to a false standard, represented as due to false causes, have wrought deadly havoc for thousands of years. But the Evolutionist knows that Ethics are a part of the cosmic process. They are as natural as gravitation. When once we realise this, we shall begin to look for the facts and laws of true morality, and not waste our time in trying to paint the dreams of other men on the living tissues of every generation.

But better days and the higher life await us. Even in art, education, ethics, and systems, the survival of the fittest prevails, and a new order of life of greater stability, reason, co-operation, and refined sympathy will yet become the common heritage of the race. Man does march from his savage past, and, as surely as he has learnt to omit cannibalism from his banquets, so surely will he attain to a life of justice and brotherhood.

Meanwhile we, who weep at the self-inflicted miseries of man, rest in sure and certain hope that no force and no combination of forces can stop that process of Evolution which from a speck of jelly has developed such living forms as Charles Darwin and Herbert Spencer, and which has produced the beauty of the earth and the heavens from formless ether.

INDEX

THE following books should be asked for in all free libraries, if the student cannot purchase them :—

	£	s.	d.
EDWARD CLODD'S *Story of Primitive Man* ...	0	1	0
,, ,, *Pioneers of Evolution*	0	0	6
,, ,, *Childhood of the World* ...	0	5	0
GRANT ALLEN'S *Story of Plants*...	0	1	0
The Story of Birds	0	1	0
HERBERT SPENCER'S *First Principles*	0	16	0
,, ,, *Principles of Biology* (2 vols.)	1	14	0
DARWIN'S *Origin of Species*	0	1	0
,, *Descent of Man*	0	2	6
Life of Charles Darwin, by Francis Darwin ...	0	2	6
HUXLEY'S *Man's Place in Nature*	0	5	0
,, *Lectures and Essays* (Selected) ...	0	0	6
HAECKEL'S *Riddle of the Universe*	0	0	6
,, *Last Link*	0	3	6
GEDDES' and THOMSON'S *Evolution of Sex* ...	0	3	6
THOMSON'S *Life*	0	2	6
BALL'S *The Beginning of the Earth* ...(about)	0	7	6
DOLBEAR'S *Matter, Motion, and Ether* ...(about)	0	3	6
KARL PEARSON'S *The Grammar of Science* ...	0	7	6
Zoology: any good text-book, as NICHOLSON'S, or SHIPLEY and MACBRIDE'S, or the one by WELLS and DAVIS.			
MITCHELL'S *Elements of Biology*	0	6	0
T. J. PARKER'S *Elementary Biology*	0	10	6
G. MASSEE'S *Evolution of Plant Life* (lower forms)	0	2	6
FOSTER BALFOUR'S *Embryology*...	0	10	6
WIEDERSHEIM'S *Comparative Anatomy of Vertebrates* ... ... (net)	0	12	6

EXPLANATION OF WORDS.

[In the following list, G. means that the word comes from the Greek, and L. means that the word is from the Latin.]

ABDOMINAL (adjective from abdomen, L. *ab-do*, to put away): Applied to the belly, generally to all the part below the ribs.

ALIMENTARY CANAL (L. *alimentum*, nourishment, food): The whole passage, from the mouth to the vent, in which food is digested.

ALLANTOIS (G. *allas*, a sausage, and *eidos*, form): So called because it is like a sausage in shape. It is a bag of membrane developed from the hinder part of the alimentary canal in the embryos of reptiles, birds, and mammals.

AMŒBA, or AMEBA; plural, AMŒBÆ (G. *amoibē*, change): This little body of protaplasm is so named because constantly changing its form. The amœba is a small animal and is a species of rhizopod, one of the lowest animal forms.

AMNION (G. *amnos*, a lamb; *amnion*, a little lamb): So called probably on account of its form. It is a bag containing fluid, developed round the embryo, called the "bag of waters," found in reptiles, birds, and mammals. All animals which develop this sac as they grow are called *amniote* animals.

ANCHITHERIUM (G. *anchi*, near, and *thērion*, a wild beast): The name given to a fossil animal which seems to connect the early form of the horse with other classes.

ANTHROPOID (G. *anthrōpos*, man, and *eidos*, form): Applied to the higher apes whose form resembles the human.

AORTA, plural AORTÆ (G. *aortē*, from *aeiro*, to raise): The great vessel (artery) which in man circulates the blood containing oxygen to all parts of the body except the lungs.

AORTIC (adjective from aorta): Belonging to the aorta. *Aortic arches* are the vessels which carry the blood to the branchiæ (gills) of fishes. These arches are found in the embryos of mammals at a very early stage.

APTERYX (G. *a*, not, and *pteryx*, wing): A New Zealand bird (kiwi) with small, undeveloped wings.

ARCHÆOPTERYX (G. *archæo*, old, and *pteryx*, a wing, from *petomai*, to fly): A fossil bird.

