(some of which may be formed naturally), ready to develop anywhere, under proper conditions, into animals in the dark, and into plants in the light. Other natural conditions also, as before remarked, probably exert their influence, especially electricity, heat, and chemical action.

It is quite possible that what are called *disease germs* are only minute portions of the diseased part itself, floating about in the air, which, if they meet with a human body in favorable condition, may start the disease anew. In a healthy state they may not infect; but if the body be prepared for them, they act at once, like the matter used in inoculation.

The minuteness of these germs is almost inconceivable. The smallest crack in a glass vessel will admit them, and if the very point of the finest needle touch the surface of an organic infusion, in which there are germs, and be then introduced into one perfectly clear, it will start their development immediately.

We must be inhaling clouds of these germs all the time; but in a normal condition they do no harm. In fact, in a healthy body *living bacteria* may be introduced into the blood without injury. In an enfeebled or unhealthy body it may, however, be very different; and pure air, under all conditions, is safer to breathe than impure.

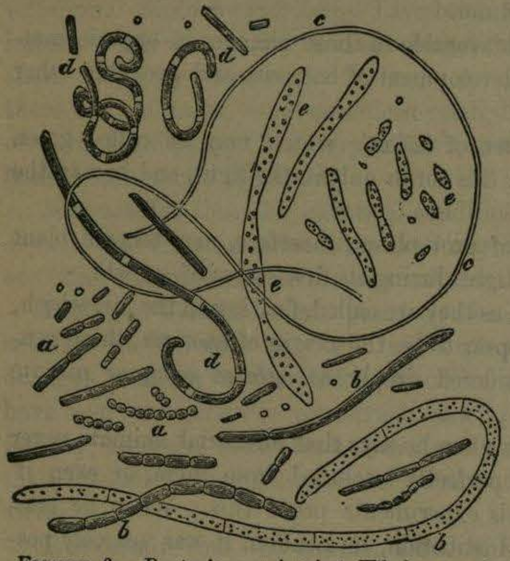

FIGURE 6.—*Bacteria growing into Vibriones and other Forms.*

a, a. Different kinds of bacteria and vibriones. *b, b,* and *c.* Different forms of leptothris. *d, d.* Spirilla, which change into fungus. *e, e.* Torulæ, or yeast plant, developing into fungus mycelia.

It is well known that surgical operations seldom succeed well in large hospitals, owing to the air being contaminated with morbid matter, acting germ-like. An open wound in such a place almost always becomes filled with *bacteria,* and has a tendency to gangrene. In a place free from such surroundings this seldom occurs. The bacteria may be harmless in a healthy body, but very hurtful in the morbid material of a wound.

Bacteria are among the simplest regular-formed beings, and are usually the first met with. They resemble wands, or straight, flat rods, like minute laths, sometimes single, but more usually jointed, as if several short ones had grown together, end to end. They are supposed to be formed by the union, in a straight line, of molecules of the original protoplasm. The longer *vibriones* resemble bacteria, and are supposed to be formed by many of them joining together. In fact, Dr. H. Bennet asserts he has seen them form in this way. They are often twisted or bent at various angles.

The nature of bacteria is much in dispute, as to whether they are animal or vegetable, or whether they are beings of a definite character, or merely transitory forms of other and higher beings which follow them. Bastian takes this view, and it is probably correct. In size they vary from the fifteenth to the twenty-thousandth of an inch in diameter. They move often quite rapidly, and are undoubtedly *living.*

The following plate shows the more common forms of monads, bacteria, vibriones, and torulæ, or yeast plant.

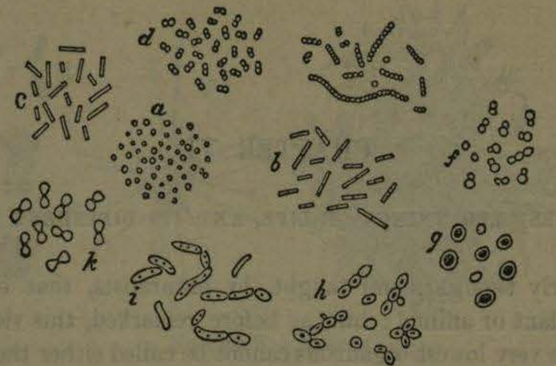

FIGURE 7.—*First Forms of Life in an Organic Infusion.*

a. Monads. *b, c, d, e.* Bacteria. *f, g, h.* Torulæ. *i, k.* First forms of vibriones.

The yeast plant, which causes the *rising* of bread, and the working of beer, is probably only a modification of bacteria. The rapidity of its growth is well known. A small portion of yeast will soon set a hogshead of wort working, or fermenting. In fact, the growth can be *seen* under the microscope.

CHAPTER VI.

THE FIRST BEGINNINGS OF LIFE, AND ITS DIFFERENT KINDS.

