

HOW PLANTS MOVE.*

IT is a month or two over twenty-one years since "The Origin of Species by means of Natural Selection" was first published; and in an address which was presented to Mr. Darwin, the other day on the occasion of the coming of age of this epoch-making work, he was told that his writings "have been instrumental in giving an impetus to biological and palæontological inquiries which has no precedent in the history of science, except perhaps in that which followed the promulgation of the gravitation theory of Newton, and that which was due to the discovery of the circulation of the blood by Harvey." This is strong language to address to any living man; but we believe that even those workers in science who differ most widely from the conclusions which have been developed from Mr. Darwin's investigations, will admit that the sentiment expressed by the Yorkshire Naturalists is not very far from the sober truth. The direction which Mr. Darwin's works have given to scientific investigation has not been confined to the particular department of science in which he himself works, Biology, or the science of living things, but has impinged upon and seriously changed the course of nearly every other department of science; so that it is scarcely exaggeration to say that students in almost every section of science move more or less in an evolutionary atmosphere, which indeed is now breathed by "searchers" as the Germans would say in almost every field of intellectual activity. The young student of science who has grown up in the midst of this atmosphere as if it were his native air, can have no idea of the extent and intensity of the commotion caused by the publication of Mr. Darwin's two works on the "Origin of Species" and "Descent of Man"; it would be needless now to

* *The power of Movement in Plants*, by Charles Darwin, LL.D., F.R.S., assisted by Francis Darwin. With illustrations. London, Murray, 1880.

recall the dreadful things that were said on both sides when the battle was hottest; we need only say that most of those who protested loudest that they would ne'er consent, have long ago more or less consented, or at least admitted that after all there can be no great harm in the doctrines propounded by Mr. Darwin. Unfortunately he has had to suffer, not only for his own sins but for those of his most violent disciples; and the wildest hypothesis promulgated by the extremist Hæckelian, is put to the credit of "Darwinism." Mr. Darwin has never himself taken any direct part in the fray; he has in his quiet retreat at Beckenham pursued the even tenor of his researches, publishing the results at leisurely intervals, never hasting, but never resting in the application of his wonderful "Open Sesame," to which so many of the secrets of nature have been compelled to yield; and now we have it applied to the investigation and explanation of the various movements of plants.

Mr. Darwin's new work may be regarded as to some extent a sequel to, or rather extension of that published some years ago on "The Movement and Habits of Climbing Plants." The present work describes his investigations on almost every variety of external movement to which plants are subject; and all except the specialists who have attended to this department, will be astonished at the variety of these movements. The guiding idea in the hundreds of experiments referred to in the volume before us is that with one or two doubtful exceptions, all the external spontaneous (if we may use the word) movements of plants are modifications of one form of movement which the Germans name circular nutation, but to which Mr. Darwin gives the handier name of "Circumnutation." The term is evidently borrowed from the peculiar vibratory motion to which the polar axis of the planets are subject, leading to the description of a more or less waved orbit. A climbing plant under the most favourable conditions will give the most complete idea of the mode of movement, describing as it does a series of circles, which its constant growth turns into spirals, round its support, the apex pointing successively to all points of the compass. Of course under the conditions under which most climbing plants are found and in all non-climbing plants, this ideal circular motion is greatly modified, and in the case say of the stem or of the cotyledons of a seedling plant, takes the form of a series of more

