PART III.

CELLS AND CELL LIFE. — ANIMAL AND VEGETABLE CELLS, AND THE DIFFERENCE IN THEIR COMPOSITION.—THE LOWEST FORMS OF LIVING BEINGS; THEIR UNIVERSAL DIFFUSION AND VARIETIES.—THE GERM THEORY OF DISEASE.

CHAPTER VIII.

THE FIRST FORMS OF LIVING ORGANISMS—VESICLES AND CELLS.

THE first forms of life, as already shown, are simply minute specks of protoplasm like spots of jelly, or white of egg. They have no definite form, no organs, nor any investing membrane. The only sign of life they exhibit is simple motion. They are probably nourished solely by absorption, from the fluid in which they live and move. Many of them are exceedingly minute, requiring a powerful microscope to distinguish them, and often can scarcely be told from the inorganic matter around them.

In all probability protoplasm is formed from inorganic matter, as before explained, and then portions of it are so acted upon, by surrounding agencies, that they separate from the mass, and assume the first form of independant vital action—simple motion. The passage from inorganic matter to this form is probably all the time taking place, imperceptibly, without any sudden transition, as we see in the beds of protoplasmic ooze at the bottom of the sea—the *Bathybius* of Huxley,—and also in atmospheric protoplasm, formed in the air by the union of water, ammonia, and carbonic acid. Small molecules may also, in all probability, be formed independently; and these may really be the germs found floating in the atmosphere. These germs, therefore, which are said by the opponents of spontaneous generation, to be necessary to the origin of life, in organic infusions, may, in part at least, be simply protoplasmic specks, formed in the air, and not necessarily derived from other beings previously existing.

The first advance from this simple protoplasmic speck is to what is called the *cell*, or *vesicle*. The surface of the speck becomes firm,—probably from heat, or from the chemical action of some of its surroundings,—and forms a covering, like a bag. We then have a true vesicle, or cell, which may be likened to a minute bladder, filled with a fluid, containing often a number of little granules, or grains, and sometimes a dark speck called a *Nucleus*. The Nucleus also is often found to contain a fluid, and to have a speck of its own, called the *Nucleolus!* That is, there is one cell within another; and how far this may go we cannot tell. Perhaps if we could see farther, we should find still other nuclei within these. It was formerly thought that the cell was the ultimate unit of every organism, or the first stage upward from inorganic material. We now, however, go beyond the cell, to the primal protoplasmic speck,—or the moner,—from which the cell originates. When formed, from the primal protoplasmic molecule, the cell is the actual building unit of every organism, animal and vegetable, they all being built up from it. It may, in short, be properly called the primary Universal Organic Germ. All cells are essentially the same, and begin in the same way from specks of protoplasm, no matter what kind of being they may build up, or how they may be modified. All kinds of animals and plants are, therefore, made in the same way, by the aggregating together of cells, as will be shown more fully farther on. All eggs and seeds are only cells.

Numerous animals, and plants also, consist only of single cells, and are therefore called unicellular, or one-celled. They are the lowest and simplest of all organisms.

These simple cell beings can seldom be classified as either animal or vegetable; probably they are neither, but capable of becoming either, according to the conditions under which they may be placed. The only difference between those cells known to be vegetable, and the animal ones, is this; that the membrane of the plant cell usually becomes hard, or woody, while that of the animal remains soft and pliable; and this difference arises in this way. They both start from the same kind of germ, as already explained, and are afterward nutrified by the same elements. Circumstances, however, so influence some that they absorb a large amount of *carbon*, and this element makes the investing membrane, and all the tissues formed after, dense and firm; makes them *woody*, in fact—carbon being the solid element in wood. In this way, the cell develops into a plant. Other cells, on the contrary, are so situated that they absorb more *nitrogen*, in the form of ammonia; and this makes a soft and pliable membrane or tissue—a *skin*, in fact—and these cells, in consequence, form animals. Nitrogen, therefore, is essentially the animal element, as carbon is the vegetable element. The life process in each is afterward modified by this primary difference in constitution. The plant needs carbon to effect its growth; it is, in fact, its nutriment, and it obtains the element from the atmosphere. The carbonic acid, always present in the air, is taken up by the plant, and decomposed, the oxygen being restored to the air, and the carbon retained to form fresh wood.