It was formerly thought, and taught, by naturalists, that every living thing must be either plant or animal; but, as before remarked, this view cannot now be maintained. The very lowest organisms cannot be called either the one or the other, but are something between the two, or lower than both. Professor Haeckel was the first to point out and illustrate this important fact. He called these intermediate beings *Protista* (meaning "*the first of all*," from a Greek word), and showed that they all propagate in a strictly non-sexual manner. He is of opinion also that these are the real beginnings of organic life, and that both plants and animals are produced from them, by further developments.

The very lowest of these, which he calls *Monera*, or *Monads*, cannot even be termed *organized*, for they consist only of specks of jelly-like protoplasm, without form or structure of any kind. They are probably the first bits of the protoplasm which separate from the rest, and are simpler than *cells* (which are described farther on), because they have neither investing membrane, nor nucleus, nor, in fact, any difference of parts. As they become acted upon by chemical, and other agencies, they become hardened on the surface, or form a membrane, and afterward, by osmose, a nucleus and granules in the interior, and so become true cells, the first real organisms.

The first spontaneous beginnings of life, however, as far as can be ascertained, are these *moners*, or jelly-like specks of protoplasm, and these are merely detached portions of protoplasm, which may be formed naturally in any waters, like bathybius in the sea—or in the atmosphere by electric agency.

First, then, we have the natural simple elements, with their inherent powers and attributes, and next we have the combinations of certain of these—carbon, hydrogen, oxygen, and nitrogen, into water, ammonia, and carbonic acid. Then, by electric and chemical action, these compounds form protoplasm, and from protoplasm, as above explained, first come the mere unorganized specks, the *moners*, and from them other beings; and, finally, *cells*. From the cells are formed the beings next above, the *infusoria*, and eventually, by gradual building up, still higher beings, till we reach the vertebrates and *man*—all going back, however, to the moners, and protoplasm or *the matter of life*, at last!

Many of the lowest orders of beings obviously pass into each other, or possibly they may all be only different stages in the development of the highest among them, as stated before. The following plates show the appearance of some of these beginnings of life.

A very interesting variety of animalcule may be produced quite readily by making thick paste of fine flour and water, which should be stirred daily for several days with a bit of wood. In four or five days it will swarm with what are called *paste-eels*, a kind of little worm. They can be readily seen with a common microscope.

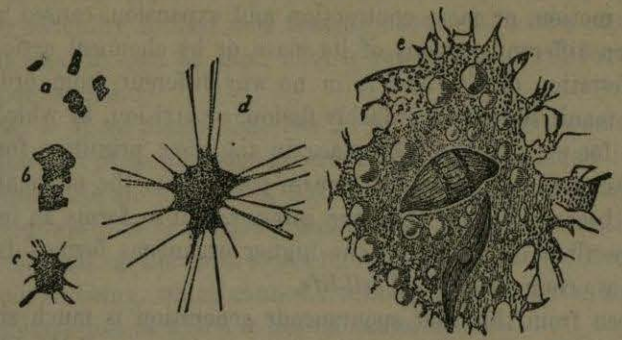

FIGURE 8.—*Monera.*

a. Mere specks of protoplasm, from the surface of the mud in a fresh-water pond. *b.* A larger mass which begins to resemble an amœba. It has just divided in two, by fission. *c* is a still farther development, prolongations being thrown out, like limbs; this form is called a *vampyrella.* *d* is still more like anamœba. *e* is a mass called a *plasmodium*, formed by many of the simpler bodies uniting. Two infusoria are seen entangled in it, being probably absorbed, or used as nutriment.

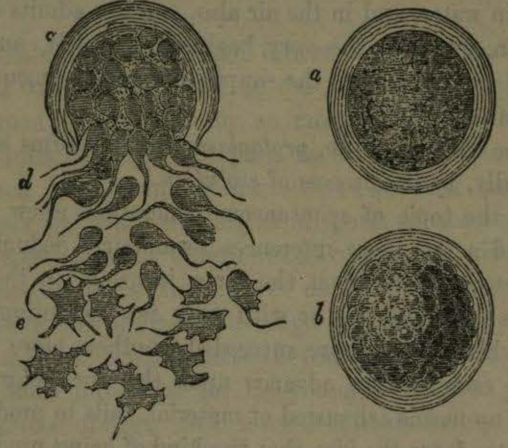

FIGURE 9.—*Development of Protomyxa.*

a shows one of the amœbas, as observed by Haeckel, drawn together into a ball, and inclosed in a membrane, or *encysted.* It then becomes filled with granules, which enlarge, and begin to move round and round, as seen in *b.* Finally, the cyst bursts open, as seen in *c*, and the developed granules are expelled in the form of *moners*, with tails, as seen at *d.* The tails gradually disappear, and they become true amœbas, as seen at *e.* Then, any of these amœbas may draw together, become encysted, and go through the same round again, from simple protoplasmic granules to moners, and from these to amœbas.

