WHAT ARE ANIMALS AND PLANTS?

THIS question: "What are animals and plants?" is a large question. In order to be able to reply to it we must know both (1) what animals and plants are, as contrasted with substances which are neither the one nor the other; and (2) how animals and plants stand towards each other—their relations and their differences. Only by learning these two things can we possibly know what animals and plants *are*.

The common sense, however, of the overwhelming majority of men will make short work of the first question; they will say: "Animals and plants are *living things*, while all other visible substances are but composed of *dead matter*." Now, we have no quarrel with common sense, we fully accept its dictates, but the patient and admirable researches of generations of men of science, and the speculations of modern philosophers, have made known so many curious phenomena, and have brought forward so many objections, that it is no longer possible for him who would be able to give an account of the belief that is in him concerning the world and its inhabitants, to rest satisfied with such a rough and ready reply.

Similarly, with regard to the second question,—the relations between animals and plants,—most men would, perhaps, reply that "animals are living creatures, which move about, and get their living by the help of their senses, while plants are living creatures devoid of sense and, for the most part, rooted to the ground."

Now, this is really a very good answer, as far as it goes, and truly expresses the distinction existing between the immense majority of the two groups of living things. Nevertheless, here again the discovery of fresh phenomena has brought us face to face with difficulties and puzzles, some of which seem, as yet, insoluble.

To put as shortly as possible what appears to be the outcome of modern scientific progress, it has, on the one hand, served to render more marked the distinction between living beings and creatures devoid of life; while, on the other hand, it has continually made more and more evident that (in spite of the distinctions between most of them) animals and plants form one great whole, and must be scientifically treated together, as well as separately.

Thus, to the two sciences of zoölogy and botany, which refer to animals and plants respectively, we have now added a fresh science, the science of BIOLOGY, which treats of animals and plants taken together, collectively, as forming *one great group*.

That the reader may have some faint notion how vast this great

group is, it may be well hastily to survey the main classes of creatures which together compose it. We think it desirable to do so, because very inadequate images are apt to rise before the minds of most persons unacquainted with natural science, when they use such words as "animals" and "plants," since they naturally think most of those with which they are the most familiar.

Thus, they are familiar with certain beasts, birds, reptiles, and fishes, but know little of the number of them. Of birds, ten thousand distinct kinds are known, and upwards of four thousand kinds of lizards, and sixteen hundred kinds of snakes have been described; while fishes are so rich in species that they probably equal in the number of their kinds the whole mass of beasts, birds, and reptiles taken together!

But such creatures as these form but a very small proportion of all animals. Creatures such as snails and oysters form another vast group, known as "mollusks."

Worms, also, have been formed into a division, so varied in nature and so prodigious in number that their proper classification is amongst the most difficult of zoölogical problems.

The star fishes and their allies constitute another great group, rich both in species and diversities of form.

But the whole of the creatures we have yet referred to, taken together in one mass, are far exceeded in number of species by the class of insects alone, of which one or more are associated with the life of each and every land plant, and probably that of every higher animal also; while closely allied to the insects are the multitudinous tribes of lobsters, shrimps, crabs, spiders, and scorpions.

We have also to take into account those coral animals which have actually built up large tracts of the earth's habitable surface; and besides these, we have their humble followers, the sponges.

All the creatures yet referred to are cognizable by our ordinary senses, but there are, as is commonly known, myriads of kinds, either so small as to be altogether invisible to the naked eye, or else invisible as regards the main points of their structure without the aid of the microscope. All the lowest animals, the bodies of which are not made up of distinct organic substances, or tissues, are called PROTOZOA.

Then, as to plants: besides the families of flowering trees, shrubs, creepers, and herbs, with members of which we unconsciously become more or less familiar, there are a multitude of other families, specimens of which we only see in our occasional visits to the hot houses of our botanical gardens. To these follow the almost numberless kinds of plants which do *not* flower—the ferns, horsetails, grasses, lichens, seaweeds (with their fresh-water allies), and

fungi. Parallel with the microscopic creatures ordinarily classed as "animals," are the microscopic plants, some of which have been, till of late years, the despair of the surgeon, while others are now recognized as, or suspected to be, the cause and origin of the most painful and dangerous diseases.

Multitudinous, however, as is the animal and vegetable life which we have about us to-day, it is but a remnant of that of which this planet has been the theatre; and especially wonderful are the discoveries of fossil remains which have been made in North America, revealing to us the past existence of living forms such as had not been pictured even in the recorded musings of any naturalist. Apart from such wonderful scientific novelties, we have in the ancient chalk cliffs, and the far more ancient coal-fields, abundant evidence of the prodigality and duration of past vitality; the chalk as it were still in process of formation, as the ooze slowly forming in the bed of the Atlantic Ocean; the coal affording evidence that rich vegetable life flourished at a period so remote that, during it, the first appearance of the chalk might have seemed as the dream of an infinitely distant future.

It is this immensely complex mass of living beings which we have to regard, in their totality, as one whole, as well as in their two component groups, if we would know what "animals" and "plants" really are.

