leaves had reached the flies, and their limbs were entangled among the bristles, and held fast. The flies were then removed three-quarters of an inch farther from the leaves, which still remained bent toward the flies, but could not reach them at this distance. The observer thinks that the action of the flies' wings may have created sufficient force to bring the leaves near enough to entangle the flies, for dead flies fail to produce the same result as living ones. On the same day bits of raw beef were placed on some of the most vigorous leaves of another species of the plant, the *Drosera longifolia.* In two hours two of the leaves had folded around the beef, hiding it from sight. Living flies were also placed upon the same species of the plant. In a little more than an hour one of the leaves had folded entirely around its victim, the other leaves had partially folded, and the flies had ceased to struggle. Two hours later, four leaves had each folded around a fly.

FIGURE 16.—*Dionea Muscipula, or Venus's Fly-trap.*

In this cut the structure of the Dionea is well shown. The trap, it will be seen, is on the end of each broad leaf, and is shown both opened flat, with the hairs spread out, and also closed, in various stages. Those tightly shut up contain insects being digested.

The *Drosera* manifests a very decided choice in regard to its gustatory fancies. Experiments were made with bits of dry chalk, magnesia, and pebbles, but the plant would have nothing to do with them, and after twenty-four hours neither leaves nor bristles had made the slightest movement toward clasping these articles. A similar result was produced upon the *Drosera rotundifolia.* This variety has longer bristles around the edge of the leaf, and simply curls its bristles around its victims, the glands on the ends of the bristles touching the substance, like so many mouths receiving nourishment. Some bits of raw beef were placed upon the leaves about 10 o'clock in the morning. In two hours the inner bristles were curving about it, and the longer bristles at the edge of the leaf were curving upward. At 9 o'clock in the evening the bristles of the three most vigorous leaves were clasping the beef, almost concealing it from sight. Nor is this ferocious plant contented with small insects. Flies of the largest size, moths without number, and butterflies, many of them measuring two inches across, were held captive till they died, the treacherous flowers and shining dew luring them to destruction. The larger insects, after death, fell around the roots of the plants, as if to fertilize them, while the smaller flies remained adhering to the leaves. These curious plants thus seem to manifest a decided preference for meat diet, absorbing the animal substances through their leaves.

The dog's-bane—*Apocynum androsemifolium*—catches insects in a different way.

but probably for the same purpose: whenever a fly is attracted by the honey of the flower, and protrudes its trunk to take it, the filaments close tightly on the trunk, and hold the fly there till it dies, when they relax, and let it fall.

Another very striking proof has been obtained of the identity between the secretion from the leaf of the *Dionea,* and animal gastric juice. It is well known that the gastric juice will dissolve almost all organic matters, even bones, if allowed sufficient time. It has been known to dissolve the stomach itself even, after death. The juice from the leaf of the dionea, as before stated, will dissolve meat, and digest it, the same as the animal gastric juice; and recently, instead of meat, a piece of the bony part of a *dog's tooth* was placed on one of these leaves, which closed upon it at once, and retained it. It a few days the leaf was opened, and the piece of tooth found perfectly softened, and fibrous, so that the mere opening of the leaf tore it into shreds.

A further proof of the similarity between the animal and vegetable gastric juice is also found in the fact, that the presence of food in both causes the juice to be immediately secreted.

The difference then, between the animal and vegetable kingdoms, disappears when we come to understand both more fully, and it is really very difficult to say if there be any faculty, or property, peculiar to either one alone. It would seem rather that the plant and the animal should be looked upon as one and the same, at the beginning, and diverging more or less in different directions as they develop. Possibly any primary protoplasmic germ may become plant or animal according as it is influenced by surrounding conditions, such as light, heat, electricity, etc., when it starts upon its career of development.

There is a peculiar fungus found in tanpits, which, when placed under new conditions, changes completely. From a decided plant, growing in one spot, it becomes an entirely different being, capable of moving about, and of eating, and digesting solid food. In fact, it becomes an animal, to all intents and purposes.

Such an occurrence still further increases the difficulty of determining what is the real, essential difference, if any, between the two kingdoms. We have plants that move about, and animals that are rooted; we have plants with sensation, and animals apparently without; we have plants that digest animal food, and animals that live upon vegetables; and, lastly, as stated above, we find that one can change into the other. The simple explanation of these seeming anomalies, is, as previously stated, that they are both fundamentally the same.