This particular form is called *Protomyxa Aurantiaca.*

All these earliest forms of life are utterly without definite shape or structure, and have neither investing membrane, nucleus, nor granules. The amœba, one of the next above, though still a mere lump of protoplasm, has a skin, and can form limbs and a stomach, when it needs them, and is, therefore, an advance, though a slight one.

One of the very simplest of the *moners*, and one of the first Haeckel discovered, was taken from the mud of a shallow pond, and was named the Protamœba. It was observed as a minute protoplasmic ball, about *one-thousandth of an inch* in diameter, perfectly alike in every part, and resembling exactly a speck of jelly. It however exhibited a power of *motion*, by pushing out and drawing back again, at intervals, different portions of its substance.

This simple motion, or mere contraction and expansion, caused by the unequal action of heat on different portions of its mass, or by chemical action, is probably the first manifestation of *life*, and is in no way different from ordinary motion. The next vital manifestation is probably fission, or division, by which it multiplies or propagates; for we see this take place in the most primitive forms, as in the protamœba. Osmose, or nutrition, of course commences the moment the exterior, by any agency, becomes denser than the interior, and so forms an investing membrane. Then results a cell, with all the higher organisms formed from it, as will be shown when we come to speak of *cell-life*.

It will be seen from this that spontaneous generation is much simpler than is usually supposed. We are not required to believe that one of the higher beings is spontaneously produced; not even one of the infusoria or amœba, nor even a *cell*, but only the separate speck of protoplasm called the *moner*, from which all the others are developed! In short, once form protoplasm, the matter of life, and portions of it inevitably become separated, and form moners, and then cells, and so on, all by natural force acting on the simple elements. And that protoplasm itself is naturally formed in water, and in the air also, scarcely admits of doubt.

In this way, then, we trace the very beginnings of life, and see how living, organized beings are produced from the simple inorganic elements by the powers or forces inherent in matter itself.

Once produce the *matter* of life, *protoplasm*, and all forms and qualities of life result from it naturally, by the process of *evolution!*

In conclusion of the topic of spontaneous generation, a few additional facts are *worthy of notice*, and a few more inferences seem fairly deducible from the facts already given. It is observable that the same infusion, in the same conditions, always produces the same beings, or with very few exceptions; beginning with the simplest kind, which die, and are succeeded by others more perfect, and larger, in successive crops, each one an advance upon the one before it. Finally, the infusion, though by no means exhausted of material, fails to produce any more.

This would seem to favor the idea that the kind of being produced depends upon the kind of material used, and the state it is in: if in one condition, it produces and supports one kind of beings, and if in another condition another kind. The decay of the first crop probably enriches the infusion, and so enables it to produce next a more advanced kind.

It is also worthy of observation that when the infusion contains but little water, and much organic matter, it usually produces vegetation, such as mould or fungus; but when there is much water animal organisms most frequently appear. This seems hardly consistent with the theory that the new organisms result from germs floating in the air, but rather favors the idea that they are spontaneously produced, and that their nature depends upon the character of the infusion used. The number of beings produced also is no way dependent upon the quantity of air present.

Another point is also well worth consideration, namely, that many of the infusoria produced in the infusions do not, so far as known, produce ovæ or germs of any kind, but always propagate by division, or by buds! Where, then, do the germs come from which are supposed to produce them? If they do result from any particles floating in the air, the fact would seem to prove that such particles are not real germs, coming from the ovaries of pre-existing animals, but only specks of protoplasmic matter, naturally formed and floating about, as before explained. Such specks of matter may, if such be their nature, produce anything found in the infusions, vegetable or animal.

The Entozoa, or those beings that live in animals' bodies, would also seem to favor strongly the idea of spontaneous generation. They are found in almost every part, not only where the air has access, but where it has not also: in the chambers of the eye, for instance, in the blood-vessels, in all the closed cavities, in the substance of the liver, and in the most secret recesses of the brain. Each place has its own special kind of being, which cannot live long anywhere else, and which soon dies when the animal dies in which it has its habitation.

Now, if these beings are not spontaneously generated, how do they reach these places so difficult of access? We cannot conceive of their germs getting there from the air, and it is still more difficult to imagine themselves being transmitted from the parents; besides, many of them do not form eggs at all, but bring forth their young alive; and when eggs are produced, they are entirely too large and heavy to be floated in the air; nor are these the only difficulties in the way of supposing such beings to come from germs.

Carnivorous animals, which feed upon others, might naturally be supposed more liable to be infested with entozoa, and of the same kind as those natural to the animals they feed upon; but such is by no means the case. Herbivorous animals are quite as much infested with such pests as the carnivorous ones; and, what is worthy of notice, each kind of animal has its own peculiar kind of entozoa. The same kind also infests the same animals in all parts of the world. And land animals have different entozoa to the water animals of the same district.