All the immense amount of wood in our present forests—all that has ever been before, and all our coal—have been taken by plants from the air, by the influence of *sunlight*, without which the plant cannot decompose the carbonic acid.

The animal needs *nitrogen*, and obtains it by absorbing ammonia, which it decomposes, and then uses both the nitrogen and the hydrogen. In its food the animal also takes more or less carbon, in the solid form, or combined with other elements; but it retains only a portion, the rest being got rid of in the process of breathing. In the lungs, the blood, containing more or less carbon, is acted upon by the air, the oxygen of which unites with the carbon to form carbonic acid gas, which is expelled as part of the expired breath. In other words, the carbon is burned, just as wood is burned in the fire; only the combustion is slow and smothering, instead of active. In this way the carbon is got rid of, and heat produced at the same time.

The animal thus throws out what the plant needs,—carbonic acid,—and the plant forms what the animal needs,—protoplasmic material from inorganic matter;—so that the two mutually work for each other. To show, however, how the two kingdoms approach each other, some of the funguses not only decompose carbonic acid, appropriating the carbon and expelling the oxygen, but also absorb nitrogen, like plants.

This will explain the essential differences, in structure and action, between plants and animals, so far as they exist.

Oxygen, it should be remembered, is the destroying, or changing, element. It has a tendency to unite with, or *burn up*, almost every known element or compound. In the case of wood, we know how it unites with it, or burns it up, in an open fire. But it does the same in the air without fire, though more slowly. If we leave a clean piece of new board out in the air, we know how soon it becomes discolored, or darkens, and finally slowly decays. This is owing to the action of oxygen, which unites with it and burns it slowly, but just as surely, as if it were burned in the fire.

Even metals are consumed by this all-devouring element in the same way. A bright piece of iron, or zinc, left in the light and air, soon becomes coated with *rust*, as it is commonly called, or *oxidized*. The oxygen combines with it, or burns it, and forms the rust, or oxide. All substances, both organic and inorganic, are constantly being consumed in this way.

This is important to be remembered, as it will have to be referred to subsequently.

Animal activity, of every kind, may be said, in one sense, to be dependent upon a constant oxidation, or burning, of the materials of the body. Plants *deoxidize* carbon and other substances, and animals oxidize them again; so that animal life is as much a result of fire action, or combustion, as is the steam of the steam-engine.

The lowest forms of cell animals—called *protozoa*, from two Greek words meaning *first*, and *animal*—the very simplest, as already stated, are only single cells, without organs or definite form: but, by almost imperceptible stages, we can trace a gradual advance to more perfect forms; that is, to the development of *organs* for special functions. These organs, at first, are but few, and the most simple conceivable.

The minuteness of some cells may be conceived when it is stated that, in a general way, as many as *twenty millions* could be placed on a twenty-five-cent piece.

The *cell membrane*, or outer skin, is so formed that fluids can pass through it, either way, under certain conditions, although it seems perfectly uniform and without pores. This is the case with every animal membrane, as with a bladder, for instance. If an ordinary pig's bladder be filled with water, and hung in the air, no water will pass through it to the outside, but if, when filled with water, it be put into strong *brine*, some of the brine will soon pass through to the water, and some of the water to the brine.

This curious and very important property of animal membrane may be stated thus: when the fluid on one side of the membrane is denser than that on the other, the two will pass through it, in opposite directions, and mix together, by what is called the action of *osmose*. This property of membrane is now much used to separate different substances from each other, by what is called *dialysis*. The way in which the growth and nutrition of the cell is effected by means of *osmose*, can now be readily understood.

Whenever the fluid in which the cell is placed is of a different density to that inside the cell, this process of *osmose* takes place. Part of the cell contents go to the surrounding fluid, and part of that enters the cell. All substances chemically different, act and react upon each other, and very quickly, if they are fluids. The contents of the cell, therefore, become affected by this admixture, and a series of changes takes place, resulting, sometimes, in the further growth of the cell, and, at other times, possibly in its death and decomposition. The whole time this process must be going on; so that the functional life of a cell, insignificant as it may seem, is as active in its way as that of a man.

The whole process of the first formation of a cell and its subsequent growth can now be easily shown.

We have only to conceive a speck of protoplasmic matter,--a monad formed by natural agency (as above explained),—placed in a fluid medium, and the cell results inevitably. The protoplasmic speck is at first homogeneous; that is, all alike, outside and inside, all through. It has no investing skin, nor any internal cavity. This is the first and simplest form of life, so far as we know.