Recent observations have also shown another point of resemblance, of a very interesting and important kind. It is well known that, in animals, muscular exertion is always accompanied by an electric current in the muscle, the force of which is in exact proportion to the violence of the exertion. This electric condition remains in the muscle even after death, till the body becomes rigid. The current is strongest in the warm-blooded mammals, gets less in reptiles, and scarcely observable in fishes. This, it must be observed, is different from the electric battery of the torpedo-fish, which is developed by a special apparatus. These electric currents in animals have been known for some time, and recently similar currents have been detected also in plants. When any of the insect-eating plants contract their leaves, to seize their prey, an electric current is established in them exactly similar to that which is found in an animal's muscles when they are exerted. This is another and very interesting point of identity between the two kingdoms.

When the leaves of the sensitive plant contract and expand, from a touch, the same thing is observed, an electric current being immediately established. And Mr. Darwin says that by pricking a point in the leaf of *Drosera,* he can paralyze half of it, and this indicates the existence of nerves or something analagous.

After all, it may be said the grand distinction lies in the possession of *mind* by animals alone. This, however, may be more apparent than real, or may be only a matter of degree. When we observe the apparent intelligence, or sense, often shown by plants, we are quite justified in supposing that it may be the same as animal intel-

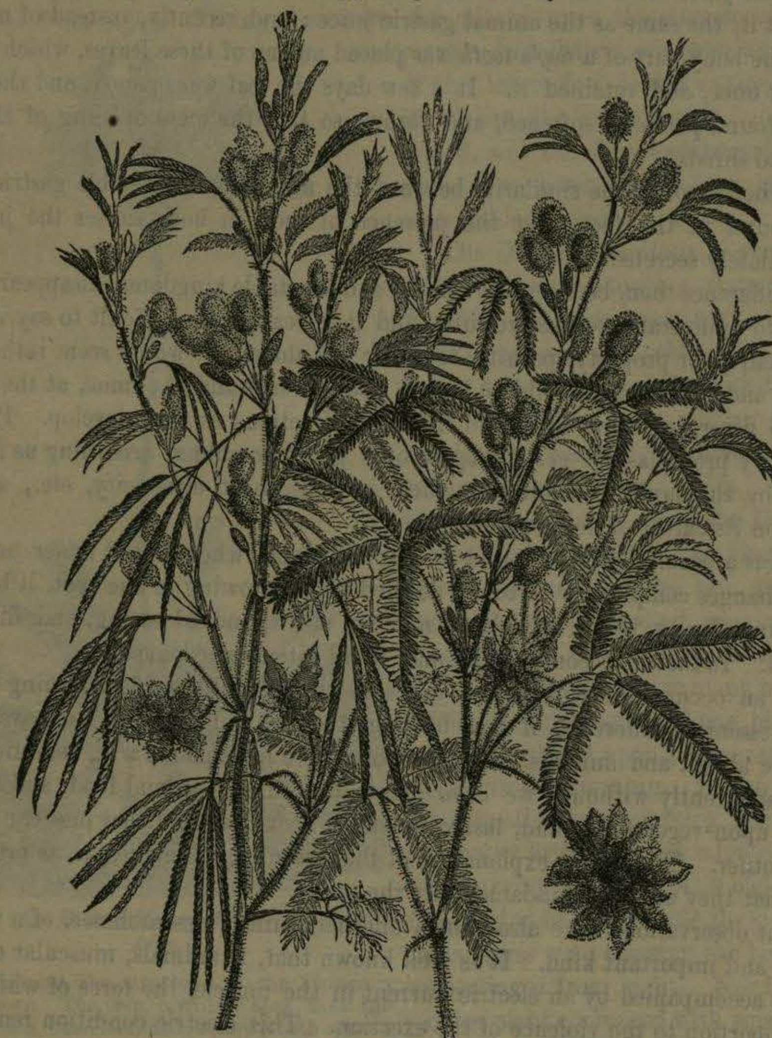

FIGURE 17.—*Mimosa Pudica, or Sensitive Plant, asleep and awake.*

The leaves on the left side will be seen fully erect, and the little leaflets expanded. On the other side the whole leaf is drooping, and the little leaflets are closed, just as they are when the plant is touched, or frightened.

ligence, only less in degree, and manifested by less perfect organs. Observe how singularly a plant will stretch and bend its branches to get into the light; and how its roots will turn, even at right angles, or around corners, to reach rich soil. Many of them always close their leaves, or flowers, on the approach of storms, and some will not unclose at all, if the weather is going to be unfavorable.

