SPONTANEOUS MOVEMENTS IN PLANTS.

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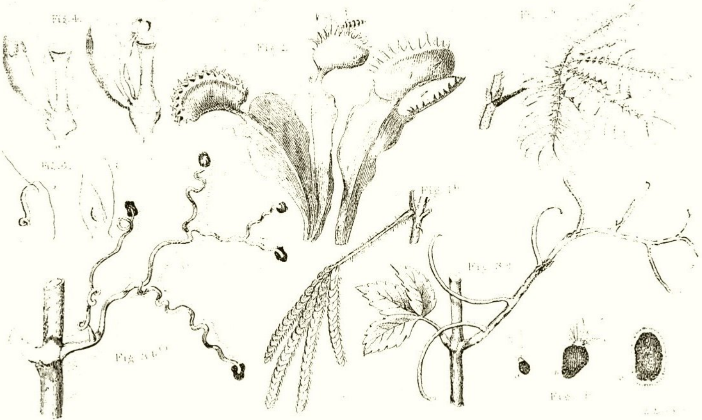
[PLATE LXXXIX.]

THAT there are no "hard and fast lines" in Nature is a truth which is more and more forcing itself upon the minds of men of science. The older naturalists delighted to circumscribe their own special domains within sharply-marked boundaries, which no trespassers were allowed to pass. We have long given up the attempt thus accurately to map out the kingdom of Nature. Her varied productions are connected with one another by innumerable links and cross-links; and our systems of classification, even the most "natural," are but an imperfect human contrivance for bringing together those forms which present the most evident marks of resemblance or affinity. While the truth of this law is most familiar in the case of those smaller subdivisions of the animal and vegetable kingdoms—classes, orders, and genera—which are connected with one another by innumerable intermediate forms, it is none the less certain in the line of demarcation which separates these two great kingdoms themselves from one another. In attempting to draw up a definition which shall serve accurately and infallibly to distinguish between the Animal and Vegetable Kingdoms, we find ourselves compelled to abandon one supposed crucial test after another, and to content ourselves at last with framing, as in the case of the lower subdivisions, an assemblage of characters, by the *tout ensemble* of which we must decide whether our organism is an animal or a plant. So great is the uncertainty as to the actual boundary-line, that large groups of lowly organisms, such as those known as Diatoms and Desmideæ, have been regarded by experienced authorities as belonging to each kingdom; and one of the ablest of living naturalists, Ernst Haeckel of Jena, has proposed the division of the material universe not into three but into four kingdoms—animals, plants, protista, and minerals, the new kingdom of Protista including the most lowly organised forms of what are generally considered animals and plants, from the Flagellate



Spontaneous Movement of Plants.

Infusoria to the Fungi, distinguished by the absence of sexes, and the mode of reproduction by gemmation or fission alone. The soundness of this new classification is not however admitted by the best remaining authorities in England or Germany.

One of the most obvious distinctions between the Animal and Vegetable Kingdoms consists in the possession by the former of a power of voluntary motion of either the whole or a part of the body, dependent on the presence of a distinct nervous system, which is absent in the latter; a distinction obvious enough when contrasting any of the higher forms of the two kingdoms, but which, like all other individual characters, fails when pressed to too rigid a test. There are animals, so regarded by the best naturalists, and possessing other characters which compel us to refer them to this class, whose power of motion is confined to the "contractility" common to all protoplasmic substance, and which are absolutely devoid of a nervous system; and there are plants, unquestionable plants, which possess powers of spontaneous motion strictly comparable to those exhibited by the lower animals. It may be interesting to collect together a few illustrations of this last-named fact, some of which appear to the writer scarcely explicable by the application of any of those laws which govern inert unorganised matter.