If, in the surrounding fluid, there be any substance that acts chemically on the albuminous protoplasm, so as to harden the outside, as many substances do, a skin or membrane is formed, which surrounds or incloses the fluid inside, just as the bladder does the water. A certain amount of heat will also do the same. This is the first step. Then begins the process of osmose through the membrane, by which the surrounding fluid is sucked into the interior of the cell, and still further modifies its contents. Once these changes are begun they continue, in a thousand different ways, thus producing all the modifications of cells, and of the beings formed from them, as revealed to us by the microscope.

One of the changes which thus result from osmose is the formation of new cells inside the original one. A portion of the hardening chemical matter is drawn in through the membrane, and acts on the fluid it comes in contact with inside just as it did outside, forming a membrane, which incloses a portion of the fluid, and thus makes a new cell. In fact, this process often goes on so fast that it can be watched under the microscope, and the new cells will sometimes multiply so rapidly that the parent cell bursts, and a swarm of new cells issues forth, while we are looking at them.

This is probably the first and simplest form of *reproduction;* and under conditions favorable to cell growth countless millions are thus incessantly issuing forth.

Many of them live and die only simple cells; others assume various forms, and aggregate together, so as to form compound beings. In fact, as we have already shown, the cell is the fundamental organic unit of every organism. Man himself is built up of cells, and nothing else; and all the time, without intermission, new cells are being formed in all parts of his body, to take the place of the old and worn-out ones that are being cast off. Nutrition is nothing but continued cell action, or the production and assimilation of new protoplasm. If this cell action supplies new material faster than the old decays, the being *grows*; if the contrary, it *wastes.* When full grown, for a long time, waste and restoration keep pace with each other, and it *holds its own,* as we commonly say. The duration of cell life, however, is limited, and this power of continued reproduction ultimately fails, and waste, or cell death, goes on faster than cell reproduction. Then decline begins, and finally, the reproductive impulse being totally exhausted, *death* ensues.

This death, however, is only a change. There is still the same matter there, to the utmost atom, with the same amount of force, and new combinations at once take place. It is only the *form,* or particular aggregation of cells, that is broken up, and destroyed. It is the same as if a mechanic should take to pieces a complicated machine, and out of its separated parts make a number of smaller new machines. There is still the same material, possessed of the same properties; and the sum of the power that was in the original large machine is embodied in the many smaller ones. He destroys neither matter nor power when he breaks up the original, nor does he create any new matter or power when he reconstructs. It is only a re-arrangement, or new *birth.*

Death is, therefore, the breaking up of one arrangement of cells, and *birth* is their re-arrangement in a new form. Life is in everything,—there is no such thing as creation,—nor death, in the sense of annihilation or total inertness.

If, after the death of a man, we could bring together again the same elements, in the same way, and under the same conditions, we should reproduce the man, just as he was.

Among the lowest forms of living cells are those called the *Gregarinas.* These are globular, ovoid, rod-like, thread-like, and of various other forms; for it must be borne in mind that the cell is not always like a ball, but may be pulled out in one direction, like a thread, or be of any irregular shape, and still be but one vesicle. In the fluid interior of a gregarina is usually seen a mass of small grains, and generally a larger body, the nucleus, which is usually free from the granules, surrounded by fluid, and containing a nucleolus. It has neither mouth nor limbs, is colorless, and with but little capability of motion.

The subjoined cuts will show some of the prevailing forms of gregarinas. But, besides these, there are innumerable others; and they are all the time varying, so that no form is constant.

The usual residence of the gregarinas is in the intestines of various animals, especially the cockroach, where they live as parasites. In size, they are found from that of a small pin's head up to sometimes half an inch long, when they have a worm-like form, and occasionally one end is turned round like a hook, apparently as a means of hanging on to any object. This is the only approach to the formation of a limb ever seen in them.

The psorosperms are usually found in the bodies of fishes, and are supposed to be only imperfect forms of gregarinas.