But in order that we may learn *what* they are, it will be well first to advert briefly to one or two facts concerning things which are neither plants nor animals, certain facts, that is, about the "*inorganic* world," by which we mean the solid earth with its two envelopes—water and air. All the substances of which this inorganic world is composed are either (1) elements, such, *e. g.*, as the gas oxygen or the metal iron; or (2) compounds of elements, such, *e. g.*, as rust, which consists of oxygen and iron united to form a third substance which is neither the one nor the other.

Very many substances can exist (as water can) in three states, solid (ice), fluid (water), aëriform (vapor).

A solid inorganic substance may be either in the form of crystal (as marble) or not crystalline (as chalk), while having all the time the same chemical composition. Thus both marble and chalk can be resolved into (1) lime and (2) a gas, commonly known as carbonic acid gas, and carbonic acid is again resolvable into (1) oxygen and (2) carbon, or pure charcoal.

The *aëriform* envelope of this planet, that is AIR, is a mixture of the two gases (1) oxygen and (2) nitrogen, with some carbonic acid gas and a certain amount of ammonia and the vapor of water.

Oxygen, itself incombustible, is the great burner or aider of combustion.

Nitrogen is remarkable at once both for its own inertness and for its instability; so that it is an ingredient in all the most explosive compounds, such as gunpowder, guncotton, nitroglycerine and the iodide, sulphide, and chloride of nitrogen.

Of *carbonic acid* there are ordinarily but four cubic feet in ten thousand cubic feet of air; yet so great is the quantity of it contained in the whole atmosphere that there are reckoned to be 371,475 tons of it in the column of atmosphere which extends above each square mile of the earth's surface.

WATER, the earth's *fluid* envelope, consists of oxygen, hydrogen, carbonic acid, ammonia, carbonate of lime, flint (in solution), and sundry salts. It is, as it were, the mother substance of life, both historically and physiologically, and has been a great agent in both the production and the destruction of fossil remains: the first, by its *deposits;* the second, by its *eroding agency.* The Mississippi has formed thirty thousand square miles of deposits, which are in places several hundred feet thick. The Ganges carries down yearly to the sea as much mud as could be carried down by 730,000 ships, each of 1400 tons' burthen. The eroding and destructive agency of water is, on the other hand, notorious.

With these preliminary notices concerning the inorganic or non-living world, we may next review such contrasts as may be drawn between it and the living world, of animals and plants, considered as one whole.

I. Now, in the first place, some inorganic substances are fluid and some solid, some moist and some dry; but every living creature, without exception, is more or less fluid, and composed to a greater or less degree of water, especially its more actively vital or growing parts.

Thus, in the human brain, seventy out of every hundred parts are composed of water, and in the jelly-fish no less than ninety-nine parts out of a hundred are so composed.

II. Many inorganic substances, such as crystals, are bounded by flat surfaces and straight lines, but living creatures have bodies which are bounded by curved surfaces and lines.

III. The chemical composition of inorganic substances is most various; some, like gold, consist of but a single element; others, like water, of two elements; others of several and very different ones.

All living bodies, on the other hand, are of very uniform chemical composition, as they invariably consist of oxygen, hydrogen, and carbon, together with the element nitrogen—the unstable nature of which has already been referred to in speaking of the in-

organic compounds containing nitrogen, which thus seems a fitting element to enter into the composition of anything so prone to change as is living matter.

IV. In every animal and plant these four elements (oxygen, hydrogen, carbon, and nitrogen) unite to form a special substance known as *protoplasm*, of which every living organism is at first entirely composed, while the whole inorganic world is destitute of such material.

This curious substance, while living, has six very remarkable powers:

(1.) A power of internal circulation, or of the movement of various parts of its substance within the whole, unlike anything in the inorganic world.

(2.) A power of contraction and expansion under conditions different from those which contract and expand inorganic substances.

(3.) A power of performing chemical changes and evolving heat more gently and continuously than in the combustion of inorganic bodies.

(4.) A power of converting other adjacent substances into material like itself—into its own substance.

(5.) A power of forming from its own substance substances both different from its own and from substances adjacent to it. Thus it is that since every living creature consists at first entirely of protoplasm, every *other* kind of substance found in every animal or plant comes from protoplasm and is formed by its agency.

(6.) A power of exchanging gases with its environment—notably of absorbing oxygen and giving out carbonic acid.

These exclusively vital powers of living particles of protoplasm give to each whole organism of which they form a part certain further characters by which they all differ from the inorganic world. Thus:

V. Every living creature, whether plant or animal, effects that interchange of gases just mentioned (absorbing oxygen and giving out carbonic acid), that is to say, it respires or breathes—whatever other changes it may effect.

VI. Every living being is a creature requiring food, which it has the power of changing into its own substance, and so, at least for a time, augmenting its size by a process of growth. This growth is not a mere *external* increment, like the growth of a crystal suspended in a suitable medium, but is an augmentation of its intimate innermost substance by what is called *intussusception.*

VII. Every living creature thus grows according to a more or less definite law, from a single, minute, spheroidal mass of protoplasm into that shape and structure which is characteristic of the group to which it belongs.

