# CHAPTER I.

Definition of "Natural History" and "Biology"—Relations of the Organic and Inorganic Series—Classification of the Natural Sciences—Characteristics of Organic and Inorganic Objects—Form—Chemical Composition—Intimate Structure—Mode of Increase—Cyclical or Periodic Change.

THE term "Natural History," used in its widest significance, has hitherto been employed to designate that department of scientific inquiry which deals with the structure and relations of the objects which exist in the world around us, and of which, indeed, the universe itself is composed. But a very little consideration will at once show us, that the term so employed has a decidedly compound nature, in that it may be said to embrace or include several distinct and individual sciences. Thus, in one way, by the name "Natural History" we may collectively designate the kindred sciences of Botany and Zoology; or we may employ the term as merely synonymous with the last-mentioned branch of inquiry; or lastly, and in its wider meaning, we may speak of "Natural History" as including the sciences of Zoology, Botany, and Geology, together with other and allied departments of science.

Of late years, however, important, and at the same time beneficial, changes have been wrought in the nomenclature of the "Natural" sciences, and a new term, that of "Biology," has been introduced into the terminology just referred to. This latter name—"Biology"—may be correctly enough translated by the words "Science of Life," or of "Living Beings;" and whilst it thus includes several departments formerly recognised under the term "Natural History," its meaning is obviously more

restricted and defined than that of the older name or expression.

But although the term "Natural History" has, in this way, been broken up, and although its former significance is almost entirely lost, yet, scientifically, the name is still used to conveniently express and include all those departments of inquiry which investigate the relations of "Natural" objects; and, employed in this latter and extended sense, it therefore includes many branches of inquiry which formerly lay beyond its meaning and import. This more recent arrangement will be presently noticed when treating of the classification of the various departments of Natural Science, but these preliminary observations will serve to impress on the minds of beginners the altered relations of this constantly recurring term.

The aim and scope of that department of scientific knowledge known as "Biology," is therefore the investigation, in its fullest sense, of *living* beings in all their relations, whether to each other, or to the objects by which they are surrounded. The term—derived from the Greek, *bios*, life, and *logos*, a discourse—sufficiently explains itself, and it will require but little thought to perceive that the wider name and science of Biology includes the two great provinces of inquiry which deal with the corresponding series into which living beings are divided. As the youngest and least erudite amongst us knows, the Animal World on the one hand, and the Plant World on the other, are the provinces or series referred to; and the sciences of Zoology and Botany could also be readily suggested, as those which investigate for us the respective details of animal and plant existence.

Hence the "Science of Life," or "Biology," includes the two sciences of Botany and Zoology. But as we gaze on the external world, we find that a complete and thoroughly comprehensive view of the wide field of Nature would necessitate our recognition of a third group of objects, in addition to the two groups we have already perceived. This third group embraces objects devoid of

life, and for these we employ the general term "Minerals;" and the Mineral Kingdom, therefore, forms the third of the great Natural Kingdoms which, from our earliest years, we have been accustomed to recognise.

Beyond this primary classification of natural objects, however, a further division has to be noticed. In speaking of these objects we are accustomed also to recognise their division, according as they are living or lifeless, into two "Series," known as the "Organic" and "Inorganic" series. And these latter are terms, with the meaning of which it will be advantageous for the student to become acquainted. By anything being "Organic," we broadly understand that it possesses life, or is alive; whilst an "Inorganic" thing, on the contrary, is one which is lifeless, or destitute of vitality. Thus the "Organic Series" includes the animal and plant worlds; whilst the "Inorganic Series" contains the mineral world, and all objects destitute of life. It is therefore the province of Biology to investigate the relations of the Organic Series; the consideration of the Inorganic Series falling to the lot of the Chemist, Mineralogist, Natural Philosopher, and Geologist.

The following table may serve to render clear the arrangement which has just been detailed:—

| Divisions of Natural Science or History. | Division of Natural Objects. | Primary Divisions, or "Series." |
|---|---|---|
| Biology ("Science of Life") includes | I. Animal World (Zoology)<br>II. Plant World (Botany) | These forming the Organic Series. |
| Mineralogy, Chemistry, Natural Philosophy, and Geology, include | III. Mineral World | This forming the Inorganic Series |

Although, as implied by the term Biology, our con-

siderations are to be devoted to an examination of the principles on which the study of living beings is conducted, yet we cannot, at the present stage, leave the inorganic series wholly out of consideration. At the outset of our studies a few questions of great interest and importance await us; and even in the case of juniors in the school of natural science, it is neither wise nor right that these questions should be passed over or omitted.