or less elongated ellipses. It is to this movement then that the name of circumnutations has been given, a movement which leads the leaf of a growing plant to describe during the twenty-four hours, by a series of jerks or unequal oscillations, one or more elliptical figures. As usual Mr. Darwin is more anxious to lay before the reader all the data on which he may form a judgment for himself, than to take up space in advocating his own conclusions. He describes minutely the methods adopted in the very delicate researches carried out, evidently for years by his son, Mr. Francis Darwin, and himself. These methods, involving the most delicate manipulation often required the most careful inspection and record of experiments at very short intervals for many hours and even for days. As in previous works Mr. Darwin is careful to point out all the disadvantages of his methods of experiment and the sources of error to be guarded against; and in drawing conclusions from them any experiments which he describes, while he indicates the direction in which the mass of evidence points, he with the utmost candour points out all the flaws in the argument, suggests all sorts of objections, and in short furnishes his opponents with weapons which if they are able they may turn against himself; with all these precautions he proceeds to record the results of his long investigations and to indicate the conclusions to which they lead. We cannot follow him through all the intricacies of his numerous experiments described in language in which not a single word is put down uselessly and without a purpose; we shall content ourselves with indicating a few of the results to which these experiments led.

Mr. Darwin and his son experimented upon plants belonging to the most varied orders. Many of the most curious experiments were, however, made with the seedlings of the common bean and the cabbage, and anyone who cares to take the trouble might repeat them for himself. Experimenting with a seedling cabbage, for instance, Mr. Darwin found that the tip of the radicle, or first little root that shoots out from the seed, does not push straight downwards into the ground, but as far as circumstances permit pushes about, as it were, attempts to move forward by a series of short oscillations or elliptical vibrations—circumnutates, in short. This was clearly shewn in the numerous tracings of the progress of the radicle, which

Mr. Darwin succeeded in obtaining on properly adjusted glass. The general tendency of this circumnutation of the radicle is always downwards (geotropic is the scientific term), and when rootlets issue from its sides their tendency is to circumnutate in a slanting direction, while their rootlets on the other hand perform the same movement horizontally, and hundreds of hairs which cover them fasten on to whatever is within their reach all round. As the radicle and all its rootlets are constantly swaying their tips around, it will be seen that they are not likely to lose any nourishment that may be in their vicinity, and the movement is well adapted to enable them to take advantage of openings such as worm-holes lying in their route. The tip of the radicle is wonderfully sensitive, and the experiments made by Mr. Darwin to test this sensitiveness are among the most interesting in his book. It seems to have the power to pursue the course most advantageous to the plant for whose welfare it is responsible. To pressure it is extremely sensitive. If it finds itself between two soils of varying hardness, it will inevitably choose the softer; the touch of a stone, or any other hard substance in its path, makes it shrink aside, whereas the upper part of the radicle will cling to and creep along such obstacle. The tiniest scrap of the thinnest cardboard, attached in the most delicate manner to one side of the tip, causes it to struggle in an opposite direction to free itself from the irritation, and so if one side is touched with caustic. It invariably prefers a moist to a less moist soil, and turns away from any light that may reach it. Lay a radicle in a horizontal direction, and its tip will speedily turn towards the centre of the earth; but if the tip of a horizontal radicle be cut off, the radicle itself will keep the direction in which it is laid until a new tip is formed. Repeated experiments proved that this wonderful tip has the power of transmitting some influence or message along the radicle, which moves in obedience to the direction thus given. "The course pursued by the radicle," Mr. Darwin concludes, "in penetrating the ground, must be determined by the tip; hence it has acquired such diverse kinds of sensitiveness. It is hardly an exaggeration to say that the tip of the radicle thus endowed, and having the power of directing the movements of the adjoining parts, acts like the brain of one of the lower animals; the brain being seated

within the anterior end of the body, receiving impressions from the sense-organs, and directing the several movements." We are here evidently in the presence of a mystery, which sensational scientists are likely enough to make much capital out of. Mr. Darwin's caution and moderation are seen in this his extreme conclusion, as it is throughout the whole work, and contrasts markedly with the rashness of the German botanist who some years ago attempted to show that plants must possess consciousness: happily for tender-hearted vegetarians, we are far enough from such a conclusion.