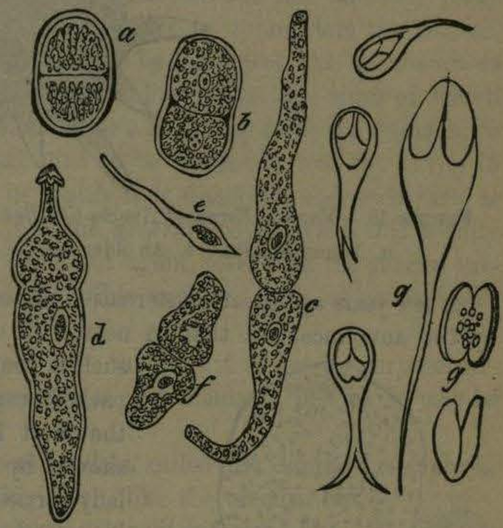

FIGURE 18.—*Various Forms of Gregarinas.*

a, b, c, d. Different forms of Gregarinas. *f.* A younger stage of *a.* *g, g.* Psorosperms. *e* is a peculiar modification, called a Navicula, or little boat. The Psorosperms are probably only immature Gregarinas, or germs not fully developed.

When being examined under the microscope, two gregarinas may frequently be seen to come together. They then flatten out at the points of contact, a membrane forms around them both, and they become one, but double. This is shown in the first stage, in *f*, and, when completed, in *a*.

This union of two seems to be something like a sexual effort, for, when it takes place, the interior soon fills up with a number of globular bodies larger than the ordinary granules, each one of which ultimately develops into a navicula, or little boat (*e*). Finally, the partition between the two parts of the double cell disappears; it bursts open; and the naviculas escape into the surrounding fluid. After a time they burst also, and out of them arise a number of curious bodies resembling those called *amœba,* some of which are shown in the plate on the following page.

These amœbas ultimately return to the usual forms of the gregarinas.

The navicula, it should be observed, sometimes forms in the interior of single individuals, as well as from the union of two.

The real nature of the gregarinas is still in dispute. Some naturalists contend they are vegetable forms, and not animals. This, however, is of little moment, for they may be either or neither, originally, and yet become the one or the other. They are simple one-celled beings, of the most primitive kind.

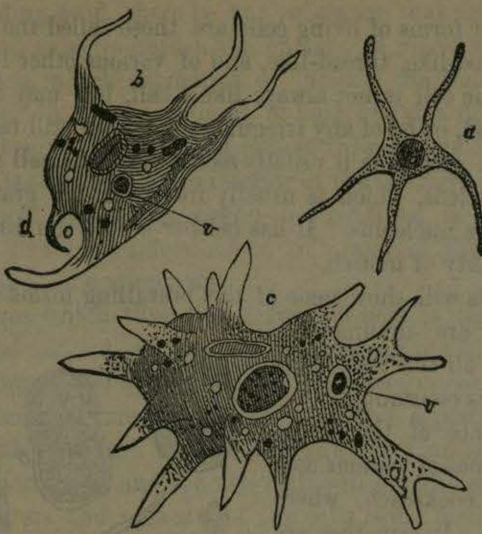

FIGURE 19.—*Various Forms of Amœba-like Bodies, resulting from the bursting of Naviculas.*
a. Young Amœba. *b.* An older one. *c.* A peculiar variety. *v.* A Nucleus.

A few years ago great consternation was excited, among ladies who wore false hair, by the announcement that in nearly all cases it abounded with gregarinas; and such is really the case, for dead hair, when closely packed, especially if not perfectly clean, is one of the most likely things to produce them. It was shown, by a celebrated microscopist, that many a lady carried millions of these creatures in her false locks, and that from them they probably often passed to her own hair. As no special harm was shown to follow from them, the excitement died away; but the idea of their presence is not agreeable, to say the least.

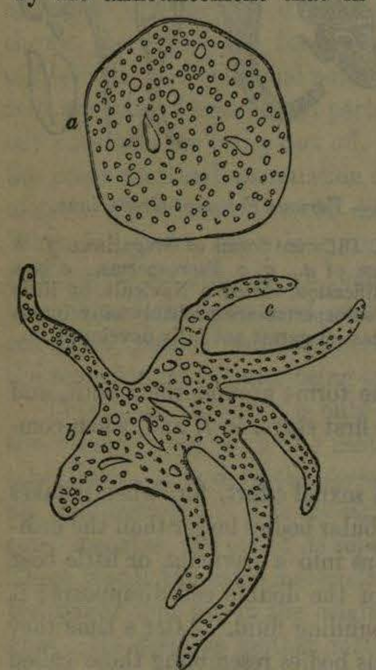

FIGURE 20.—*Amœba.*

a. An Amœba at rest. *b.* One with limbs thrown out. At *c* two limbs are seen forming a temporary stomach. At *d*, Fig. 19, the stomach is more nearly completed, and is seen folding round a grain of starch.