ARITHMETICAL INCREASE (G. *arithmos*, number): Increase by any constant sum being *added*, as 2, 4, 6, 8, 10; geometrical increase is *multiplication* by any constant sum, as 2, 4, 8, 16.

ARTHROPODA (G. *arthos*, joint, and *podes*, feet): The class of creatures with jointed limbs, as crabs and spiders.

ARTICULATA (L. *articulatus*, jointed): A term often used in place of *arthropoda*.

BALANO GLOSSUS (G. *balanos*, acorn, and *glōssa*, the tongue): The acorn-worm.

BIMANA (L. *bis*, in a twofold manner, and *manus*, a hand): Meaning two-handed. An old term for the division of animals including only man.

BRACHIOPODS (G. *brachus*, short, and *podes*, feet): A class of marine Mollusca, or soft-bodied animals, furnished with a bi-valve shell. They are usually found attached to some sub-marine object.

CAMBRIAN (literally, belonging to Cambria, or Wales): In geology, a bed of very ancient rocks, lying immediately below the Silurian.

CARPUS (G. *karpos*, wrist): The wrist, having eight small bones in two rows. META-CARPAL BONES are the long bones in the back of the hand, between the wrist and the knuckles.

CAUDAL (L. *cauda*, a tail): Of, or belonging to, or near to the tail.

CEPHALOPODA (G. *kephalē*, head, and *pous*, a foot): The highest division of Mollusca, containing such creatures as the cuttle-fish and nautilus. They are distinguished by having the mouth surrounded by fleshy arms, or tentacles.

CILIATE, CILIATED, CILIARY (L. *cilium*, eyelid): Furnished with, or pertaining to, CILIA, which are small (generally microscopic), hair-like, and vibrating appendages.

CLOACA (L. *cloaca*, a sewer): The common chamber into which open the ends of the alimentary canal, the urinary organs, and the reproductive organs, in the case of some animals, such as fowls.

CŒLENTERATA (G. *koilos*, hollow, and *enteron*, intestine, from *en*, within): A branch of animals with a hollow in the entire interior of the body. This hollow has to do the work of circulation and digestion. Corals and jellyfish are of this order.

COMPSOGNATHUS (G. *kompsos*, pretty, *gnathos*, jaw): A reptile with a beautiful, bird-like head.

CRETACEOUS (L. *creta*, chalk): Chalky; in geology, rocks belonging to the latest group of the reptilian age.

CRYSTALLINE LENS (G. *krystallos*, a crystal, from *kruos*, frost; L. *lens*, a lentil). A doubly convex clear body in the eye behind the iris, by which the rays of light are focussed upon the retina.

DEPOSIT (L. *depositum*, from *depono*, to lay down): Matter settling or settled, as a deposit of clay, a vein of ore.

DIGIT (L. *digitus*, a finger): A finger or a toe.

DIMORPHISM (G. *di*, two, *morphe*, form): In zoology, difference in form, colour, etc., marking off two distinct types of the same species.

DIŒCIOUS (G. *di*, two, and *oikos*, house): Having the male and female organs borne by different individuals.

DOGMA (G. *dogma*, opinion, from *dokeo*, to think): A doctrine adopted and asserted on authority.

DORSAL (L. *dorsum*, back): Of, or belonging to, the back.

ECHIDNA (G. *echidna*, adder): A porcupine ant-eater in Australia.
EOCENE (G. *eos*, dawn, *kainos*, new): In geology, the earliest period of the tertiary age.
EOHIPPUS: *See* Hippus.
EPIDERMIS (G. *epi*, upon, *derma*, skin): The thin outer skin.
EXTRINSIC (L. *exter*, outside, and *secus*, beside): Being outside—not included in a thing.

FORAMEN (L. *foro*, to bore): An opening or hole. Foraminifera form an order of rhizopods, so called because they bear a shell full of small holes.
FOSSIL (L. *fossa*, ditch, from *fodio*, to dig): Any organic body which, by being buried in deposits, has been preserved. Literally, a thing dug up.

GANGLION (G. *ganglion*, a tumour; plural, *ganglia*): Any nerve centre—an enlargement consisting of many nerve cells.
GEOLOGY (G. *gē*, the earth, and *logos*, a word, reason, science): The natural science that treats of the structure and constitution of the earth.
GEOMETRICAL INCREASE (G. *gē*, the earth, and *metron*, a measure): *See* Arithmetical increase.
GESTATION (L. *gesto*, a frequentative verb of *gero*, to carry): The act of carrying young—pregnancy.