It has been supposed by some that the ovæ of these parasites may reach the secret parts of the body where they are found, through the blood; but this cannot be admitted, with regard to many at least, because they are too large to pass the capillaries. Of course, it is still more impossible for the young of those to pass who bring forth their young alive, instead of eggs. Still more is it inadmissible that either one or the other can pass from mother to child, during gestation; and besides, mother and child are not always infested with the same kind of parasite. In some cases entozoa have been discovered in the human fœtus at birth, and it becomes exceedingly difficult to give any reasonable explanation of such an occurrence, except by spontaneous generation; for they can hardly be supposed to have come, by any route, from either mother or father.

It is remarkable also that animals of the same kind, living at the same time and place, and in the same way, will have different kinds of entozoa.

All these parasitic beings, however they may come, when once produced, propagate like others of a similar kind, some by eggs, and others producing living young.

The whole subject is beset with difficulties, and must not be considered by any means as settled, either one way or the other. Careful and long-continued observation and experiment, with candid and fair discussion, can alone lead us to the truth, which is all we want, let it be whichever way it may.

Another remarkable fact may also be stated. Dr. Bastian found that an organic infusion, such as he experimented with, could be *sterilized* by long subjection to great heat, so that when left still, without any contact with the air, no life would appear in it. But if he then added only a little *potash*, to neutralize its acidity, bacteria appeared at once.

Apparently the life resulted, in this experiment, from a mere *chemical change* in the infusion. But it may be said that the germ was there, but could not develop while the infusion was acid. If this be supposed, however, we are then obliged to admit that the germ could withstand an amazing degree of heat for a long period.

In short, though spontaneous generation has not been proved beyond dispute by these experiments, it seems, in many of them, to be undeniably the most probable explanation of the phenomena observed.

All this shows that, properly speaking, there is no beginning of life in an absolute sense, nor any real separation between what is called dead, and living, matter. All is living; every single atom has life; and the life of any compound body is merely the aggregated life of the atoms composing it, varied according to the manner in which they are associated.

Although in their simplest forms organic beings are neither plants nor animals, but may become either; yet in their fully developed state, when their characters are fixed, they are distinct enough. The plant works for the animal, by taking the inorganic matter and working it up into organic material suitable for animal food. This the animal cannot do for itself, and therefore it is dependent upon the plant for its existence. The great work of vegetation is to take carbon from the air, in the form of carbonic acid gas, decompose it, fix the carbon in the solid form of woody matter, and return the oxygen to the atmosphere. The animal, on the contrary, consumes the carbonaceous matters the plant has formed, using them for food, recombines the carbon with oxygen, in the process of breathing, and returns it to the air in the form of carbonic acid again. Thus the two different organisms work in a circle.

All this is accomplished primarily by the *sun*, whose action on the leaves of plants enables them to decompose carbonic acid gas, and fix the carbon, with other elements, in the form of starch, gum, sugar, and other vegetable products upon which animals subsist. Without the sun plants could not fix carbon, and, consequently, animals as well as plants depend upon the sun for life. The amount of other elements, in most vegetable matters, is comparatively small, carbon being always the main ingredient, as we see by the amount of charcoal that wood will leave, when properly burned—charcoal being nothing but carbon. The quantity of mere mineral matter is always small, and only of subordinate importance.

The leaves of plants also decompose water to obtain its hydrogen, and ammonia to obtain its nitrogen, and this is effected solely by the action of sunlight, without which no such decomposition would take place.

In regard to the sources whence the secondary compounds are derived on which plants subsist, M. Dumas remarks: "They are, in fact, produced upon the grand scale by the action of those magnificent electric sparks which dart from the storm-cloud, and, furrowing vast fields of air, engender in their course the nitrate of ammonia which analysis detects in the thunder-shower. . . . As it is from the mouths of volcanoes, whose convulsions so often make the crust of our globe tremble, that the principal food of plants, carbonic acid, is incessantly poured out; so it is from the atmosphere, on fire with lightnings from the bosom of the tempest, that the second scarcely less necessary aliment of plants, nitrate of ammonia, is showered down for their use."

The air, therefore, is the great storehouse from which the organic material both of plants and animals is derived, and in one sense they may all be called *the children of the air*.

The common notion of many people that plants draw all their nourishment from the earth is therefore erroneous. The mineral constituents of plants are derived from the earth; but they are small in amount, and of subsidiary importance for the most part. Plants grown in pure sand, and wet with distilled water, will form solid woody fibre, the same as if they grew in the earth; and this of course comes solely from the air, for it is mostly carbon, and there is none of that element either in the sand or the water.

The amount of carbon thus fixed by plants from carbonic acid gas is something astounding to contemplate. Take a forest, for instance,—in one that is properly worked it is estimated that an acre will yield annually, only by due thinning out, at least four thousand pounds of dry wood, or about one thousand pounds of solid carbon. Then reflect upon the millions of acres on the globe covered by forests, besides other vegetation, and some idea may be formed of the immense annual production.