The movements to which reference is here made belong in most cases to a part rather than to the whole of a plant; in some cases, however, we find the whole organism endowed with spontaneous motion of a very remarkable character. An instance of this occurs in the case of the regular undulating motion, exceedingly similar to that of some of the lower animals, characteristic of a class of Algæ hence called Oscillatoriæ. The mode of reproduction of the Algæ, the lowest class of the vegetable kingdom, to which the sea-weeds and the freshwater confervæ belong, is often obscure, and in some cases different distinct processes exist in the same species. In certain freshwater Algæ, reproduction takes place by the formation of "Zoospores," (fig. 5), which are the results of the separation and isolation of the protoplasmic contents of certain special cells. According to the observations of M. Thuret, who has paid great attention to this subject, these zoospores, which are of extreme minuteness, are ovoid in form, and are furnished, either over their whole circumference or towards one extremity, with very fine cilia, varying from two to a large number. As soon as these minute bodies free themselves from the cell in which they are enclosed, the cilia begin to vibrate with great rapidity, the vibration being accompanied by a movement of rotation of the bodies themselves on their axis, occasioned apparently by rapid and spontaneous contractions; the result being a quick motion of the body through the water—undistinguishable in fact from that of some of the lower forms of animal life—continuing for a period varying from half an hour to several hours, at the expiration of which they settle down, reassume the characters of ordinary vegetable cells, lose their cilia, and give rise, by cell-division, to new individuals resembling the parent-plant. Those zoospores which are furnished with cilia at one extremity only, direct that extremity, which is destitute of chlorophyll or green colouring matter, towards the light. Closely resembling these zoospores are the "spermatozoa" of the higher orders of cryptogamic plants, ferns, equisetums, and mosses. These bodies (fig. 6) are produced in the antheridia or male organs, again by a modification of the protoplasmic cell-contents; they are filiform bodies of various forms, mostly presenting one or more spiral curves, and furnished with vibratile cilia. When released from the parent cells, they move about with great activity until they come into contact with the opening of the archegonium or female organ, which they enter, and thus fructify the germ of the new plant. Pringsheim describes the process by which the spermatozoa enter the archegonium as a very peculiar twisting motion, due to the action of the mucus or protoplasm of the germ-cell. He has seen a large number of spermatozoa enter a single cell, forming a kind of chain.

In describing these curious bodies, of the connection of which with the vegetable kingdom there is no room for doubt, one is irresistibly reminded of these lowly forms of animal life known as *Amœba* and *Gromia*, consisting apparently of shapeless masses of protoplasm, possessing indeed far more restricted powers of locomotion than the zoospores and spermatozoa, their faculties in this respect being confined to the protrusion and retractation of arms or pseudopodia, by means of which a slow movement is effected. If the possession of consciousness and of a voluntary control over the movements of the body belongs to the animal kingdom even to its lowest forms, it is difficult to frame any cogent reason for denying these faculties to the vegetable organisms which we have been considering. A very interesting problem also presents itself for solution in the almost perfect identity of constitution between these lowest forms of animals and the protoplasmic elements in the constitution of more highly organised forms. If the *Amœbæ* and *Gromiæ* are admitted to be distinct individual animals, the same line of reasoning would almost compel us to admit to the same rank the white corpuscles of the blood of mammalia, which present almost the same characters and possess the same power of protrusion and retractation of a portion of their substance.

The instances above cited illustrate the faculty of spontaneous motion possessed by detached portions of protoplasm endowed with the power of forming themselves into new individuals. This phenomenon appears, however, to be but a form of the property possessed by all protoplasm of constant motion in some form or other. The circulation of the protoplasmic mucous fluid within the cells of plants is one of the most beautiful phenomena of vegetable life revealed by the microscope, and one of which the explanations at present offered appear quite inadequate. A favourite object for exhibiting this circulation or rotation is formed by the jointed hairs which cover the stamens of the Virginian Spider-wort (*Tradescantia virginica*). The movement is rendered visible by the presence in the otherwise colourless fluid of minute opaque granules of chlorophyll or other colouring matter; and is observable with great ease in the semi-transparent tissue of certain water-plants, as *Chara*, or the *Valisneria* commonly grown in fresh-water aquariums. It consists of a slow movement of the protoplasmic fluid up one side of the cell, across the ends, and down the other side; not perpendicularly, but in an oblique or spiral course. The subject has been carefully investigated by three French physiologists, MM. Prillieux, Roze, and Brongniart, who find that the rotation is directly influenced in a remarkable manner by the presence of light. M. Prillieux kept a moss in the dark for several days, when the cells presented the appearance of a green net-work, between the meshes of which was a clear transparent ground. All the grains of chlorophyll were applied to the walls which separate the cells from one another; there were none on the upper or under walls which form the surfaces of the leaf. Under the influence of light, the grains, together with the thin mucous plasma in which they are embedded, change their position from the lateral to the superficial walls, this change taking place, under favourable circumstances, in about a quarter of an hour. On attaining their new position, the grains do not remain absolutely immovable, but continually approach and recede from one another; and if again darkened, they leave their new position, and return to the lateral walls. Artificial light produces the same effect as daylight.