The true amœba is a being a little further advanced; for we see in it the rudiments of a stomach, and limbs. It is simply a unicellular organism, like a small bag filled with jelly-like protoplasm, living in fresh water, usually when it is stagnant and full of putrefying matter. It may be said to possess a stomach, a circulating apparatus, and limbs, but of the most simple and strange character. It propagates either by dividing itself, or by casting off bits of its substance, which grow into new beings, or it gives off buds, which develop in the same way.

The ordinary form of the amœba is that of a shapeless bag containing granules, and a nucleus, as seen in *a*, Fig. 20.

In this being, then, we have the first definite organs, not permanent, but formed as the animal needs them. When an amœba, as *a*, for instance, needs a limb, to reach anything not close by, it simply pushes out, or elongates, a portion of its substance, like a finger, till it is long enough, and then, when the purpose is effected, the limb is drawn back, and is again lost in the substance of the body. When active, the amœba pushes out a number of these false limbs, of all shapes and sizes, in all directions, as shown in *b*, and when no longer needed, draws them all in, and becomes again a shapeless bag.

It is this constant change of form which has caused it to be sometimes called the *Proteus,* meaning the *changeable.*

When it needs a stomach, for a temporary purpose, it is formed similarly to an arm. Rolling about in the surrounding fluid, the amœba comes in contact with a portion of matter suitable for food, but, having no mouth nor stomach ready formed, one has to be made on the instant, in order to appropriate the morsel, and it proceeds in this way: As soon as touched by the object, the amœba draws itself in at the point of contact, so as to form a hollow place, the sides of which roll round the object till it is entirely inclosed. Or a limb may form the stomach, as at *d*, Fig. 19. The substance may be said thus to be swallowed, and the cavity in which it is shut serves as a stomach, in which it is dissolved, and such parts as are fit for food are absorbed, by osmose, into the general body. When this is fully effected, the temporary stomach pushes itself out again, level with the general surface, or possibly becomes a limb. Any indigestible portion of the object so swallowed is thus thrown out and got rid of.

Nothing can be imagined more simple than this, but it serves its purpose perfectly. Every part may be stomach or limb at any moment, just as it may be needed.

The following is another being of the same class, called the Gaping Leucophrys. This animal is merely a bag of jelly, a single cell, like the amœba, but it may be considered a slight advance, inasmuch as it is formed like a pouch, or pocket, the cavity inside serving as a permanent stomach. It does not need, therefore, to make a new stomach each time it takes food. This stomach, however, is only like a fold of the skin pushed in, and is in no way specialized. To facilitate nutrition it has no mouth, properly speaking, but the entrance to the inner cavity is always gaping open, so that the surrounding fluid flows in and out all the time, without hinderance, and from this fluid the walls of the cavity imbibe nutriment, as needed,—or practice osmose.

FIGURE 21.
The Gaping Leucophrys.

It may be said that the movement of the amœba in taking its food is simply automatic, or like that of a plant in the process of growth, with no element of intelligence or *mind* in it whatever. This view, however, does not accord with the facts. There may be numerous portions of matter floating around, and it will take only the appropriate one, which it will separate from the rest. If a portion of its proper food be dropped in while the arms of the amœba are extended, they will immediately turn and seize it, as an animal does its prey. In some cases it has even been seen to lie in wait, or watch, for starch granules floating out of a piece of a torn plant. If this be not *intelligence* and *will*, though in a low degree, we cannot truly say what is, nor can we begin to imagine where mere automatic motion ends and true mind begins.

The more reasonable supposition seems to be, that what we call *attraction* and *repulsion* in inorganic matter, or *selection* in the lower organisms, is the same power that we call *intelligent will*, or *choice*, in the higher animals. It is merely different in degree or amount, according as the parts of the organism are more or less differentiated and perfected.

This fact of the original *oneness* of power, and function, in every part of the cell body alike, is very important and interesting. All our senses—sight, hearing, smell, and taste—are only modifications of *touch* or feeling. The eye feels one way, the ear another, the nose another, and the tongue still another. It is all touch, or feeling, with different instruments.