These facts are important to bear in mind, as they not only serve to explain vital processes now going on, but also make it clear how immensely different were the conditions under which life originated in past times.

There was a period in the early history of the earth when the atmosphere contained immensely more carbonic acid gas than it does now; so much, indeed, that land animals could not live in it. But such an atmosphere as that, surcharged with hot watery vapor also, is just what plants thrive upon, and we accordingly find that vegetation, at that period, attained to a size and luxuriance of which we can have but faint conception. Ferns and mosses which now are small and insignificant were then large *trees*, and grew in dense forests. From this superabundant vegetation is derived our coal-beds, which thus represent, in reality, the concentrated *sun power* of a former age.

This very abundance of plant life, however, of itself ultimately changed the atmosphere, and made it fit to be breathed by land animals, which then came into existence. By continually decomposing the abundant carbonic acid gas and fixing the carbon, it gradually brought the air nearer to its present constitution.

If this process of active vegetation had gone on alone, all the carbonic acid gas in the world would finally have been decomposed, and the carbon fixed. But next came in the era of great animals, who by reversing the process, as before explained, burned up this carbon in the process of nutrition, and in their breath returned it, as carbonic acid gas, to the air, so that the plants could use it over again. In this way the balance was maintained as it is at the present day.

Plant life could not go on alone, because it would ultimately fix all the carbon solid, and have none left in an available gaseous form; and animal life could not go on alone, because it could not obtain solid carbonic and nitrogenous food from the simple elements. The two are necessary to each other, and each works for the other in working for itself.

Even in the small field of infusorial life, in plants and animals, such as we have been describing, this great fact is exhibited, and microscopic plants and animals act and react upon each other just like their larger representatives. Funguses, moulds, and animalcules appear together in the same infusion, follow one another, and apparently pass into one another by insensible gradations.

Possibly the simple *protista*, which are either plants or animals, or neither, may be capable of assimilating carbon either in the fixed form, as animals, or of decomposing carbonic acid gas, as plants, and thus truly belong to both the animal and the vegetable kingdoms at the same time, in the same way that amphibious animals can breathe either in air or in water.

When we see how life has thus changed on the large scale on our globe, by the change in its condition, we can the more easily understand how it can be similarly varied on the small scale of our experimental infusions. By varying their composition and strength, the amount of heat to which they are subjected, and the electric and other conditions around them, we should naturally expect to vary the result; and such is in fact the case, as we have already shown.

The large plate here introduced shows admirably the astonishing luxuriance of vegetation in the age which produced the material of our coal-beds, when the atmosphere was filled with carbonic acid.

For the primary beginning of life,—as a starting-point for all the plants and animals that now live, or that ever have lived,—the minutest speck of protoplasm would be sufficient. This speck, too small for our best microscopes to detect, would inevitably form a *moner*, or some kindred organism, which would speedily multiply by simple division into millions like itself; and these would soon pass into other forms, in the way we have shown, and these again into others, each a stage higher, till the whole organic world would, slowly and surely, be evolved.

The death of one generation, by providing more abundant organic material, would give increased development to the rest; and thus the simple primary forms would insensibly pass into the complicated organisms we now see.

Such, it would seem, *must be* the result of the production of even the minutest portion of protoplasm, *the matter of life!* And, from what we know of the properties of matter, it seems scarcely open to doubt that, in the ceaseless whirl of activity and change in the material world, all kinds of combinations of its elements must take place, protoplasm among the rest! It is scarcely possible even to suppose that it should not! If all organic matter were now destroyed by heat, nature would, in all probability, again produce a protoplasm, and the circle of organic life would begin anew. Under former conditions, it was probably produced abundantly; but even now, there is every reason to suppose, it not unfrequently springs into existence. For protoplasm, it must be remembered, is not a new kind of matter, but only a particular combination of the simple elements common to the whole universe.

"See! through this air, this ocean, and this earth,
All matter quick, and bursting into birth!"—Pope.

PLATE I.

Vegetation in the Coal Period.

CHAPTER VII.

THE DIFFERENCE BETWEEN ORGANIC AND INORGANIC MATTER, AND THE RELATION BETWEEN PLANTS AND ANIMALS.

PROTOPLASM, or the matter of life, both animal and vegetable, differs from mere mineral matter in this way: inorganic matter, as a solution of *salt,* for instance, when it solidifies nearly always assumes some regular form, usually geometrical, or *crystallizes,* the crystals having certain definite angles and, usually, straight sides.