As with the radicle, so *mutatis mutandis*, with the hypocotyl or leaf-stem. While the former shuns the light, the latter looks about for the faintest glimpse, and while yet beneath the soil it nods around, circumnutates, a movement admirably adapted for enabling it to discover the feeblest ray that may penetrate from the upper air; and when this is found the leaf-stem so modifies its swinging motion as to take the shortest road to it. When above ground the leaf-stem continues to circumnutate, naturally with much more freedom than when its movements were encumbered by the overlying soil. The tips of the spouting leaf-stem seems to be about as sensitive as the tip of the radicle, and Mr. Darwin devotes much space to experiments on this point with sprouting cabbage and other plants. He found that the sensitiveness to light, heliotropism, rests in the tip of the sprout, and that if these were severed or cut off, the rest of the stalk, remained motionless in presence of a one-sided light, or moved but slightly. Everyone knows of the strong tendency in all kinds of plants to bend towards the light, but we believe it has remained for Mr. Darwin to prove the extreme delicacy of this sensitiveness; a mere line of dim sunlight admitted to the tip of a stalk, a glint scarcely perceptible to the eye, would immediately cause the tip to bend towards it. But whatever may be the immediately stimulus to movement in stalk, or leaf, or radicle, that movement Mr. Darwin finds to be a modification or adaptation of that circumnutation or elliptical oscillation, which is the native mode of motion of all plants. Under this idea some chapters are devoted to investigations on cotyledons and leaves under the influence of light, or heliotropism, under the influence of "sleep," or nyctitropic movements, and under the influence of gravitation. The two former classes of movements

are gone into in minute detail, and the experiments and results are of the highest interest. The idiosyncracies of leaves in their method of folding themselves up or down at night are very varied and very peculiar, and the illustrations to this part of the work are most instructive. Mr. Darwin found that in this nightly movement of the leaves of many classes of plants the object is to shelter the upper part of the leaf from the night air, and its purpose is to prevent radiation of heat and consequent cooling. In some plants the leaves perform a complicated movement, so as to bring the upper part of two neighbouring leaves face to face and close together, leaving only the under sides exposed. Although apparently at rest during the night, Mr. Darwin shows that these "sleeping" leaves are really not so, but are continuing their circumnatory course, though at a slower rate than during the day. This oscillation is so adjusted that at night the sweep upwards or downwards is prolonged and slackened so as to enable the leaf to maintain the position most conducive to its well being. The heliotropic, or light movements of leaves, are as varied and peculiar as those just referred to. Some leaves cannot stand much light, and therefore so twist themselves about as to present only their edges to the scorching sun; in fact, light seems to act on the nervous system of plants in a manner entirely analogous to its action on the nervous system of animals. The carnivorous *Drosera*, though it circumnutates largely, is not at all, or only slightly, heliotropic, the reason evidently being, as Mr. Darwin states, that as this and other insectivorous plants do not live chiefly by decomposing carbonic acid, it is much more important to them that their leaves should occupy the best position for capturing insects than that they should be fully exposed to the light.

These are only a few pickings from a work, every sentence of which is full of suggestiveness and information. Mr. Darwin discusses the physiological causes of the curious oscillating movement of the various parts of plants, and many other points with which we cannot enter into here. The text and moral of the book are that all the varied movements investigated are adaptations of the one movement which he names circumnutation, adaptations which the experience of ages has taught to the lowest forms of life are most conducive to their welfare.

“If we look at a great acacia tree, we may feel assured that every one of the innumerable growing shoots is constantly describing small ellipses; as is each petiole, sub-petiole and leaflet. . . . The flower peduncles are likewise constantly circumnutating. If we look beneath the ground, and our eyes had the power of a microscope, we should see the tip of each rootlet endeavouring to sweep small ellipses or circles, as far as the pressure of the surrounding earth permitted. All this astonishing amount of movement has been going on year after year since the time when, as a seedling, the tree first emerged from the ground.” If ever the reader, who has no knowledge of botany, takes the trouble to learn the meanings of the very few technical terms used and identify the plants experimented on, he will find Mr. Darwin’s latest work teeming with interest. He has revealed to us a new and undreamed of world of activity directed by something that looks wonderfully like the rudiments of intelligence.