HELIOTROPISM (G. *hēlios*, sun, and *tropos*, turn): The chemical change which causes plants or animals to turn to the light.
HIPPUS (G. *hippos*, a horse).
PLIO HIPPUS: The pliocene hippus.
PROTO HIPPUS (G. *protos*, first): The lower pliocene hippus.
MIO HIPPUS: The miocene hippus.
MESO HIPPUS (G. *mesos*, middle): The lower miocene hippus.
ORO HIPPUS (G. *oros*, a mountain—refers to the Rocky Mountains): The eocene hippus.
EO HIPPUS (G. *eos*, dawn): The lowest eocene horse.
HOMOLOGOUS (G. *homos*, same; *logos*, word): Having a similar structure—of the same make-up.
HUMERUS (a Latin word): The bone of the upper arm, or fore limb, from the shoulder to the elbow.
HYBRID (L. *hybrida*): The offspring of the union of two distinct species.

INFUSORIA (plural of infusorium, from L. *infundo*, to infuse or pour in): Very small animals which occur in infusions of decaying substances. They are divided into several families.
INSECTIVORA (L. *insectum*, an insect; *voro*, to devour): Animals such as shrews, moles, and hedgehogs, which eat insects.
INTRINSIC (L. *intrinsicus*, from *inter*, within, and *secus*): Real; belonging to the nature of a thing or person.
IRIS (G. *iris*, a rainbow): A thin coloured curtain stretched across the aqueous chamber of the eye, in front of the crystalline lens, having an opening which can contract, called the pupil. When we speak of grey eyes or blue eyes we refer to the iris.

JURASSIC (literally, of or belonging to the Jura mountains): In geology, the Jurassic period is the middle age of the Mesozoic, between the Triassic and the Cretaceous.

LARVA (L. *larva*, a ghost, spectre, pl. *larvæ*): The first condition of an insect at its issuing from the egg, usually in the form of a grub or caterpillar.

LAURENTIAN: Applied to a group of extremely ancient rocks, very greatly developed along the course of the St. Lawrence river, from which the name comes. The Laurentian hills, along the line of division between Canada and the States, were the first portion of the American land lifted above the ocean. They are the oldest rocks immediately below the Cambrian, and contain no fossils, unless the doubtful Eozoon Canadense is of organic origin.

LEGUMINOSÆ (L. *legumen*, from *lego*, to gather): An order of plants, represented by peas, beans, and lentils.

LENS: *See* Crystalline.

MANDIBULAR (L. *mandibula*, jaw): Of, pertaining to, or formed by, the mandible, or lower jaw.

MEMBRANE (L. *membrana*, pl. of *membrum*, a member): A thin sheet-like structure, connecting other structures, or serving to cover or line some part or organ.

METACARPUS: *See* Carpus.

METATARSUS: *See* Tarsus.

MESOHIPPUS: *See* Hippus.

MIOCENE (G. *meion*, less; *kainos*, recent): Applied to rocks belonging to the middle of the Tertiary period.

MIO HIPPUS: *See* Hippus.

MOLLUSCA (L. *molluscus*, from *mollis*, soft): Animals with a soft body and usually a shell, as snails, whelks, oysters, and cockles.

MUSCLE (L. *musculus*, a little mouse, from *mus*, a mouse): An organ composed of contractile fibres.

NEURAL (G. *neuron*, nerve): Of, or pertaining to, the nerves or nervous system.

NEUTERS (L. *ne*, not, and *uter*, either): Organisms not belonging to either sex—neither male nor female. Among social insects, as ants and bees, the neuters are imperfectly developed females, and as they have the work of the hive to perform, they are often called "workers."

ŒSOPHAGUS (G. *oisophagos—oiso*, from future of *phero*, to bear, and *phagein*, to eat): The part of the alimentary canal between the pharynx and the stomach, commonly called the gullet.

ORIENTATION (L. *orientalis*, from *oriens*, rising, *orior*, to rise, as the sun): Orient means the East, and orientation is the building a church upon an East to West line; so it comes to mean generally the act of correcting one's conception of an object.

ORIFICE (L. *os*, *oris*, a mouth, and *facio*, to make): A small opening—a vent.

ORNITHORHYNCUS (G. *ornis*, gen., *ornithos*, a bird, and *rhyncos*, snout, beak): The duck mole of Australia, which is bird-beaked.

OROHIPPUS: *See* Hippus.
OSSEOUS (L. *os*, bone): Bony.