Organic matter, on the contrary, instead of being crystallized, usually assumes what is termed the *colloid* form, as we see in gum, or sirup, and never has a definite shape, like a crystallized body. This difference probably results from the difference in the character, and number, of the elements of which the two kinds of matter are composed. An inorganic crystalline body is formed of few elements, usually of only two, and these of a stable character, most of them being solids, so that it is not prone to change. There are, therefore, but few formative forces at work, and hence comparative simplicity and regularity of outline. An organic compound, on the contrary, is most frequently formed of many elements, mostly gaseous, and mobile; so that its form is determined by numerous formative forces acting in contrary directions, and hence its homogeneous or apparently formless appearance. The same causes also make it more prone to decomposition or decay, because its varied and mobile constituents are but loosely held together.

Organic matter, in consequence of this peculiarity of composition and structure, forms itself into some rounded, soft, and mobile form, which being easily acted upon by the forces around, readily contracts and expands, or *moves,* and so begins to *live;* or, in other words, it organizes into a living being.

Inorganic matter, on the contrary, in consequence of its structural simplicity, and the more stable character of its constituents, always assumes rigid determinate forms, straight and angular, which are said to be inorganic, or dead, to distinguish them from organic bodies, which are called living. It would perhaps be more proper to say that both kinds are living, in different ways and degrees. The crystal has fewer constituent atoms than the animalcule, and they are less varied; it has, therefore, a less *amount,* and less *variety* of life. As Schwann observes, "The formation of crystals bears the same relation to inorganic matter as the formation of cells does to organic." Each is an advance *in life.*

Not only, however, are plants and animals the same at the beginning, so that one cannot be distinguished from the other, but, even when full grown, they often have many functions in common. In fact, it is very difficult to state any essential and constant differences between them.

It was once thought that the difference lay in the power of motion, animals being able to change from one place to another, while plants were fixed. It is now known that there are plants which move about from place to place, and animals that are fixed to one place, rooted like plants.

It was then supposed that animals were exclusively gifted with sensation, or feeling; but this also is more than doubtful. The *sensitive plant,* for instance, will draw its leaves together, and even bend down its leaf-stem, when the finger is pointed to it. Like many other plants, it is also affected by electricity; and may be killed by poisons,—by piercing with the fang of a rattlesnake, for instance, just as animals are.

The grand distinction, however, was thought to be in the nature of their food, and the mode of nutrition. Animals have *stomachs,* it was said, in which they digest their food, which must be organized material, either animal or vegetable; while plants have but roots and leaves, by which they absorb the inorganic elements only. There are, however, many plants known that make prey of animals, and digest them, a portion of their structure acting as a stomach, and secreting a true *gastric juice,* exactly like that found in the stomachs of animals.

The *Dionea Muscipula,* or Venus's flytrap, for instance, and the *Drosera,* are each provided with an apparatus by which they catch insects, kill them, and afterward digest them. In these plants parts of certain leaves are endowed with a peculiar sensibility, which causes them to fold over upon any insect that alights upon them, and imprison it till it dies. Then certain glands pour out a fluid, which has the same properties as the gastric juice secreted in the stomachs of animals, and which dissolves and digests the insect the same as the animal digests flesh. If a small piece of *raw meat* even be placed on a sensitive leaf, the plant will *eat it* in the same way, and we can thus feed the plant as we would an animal. A list can be made out, by careful observation, of the substances it will eat, and those it will not, and some will be found even that will disagree with it, or cause sickness, as with our own stomachs.

It is not mere common sensibility which these plants exhibit; for if any other body is placed on the leaf, or other sensitive part, it will not fold over to hold it, though it may throw it off, as it does the indigestible parts of the insect.

That this is really a process of digestion, and that the leaf acts just as an animal's stomach, there can be no doubt. If we take a piece of meat, and place it in a bottle, with some gastric juice taken from an animal's stomach, it will not taint, nor decompose, but will slowly dissolve, or be digested, just as it would be in the stomach itself; and the secretion from the leaf of a Dionea, or Drosera, acts in exactly the same way: it is, therefore, true gastric juice. As a further proof that this is the way the plant feeds, or, at least, the chief way, its *roots* are but very partially developed; they seem adapted only for anchoring the plant in the ground, and keeping it upright, and not for purposes of nutrition, as we usually find them in the vegetable world. The leaves also retain their power of seizing and digesting animal food for a long time after they are torn from the plant—even till they are beginning to wither —which shows that they act independently of the roots.

Besides the two above mentioned, there are many other plants now known that exhibit this remarkable habit of insect-eating. In fact, new ones are being discovered all the time, the habit being more general than was formerly supposed.

The sensitive leaf of the Drosera is somewhat like a flat button, surrounded on the edge by a fringe of arms, or tentacles, as they are called. These are formed of thin stems, or filaments, each with a small round disk, or gland, on the top. These arms easily bend at the lower part, and curl over, so as to bring the gland on the top down to the central disk. They act just like the limbs of an animal. If an insect alights on the small disk on the top of one of these arms, it bends over till it touches the center of the leaf. What is very remarkable, also, all the arms near enough to help bend over at the same time, and to the one point; but none of those do so that are too far away.