Analogous to the circulation of the protoplasm within the cell is that of the sap or nutritive fluid through the whole plant, passing through the permeable walls of the cells. This circulation of the sap, by which fluid is conveyed equally to all parts of the plant, apparently in opposition to the laws of gravity, is no doubt explicable to a certain extent by the application of known physical laws, of which the most important are capillary attraction, osmose, or the law by which a less dense fluid passes through a permeable diaphragm to mingle with a denser fluid, and the upward pumping force to supply the partial vacuum occasioned by the evaporation of water from the leaves. Allowing, however, full scope to all these physical forces, there would seem to be a residuum of energy still unaccounted for connected with the vitality of the plant itself. In particular, the selective power of plants in absorbing from the soil a larger portion of those ingredients which are required for the formation or healthy life of their tissues, is an absolutely unexplained phenomenon. A familiar instance of this is furnished by the difference in the amount of silica absorbed by corn-crops and by leguminous plants, amounting in the former case to 2·5 per cent., in the latter to ·3 per cent. of the dry foliage. Indeed, if any two plants are grown together, side by side in the same soil, the constitution of the ash, i.e., of the solid ingredients derived from the soil, will be remarkably different; while in the same plant in the same soil the constitution is constant. It was pointed out by the Duke of Argyll, when criticising Darwin's "Origin of Species," how unavoidable it seems, in describing the phenomena of nature, to use language involving the idea of contrivance and design. In the same manner it seems impossible to describe the process of vegetative life without appearing to attribute to the plant some conscious power of its own. A striking instance of this, as well as of the liability to consider a mere statement of an obscure law in other terms as an explanation of that law, occurs in an admirable treatise on the growth of plants—Johnson's "How Crops Grow." * "The cereals *are able to dispose* of silica by giving it a place in the cuticular cells; the leguminous crops, on the other hand, *cannot remove it* from their juices; the latter remain saturated, and thus further diffusion of silica from without becomes impossible, except as room is made by a new growth. It is in this way that we have a *rational and adequate* explanation of the selective power of the plant." The "rational and adequate explanation" seems to me, on the contrary, to be merely a restatement of this selective power of the tissues in other terms. Because the tissues want the silica, is no explanation of how they get it.

The curious and interesting movements of climbing plants have been investigated by Palm, Mohl, and Asa Gray, and form the subject of one of the most charming of Mr. Darwin's works. It is well known that climbing plants, such as the hop, honey-

* "How Crops Grow:" A Treatise on the Chemical Compositions, Structure and life, of the Plant, for Agricultural Students. By S. W. Johnson. Revised and adapted for English use by A. H. Church and W. T. T. Dyer. London: Macmillan & Co., 1869, pp. 345.