The preliminary questions to which I allude, bear chiefly upon the distinctions which the biologist is led to draw between living and lifeless things, and between animals and plants. And to the popular mind the thought of the actual necessity for drawing such distinctions, may, and not inaptly either, suggest itself. "Why," it may be asked, "do we require to draw and define lines of demarcation between living and lifeless things, or, for that matter of it, between animals and plants?" But, on the other hand, it is the province of a true scientific method to be in every way thorough and exact. And without, at first, perhaps, fully recognising the necessity or importance of clearly understanding the relations between any two groups of objects, yet we must needs have these relations clearly in view; since we may be called upon to discuss questions concerning such relations, and the correctness of our judgment and reasoning will most surely depend on the estimate we have previously formed of them. This holds particularly true of the relations between the animal and plant worlds; the scientific observer, as we shall hereafter see, setting at nought most, if not all, of the means and ways by which the ordinary or unscientific observer would seek to separate the one great group of living beings from the other.

The differences or distinctions which the biologist is led to draw between organic and inorganic things are included under the five heads of—(1.) *Form;* (2.) *Chemical Composition;* (3.) *Intimate Structure and Arrangement of Parts;* (4.) *Mode of Increase;* and (5.) *Cyclical or Periodic Change.* To the consideration of each of these points, therefore, we may devote a little attention.

Firstly, then, living bodies are distinguished from lifeless or inorganic bodies, by differences in *Form* or *General configuration*. Inorganic things may be destitute of any distinct or definite shape, in which case the term "amorphous" is applied to them. Their form may, in some instances, be inappreciable at first sight, but generally, and without much trouble, inorganic things are ascertained to be bounded by straight lines and by plane surfaces. If we select a crystal of any kind as an example of an inorganic body, we can readily enough admit the truth of the definition just given. Its facets and angles offer definite points of arrangement; its boundaries are straight lines, and its surfaces are plane or flat surfaces.

A living body, on the contrary, is generally bounded by curved lines, and by convex or concave surfaces; or, if we care to extend the definition, we may use the words "irregular surfaces," as serving to include those living bodies, which may seem to fall without the boundaries of a definition savouring of the strictly mathematical kind. At any rate, there is little chance of confusing the outline of the living organism, with the generally mathematical boundaries of the inorganic body.

Look at the body of a horse, for example, or of a fish; or extend your glance throughout the wide area of either plant or animal life, and notice how form and symmetry partake of the curved outline. Indeed, so accustomed have our ideas and thoughts come to be associated with symmetry, that we describe the "line of beauty" as a curve; and in the shape and symmetry of animal or plant form, we rarely or never see a perfectly straight outline, but in its place a graceful curve or undulation.

Then, as this curved condition appears to be invariably connected with the outline of the living organism, so also are the surfaces of the organic body similarly convex or concave. Rarely or never do we see in a living body the flattening and strict planes of the inorganic object; but with wavy curves, and bulgings, and shallows, the symmetry and contour of the living being is at once beautifully and gracefully formed. The foregoing remarks with

regard to form and general configuration must, of course, be held as applying to the living body as a whole, and generally, although not invariably, to its parts also. But in some instances, the terms of the definition would appear to be infringed, as, for example, where mineral concretions are developed, normally or abnormally, in the textures of the living body. Such structures will be found, irrespective of their origin, to present the characteristics of inorganic things. The definition as here employed, however, includes all the essentials for distinguishing, on this first head, between things living and things lifeless.

Secondly, the study of their *Chemical Composition* affords grounds of distinction between organic and inorganic objects. The science of Chemistry deals with the intimate composition of bodies, and in analysing substances of all kinds, the chemist finds that they consist or are made up of a number of bodies which themselves are ultimate, or which, in other words, cannot be split up into two or more bodies of different kinds.

Such ultimate bodies are known as "elements," and of these bodies Iron, Sulphur, Zinc, and Arsenic, may be selected as familiar examples; whilst certain bodies, existing in their single and ultimate state in the form of Gases—such as Oxygen, Hydrogen, and Nitrogen—also fall under the classification of "elements," since they cannot be analysed into two or more gases of different composition.

The information, therefore, which the chemist has to convey respecting the relative composition of living and lifeless things may be generally stated as follows. In inorganic bodies a plurality or considerable number of elements is found, and these elements may exist in the inorganic body, either singly, or in combination with each other, in which latter case they form "compounds." The "compounds" so formed by the union of the elements of lifeless bodies, are not prone to resolve themselves into the individual elements of which they are composed; and lastly, the number of elements in such inorganic "compounds" is never very great.