VIII. In this process each such creature forms certain substances which are *not* protoplasm,—at the very least it forms minute granules which may be fatty or starchy; while, generally, living creatures *do* form the most complex structures, namely, all those found in the animal and vegetable kingdoms—the woods, resins, oils and sugars of plants, and all the varied components of the bodies of animals; this process is known as "*secretion.*"

By this latter process the living world, as one whole, is continually taking matter from the earth's aërial and aqueous envelopes and adding it to the substance of the earth's solid crust. The past effect of this action we see, as before mentioned, in the enormous fields of coal and peat; in the extensive chalk formations and coral reefs (one reef extending for a thousand miles along the coast of Australia, and such structures forming a great part of Florida); in the vast accumulations of fossil remains—evidenced by the fact that the fossil ear bones of whales (a valuable manure) have given rise to a lawsuit, and by the five million cubic feet of shell-sand annually collected on the shores of Devon and Cornwall.

As to the present activity of the vegetable world in this direction, we have but to recollect that the Empire of Brazil is mainly a forest region which may be roughly represented as an equilateral triangle, each side of which is twelve hundred miles long, and that other vast regions of the earth's surface are, like it, clothed not only with herbage, but with teeming vegetable produce of all kinds and dimensions.

Now, if we suppose two-thirds of the earth's dry land to be clothed with only such vegetation as may be estimated to produce an average increase of its substance, amounting to but one three hundred and sixty-fifth part of an inch daily, then we should have freshly formed each year as much vegetal matter as would constitute a cube fifteen miles in extent in each of such cube's three dimensions!

IX. But living creatures not only grow and develop their own bodies; they also reproduce their kind; and this is again an action to which there is nothing comparable or analogous in the whole inorganic world.

Thus every living being may be said to be a creature possessing an innate tendency to undergo a definite cycle of changes when exposed to certain fixed conditions; that is, when supplied with an adequate amount of temperature, moisture, suitable gaseous matter, food, etc. Inorganic and dead substances may tend to undergo a *series* of changes, but such series never constitutes a "*cycle*"—*i.e.*, a series returning to the point whence it set out. We see such a *cycle* of changes in the egg, the chick, the fowl, and the egg again; or the egg, the grub, the chrysalis, the butterfly, and ultimately its

egg; or the seed, the young plant, the mature plant, the flower, the fruit, and the seed again.

Inorganic substances tend simply to persist as they are, and have no definite relations either to the past or to the future. Whence it comes, or what it has been or shall be, is nothing to its present being—which is its *only* being. But every living creature, at every step of its life, regards both the past and the future, and thus lives continually in a definite relation to both these as well as to the present. Every stage of its cycle of life, just because it *is* a cycle, is conditioned by the anterior states which alone have made it possible, and refers to future states for which it is in active preparation. Thus, as it were, at every present moment of its existence, it lives *both* in the past and in the future, a mode of existence which attains its fullest development in the highest living organism—man, the one creature emphatically, because consciously, "looking before and after!"

X. But living creatures present another still more distinctive character, one which is indeed but obscurely indicated in plants, but is very evident in animals. This is *the power of forming habits*, which is itself the sign of the possession of a special *internal spontaneity* in living things, by which they each and all tend to act and to "*react*" *when acted upon.*

For what is a "habit?" A "habit" is not formed by repeated actions, though it may be strengthened and confirmed by them. If an act performed *once only* had not in it *some* power of generating a "habit," then a thousand repetitions of that act would not generate it. Habit is the determination in one definite direction of a previously vague tendency to action. All living organisms tend to act. With them action is not only their nature, 'tis a positive *want.* Moreover, within limits, the powers and energies of living creatures increase with action, and diminish, and finally perish, through repose. Thus the general activity and power of organisms, and also the exercise of this power in definite modes and directions, are facilitated and increased by actions in the very first of which the power of "generating habit" lies hid.

This second, mysterious, internal tendency, as we have said, eminently distinguishes living organisms from all inorganic bodies, and leads naturally to the next point we would refer to.

Closely allied to habit is *instinct*, a power, the presence of which cannot indeed be adduced as a character distinguishing all living beings from bodies devoid of life, but which none the less is so remarkable a property of many animals that it may well claim, *for our present purpose*, to be here briefly referred to in passing.

We have no space here to describe at length examples of animal instinct; we can but very briefly refer to such well-known instances

as the simulated lameness of certain birds, the insects which become quiescent to escape an enemy (what is wrongly called shamming death), and provision for the future, as in the wasp sphex, the carpenter bee and the stag beetle. Certain instincts, however, have a very peculiar significance; such are those by which a grub will repair its injured cocoon or a spider its injured web, and those by which lobsters and crabs, when one of their limbs is injured, will throw off the injured stump as far up as one of its joints, whence alone the limb can again grow forth and be reproduced. Such creatures cannot be supposed to *know* the effect of such spontaneous amputations, and therefore their actions lead us naturally to consider other unconscious organic actions by which lost parts are more or less perfectly reproduced—actions which display a purpose and intention (although unconscious) in a way which resembles nothing in the inorganic world.