suckle, or major convolvulus, always twine round the stem or other object which supports them in one direction, that is, always either from right to left or from left to right; but few probably have reflected, and fewer still attempted to observe, by what process the end of the growing shoot contrives to change its position from one side to the other of the stem. If the extremity of a living stem, say of convolvulus, growing perfectly free and in a normal position, is observed, it is seen to hang over from its support in a horizontal direction; and this horizontal portion is found, if observed at intervals of some hours, to point in different directions. The end of the growing shoot has, in fact, the property of revolving in a large circle round the support, always with the same species in the same direction, either with the sun or opposed to the sun. The rate of revolution varies with different plants, and with the same plant at different periods of its growth; it is much quicker in warmer than in cooler weather. With the hop Darwin found it to vary from two and-a-half hours to nine hours. The object of the climbing power of plants is no doubt to reach the light and to expose a large surface of leaves to its action and to that of the free air; but the mode by which this power of motion is gained is by no means clear. The late eminent physiologist Mohl supposed that it was caused by a dull kind of irritability in the stem, which caused it to bend towards the support when in contact with it. Mr. Darwin has, however, carefully tested this theory experimentally, and always with negative results. He rubbed many shoots much harder than was necessary to excite movement in any tendril or in any foot-stalk of a leaf-climber, but without result. This view seems also entirely negatived by the fact that not only do the stems of climbing plants revolve when they are not in contact with any support, but even more freely under such circumstances than when climbing. When a climbing plant first springs from the ground, the extremity of the shoot performs slow gyrations in the air, as if, as Darwin expresses it, it were *searching* for a support. I do not here discuss the question whether this habit may be the result of a tendency transmitted and enhanced through thousands of generations; the movement itself is, in the individual plant, entirely "spontaneous" in every sense of the term; that is, is not the necessary result of known physical laws acting upon the individual. Darwin's paper "On the Movements and Habits of Climbing Plants" published in the Journal of the Linnean Society, contains a number of the most interesting observations on this class of plants; and the language employed is everywhere suggestive of some hidden sentient controlling power in the plant itself.

The same purpose as that served by a climbing stem is answered in other plants, as the vine, Virginian creeper, and passion-flower, by tendrils; and the phenomena of spontaneous motion in tendrils, are, if possible, still more curious. Some tendrils display the same power of rotatory motion possessed by the extremities of the shoots of climbing plants, others do not revolve, but are sensitive, bending to the touch. The curling movement consequent on a single touch continues to increase for a considerable time, then ceases; after a few hours the tendril uncurls itself, and is again ready for action. A tendril will thus show a tendency to curl round any object with which it comes into contact, with the singular exception that it will seldom twine itself round another tendril of the same plant. It is also very curious that with some exceedingly sensitive plants, the falling of drops of rain on the tendril will produce no effect whatever. The mode in which a tendril of a *Bignonia* catches hold of a support is thus described by Darwin:—"The main petiole is sensitive to contact with any object; even a small loop of thread after two days caused one to bend upwards. The whole tendrils are likewise sensitive to contact. Hence, when a shoot grows through branched twigs, its revolving movement soon brings the tendril into contact with some twig, and then all three "toes" bend, (or sometimes one alone) and, after several hours, seize fast hold of the twig, exactly like a bird when perched." The Virginian creeper has another mode of attaching itself to a wall or other solid support, by the formation at the extremities of the branches of the tendril, of little disks or cushions, very similar to the disks on the foot of the house-fly by which it is enabled to attach itself to our windows and to walk along the ceiling. These disks secrete a glutinous fluid which attaches the tendril to the support with such strength that it is often impossible to detach it without destroying the tendril or even removing a portion of the wall itself. As soon as the attachment is accomplished the tendril gradually thickens and contracts spirally, as shown in Fig. 3, *a*, *b*. This spiral contraction, indeed, is always the result of the tendril meeting with a support; and if no support is found, the tendril soon shrinks and withers away. Some tendrils exhibit a most remarkable power of selection, which, to use Mr. Darwin's words, "would, in an animal, be called instinct." The tendrils of a species of *Bignonia* slowly travelled over the surface of a piece of wood, and when the apex of one of them came to a hole or fissure, it inserted itself; the same tendril would frequently withdraw from one hole and insert its point into a second one. Mr. Darwin has seen a tendril keep its point, in one instance for twenty hours, and in another instance for thirty-six hours, in a minute hole, and then withdraw it. After the record of this fact on such unexceptional evidence, we are the more prepared to credit the statement of Mr. Anderson-Henry that a climber will, in running up a wall, carefully avoid contact with another climber which it dislikes; and even the account by M. Paul Lévy * that the *lianes* of tropical forests have an affinity for certain trees, towards which they direct their growth, and not towards those nearest to them; carefully drawing themselves away when they encounter one of the objectionable trees.