It will be said, I know, that this is all mechanical, and that there is nothing like *mind* about it! But we cannot be sure about that; for, as said before, it may only be a very low degree of mentality. Some idiots have scarcely any more mind than some plants; and the vital functions they perform are almost, if not quite, as mechanical. In fact, the difference between a thorough idiot and some plants, seems not greater than that between the same idiot and a perfectly sane man of large mental capacity.

We may even go beyond this, and when we see one kind of matter unite with a certain other kind only, selecting it by *preference* from among many others, we may not unreasonably say,—here is the same faculty, in a less degree, that we see in plants and animals,—that of *choice!*

The formation of crystals, of frost figures on our window-panes, and numerous other familiar instances, show us that matter always arranges itself according to fixed and unchangeable laws, whose action is simply more perfectly manifested in organized bodies than in simple ones. What we call *attraction* only in the crystal, is *selection* in the plant, and *choice* in the animal. Nature is *one,* and the same powers exist in her atoms, and primary forms, as in the most complicated organizations.

The well-known sensitive plant, *Mimosa pudica,* exhibits sensibility in a very marked manner, and has, in consequence, always been an object of interest and wonderment.

In Fig. 17, the Mimosa is seen asleep and awake. On the left-hand side the leaf-stalks are seen all erect, and the little leaflets spread out. If one be touched with the finger, even slightly, the small leaflets close together, and the stalk bends down, as seen on the other side. After remaining closed, and drooping for some minutes, if not further irritated, the leaflets again slowly open, and the stalk again becomes erect. This may be repeated over and over again, and the Mimosa may in this way be readily put to sleep, and kept so for a long time. A drop of acid on one of the leaves will make the whole plant close up, and the same effect follows if we throw the focus of a burning-glass on any part. Even striking the ground, some distance away, will affect it; or a loud noise, like thunder, or the discharge of a gun. It is also sensitive to sudden sunlight or shadow, and can be stupefied by opium, or killed by an electric shock. Prussic acid is instantly as fatal to it as it is to animals; ether spray paralyzes the leaves; and a current of galvanism from Ruhmkorff's coil closes them immediately.

In short, it is affected by any of these agencies just like an animal, and can become accustomed to many of them, as an animal does. A sensitive plant when first taken into a carriage closes up, from the motion, but after a while seems to get used to it, opens out again and remains open, but closes when the carriage stops, to open again as before.

Undoubtedly, this is *true sensation,* of the same kind as that we experience ourselves, and quite as strong as we see in many of the lower animals.

Many other plants, however, are known to be sensitive, more or less, and probably all are so in some degree.

Motion in plants is also common enough, and sometimes is quite vigorous. The *Colocassia esculenta* moves in regular periods, like the beating of the pulse, and sometimes so violently that it will almost overturn the pot in which it is growing. The *Desmodium gyrans,* or telegraph plant, is still more remarkable. Its leaves are in threes—one at the end of the stem, and one on each side. The two side ones flap up and down all the time, day and night, at regular intervals, while the center one moves up and down, according as there is more or less light.

If we touch the stamens of some plants with a needle or knife, especially those of the Barberry, Nettle, and Cactus, they obviously shrink away from it; and in other plants the pistils will draw together when so touched.

The pollen of some plants resembles animalcules, and will swim about in water, just as they do, being provided with little oars, or cilia, for the purpose. Some pollens are even formed like eels, and move about by means of two long filaments on their heads. Others, again, resemble the tadpoles of frogs, and flit about just like them.

Many plants move in a remarkable manner, and put forth astonishing efforts, to reach water or light. Thus, M. Grimàrd tells us of a little plant—*Lathrea squamaria*—which, happening to germinate at the bottom of a mine, extended itself 120 feet to reach the light at the top, and yet its ordinary height is not more than six inches.