Now, in the simple cell, this sense is exhibited in one form only, because there is no variety of structure, no special organs, but every part is *capable,* under proper conditions, of being specialized, and so modified as to become eye, ear, nose, or tongue, or equivalent to them.

A man, being built up of cells, exhibits their properties, and, in his early existence, before his organs have been differentiated to their special uses, he probably has, like them, only the simple sense of touch all over his body ; and if either of the special sense organs becomes imperfect, as we well know, it becomes capable of simple touch only. Thus, an imperfect eye feels only, but does not see.

It is this fact, that every part of the living structure, primarily, is alike, in regard to sensation, and that certain parts are specialized so as to modify it, which has led some people to suppose that any and every part may, under peculiar conditions, be so modified as to see, hear, smell, or taste. In some forms of disease, it is said, or in highly wrought nervous states, various parts of the body may become so intensely sensitive to light that they can see, like the eye; or they may even hear, smell, or taste. Thus, people are reported to have been able to see with the backs of their heads, or with the ends of the fingers.

Without stopping here to discuss the truth of this assumption, it is useful to show on what it is founded. All parts of the body are endowed with common touch, or feeling ; but whether any part can be so over-sensitive as to have special sensation without a special organ is doubtful, to say the least of it. In the lower animals, simple *touch* serves every purpose of sensation, and they have no need of special senses.

CHAPTER IX.

UNIVERSALITY OF THE LOWER ORGANISMS, AND THEIR VARIETIES.

To those not accustomed to the wonders of the microscope, some of the details we give of the minute beings, called infusoria or animalcules, must appear very astonishing. When it is remembered, however, that some of our best microscopes, in ordinary use, will enlarge objects *fifteen hundred times* their natural size, and some even many *thousands* of times, the wonder will lessen. Numerous classes of these beings are totally invisible to the unaided eye, and but for the discovery of the lens, we should never have known of their existence.

The great difficulty in examining these beings, next to their smallness, is their extreme transparency, and absence of definite color: they form no vivid contrast with their surroundings. This difficulty, however, has, in a great measure, been overcome by the application of a very simple discovery. It is found that if *carmine,* a bright-red coloring matter, be put in the fluid where animalcules are, they will fill themselves with it, so that they become deep red and very plainly visible.

It must be remembered, also, that among the animalcules there is great diversity of size. Some of the *monads,* for instance, are so minute that powerful glasses are needed to make them visible ; while others, like the *kolpodes,* can be plainly seen with the naked eye. In fact, there is as much comparative difference of size between the two, as between a mouse and an elephant.

In one respect, they are all very peculiar. Every other known being requires stated periods of rest: in animals, this is taken in the form of sleep; but these primitive beings *never rest!* They are always, so far as examined, in incessant motion, night or day. Owen thought that this never-ceasing activity was the result of their immense powers of digestion.

These beings are found in all decaying matter, in water, in the polar ice, in snow, in the depths of the ocean, and in the air. In short, no place is free from them, and though so minute, yet are their numbers so enormous, that in mere bulk they go far beyond all the larger beings that ever existed. Their tenacity of life, under every variety of condition, is another wonderful trait. At the extreme North, where only a few scattered large animals are met with, and where all ordinary vegetation ceases entirely, the animalcule, in some form, is always found living and active. Sir James Ross collected over fifty species of microzoa on the ice, in the polar seas, all living, and many of them were even brought home alive. In the same regions, mud brought up from an ocean depth of 12,000 feet was also found to contain them.

All muddy water is full of them, and even most of that we drink contains them in immense numbers, so that we swallow constantly millions of them, fortunately without injury.

The luminosity of the sea, so often seen, is caused by myriads of phosphorescent animalcules, and the shining of dead wood in the forest results in the same way—from fungus growth.

Sometimes water has been known to turn *red*, like *blood*, to the great terror of superstitious people, and many strange explanations have been given of the phenomenon. The microscope, however, shows us that the blood-red appearance is caused by infusoria of a deep-red color. These at times, from some favorable conditions, multiply in enormous numbers in an incredibly short time. They appear to be both plants and animals, and many different species of them are known. The *Red Sea* owes its color to this cause.

It will be remembered that in the time of Moses, it is said, the water turned to blood.

Even in the bowels of the earth we find the infusoria in such incredible numbers, dead and alive, that they form beds many feet thick; and yet several of them are not more than the *forty-five-thousandth of an inch* in diameter. The city of Berlin, in Prussia, is built upon a living, moving bed of this kind, and so is Richmond, in Virginia. In other places they form a large part of the soil, especially where this has resulted from muddy deposits.