We may conclude our account of climbing plants with the following remarks by Mr. Darwin:—"It has often been vaguely asserted that plants are distinguished from animals by not having the power of movement. It should rather be said that plants acquire and display this power only when it is of some advantage to them, but that this is of comparatively rare occurrence, as they are affixed to the ground and food is brought to them by the wind and rain. We see how high in the scale of organisation a plant may rise, when we look at one of the more perfect tendril-bearers. It first places its tendrils ready for action, *as a polypus places its tentacula.* If the tendril be displaced, it is acted on by the force of gravity, and rights itself. It is acted on by the light, and bends towards or from it, or disregards it, whichever may be most advantageous. During several days the tendrils or internodes, or both, spontaneously revolve with a steady motion. The tendril strikes some object, and quickly curls round, and firmly grasps it. In the course of some hours it contracts into a spire, dragging up the stem, and forming an excellent spring. All movements now cease. By growth, the tissues become wonderfully strong and durable. The tendril has done its work, and done it in an admirable manner."

The phenomenon known as Sensitiveness is of by no means uncommon occurrence in the vegetable kingdom. It consists of a sudden movement of the leaf, a portion of the flower, or the whole plant, on contact with, or even on the approach of, a foreign body. One of the most familiar examples is that of the Sensitive Plant, *Mimosa pudica* and *sensitiva*, fig. 1, *a* and *b*, in which three distinct movements are observable when the leaf is touched by the hand or the warm breath. First, the numerous leaflets close in pairs, bringing their upper faces together, and also inclining forwards; then the four branches of the leaf-stalk, which were outspread like the rays of a fan, approach each other; at the same time the main leaf-stalk turns downwards, bending at its joint with the stem. The explanation offered in one of our best botanical text-books of this phenomenon is as follows:—"There is a swelling at the base

* Bulletin de la Société Botanique de France. Translated in the "Gardener's Chronicle," March 19, 1870.

of the petiole, the cells of which constitute, as it were, two springs acting in contrary directions, so that if the one from any cause be paralysed, the other pushes the leaf in the direction of least resistance. These springs, if they be so called, are set in action by the rush of fluid creating a turgid state of the one set of cells and an empty state of the other. What circumstances regulate the turgescence are only imperfectly known." It will be obvious, that, even if this is correct as a statement of facts, it offers no real explanation of the phenomenon; for it is quite as difficult to understand how the mere approach of the hand, which gives rise to a sensitiveness commencing, it will be remarked, at the *extremity* of the leaf, will account for a "turgescence" of the springs at the *base* of the leaf, which then causes the movement. It should be observed also that we are unaware of any use which these movements are to the plant. Similar sensitiveness occurs in the leaves of some other leguminous plants, in several species of *Oxalis*, &c. M. Bert has observed that the sensitiveness is destroyed by the continual application of chloroform, and also by placing the plant constantly in the dark or in green light.

Similar movements to that of the Sensitive Plant, but occurring spontaneously, may be observed in other plants. Thus in the *Desmodium gyrans* or "Telegraph Plant," sometimes grown in our hot-houses, belonging to the same order, Leguminosæ, the leaf consists of three leaflets, a large central, and two smaller side ones. The motion is especially observable in the small side leaflets, which on a warm summer's day may be seen to rise and fall by a succession of jerking movements; now stopping for some time, then moving briskly, always resting for a while in some part of their course, and starting again without apparent cause, "seemingly of their own will," as Prof. Asa Gray remarks. The movement is not simply up and down, but the end of the moving leaflet sweeps more or less of a circuit. It is not set in motion by a touch, but begins, goes on, and stops, of itself.

