SOME NEW BOOKS.

Darwin on the Movements of Plants.

Before the hypothesis of evolution can be deemed established, it will, of course, be requisite to bridge over two gaps which were long believed impassable, viz., the interval between organic and inorganic existence and the hiatus between vegetable and animal life. It is the latter of these two supposed breaks in the chain of being whose reality Darwin has undertaken to disprove in his recent discussions of insectivorous plants, climbing plants, orchids fertilized by insects, and of the various modes of fertilization in the vegetable kingdom. In these treatises he has shown that very many of the capacities, aptitudes, and habits once regarded as specific distinctions of animal life are really shared by plants, and he has now supplemented the evidence upon this head in his new book describing *The Power of Movement in Plants*, by CHARLES DARWIN, assisted by FRANCIS DARWIN (Appleton's).

The chief object of this work is to describe and connect together several large classes of movement common to almost all plants. The most widely prevalent movement is essentially of the same nature as that of the stem of a climbing plant, which bends successively to all points of the compass, so that the tip revolves. This gyratory motion has been called by some botanists "revolving nutation," but the author of this volume finds it more convenient to use the terms circumnutation and circumnutate. The precise nature of the movement is thus defined. If the reader observes a circumnutating stem, which happens at the time to be bent, we will say toward the north, it will be found to bend gradually more easterly until it faces the east; and so onward to the south, then to the west, and back again to the north. Now, had the motion been quite regular, the apex would have described a circle, or rather, as the stem is always growing upward, a circular spiral. As a matter of fact, it generally describes irregular, elliptical, or oval figures, which the author has succeeded in tracing and reproducing by means of an ingenious apparatus, whose principle and working will be found clearly described in the introduction. As regards the cause of all such bending movements, this has usually been ascribed to the increased growth of that side of the stem which becomes for a time convex. Mr. Darwin's researches, however, have led him to the conclusion that such increased growth on one side, then on another, is a secondary effect, and that the primary impulse to the movement of circumnutation must be sought in the increased turgescence of the cells, together with the extensibility of their walls, which need not be followed by increased growth, as in the case of parts provided with a so-called pulvinus—that is to say, joint or cushion, made up of cells that have ceased to increase in size from an early age.

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All the parts or organs in every plant, even before the stems have broken through the ground, and afterward, so long as they continue to grow—and some parts which are provided with pulvini or joints after they have ceased to grow—are continually circumnutating. Why every part of a plant, while it is growing, and in some cases after growth has ceased, should have its cells rendered more turgescent, and its cell walls more extensile, first on one side and then on another, thus inducing such bending movements, is not known. Darwin, however, would draw the inference from the phenomena in question that the changes in the cells require periods of rest. He goes on to show that circumnutation is of paramount importance in the life of every plant, for through its modification many highly beneficial or indispensable movements have been acquired. When light, for instance, strikes one side of a plant, or light changes into darkness, or when gravitation acts on a displaced part, the plant is enabled, in some unknown manner, to increase the always varying turgescence of the cells on one side, so that the ordinary circumnutating movement is modified, and the part bends either toward or away from the exciting cause, or it may occupy a new position, as in the so-called sleep of leaves.

The so-called sleep or night-turning (nyctitropic) movements of leaves, are determined by the daily alternations of light and darkness. It is not the darkness which excites them to move, but the difference in the amount of light which they receive during the day and night: for with several species, if the leaves have not been brightly illuminated during the day, they do not sleep at night. They inherit, however, some tendency to move at the proper periods, independently of any change in the amount of light. The nyctitropic movements are, in some cases, extraordinarily complex, but the most intricate examples are reproduced and explained in a chapter of this book devoted to the subject. As regards the means of assuming their nocturnal position, it appears that when leaves and cotyledons (the organs which represent the first leaves) are furnished with pulvini, the sleep movement continues, as long as the leaf or cotyledon remains in full health; where, on the other hand, pulvini are lacking, it continues only while the part is growing. Cotyledons seem to sleep in a larger proportional number of species than do leaves. In some species the leaves sleep and not the cotyledons; in others the cotyledons, and not the leaves: or both may sleep, and yet assume widely different positions at night.