Travelers in snowy regions have often been astonished to see the snow, as the water sometimes is, quite *red*, and this is now known to be caused by the rapid multiplication of a peculiar microscopic organism, called the *Discera nivalis*, which lives and propagates on the snow. This appearance has been noticed in various parts of the world, and it is always found to be owing to the same cause.

The astonishing rapidity with which these peculiar beings multiply will be better understood by considering their mode of propagation. They simply subdivide, by fission, and the process is constantly repeated with every individual, and with all its descendants. Thus, one divides into two, each of these into two, and so on without ceasing. Imagine, then, one hundred of them only, to begin with; their descendants would soon be *countless*. Ehrenberg says, *one* individual may produce a *million* in twenty-four hours, and in four days *one hundred and forty billions*, or equal to a cubic foot of ground.—The rapidity with which funguses grow in a single night is also well known.

The dead and living microscopical organisms, of various kinds, in the *air*, are perhaps as numerous as those in the earth or the water. Sometimes they form real clouds, like fogs, which intercept the light, and make it difficult to breathe. And in this way are probably often formed those showers of flesh, as it is called—a jelly-like matter—which often fall over a large extent of country. It is simply a rapid formation of fungoid protoplasm, and it may be of a nutritious character, like real flesh. It is also sometimes *red* in color, and more fluid, so as to stain whatever it falls upon red. It is then often called a shower of *blood*, and the world has frequently been alarmed by such showers, which are, however, just as natural as ordinary rains. The *manna* in the wilderness, it is thought, was of this character.

But, in addition to all these varied conditions, similar beings are found, in perhaps equal numbers, in the very material of all plants and animals, and in all substances we consume as food or drink. On our teeth, in the saliva, all through the intestines, in the liver, the brain, the eye, and every other part, strange beings live and multiply their kind. The *staggers* in sheep is caused in this way, by colonies of small worms, which develop in the brain; and peculiar liver affections result in the same way, while intestinal worms are only too well known.

Most of them, however, do no serious harm, and some are perhaps natural and

inevitable; but there are others which cause great suffering and loss of life. Among them may be mentioned the *Trichina spiralis*. This terrible little worm seems natural to the pig, and from it is often transferred to man. To the pig itself, the trichina is not especially hurtful, except when very abundant, but in man it causes intense suffering and even death. The trichina and its young are contained in the flesh of the pig, and that being eaten by man, they are taken into his intestines, from whence they burrow through the intestinal walls and make their way into the muscles, where they live, causing pains like those of rheumatism, with fever, diarrhœa, and even death.

The trichina is found only in the lean or muscle of the pig, and not in the fat, and may be killed by *thorough* cooking. It will apparently stand boiling-heat for a *short time*, but if it be kept up long enough to perfectly cook the flesh, the trichina is killed. The *ham* is the part worst affected, and many fatal cases of *trichinosis*, as it is called, have resulted from eating ham raw, or only smoked. Many Germans have lost their lives from so using it, and also from eating half-cooked sausages. When fried or broiled, some part may easily escape being perfectly cooked. *Thorough boiling* is the only safe mode of preparation. It should *never* be eaten *raw!*

Below is shown the trichina in its various stages.

FIGURE 22.—*Trichina Spiralis.*

This figure shows a Female Trichina, giving birth to her young. They are developed from eggs within her body, and ejected alive, as seen in the picture. This is magnified six hundred diameters, from which the natural size can be estimated.

FIGURE 23.—*A thin slice of ham*, magnified, showing the Trichinas actively at work, boring among the muscular fibers.

Once introduced into the body, we know of no way to dislodge them, and therefore *extreme care* should be exercised in having pork always *thoroughly* cooked. Smoking, salting, or pickling will not kill trichina.

Measly pork, it should be stated, is by some thought to result from trichina.

Numerous as infusorial beings are at the present day, there is good reason to suppose that in former ages they were still more so, for in some parts whole mountains are composed of their remains. Some *siliceous* beds even, the hardest material we generally find among rocks, are made up of similar remains. The powder called *tripoli*, used for polishing, is almost entirely made of the flint skeletons of infusoria, many of which are so perfectly preserved that their species can be determined.

A bed of tripoli is, therefore, only the cemetery of the infusoria of past ages.