In the process of healing and repair of a wounded part of our body, a fluid, perfectly structureless, substance is secreted, or poured forth from the parts about the wound. In this substance small particles of protoplasm, called "cells," arise and become abundant, so that the substance, at first structureless, becomes what is called "cellular tissue." Then, by degrees, this structure transforms itself into vessels, tendons, nerves, bone, and membrane—into some or all such parts—according to circumstances.

In a case of broken bone its two broken ends soften, their sharp edges thus disappearing. Then a soft substance is secreted, and this becomes at first gelatinous, often afterwards cartilaginous, and, finally, osseous or bony. But not only do these different matters arise and develop themselves in such a neutral substance, but very complex structures, appropriately formed and nicely adjusted for the performance of varied functions, may also be developed. Thus a certain railway guard had his arm so injured that he was compelled to have the elbow, with its joint, cut out; but he afterwards developed a new joint almost as good as the old one. In the uninjured condition of these parts, the outer bone of the lower arm—the *radius*—ends above in a smooth-surfaced cup, which plays against part of the lower end of the bone of the upper arm, or *humerus*, while its side also plays against the side of the other bone of the lower arm (called the *ulna*) with the interposition of a cartilaginous surface. The *radius* and *ulna* are united to somewhat descending processes, at the lower end of the humerus, by dense and strong membranes or ligaments. Such was the condition of the parts which were removed by the surgeon. Nine years after the operation the patient died, and the well-known surgeon, Mr. Syme, had the opportunity of dissecting the arm, which in the meantime had served the poor man perfectly well, he having been

in the habit of swinging himself by it from one carriage to another while the train was in motion, quite as easily and securely as with the other arm. On examination Mr. Syme found that the amputated end of the radius had formed fresh polished surfaces and played both against the *humerus* and *ulna* as before, a sort of cartilaginous material being freshly interposed. The ends of the bones of the forearm were again locked in by two freshly formed descending processes of the humerus, and were again joined to the latter by freshly formed strong and dense ligaments. Repairs of injuries of a far more surprising kind are found amongst the lower animals, and repair in the vegetal world is so common that it ceases to excite our surprise. Such unconscious and purposive organic actions are allied to instinctive action, using that term in a wide analogical sense. But *truly* instinctive actions take place IN US at the dawn of life. It is by the aid of such alone that the infant lives. Instinctive also are many of the phenomena of adolescence and those of the earlier years of our own race—for no one can maintain that the first beginnings of literature, art, science, or politics were ever deliberately invented.

How, then, are we to regard that great world of living creatures, both the lower and the higher members of which present phenomena so different from anything to be found in the whole inorganic world? Are, or are not, the bodies of animals and plants vehicles for the exhibition of some force or energy radically different from any to be found in the non-living world about them, or are all their actions to be regarded as only the very curious activities of very complex machines, moved by no other power than such as are inherent in the inanimate matters of this planet? Are we, in a word, to accept a merely mechanical explanation of the universe, or must we demand something more, and if so, what?

To many of our readers it may seem altogether absurd to attempt to explain the phenomena of life in terms of the movements of solid particles. Their common sense revolts at such an explanation, but "common-sense" cannot be allowed by itself to decide any question when an appeal has once been made to the higher tribunal of pure reason, and such an appeal *has* been made.

For there can be no question but that a thoroughly mechanical conception of nature is the scientific ideal of a very large and a very influential school of thinkers, and is the goal towards which they strive—following the footsteps of their great predecessor Descartes. Thus Kirchenhoff tells us that "the highest object at which the natural sciences are constrained to aim, is the reduction of all the phenomena of nature to mechanics." Helmholz has declared that "the aim of the natural sciences is to resolve themselves into mechanics." According to Wundt, "the problem of physi-

ology is a reduction of vital phenomena to general physical laws, and ultimately to the fundamental laws of mechanics;" and Haeckel tells us that "all natural phenomena without exception, from the motions of the celestial bodies to the growth of plants and the consciousness of men . . . . . are ultimately to be reduced to atomic mechanics."

Many, if not most, of the scientific men of our day strongly favor a mechanical explanation of nature, and treat with disfavor, not to say contempt, the conception of a distinct *kind* of energy or a "VITAL FORCE"—a conception which has been maintained by a school of physiologists called on that account "*vitalists*."

Now it is surely not to be supposed that this preference for "mechanism" by so many distinguished men of science can be due to any mere prejudice on their part, or that there are not some good and substantial reasons *why* they should favor it, and yet it is hard to suppose that the common sense of mankind, which has ever opposed the mechanical view, can be entirely due to a mere delusion either, and have *no* solid support from reason!