In living or organic bodies, on the contrary, the chemist finds but few elements; these few, however, rarely existing in their single and elementary state, but generally forming among themselves very elaborate compounds. And in living bodies, as opposed to inorganic things, the chemical compounds are prone to resolve themselves into their respective elements; in other words, the compounds of organic objects are exceedingly liable or predisposed to "decompose." A simple and ultimate fact in the chemical composition of organic bodies, is the invariable presence of water; and this latter fact is not without its due weight and importance, in the face of the considerations which await us, when we discuss the probable nature of life and vitality.

Lastly, it may be a useful fact to bear in remembrance, that the elements Carbon, Hydrogen, Oxygen, and Nitrogen, are the "essential" elements found in the composition of animals and plants. These are so termed from their invariable presence in organic bodies, and in contradistinction to other elements of less frequent occurrence, which latter are accordingly known as "incidental" elements.

Thirdly, in the details of *Intimate Structure and Arrangement of Parts*, we find a further means of distinguishing between the organic and inorganic series. The lifeless crystal, as the type of the inorganic body, presents throughout its substance, when pure, and apart from chemical considerations, a perfect similarity of structure. To use other terms, a homogeneity or sameness of structure is characteristic of inorganic bodies. A bit of chalk, for example, to use a homely phrase, is chalk "all over;" and of a block of coal, a lime crystal, or any other and ordinary inorganised body, the same remark holds good. Nay, if we pulverise our crystal to the finest state of division—so finely, indeed, that the naked eye cannot discern with any degree of precision the separate particles, the microscope will, nevertheless, demonstrate to us that each minute particle or crystal will bear all the essential characters which marked and distin-

guished the entire crystal as a whole. Each particle, in fact, will be the prototype of the mass from which it was derived.

On the other hand, a living body generally consists of diverse or heterogeneous parts. Dissimilarity of structure may be said to characterise the living body, just as a sameness or similarity of structure is characteristic of the inorganic thing. And between the diverse parts of an organic body, that is between the tissues or organs of which it is built up, there exist certain definite and decided relations, evinced and manifested after a defined order or succession. The want of anything in the lifeless body, approaching in nature to such relations, sufficiently indicates the want of parallelism on this special point. In the lower forms of life, it is true, these relations may not be either strongly or appreciably marked; but even in the case of these lowest organisms, their intimate structure, as distinguished from that of the inorganic body, affords perfectly clear and unmistakable grounds of distinction.

Fourthly, the *Mode of Increase*, in the case of a living and of a lifeless body, offers a very marked ground of separation and distinction. A typical example of the mode of increase in an inorganic body is seen in the case of those naturally-formed calcareous or limy pillars which depend from the roof of many limestone caverns, and which are known as "stalactites." Such a pillar, often of very large size, is formed by the slow dripping of water holding in suspension a large quantity of lime. This water percolates through the rocks forming the roof of the cavern, and thus drops on to the floor beneath. As each drop of water trickles slowly downwards, it leaves behind it, and before it drops on the floor of the cavern, a small proportion of its calcareous burden, which thus remains attached to the roof of the cave. Gradually, and as time rolls on, this deposition of lime particles continues, until at length we find a solid pillar-like structure formed, which depends from the roof into the cave below. Or, in a similar manner, we may find that the

water dripping from the roof, or from the "stalactite" itself, on the floor of the cavern, may gradually deposit lime particles, to form in time a pillar springing from the floor towards the roof, and which is known as a "stalagmite;" this latter structure being in every particular, save in position or point of origin, the prototype of the "stalactitic" growth.

How, in either case, has the lime-pillar been formed By what process has the gradual increase in size been carried on? Simply by the slow and gradual deposition of new particles of lime on the outside, or on top of those particles which were already deposited. The process is a purely mechanical one, that of adding to the substance of the stalactite by fresh additions to its outside or external surface; such a process, indeed, as a child endowed with sufficient patience might imitate in the construction of a pillar of clay, by sticking new particles of matter on the top of those which were already placed. Each drop of water, bringing its quota of calcareous matter, left behind a proportion of its burden attached to the already-formed material. The process, therefore, merely demands a certain rough mechanism, and a sufficient period of time. And to this mode of increase, namely by the addition of fresh particles of matter to the external surface, the term "accretion" has been applied.