An exceedingly remarkable instance of sensitiveness occurs in the case of the "Venus's Fly-trap" of North Carolina, *Dionœa muscipula*, represented in fig. 2. The mid-rib of each leaf serves as a kind of hinge. When the inside of the blade of the leaf, or the fine bristles which grow on its surface, are touched by any foreign substance, the hinge suddenly closes, and if the intruding substance be a fly or other small object, it is immediately imprisoned as represented in the figure, the teeth on the margin of the leaf closing firmly upon one another like a steel trap, the sides of the trap then flatten down and press firmly upon the victim, and it now requires a very considerable force to open the trap. If nothing is caught the trap presently re-opens of itself, and is ready for another attempt. With regard to the object of this strange proceeding, there can be no doubt that the insect is retained until the softer parts of the body are completely dissolved in the thick mucous fluid which is exuded by the leaves: and Professor Asa Gray considers that the evidence is nearly complete that the animal matter is actually absorbed in the leaf itself. It is even stated that pieces of raw beef are digested by the leaf in the same manner! Seeing, however, that it is now generally admitted by physiologists that even pure water is not absorbed through the pores of leaves, which serve only for the *exhalation* of vapour, this explanation is very hard of belief. The "pitchers" of the *Nepenthes*, or pitcher-plant, act also as fly-traps, large numbers of insects being enticed into them by the fluid they secrete, and are then unable to extricate themselves.

The sensitiveness of the leaves of plants is but an excessive development of the phenomenon known as the Sleep of plants. In the case of the Sensitive Plant the position assumed by the leaf and leaflets in the night is the same as that which they assume when disturbed in the day-time; and with many other plants, such as the clover and the *Robinia* or "acacia" tree, the change in the position of the leaflets, morning and evening, is a familiar fact. The Sleep of Plants extends also to the flowers, many plants opening their flowers only at particular times of the day. Thus the major convolvulus of the gardens and the goat's-beard open at sunrise and always close by about noon, the evening primrose opens only in the evening, and many others last for but a single day. So regular is the time of opening and closing of some flowers, that Linnæus drew up a list, which he termed a "floral clock." The singular part of the affair is, that with many flowers the time of opening and closing is determined, not by the degree of light, or by the temperature or humidity of the atmosphere, but absolutely by the hour of the day. The giant water-lily of the Amazons, the *Victoria regia*, opens, for the first time, about 6 P.M., and closes in a few hours, then opens again at 6 A.M. the next day, remaining open until the afternoon, when it closes and sinks below the water. Other plants, again, open their flowers only in the bright sunshine, as the beautiful yellow centaury or *Chlora perfoliata*, the sundew, *Drosera rotundifolia*, &c. In the latter plant, belonging to the same natural order as the Venus's Fly-trap, and possessing a slight irritability of the leaves, Mr. Worthington Smith has noticed also a strong sensitiveness in the petals, the flowers closing suddenly when touched.

Irritability or sensitiveness, similar to that of the leaves of the Sensitive Plant, is not uncommon in the flower. An instance has been alluded to in the petals of the sundew; it occurs also in the lip of the corolla of several of the orchis tribe. It is, however, more common in the proper organs of reproduction, as the style of *Stylidium*, the stamens of the berberry, &c., and is then directly connected with the process of fertilisation of the ovule. In *Stylidium*, an Australian genus, the style and filaments are adherent into a column, which hangs over on one side of the flower. When touched, it rises up and springs over to the opposite side, at the same time opening its anthers and scattering the pollen. The stamens of the various species of *Berberis* and *Mahonia*, to the former of which our common berberry belongs, exhibit this irritability to a remarkable degree. If touched with a pin or other object at the base of the inside face of the filament, the stamen will spring violently forward from its place within the petal, so as to bring the anther into contact with the stigma, as shown in fig. 4, and will after a time slowly resume its original position. At first sight it may seem as if this contrivance were intended to ensure the fertilisation of the pistil from the pollen of its own flower. In reality, however, the reverse is the case; the excitation takes place in nature when an insect entering the flower for the sake of the honey in the glands at the base of the pistil, touches the inside of one of the stamens. The pollen is thus thrown on to the head or body of the insect, which carries it away to the next flower it visits, and leaves some of it on the stigma, and thus cross-fertilisation instead of self-fertilisation is secured. Similar motion of the stamens towards the pistil, but spontaneous, takes place in the case of the London Pride, and other species of *Saxifraga*.