In short, we find in plants the power of motion, apparently voluntary—selection, or choice—and sensibility, exactly as we see them in animals; and the conviction forces itself upon us that they are the same in both kingdoms of nature, only modified and different in degree.

When we come to speak upon reproduction, other points of resemblance will be shown still more striking.

In a lecture delivered at the London Institution, Mr. Francis Darwin gave some very interesting information concerning the analogies between plant and animal life, in addition to what had previously been imparted by his father, Mr. Charles Darwin.

After first illustrating, in a very felicitous manner, the striking resemblance between a vegetable seed and an animal egg, in their structure and manner of development, he alluded to the recent discovery, by a German chemist, of the existence in all germinating seeds of a peculiar ferment, which acts like the pancreatic juice in animals. This ferment changes the starch and nitrogenous matters of the seeds, which the young plant cannot use as nutriment, into sugar, and other compounds, which it can use. In other words, it digests them, just as they are digested in the stomachs of animals.

A ferment of this kind exists in all seeds, when they are germinating, and thus a young plant acts just like a young animal, in regard to its food, and is nourished in a similar manner. Farina or arrowroot, which are forms of starch, will not nourish a child until they are changed into sugar, and other compounds, and this change is effected by digestion. In the same manner exactly, the starch in a seed cannot nourish the young plant, till it undergoes a similar change, by the action of the digestive ferment.

If we carefully examine a seed, as a bean, for instance, we find it composed of two similar halves, called the cotyledons, which may be compared to the yelk of the egg. They are composed chiefly of starch, with some nitrogenous material, and between them lies the embryo, or germ, of the future plant, which, when it begins to grow, sends one shoot down as the root, and another up as the stem. All its nourishment, before the root and leaves are formed, is derived from these two halves of the seed, which are gradually converted, by its digestive ferment, into suitable nutritive material. They gradually change from white to green, and finally become the first pair of leaves, charged with chlorophyl, or green protoplasm.

To prove that this is what really occurs, Van Tieghem cut away from a growing seed all the substance of the cotyledons, leaving the shoot, or embryo, only, which of course could not then grow, any more than a young chicken could grow without the yelk of the egg. When placed, however, in a paste made of starch and water, it began to develop, the same as it would have done had it been left in connection with its own store of nutriment; but first, by the action of its digestive ferment, changing the starch into suitable material.

The young plant, therefore, digests its food just as the young animal does, and when we eat a grain of wheat it undergoes, in our stomachs, just the same change as it would have undergone, had it grown into a plant.

Among animals, we have some kinds that live entirely on flesh, and others that live entirely on vegetable matters, and it is just so with plants. The Drosera, for instance, feeds on insects, or meat, while the bean feeds on starch. But both digest their food just the same. It is the same function in all, modified only by difference of structure.

In the degree of development to which they attain, before being left to themselves, young plants also vary the same as young animals. Some young animals are connected with the mother till fully grown; others are cast off imperfect; and in many the egg develops entirely away from the parent. It is the same in plants. Most seeds are thrown off and develop independently, but others remain attached to the parent till fully grown and rooted; as the mangrove, for instance. As a rule, those seeds that have the largest cotyledons, or stores of food, grow the most vigorously at first, before they become rooted, and thus have the advantage over others not so well provided, and crowd them out. Some young animals have a similar advantage, and in the struggle for existence hold their own better in consequence.

Even what are called instinctive actions, in young animals, are paralleled by similar actions in young plants. The child will take the breast as soon as born; the chick, just hatched, will peck at its food; and the young caterpillar will work its way out of the cocoon. In the same way the young plant sends its root down into the ground, and its stem up to the light with unerring certainty. The root will twist and turn in various directions to find water, or food, and the stem will similarly turn and bend to reach the light. These actions are just as wonderful as those of the animal, and probably are fundamentally the same, only modified by difference of organization.

Some plants even sleep, just like animals: the Mimosa, for instance, closes its leaves at night, just as an animal closes its eyes, and droops its fronds, just as the animal does its limbs. Many others always close their flowers at night. These sleeping plants may also be awakened, just like animals, and kept awake, by artificial light and stimulation.