Let us first for a moment consider what is the aim and end of all physical science. Surely it is to understand the coexistences and successions of natural phenomena in such a way that they can not only be arranged in convenient groups suitable for the limited powers of the human intellect to grasp, but also serve as a basis of scientific prediction—while the coming true of "predictions" which men of science feel justified in making affords a strong ground for believing that the operations which served as a basis for such fulfilled predictions were themselves true.

Thus, as regards the science of astronomy, who does not now see that our conceptions of the motions of the heavenly bodies have been greatly facilitated by the discovery of the law of gravitation? and who does not perceive in the verification of scientific prophecy, by the discovery of the planet Neptune, a signal triumph of modern astronomical science?

Nevertheless, the fulfilment of predictions alone will not always suffice to prove the absolute truth of the views upon which they are supposed to be based, or else the prediction of eclipses by astronomers who followed the Ptolemaic system would have proved the truth of that erroneous theory.

Bearing in mind, however, the aim and end of physical science, let us next glance at the only means which it is in the power of scientific men to use. These means are the employment of present sense-impressions, together with the reproduction in the investigation of groups of past sense-impressions.

All our knowledge is called forth by the play of surrounding nature upon our sense-organs; nor can we imagine *anything* which

we have not previously had sensuous experience of—at least in its elements or component parts.

Again, there is a quality of distinctness and vividness in our sense-impressions. How vague, for example, is our imagination of a perfume, compared with our imagination of a visible triangular figure, or of a cube, or of a ball, held in the hand?

It is especially what is *visible* and *tangible* that comes home most readily to the imagination; vague internal sensations are always described by us in terms of sight or touch. We speak of a "*gnawing*" pain, a "*sharp*" pain, *like a knife*, a "*rough*" taste, and even a "*bright*" intellect, and a "*hard*" heart.

Now, the "explanation" of any phenomenon may be its reference to the causes which produce it; but its "explanation" is very often nothing more than the assigning of some new or unfamiliar object to a class of objects which has already become familiar; and our minds are so formed that they feel an almost inevitable satisfaction in the reference of some object or action, difficult or impossible to imagine, to a class of objects or actions easy to imagine, and this whether or not such reference, when closely examined, turns out to be really justifiable, and therefore truly satisfactory.

Now there is nothing so easy for us to imagine as the motions of solid bodies, phenomena which appeal both to sight and touch. Thus it is that (apart from scientific utilities we shall shortly refer to) "heat," "light," "chemical phenomena," the action of nerves and of brain cells, are apt to appear easier to understand, and to be more or less "explained," when they are spoken of as "MODES OF MOTION."

Nevertheless, such an explanation of the action of living beings is, as we have said, shocking to common sense, and therefore, as has just been mentioned, another force was invented to account for them, and the actions of living beings have been explained as being due to the energizing within them of a "VITAL FORCE."

But the doctrine of the existence of any such force has been more and more successfully opposed by men of science on the ground that (1) living beings are *not* isolated phenomena in nature, but are affected by and react upon all physical forces; (2) that no distinct evidence is forthcoming of the existence of any such "vital force;" and (3) that while the use of such a conception in no way furthers the ends of science, the mechanical conception of nature aids in the discovery of natural laws, and has powerfully helped on the progress of science.

And it is true that living beings are *far indeed* from being isolated; for the life of each largely consists of an interplay between what we consider its own body and environing nature. So intimate, in fact, is the connection between each of us and his environ-

ment, that it is even difficult to determine, in minute detail, the line of separation between the two. Food, even when swallowed, is not yet "the tissue." When digested and entering the absorbents which convey it to the bloodvessels which carry it to the intimate tissues of the body, who can say exactly how soon the foreign body becomes the living being, or precisely when and where it is transformed into our very substance? It is the same with the streams of air carrying inwards the life-sustaining oxygen and outwards the deleterious vapors. By such agencies the outer world blends with us and we with it. Far from finding any such indubitable evidence of the existence of a "vital force," as we have of those phenomena we speak of as "heat," "motion," and "light," each living organism thus viewed purely from the standpoint of *physical science* seems, in the words of a distinguished German philosopher, Lotze, only as a place in space where the matter, the forces and the motions of the general course of Nature meet each other in relations favorable for the production of vital phenomena. These phenomena excite our admiration, as do the phenomena of heat and pictorial transmission in that part of space near a lens which is called its "focus." Yet the phenomena of the focus are not explained by any peculiar force common to all "foci" (and so comparable with the agency of "vital force"), but are scientifically accounted for by light and the agencies of media of different densities, through which it is said to be transmitted.

The life of an organism may be compared (*from the physical science point of view*) to the quiet light of a wax candle which seems, to the uninstructed observer, to be the simple action of what he calls "fire," while to the man of science it is a most complicated series of changes, chemical and physical—oxygenation, decomposition, the formation of water, capillary attraction, etc., etc., all of which must be taken together to explain by their diverse simultaneous activities, the apparently simple effect.