Elasticity is, indeed, a common property of organised tissue, though it is not often developed to so evident an extent. In the "touch-me-not," or *Impatiens*, we have a familiar instance in the seed-vessel, which, if touched when nearly ripe, suddenly coils back, throwing the seeds to a considerable distance. The "squirting cucumber" (*Momordica Elaterium*) marks the period of ripeness by the fruit separating from its stalk, and expelling the seeds and juice with great violence. Mr. Thomas Meehan described a remarkable instance of elasticity at a recent meeting of the Academy of Natural Sciences of Philadelphia. The seeds—or, as would appear from his description, more correctly the embryos of the seeds—of the American "witch-hazel" (*Hamamelis virginica*) are thrown out with such force as to strike people violently in the face who pass through the woods. Collecting a number of the capsules, and laying them on the floor, he found the seeds or embryos were thrown out generally to the distance of four or six feet, and in one instance as much as twelve feet.

Many of the instances of spontaneous motion or irritability we have now recorded may doubtless be explained by the application of known physical laws. With others this is not so easy; and it is but reasoning in a circle to say that because the organisms which manifest them belong to the vegetable kingdom, therefore the phenomena cannot be the result of a sentient force acting upon, and independent of, matter. Darwin has described how certain movements of the tendrils of climbing plants would be termed instinctive if they were observed in animals. The rapid rotatory motion of the zoospores of the lower Algæ is absolutely undistinguishable from that of certain undoubted lowly organised forms of animal life. It is very difficult to distinguish between the movement of a shoot of a climber performing its circles in the air in search of a support, and that of the tentacula of a coral-polyp in search of food. The mode in which the Venus's Fly-trap seizes and encages its prey is very like that adopted by a sea-anemone. Every fresh addition to our knowledge seems to confirm us in the view that it is unwise to dogmatise by laying down too rigid generalities, and absolutely to deny certain functions to whole classes of animated beings because we do not find them exhibited in the forms most familiar to us. I do not wish distinctly to claim for plants the actual possession of a voluntary or sentient faculty. But I do wish to point out that facts do not support us in asserting that a clear line of demarcation separates the animal from the vegetable kingdom; the power of voluntary motion belonging to the one and not to the other. Taking all the facts we have described into consideration, the statement seems justified which has been made by one of our most experienced naturalists, Professor Wyville Thomson*:—"There are certain phenomena, even among the higher plants, which it is very difficult to explain without admitting some low form of a general harmonising and regulating function, comparable to such an obscure manifestation of reflex nervous action as we have in sponges and in other animals in which a distinct nervous system is absent."†

* Introductory Lecture to the Natural History Class at the University of Edinburgh, May, 1871. See "Nature," vol. iv. p. 91.

† Since writing the above, I have met with the following remarks by the Italian botanist, Prof. Delpino ("American Naturalist," July, 1871, p. 297):—"I must here, as always, declare myself a teleologist and a vitalist. Now teleology and vitalism, far from being vanquished by the Darwinian doctrine, find in it their most solid support. What do teleology and vitalism mean? They mean that we believe that there is in all living things an

EXPLANATION OF PLATE LXXXIX.

FIG. 1. Leaf of Sensitive Plant, *Mimosa pudica*; *a*, in normal position; *b*, after depression by the approach of the hand.
„ 2. Leaves of Venus's Fly-trap, *Dionœa muscipula*, one of them closed on an imprisoned fly.
„ 3. Tendril of Virginian Creeper, *Ampelopsis virginica*; *a*, before contact; *b*, after contact with a wall.
„ 4. Stamen of Berberry, *Berberis vulgaris*; *a*, normal position; *b*, after excitation of base of filament.
„ 5. Zoospores of Algæ; *a*, *b*, *Conferva*; *c*, *Vaucheria*.
„ 6. Spermatozoa; *a*, *Chara*; *b*, Sea-weed, *Fucus serratus*.

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innate, specific principle, intelligent, free, and teleological. This principle is the hidden cause of the variability of organised beings, as well as the wonderful harmonies which have been established between one being and another."