PALEONTOLOGY (G. *palaios*, ancient, *ontos*, being, *logos*, science): The science of ancient living things, or of fossil organisms.
PERICARDIUM (G. *peri*, about, and *kardia*, heart): A membranous bag that surrounds and protects the heart.
PERMIAN (at first referring to the district of Perm, in Russia): In geology, applied to the uppermost division of the rocks called Paleozöic.
PHARYNX (G. *pharynx*, throat): The part of the alimentary canal between the palate and the œsophagus, serving as an air-passage to the larynx in addition to being a food passage to the gullet.
PITHECANTHROPUS ERECTUS (G. *pithēkos*, ape, *anthropos*, man, and L. *ērectus*, upright): The name given to the Java man, meaning the ape-man with erect walk.
PLIOCENE (G. *pleion*, more, *kainos*, recent): The latest division of the Tertiary period.
PROBOSCIS (G. *proboskis*, from *pro*, before, and *bosko*, to feed): A prolonged, flexible snout, of which the elephant's "trunk" is a good example.
PROGENITOR (L. *progenitor*, from *pro*, before, and *gigno*, to beget): An ancestor in the direct line.
PROGNATHOS (G. *pro*, before, and *gnathos*, jaw): Having the jaws projecting forward, as in the Australian and some African races, and still more in the case of apes.
PROTOTYPE (G. *protos*, first, and *tupos*, type): A first form, or rude and general design, to which later forms are traced.
PROTOZOON (G. *protos*, first; and *zoon*, animal): A member of the lowest division of the animal family. The plural is PROTOZOA.
PTERODACTYLE (G. *pteron*, wing; and *daktylos*, finger): An extinct flying reptile.
PSEUDOPODIA (G. *pseudēs*, false, and *podion*, little foot): A plural word, meaning processes formed by the temporary extension of the protoplasm of a cell.
QUADRUMANA (L. *quadru* or *quadri*, from *quattuor*, four, and *manus*, a hand): The group of animals which can use hands and feet for climbing, as if they had four hands. The term is misleading, as these animals (monkeys and apes) have two hands and two feet. The word is neuter plural.

RADIUS (a Latin word, pl. *radii*): In biology, that one of the long bones of the forearm which is on the same side as the thumb.
REACTION (L. *re*, back, or again, and action): In chemistry, this signifies the mutual action of chemical agents, or some distinctive result of such action, as the appearance of a precipitate.
REFLEX ACTION (L. *re*, and *flecto*, to bend): An action produced by the transmission of an impulse to a nerve centre and its return action independently of the will. As Professor Loeb says, "The passage of an impulse from the stimulated part to the central nervous system, and back again to the peripheral muscles, is called a reflex."

RETINA (L. *rete*, a net): The inner coat of the eye, containing the nervous apparatus essential to vision.

RHIZOPOD (G. *rhiza*, root, and *pous*, foot): A member of the rhizopoda, a division of protozoa including foraminifers, amœbas, etc.

SQUAMOSAL (L. *squama*, a scale): Like a scale—applied to a thin plate of bone, especially to the thin plate of the temporal bone. Squamoso-mandibular means pertaining to this squamosal bone and the lower jaw.

SACRAL (L. *sacra*, sacred): Of or belonging to the sacrum, the lower part of the vertebral column, which used to be offered in sacrifices, and so came to be regarded as sacred.

SALAMANDER (G. *salamandra*): A lizard-like amphibian, with a tail, but without scales.

SCUTIELLA (a Latin word, pl. *scutellæ*): A small shield or plate, the name being applied to the broad scales on the legs of birds.

SEBACEOUS (L. *sebum*, suet) GLAND: A small sac-like gland secreting an oily substance.

SEMI-HUMAN (L. *semi*, half): Half-human.

SEMI-LUNAR FOLD (L. *luna*, the moon): A fold in the living membrane of the eye, near the inner angle of the eyelids, in shape like a half moon.

SEROLEMMA (L. *serum*, whey): The outer sheet of the amnion.

TARSUS (G. *tarsos*, any flat surface): The ankle. It consists, in man, of seven bones. See fig. 10 of the foot. The METATARSUS is the part between the ankle and the bones of the toes.

TERTIARY (L. *tertius*, third): In geology, applied to the bed of rocks between the Mesozoic (formerly called Secondary) and the Pleistocene (or Quaternary) formation.

TRIASSIC (G. *trias*, the number three): Applied to the lowest division of rocks of the Mesozoic era, underlying the Jurassic.

ULNA (Latin word meaning elbow): That one of the two long bones of the forearm, which is on the same side as the little finger.

VENTRAL (L. *venter*, belly): Of or belonging to, or on or situated near, the abdomen or belly.

VERMIFORM APPENDIX (L. *vermis*, a worm): A worm-shaped body, which is slender, hollow, and closed at one end, attached to the end of the caecum in man and some other mammals. The caecum is situated between the large and small intestines and is open only at one end. (L. *caecus*, blind).

VISCERA (a Latin word, plural of *viscus*): The organs of the great cavities of the body (the belly, the chest, and the head), such as the stomach, lungs, and brain.

VITREOUS BODY or HUMOUR (L. *vitrum*, glass, from *video*, I see): The jelly-like mass that fills the ball of the eye.

ZOOLOGY (G. *zoon*, animal; pl., *zoa*; from *zao*, I live): The science which treats of animals—a branch of biology.

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