In Fig. 10, a bit of meat has been placed on the central disk, near one side, and all the arms on that side have bent down on to it, or are bending down, to secure the prey, while those on the opposite side out of reach remain erect.

In Fig. 11, the bit of meat being placed in the center of the leaf, *all* the arms are bent down on to it alike, from all parts of the circumference.

It will be observed that the arms bend only at the lower part, but their sensibility rests in the gland, and upper part. No animal could detect its prey quicker by sight than these plants do theirs by the sensibility of their glandular hairs. It seems as if they were continually on the watch. But place any substance on the disk not suitable for food for them, and they will not notice it.

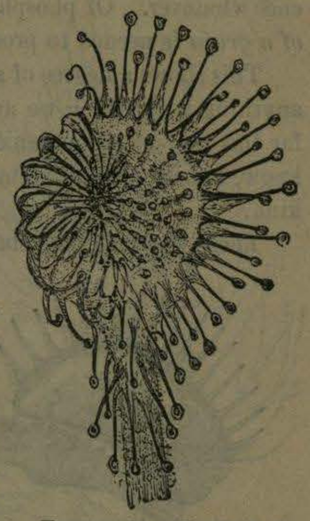

FIGURE 10.—*Leaf of the Drosera,* showing part of the tentacles bent over, and part erect.

FIGURE 11. —*Leaf of Drosera,* with a bit of meat in the center, the tentacles all round bent down upon it.

If two or more bits of meat be placed on the central disk, at different points, all the tentacles nearest to each one will bend over to that, and seize it. They seem never to make a mistake, but each one helps to seize the piece that is nearest within its reach. Any one might readily imagine it was an animal, grasping its prey.

The minutest portion of animal substance is sufficient to cause this wonderful action. A fragment of hair, weighing not more than the *seven-thousandth* part of a grain, will cause a tentacle to bend over. It is remarkable however, that, in spite of this extreme sensibility, drops of rain may fall on the glands without any effect.—The tendrils of climbing plants also, which are extremely sensitive to almost everything, are similarly unaffected by rain-drops.

It is observable, further, that after these arms have been active, in bending over, a remarkable change takes place, for the time being, in the molecular structure of the base, where the bend occurs. In other words, *cell transformation* takes place as it does in animal muscle, when that is active.

In regard to the digestion of the animal matters thus seized, Mr. Darwin says that the action of the fluid secreted by the glands of the Drosera, on albuminous matters, is exactly like that of animal gastric juice. Chemical tests, and experiments, in fact, show the two to be identical.

It is very curious, also, that if leaves of the Drosera be stripped from the plant, they still retain, for a long time, this power of seizing prey, and digesting it. A leaf will seize an insect even when it has begun to wither.

As another instance of the wonderful sensitiveness of the glands of the Drosera, it has been found that the *two-hundred-thousandth part of a grain* of carbonate of ammonia will affect them; while the same salt, absorbed by the root, exerts no influence whatever. Of phosphate of ammonia not more than the *nineteen-millionth part of a grain* is needed to produce the same result.

This shows a degree of sensibility in the glands of the Drosera, a plant, far beyond anything with which we are acquainted in the nervous systems of animals. How far this may be accompanied by anything corresponding to *consciousness*, we do not know, but we scarcely seem justified in saying positively, that there is nothing of the kind.

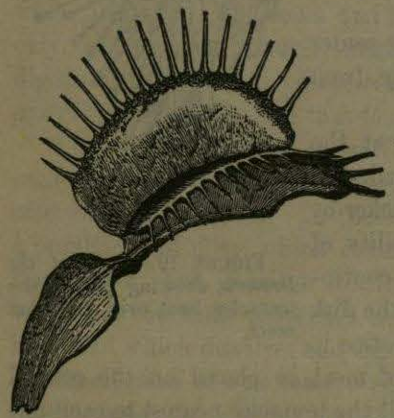

FIGURE 12.—*The sensitive end of a Leaf of the Dionea.* The pointed bristles act like the teeth of a trap, and assist in holding the prey.

These wonderful vegetable glands may also be *poisoned*, by many substances, just as the human stomach may be; or they may be made to suffer from *indigestion* by too much food, or from that of an improper quality.

In short, here are true nervous action and sensibility, with a real power of seizing animal prey and digesting it, besides being able to distinguish it from other matter.

In Fig. 12 is shown the sensitive part of a leaf of the Dionea, or Venus's flytrap. In ordinary conditions, this is spread out flat, but if an insect alights upon it, the two parts of the leaf close together like a trap, so as to shut it in. When once entrapped, the leaf remains closed till the insect is digested, and then opens again, ready for more.

On the edge of the leaf are certain stiff hairs, like thorns, in which the extreme sensibility appears to reside, and which assist materially in holding the prey firmly when caught.

FIGURE 13.—*Leaf of Butterwort, or Pinguicula,* showing how it curls over to trap its prey.