But not only is the existence of a diffused "vital force" not demonstrable, and not only do men of science yield to a general tendency of human nature in imaging forth the world's activities generally, in terms of moving matter; but they very properly advocate the use of a means which experience has shown them to be most efficacious for their own legitimate end, which is the progress of physical science. The wonderful discoveries which modern research has made, have been made, not by investigating the ebb and flow of an imaginary "vital force," but by the application to the study of living nature of the previously ascertained laws of chemistry and physics. The discovered laws of the phenomena of digestion, of respiration, of the circulation of the nutritive fluids, etc., are all instances of the successful application of

physics to the investigation of the phenomena of life. To that fruitful source alone we have also to look for the remedies of the physical ills of bodily life, for the perfecting of the trained skill of the physician, as well as, and no less than, that of the more obviously mechanical art of surgery.

Physical science can repose upon and appeal to nothing but things evident to the senses. It is thus compelled to make use of a mechanical imagination of nature, and no blame can therefore attach to physicists who regard this as their *practical* ideal, and attend exclusively to the physical forces, disregarding that discredited figment termed "vital force."

Should we, then, really accept the mechanical theory of the universe as an ABSOLUTE TRUTH? and are we to regard the world of animals and plants as presenting no really *essential* difference from that of the inorganic world?

We are far from thinking men *are* compelled to do this, and we will endeavor briefly to give our reasons why we think men are *not* so compelled.

Physical science is great, but it is not everything; and it cannot, by its very nature, be supreme. It essentially reposes upon our sense-perceptions, but it is not "*sense*," but "*intellect*" which is and *must* be supreme in us. It is not "*sense*," but "*thought*," which tells us that we have sense-perceptions at all, and which criticises them and makes use of them. They are the indispensable servants of our intellect, without them it cannot move a step, but they are none the less its *servants*. Though we can have no imagination, and therefore no thoughts, till our minds are roused to activity by the action of the world about us on our sense-organs; though we can imagine nothing of the elements of which we have not had sensuous experience, nevertheless we gain *through* the ministry of sense that which is *not* sensuous, but which regulates our every thought and rational action. The great principle, called *that of contradiction*, which lies at the root of our intellectual life—the principle that *nothing can, at the same time*, "*be*" *and* "*not be*," may be taken as the type of conceptions which are gained *through* sense, but are not *of* sense.

Reason in man is supreme; and it relates to those first principles which have been recognized by one of our greatest living physicists as "*underlying all physical science*." Great, therefore, as may be the *utility* of a mechanical view of nature, fully justified as men of science are in making use of it, and advocating its use for their own ends, it by no means follows that we should regard this useful working hypothesis as the *very truth!* We should or should not so regard it according as it may appear when viewed,

not in the light of physical science, but in that of philosophy, which is the *judge of physical science*.

Here, then, we may return, for a moment, to the consideration of nature as the arena for the play of forces, whether "physical" or "vital."

It is, as we know, the scientific fashion of the day (and a *practically* useful fashion) to regard the phenomena of living beings as "physical," and to also consider the various physical forces, heat, light, chemical affinity, etc., as so many *modes of motion*.

But when we raise ourselves above the horizon of physical science to the broader outlook of philosophy, can we then regard this practical reduction of all things to "motion" as really an explanation?

We have freely conceded that "vital force" is a figment, but what are we to say of heat, light, and motion also? Are *they* realities?

In fact, they are in *themselves* nothing more than abstractions of the mind. There is no such thing as "heat," or as "motion;" though, of course, there are numberless warm bodies of different temperatures, while as to the quality "moving," nothing, so far as we know, is absolutely at rest. But they are commonly spoken of as if they were *not mere qualities of bodies*, but actual *substances*, which may pass from one body into another and mutually transform themselves. To explain the phenomena of living beings, then, by "mechanical motion," however practically convenient for the investigation of physical science, is, from the point of view of pure reason, a philosophical absurdity. It is an attempt to explain them by a nonentity—a mental abstraction from a certain quality found in things. Moreover, as living creatures make known to us various *different* "qualities," to attempt to explain them all by different *quantities* of *one only quality* is an attempt to extract the category of QUALITY out of the category of QUANTITY, which every one at all versed in philosophy will recognize as a self-evident absurdity.

Please recollect that we are in no way objecting to the use of such conceptions as that of the "transformation of force" for the purpose of aiding calculations and for general advance in physical science; we only object to the incautious use of such language as may lead persons to believe that "forces" are *substances*, or to the notion that such conceptions are really profound truths; as if we really knew physical motion better than we do thought or will.

What essential distinction, then, does there remain to draw between living beings and beings devoid of life? There remains that distinction which was drawn more than two thousand two hundred years ago by the greatest of philosophers, and which has the advantage of agreeing with what common sense tells us to-day.

It is the view that each living being, in addition to possessing those properties of which the senses inform us, also possesses, or rather IS, a unifying principle, "*a principle of individuation*" which altogether escapes the cognizance of our senses, though reflective reason agrees with common sense in assuring us that it is by it that an animal concentrates into one mental centre the multitude of impressions made simultaneously and successively upon its various organs of sense.