The deposit on which the city of Richmond, Virginia, is built, is of a similar character, and is several hundred yards deep.

The material called *electro silicon* is a similar deposit, being formed almost entirely of flint-shell diatoms; and there are many other deposits of a like character in various parts of the United States. They all make excellent polishing powders.

In the Isle of France there is a similar deposit, which extends some ten leagues, and is from ten to fifteen feet thick. A cubic inch of this will contain forty million infusoria. The numbers in the whole deposit are, therefore, past all our power of expression.

We find similar remains in solid flints, and other hard stones, sometimes richly colored. The red stone called *carnelian*, used in jewelry, owes its beautiful color to red infusoria.

It has long been known that in some parts of the world there are peculiar beds of earth, a sort of clay, which is eaten both by men and animals in large quantities, and it is beyond doubt capable of serving as food. The nature of this earth was long a mystery, till the microscope showed that it was mainly composed of minute infusoria. It is, therefore, an organic matter, probably both animal and vegetable. An earth of this kind is sold in the markets in Bolivia, and is often preferred to other food. In the forests of Carolina, and Florida, the negroes also use a similar substance for food.

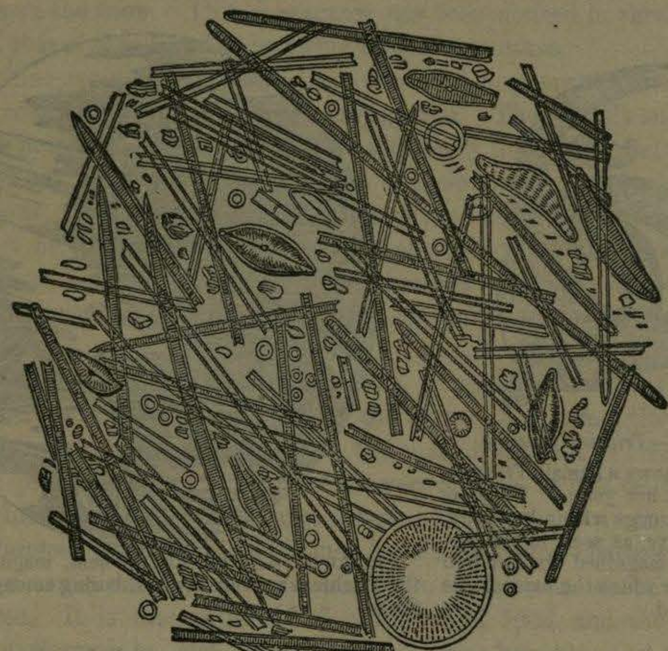

FIGURE 24.—*Infusoria in Mountain Meal, from Ebstorf.*

A common name for such earth in Europe is *mountain meal*, and it is often mixed with real meal, to increase the quantity. In some regions hundreds of wagon loads are used in a season. The preceding cut shows the appearance, under the microscope, of a few grains of mountain meal from Ebstorf, in Germany.

In Lapland a variety of this material is found so highly nutritious, and so much like real meal, that it is even made into bread.

Many varieties of limestone used for building are composed almost entirely of infusoria and other small beings. The stone of which the *Pyramids* of Egypt are made is of this kind, being mostly composed of the shells of *nummulites*, which lived in a far-distant period. There were other builders, therefore, millions of years before the Pyramids were erected.

At the present moment, the same process is going on as of old. In the bed of the sea just such formations, of unknown thickness, are being made by similar beings to those which made the fossil beds which we have spoken of.

In fact, the minute, simple, and apparently insignificant beings, such as those we have been describing, both animal and vegetable, have made a large portion of the bulk of the earth with which we are acquainted.

FIGURE 25.—*Infusoria, dredged from the bottom of the Antarctic Ocean.*

This shows the abundance and variety of these beings in the ocean ooze, now forming new beds, similar to the ancient chalk. They are mixed, in many parts, with *bathybius*, Huxley's protoplasmic jelly, from which new beings are probably being continually generated spontaneously. When the membrane of one of the protozoa assimilates lime, or silex, to form a shell or framework, it often assumes the most beautiful geometrical forms, instead of being without regular form, as in those that remain soft.

This is probably due to the fact that *crystallization*, an inorganic process, here comes in and modifies the organic animal development. The variety, beauty, and perfect regularity of these coverings of simple cell beings, are truly wonderful.