The closed leaf in this case is a real stomach, as well as a trap, and the fluid it secretes is true gastric juice, like that of the Drosera. See also Fig. 16, on page 52, in which the leaves will be seen fully expanded, and in all stages of contraction.

Besides these two, there are many other animal-eating plants known, and daily being discovered. The common *Butterwort*, or *Pinguicula*, is one of these: it is shown in Fig. 13. The edge of the leaf is seen bending over a row of flies, attracted there by the secretion of the leaf glands, which holds them fast. Once inclosed, the leaf remains curled over till they are digested, and then opens, to act the same part over again. This plant, however, will dissolve some vegetable matters, as well as animal ones, especially those that are nitrogenous.

Fig. 14 shows the common *Utricularia*, or Bladderwort, a water plant, which is also an animal-feeder, but catches its prey in a different manner. This figure is about twice the natural size. It will be seen that on the branches there are a number of small round bodies, most of them with hair-like fringes, or bunches of bristles, on the top. These are the bladders; they are about the tenth of an inch in diameter, hollow, with a mouth, and the hair-like tentacles around the lips, exactly like some of the infusorial animalcules. The mouth is closed by a kind of valve, which opens only inward. Into these bladders, or traps, small animals enter, and find it impossible to escape, owing to the valve. They are then retained till they die, and are used as food. The bladder is thus a stomach, which catches its own animal food, by which the whole plant is nourished.

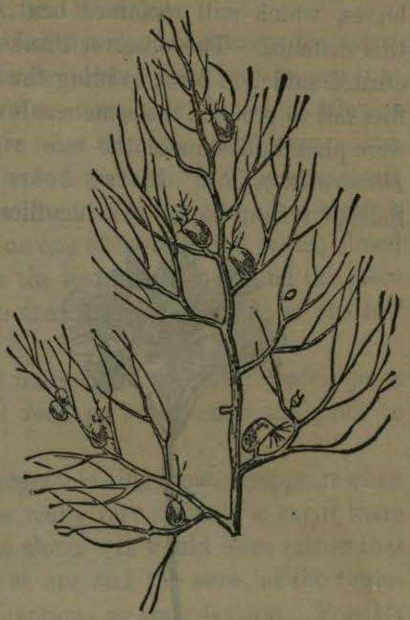

FIGURE 14.—*Utricularia, or Bladderwort,* showing the bladders or sacs in which it catches its prey.

It does not appear, however, that the animals so caught are digested in the same way as in the Drosera, or Dionea, for there is no proper gastric juice secreted. They simply remain there till they decompose, and are then absorbed, probably in the gaseous form.

Fig. 15 shows one of the bladders cut open, and much enlarged, so that the mode in which the valve acts may be better understood.

Besides the mechanical action of the leaves and tentacles, most insect-feeding plants are also covered with a shiny, sticky fluid, which both attracts their prey, and also helps to retain it. This is the reason for the name of *Sun-dew* applied to the Drosera, because it shines in the sun like dew.

The common *Catchfly*, or Campion, catches insects in this way only, and is nearly always covered with them. It has no tentacles or other apparatus, but holds them merely by the sticky secretion till they die. Many other plants do the same, but in what way they use the prey so caught, if they do use it, we do not know; probably it merely decays, and they absorb its gaseous emanations.

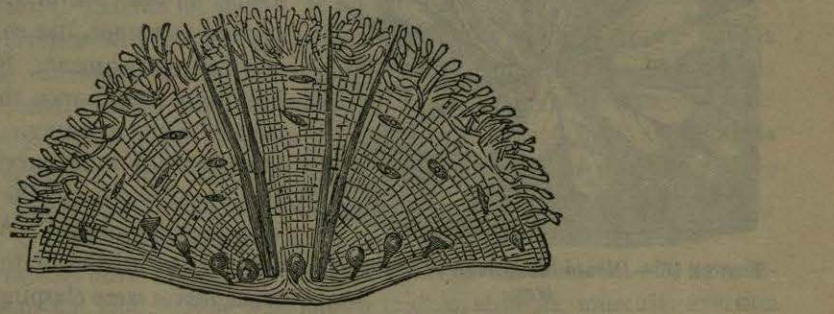

FIGURE 15.—*One of the Bladders of the Utricularia,* cut open and spread flat, to show the fringes, and the ribs which work the valve to close the mouth.—Magnified.

Mrs. Mary Treat has contributed to the *American Naturalist* some very curious observations made upon the Drosera. She found the specimens upon which she experimented in New Jersey. The plant was in full bloom, and growing very thickly on either side of an extensive cranberry plantation. The first experiment was made with the best-known species, the *Drosera filiformis*. Some living flies were pinned half an inch from the leaves near the apex, about 10 o'clock in the morning. In forty minutes the leaves had bent perceptibly toward the flies. In two hours the