This view, at once popular and philosophic, has of late years received a remarkable adhesion from one who has been amongst the foremost advocates of a mechanical conception of nature. We refer to the German philosopher, Hermann Lotze, a man free altogether from theological or other prejudices or prepossessions. Moved alone by a profound and patient exercise of his reason, he has come to enunciate in the most uncompromising way that view (so long ago maintained by Aristotle), the existence in each living being of a "Psyche"—a term most difficult to render into our own tongue because of the misleading connotation of the word "soul," which is its nearest English equivalent.

The existence of such an internal principle *in ourselves*, is the most certain object of all knowledge. It is conceivable that we may doubt as to the existence of our body, but it is absolutely impossible to doubt the existence of a something which is actually thinking and feeling, and which recollects more or less of its own past. This knowedge, as to our own nature, enables us to conceive the existence of a principle of individuation in other living beings, though we can never *imagine* such a thing, which, as Lotze says, is as impossible as to know *how things look in the dark.*

The recognition of the existence of this principle, however, is a matter of philosophy, or pure science, and not of mere physical science, which must ignore it, since it cannot rise to its recognition without going beyond its own province, which is nature, as cognizable to us in and by our senses.

Nevertheless, physical science may serve to confirm the teaching of philosophy, inasmuch as the whole tendency of modern researches is to show that living creatures do not arise except from antecedent living creatures and refutes the notion of "spontaneous generation." We have no disinclination to believe in spontaneous generation; we confess, it has been with reluctance that we have found ourselves forced by experimental evidence—especially by the evidence adduced by M. Pasteur, to whom we are all so greatly indebted—to reject all belief in it.

According to our present knowledge, then, a great gulf yawns between the living world and the world devoid of life—a gulf which nothing we can imagine seems capable of bridging over. It is true

that certain physicists think that though spontaneous generation cannot take place *now*, it must have taken place a long while ago; but if asked *why* they think this, they have no reply but that they cannot otherwise imagine how living creatures could have ever come to be! But we have had no experience of creatures "coming to be." No wonder, then, if we cannot imagine it; for we can imagine nothing of which we have not had sensuous experience. The wisest course, I venture to think, is at present to say that physical science affords us no ground for affirming anything one way or another about the mode in which living things came to be, though it affirms the *fact* that all our experience is against the *spontaneous* origin of *living things*.

If this conception, that the essential, intimate nature of living things is something beyond the reach of the senses, commends itself, on reflection, to the reader's reason, he will then see how pregnant with true philosophy, and how essentially sufficient, is the popular, common-sense reply to the question, "What are animals and plants?" namely, the answer that "they *are living things*," in so far as it implies that each has its own principle of individuation and of *spontaneous internal activity*.

Apart, however, from the acceptance of this view, we have seen that the totality of animals and plants form together a single immense group of creatures, possessing the ten characteristics which we have hereinbefore briefly enumerated, namely, that they are more or less rounded, aqueous, protoplasmic bodies, of very uniform chemical composition—breathing, feeding, secreting, and growing by intussusception, according to definite laws, reproducing their kind by a series of cyclical changes, and more or less able to form habits through their internal spontaneity.

Such is our answer to the first question: "What are animals and plants, as contrasted with substances which are neither the one nor the other?" It remains to say a few words as to the second question—that concerning the relations of animals and plants, one to the other.

At first sight nothing could seem more obvious than the distinctness of animals from plants; but a very little science soon shows that to draw a distinction is not so easy a matter. Elaborate and recondite distinctions have been, one after another, drawn out, but these have, one after another, broken down, until there remains no one character which can be at the same time affirmed of all animals and denied of all plants (or *vice versa*), while these two great groups remain such as they are generally taken to be, the creatures known as Protozoa being reckoned as animals; that is, the lowest so-called animals, the bodies of which are not constituted of "*tissues*."

Let us look at these distinctions, beginning with the most obvious:

1. The first of these relates to external form. The predominant branching vegetal form is denoted by the word "*arborescent*," but many species of the animals (allied to the Corals) are arborescent also, while multitudes of the lowest plants are more or less spheroidal, and some are worm-like in figure.

2. Secondly, locomotion is common to almost all animals, but some are permanently fixed, like plants, while certain lower plants, especially in the earlier stages of their existence, are actively locomotive.

3. Animals generally live on more or less solid food, which they take into an internal digestive cavity. All animals, however, do not do this, notably the Entozoa, while certain plants are said to more or less nourish themselves on captured prey, as is the case with Venus's fly-trap and Dionœa (the sun-dew), while others, as the Pitcher plants, can receive them into a cavity, which is, to a certain extent, comparable with the animal alimentary cavity, since that is, morphologically, but an involution of the external surface.

4. Plants generally contain a greater amount of non-nitrogenous material in their composition than do animals generally, but this distinction is of little avail as regards the lowest forms of life of both groups.