Although the nyctitropic movements of plants are wonderfully diversified, and sometimes differ much in the several species of the same genus, yet the blade is always placed in such a position at night that its upper surface is exposed as little as possible to full radiation. There is no doubt that this is the object gained by these movements. It has been proved that leaves exposed to a clear sky with their blades compelled to remain horizontal suffered much more from the cold than others which were allowed to assume the vertical position, to which, at night, they inclined. Some curious facts are cited by Darwin under this head. It is pointed out, for example, that in some species the petioles rise up greatly at night, while the pinnæ draw close together. Obviously the whole plant is thus rendered more compact, and a much smaller surface is exposed to radiation. That the various nyctitropic movements of leaves result from modified circumnutation seems conclusively demonstrated. In the simplest cases a leaf describes a single large ellipse during the twenty-four hours, but the movement is so arranged that the blade will stand vertically during the night, and reassume its former horizontal position on the following morning. The course pursued differs from ordinary circumnutation only in its greater amplitude and in its greater rapidity late in the evening and early in the subsequent day. In other cases leaves and cotyledons describe several vertical ellipses during the twenty-four hours, but in the evening one of them is increased greatly in amplitude until the blade stands vertically, either upward or downward. In this position it continues to circumnutate until the following morning, whereupon it returns to its former posture.

Two chapters of this volume are assigned to the highly important class of movements due to the action of a lateral light during the day. When stems, leaves, or other organs of plants are placed so that one side is illuminated more brightly than another, they bend toward the light. This heliotropic movement unquestionably results from the modification of ordinary circumnutation, and every gradation between the two movements can be followed. Heliotropism prevails widely throughout the vegetable kingdom, but whenever, from the changed habits of life of any plant, such movements become injurious or useless, the tendency is easily eliminated, as we see with climbing and insectivorous plants. As regards apheliotropic movements or tendencies to turn away from the sun, these are comparatively rare in a well marked degree, excepting with sub-aerial roots. The position which leaves and cotyledons commonly occupy during the day, viz., more or less transversely to the direction of the light, is due to a tendency which Darwin would term diaheliotropism. From the fact of leaves frequently rising a little in the evening, it appears as if diaheliotropism had to conquer, during the middle of the day, a widely prevalent tendency to apogeotropism (or inclination to turn away from the earth). Again, the leaflets and cotyledons of some plants are known to be injured by too much light; so, when the sun shines brightly on them, they move upward or downward, or twist laterally, so that they direct their edges toward the light, and thus escape being injured. These paraheliotropic movements have sometimes been called diurnal sleep, but they differ wholly with respect to the object gained from those properly called nyctitropic, and in some cases the position occupied by the leaf during the day is the reverse of that taken during the night. The evidence adduced by Darwin indicates that these heliotropic, apheliotropic, diaheliotropic, and paraheliotropic movements are all modified forms of circumnutation. The same thing may be said of another class of phenomena, viz., the geotropic, apogeotropic, and diageotropic movements, which represent, of course, so many tendencies to move toward, away from, or transversely to the earth.

It is impossible not to be struck with the resemblance between the movements of plants, described in this volume, and many of the actions performed unconsciously by the lower animals. The habit of moving at certain periods is inherited both by plants and animals, and is often exercised when the primary exciting cause is absent. Several other instances of similitude are here specified, but the most striking point of likeness is the localization of their sensitiveness in plants, and the transmission of an influence from the excited part to an adjoining party which consequently moves. Yet plants do not, of course, possess nerves, or a central nervous system; and Darwin infers that with animals such structures are not indispensable, but serve only for the more perfect transmission of impressions, and for the more complete intercommunication of the several parts. The most wonderful feature of plant structure, so far as its functions are concerned, is the tip of the radicle. The author points out that if this tip be lightly pressed, or burned, or cut, it transmits an influence to the upper adjoining part, causing it to bend away from the affected side; and what is more surprising, the tip can distinguish between two objects, one of which is slightly harder than the other, but which are simultaneously pressed on the tip's opposite sides. If, on the other hand, the radicle is pressed by a similar object a little above the tip, the pressed part does not transmit any influence to the more distant parts, but bends abruptly toward the object. Again, should the tip perceive the air to be moister on one side than on the other, it will transmit an influence to the upper adjoining part, which bends accordingly toward the source of moisture. In almost every case we can perceive the final purpose or advantage of the communicated movements. When we bear in mind that the course pursued by the radicle in penetrating the ground must be determined by the tip, we can understand why the latter organ—for organ it is—has acquired such diverse kinds of sensitiveness. Darwin deems it 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.