Mr. F. Darwin even supposes that the sensitive plant may *dream*, because sometimes at night, when asleep, it will suddenly awake, as it were, with a start, and then go to sleep again, just as a man often does from a vivid dream.

Many of the systematic motions of plants, and many of their periodic actions, are wonderfully like memory. They do the same things at regular times, or under the proper conditions, just as we do from habit. And we often do things thus habitually, with no more thought than the plant.

It is certain the plant knows, in some way, the right thing to do, and does it, at the right time, just as the animal does; and it is quite reasonable to suppose that the moving impulse is fundamentally the same in both.

Mr. Darwin says, in conclusion, "Until a man begins to *work* at plants, he is apt to grant to them the word *alive* in rather a meager sense, but, the more he works at them, the more vivid does his sense of their vitality become!"

All which goes still further to show, as we have endeavored to illustrate elsewhere also, that nature is one all through, and that in the organic world, animal and vegetable are fundamentally the same. That all the phenomena we call *mental*—consciousness, desire, aversion, will—are attributes of matter, existing in all forms and quantities of it, down to the merest molecule, is now considered probable by many of the first thinkers and observers of the day. It is even conceived that mind may be only a form of the force, or power, inherent in matter, which underlies all natural phenomena of every kind, so that the world of thought is a part of the material universe, and not something outside of it.

Von Zellner, in his work on the nature of comets, distinctly states that position, and argues that it is only the imperfection of our own faculties which prevents us seeing the life and mind that are in all material bodies, whether organized or not. We are not justified, he says, in asserting that the motions which occur in an injured crystal are totally unaccompanied by sensation. If our faculties were acute enough to trace all the changes accompanying the injury, and to appreciate the conditions they give rise to, we might find in the crystal a sensation strictly analogous to the pain felt by an animal when hurt. It would, of course, be modified, and be in lesser degree, from the greater simplicity of composition and structure of the crystal, compared with that of the animal.

In short, if our senses were acute enough, and our brains sufficiently developed, we could probably trace all the complicated phenomena of life and mind from one stage to another, down to the simple motions of protoplasmic animalcules, and from thence down to the force which is inseparable from molecules and atoms.

Geiger has well remarked that there may be, farther down, below the world of *nerves*, a sensation which we cannot understand. Indeed, he says, "It probably must be so. For as a body that we feel could not exist unless it consisted of atoms that we do not feel, and as we could not see a motion, were it not accompanied by waves of light which we do not see, neither could a complex living being experience a sensation strong enough for us to feel it also, in consequence of the motion by which it is manifested, if something similar, though far weaker, and imperceptible to us, did not occur in the elements, that is to say, in the atoms."

It is true we do not *know* that the stone we break with a hammer really *feels* the blow, in some sense; but neither do we *know* that it does *not feel!* Each one must decide for himself as to which is the most probable.

It has been argued that plants have no *nerves*, so far as known, and therefore cannot feel! But there are also animals in whom not a trace of a nervous system can be found, and yet they plainly exhibit some kind of a sense. The Amœba is apparently as nerveless as any plant, and yet it feels when any bit of nutriment touches its body, and folds around it at once. Several others of the lower organisms will direct their tentacles toward their food and seize it, as certainly as if they saw it, and yet no nerves can be traced in them.

The fact seems to be that all organic bodies possess *nervous currents*, which

PLATE II.

Sap-Gathering in a Canadian Forest.

influence their motions, just as all simple inorganic molecules possess polarity. These currents run in certain lines, and, as the organization becomes more perfect, these lines become *specialized* as nerves or *conductors*. The power is there, whether the nerves are or not; but with them it is distributed with more precision and intensity.

The circulation of the *sap* in plants may also be referred to as another correspondence between them and animals; for it is strictly analogous to the circulation of the blood, and undergoes similar changes, by osmotic cell action, to convert it into protoplasmic material. The subjoined plate, showing the yearly gathering of sap in a maple-sugar forest, will serve to show the immense scale upon which this circulation and conversion takes place.

[It should be remarked here that many of the names made use of in this chapter, and many of the things referred to, will be more fully explained farther on. It was necessary to speak of them here, by way of illustration, before they had been properly introduced. **In fact, this chapter should be read again after the next one on *cell life*.**]