5. Plants generally have a less evident power of forming habits or of responding to stimuli by increased activity; but this again does not serve as a distinction as regards the lower plants and animals.

6. Until quite recently it could be said that no animals possess that power of liberating carbonic acid and fixing carbon which is possessed by plants; but now it is known that certain worms also exercise this power. Nevertheless, we may still say that plants generally possess the power of feeding directly on the inorganic world and building up organic matter from it, while the animal kingdom has it not; and this difference constitutes what is sometimes spoken of as "the circulation of the elements."

Until the other day it could have been said that with the exception of a lowly species called *myxomycetes*, all plants were organisms composed of one, few, or many small masses of protoplasm, separated from each other by partitions of a non-nitrogenous substance called "cellulose," while in animals the protoplasmic particles were not so separated. Quite recently, however, it has been found that in some, and probably in very many if not in all plants, protoplasm *is continuous*, passing by minute filaments from cell to cell, through such cellulose partitions.

With the failure of this differential character, the very last distinction between the two kingdoms, *as ordinarily understood*, falls

to the ground. We must profess ourselves utterly unable to frame any definition which shall at the same time include all kinds of one of these two groups, while excluding all kinds of the other group.

Nevertheless, it is obvious that there is an immense difference between animals and plants generally—a difference well expressed by that common-sense assertion we quoted at starting, that "animals are creatures which get their living by the help of their senses, while plants are senseless." Now, this common-sense view accords with the distinction drawn so many centuries ago by Aristotle, that animals feel, while plants do not.

In biology, however, groups are characterized by *structure* rather than by *function*, and we know, moreover, that every difference in "function" has some difference in "structure" as its accompaniment. But what is the structure which is related to the function of "feeling"? It is the *nervous system.* "Nervous tissue" is the "organ of feeling," and modifications of it, with accessory accompaniments, constitute every organ of special sense, *i. e.*, of sight, hearing, smell, taste, and touch.

Now, no plant is yet known to possess anything like nervous tissue, and the same may be affirmed of the lowest organisms commonly recognized as animals. We know at present no way of defining a plant save the negative one of saying "a plant is an organism which is not an animal," while the essence of animal life seems to us to be the power of "feeling," together with its necessary correlation, the "possession of a nervous system." If, then, we must draw a hard and fast line between the two kingdoms, we see no way left for us but that of transferring to the vegetal kingdom those lower organisms generally reckoned as animals, which possess no nervous systems. To botanists they will perhaps be an unwelcome present, but they can hardly be refused on any valid scientific grounds. The activity and irritability of many of them are, no doubt, very suggestive of animal life, but so are the activities of some of the lowest organisms always recognized as plants—many of the Algæ, especially in their younger stages and reproductive parts, together with such curious plants of prey as Venus's fly-trap and its allies—lately referred to.

We do not, indeed, yet positively advocate, though we regard with favor, such a mode of dividing the two component groups which together constitute animated nature; but we confess that we see no possible manner in which these two predominantly diverse groups of organisms can be divided, if the whole mass of living creatures, which we have seen to be so sharply and distinctly separated off from the non-living world, are to be completely, sharply, and distinctly separated, one from the other.

Thus, we venture to think, may at present best be answered the

two questions with which we set out: (1) What animals and plants are, as contrasted with substances which are neither the one nor the other; and, (2) How animals and plants stand towards each other; the answers to which constitute the only reply we know of to the fundamental question we have taken as the title of this paper: "What are Animals and Plants?"

THE ENCYCLICAL "IMMORTALE DEI."

THERE never, perhaps, was a time when clearness of ideas was more demanded among Christian nations than at the present day. Protestantism, which, as its name imports, is a rebellion against God's Church, and, as His Eminence Cardinal Newman has observed, can maintain its position only by asserting that the Church of Rome has gone astray, set up its tribunal of private judgment. That tribunal has called before it every question, religious or moral, with the result of a confusion such that the most ordinary and obvious truths are misapplied, distorted, or rejected, while the most pernicious theories of religion and morality are working havoc among our poor misguided fellow men. It is no wonder this has occurred. At best, as the sacred writer has said: "The thoughts of mortals are timid, and our foresight uncertain" (Wisdom ix., 14). When men deliberately stray away from the fount of living waters, and from the source of truth, they must expect the natural result. Reason, always of its nature liable to err, will then find itself irresistibly driven to conclusions the folly of which will be shown by the practical results. In the midst of the upheaval of society at this epoch, when the masses rise up against legitimate authority, class is arrayed against class, the most sacred duties are disavowed, and the most tender and delicate ties are sundered and the family made desolate, what a blessing to have speak to the world one whose thoughts are not timid, and who, like his Divine Master, gives forth his utterances "as one having authority!" The Encyclical "Immortale Dei," dated All Saints' Day, of the year 1885, is a boon to the world. Not since the Vatican Council has a more important document issued from the pen of the Sovereign Pontiff. Non-Catholics as well as Catholics recognize its truth, its wisdom, its opportuneness, and its eminently practical utility. The liberal press of Vienna was, we