Contrast now with this state of matters the mode of increase of a living body, and observe the essential and characteristic differences which are at once and readily perceptible. The living body increases in size, or adds to its substance, by absorbing matter from the external world, by receiving such matter into the interior of its body, and by "assimilating" the matter so received—that is, by incorporating the matter with, and converting it into the substance of which its body is composed. As opposed to the process and term of "accretion," the living body may be said to nourish itself and to increase by a process of "intussusception." The lifeless body thus increases from without: the living body is built up from within.

The elaborate processes included under and implied by the terms "assimilation" and "intussusception," are performed by the digestive and absorptive systems of the organism. These special functions, as we shall afterwards see, are as distinctive of the living organism, as we now notice the mere result of their working, to characterise and distinguish the living body. The term "assimilation" therefore, means something more than the mere reception within the body of foreign material. It carries with it the sense and meaning of such matter being further subjected to a process of alteration, of elaboration, and finally of absorption, in a new form into, and incorporation with, the tissues which it is destined ultimately to nourish and support.

Such a process, therefore, so far from being merely or in any way mechanical, is of the kind we ordinarily term "vital;" in other words, the process of nutrition, or that by which a living body nourishes itself, is dependent upon, and follows, the exhibition of those complicated phenomena, which, taken collectively, constitute what we know as "life." And thus the living body alone and truly "grows:" the lifeless or inorganic object merely increases in size. The "growth" of the living organism is thus carried on in virtue of the several actions and phases which are essentially concerned with the elaboration internally of matter derived from the outside world.

Fifthly, and lastly, we may distinguish between organic and inorganic bodies, under the head of *Cyclical or Periodic Change.* Inorganised bodies present in their history no series of defined actions or processes which tend to effect changes or alterations of a similar character in their substance or history. They are, it must be allowed, acted upon by the chemical and physical forces which are everywhere and ceaselessly at work in the universe around us. But within themselves, they possess no source of active or potential change, and are solely and passively acted upon from without.

A stone or boulder, for example, in the centre of a

plain, will exhibit but little change throughout a long course or cycle of years. The rains and frost may effect some alteration in its outward aspect; the chemical action of the atmosphere may affect the constituent parts or elements of which the stone, chemically speaking, may be composed. But beyond these purely physical alterations, the history of the boulder will be one without variation or change. And what is true of the boulder is also true, in a greater or less degree, of every other inorganised body.

Very different, however, is the case of the living being. Its entire existence is made up of changes and alterations. Its entire "life," as we know it, from beginning to end, consists of defined stages, each accompanied by characteristic phenomena, which vary widely in the phases or actions through which they are manifested. From the commencement of its existence, ceaseless action and consequent change are to be perceived as pre-eminently characteristic of the living organism. Its growth, its progress towards structural perfection, its maturity, its decline and decay—are each and all periods and phases, heralded and accompanied by, and manifested through, active and characteristic changes.

Nor less striking are the changes, which, in its relations to physical and chemical forces and laws, the living body presents. The physico-chemical actions, which, unopposed, effect change and alteration on the lifeless or inorganic mass, are made subservient in the living organism to the ends and aims of its existence. The living body has a chemistry and a system of physics peculiarly its own. But further, it may not only be the source of active change within itself, but may also effect changes in other bodies or things. It may be the source of various forms of energy or power, and in this capacity may produce light, heat, or electricity, which in turn may affect either beings similar to itself, or the inanimate and lifeless material by which it is surrounded. It may possess the power of independent motion, and in virtue of this power may move about from place to place, com-

bining thus alterations in texture, form, and substance, with changes in locality or situation.

Nor are the changes which mark the existence of a living being, without co-ordination or arrangement. The definition previously given expressly indicates that the changes are "cyclical" or "periodic" in character; in other words, that they extend throughout a cycle, or recur at regular intervals, or at any rate evince some defined arrangement and order. The changes which mark the living organism are therefore exhibited in a defined order, which bears a certain relation to the successive periods or cycles of which the life of the organism, and that of its fellows, is made up. The phenomena of waste and wear, of nutrition and repair, the phenomena of reproduction and of extermination or "death"—the death of the tissues necessitating tissue-repair by the process of nutrition, and the death of the organism demanding the reproduction of the species—these afford examples of cycles and periods in the life-circle of the living organism, which repeat themselves in due and regular succession.

The entire existence of the organism is merely a period; inaugurated amid change, carried on through changes, and by its termination involving change to itself and to other bodies of like nature. Distinctly then, on this as on the preceding grounds, we may determine very clear points of distinction between the organic and inorganic series.