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THE MOVEMENTS OF PLANTS.*

A new book by Mr. Darwin is always a literary event. It is sure to be interesting, to be well written, and to embody some brilliant theory which will create a fluttering in the dovecots of orthodoxy. There are few names in England more widely known than that of the Kentish squire who has been so profuse a contributor to her literature. Yet, twenty-one years ago Mr. Darwin was comparatively obscure. To Naturalists he was, of course, familiar as the author of "The Narrative of the Voyage of the Adventure and Beagle," and to specialists for his works on the difficult group of the "Cirripedia"; on "Coral Islands"; and on the "Geology of South America." But these treatises scarcely appealed to the general reader. Accordingly, when the "Origin of Species" appeared, the world was taken by storm, for a new man and a new theory—very charming, very fresh, and exceedingly "wicked"—were all at once presented to them. It is needless at this time of day recalling the history of the Darwinian hypothesis—or theory, as its disciples insist on calling it—the storm of invective, and the counter-hurricane of plaudits, which it invoked. In twenty-one years it has gradually taken its place among the commonplaces of Science, and even its worst enemies now readily acknowledge that in it is much that is true, valuable, and worthy of all praise. It has, indeed, raised a School. In England, France, Italy, and America the Darwinians number among them some of the keenest of the rising generation; while in Germany "Darwinismus" is a Religion rather than a Scientific speculation. There are, indeed, certain enthusiastic Evolutionists who declare that in future ages the theory of gravitation and natural selection will be bracketed together as generalisations of equal moment. Indeed, among the younger *savants*, who have, as it were, been born into the Darwinian atmosphere, there is a tendency to pooh-pooh doubts regarding their pet hypothesis as the mad ravings of ignorami not much more worthy of consideration than anathemas against the Verdict of the Jury who tried the Tichborne case. Be that as it may, it is certain that Mr. Darwin's books will live. They are simply indispensable to the Biologist on account of the wonderful series of observations which they record, generally bearing directly upon the "theory," and, like those in the present volume, they may be studied with equal profit and peace of mind by the most steady-going of the pre-Darwinian Naturalists.

The fact that there is a movement, temporary or otherwise, in certain plants and their organs has for long been among the platitudes of botanical writers. Linnæus, indeed, constructed a floral clock, the hours being marked by the times at which particular flowers closed or opened during the twenty-four hours, while the bending of sunflowers is so familiar that even Hood, who loved men more than plants, refers to "Mad Clytie whose head is turned by the sun." The bending down of the leaves of certain plants at night has also been known for many years under the name of their "sleep," and the cause of this movement was investigated and sufficiently explained long before Mr. Darwin was known to have turned his attention to the subject. Indeed, the famous Naturalist has himself greatly contributed to the elucidation of the phenomenon by his remarkable observations on climbing plants published in the *Journal* of the Linnean Society just fifteen years ago. Hence, the main value of the present treatise is not so much in the novelty of the facts—though it also abounds with new and interesting observations—as in the demonstration which it affords of the universality of the movement or "circumnutation," and of the benefit which it confers on plants generally. A stem circumnutates first, say, to the north, then it will gradually bend more and more easterly until it faces the east; and so on towards the south, then to the west, and back again to the north. If the movement had been quite regular the apex would have described a circle, or rather a circular spiral. But as the apex, after pointing in any one direction, commonly moves back to the opposite side, not, however, returning along the same line, the stem generally describes irregular elliptical or oval figures. Afterwards Mr. Darwin shows that other irregular ellipses or ovals are successively described, with their longer axes directed to different points of the compass. Whilst cutting such figures the apex often travels in a zig-zag line, or makes small subordinate loops or triangles. In the case of leaves the ellipses are generally narrow; but, day or night, there is always some movement going on in the organs of the plant. In brief, this strange circumnutation, this describing of spirals and ellipses, goes on from the moment the little rootlet projects from the seed until the hour when the plant ceases growing or is resolved into its primitive elements. Increased growth, first on one side and then on another, was at one time considered to be the cause of these movements; but this is now believed to be not a cause but only a secondary effect, the primary reason for circumnutation being the increased turgescence of the bladder-like cells of which so much of a plant is built up, together with the extensibility of their walls. But why these walls are extended, or how the cells become turgid, is not quite so easy to explain. Though every part of a growing plant is continually circumnutating, the movement is rarely perceptible. It is only perceived after a lapse of time, or by the lines which a tiny bead at the end of a delicate glass thread attached to the organ traces on a sheet of smoked glass; the stems of seedlings begin to sweep before they have broken through the ground, and their buried radicles circumnutate also as far as the pressure of the surrounding earth will permit. In some cases, as in the leaves of the dionæa and the joints of the grass family, the movement, when viewed under the microscope, is seen to consist of innumerable small oscillations. The part under observation suddenly jerks forward for a length of .002 to .001 of an inch; then slowly retreats for a part of this distance; and after a few seconds it again jerks forward, but with many intermissions—as if a little earthquake had affected the plant. The value of circumnutation is considerable, for it is through its modification that many highly beneficial or necessary movements have been acquired. "When," to use Mr. Darwin's words, "light 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 to or from the exciting cause; or it may occupy a new position, as in the so-called sleep of plants." The influence which modifies circumnutation may be transmitted from one part to another. Innate or constitutional changes, independently of any external agency, often modify the circumnutating movements at particular periods of the life of the plant. As circumnutation is universally present, we can understand how it is that movements of the same kind have been developed in the most distinct members of the vegetable series. But it must not be supposed that all the movements of plants arise from modified circumnutation. There are others in which this is not the case. Such are the contraction of the sensitive plant, which has been shown by Brücke to be due to a different state of turgescence in the cells from that which occurs during sleep; the curling of the extremity of a tendril when touched; the curvature of a leaf tentacle of the sundew when touched with a bit of raw meat, and various similar phenomena.

Circumnutation is remarkably well seen in the delicate, tiny rootlet which is the first part of a plant appearing out of the seed. The moment the little radicle emerges from, say, a germinating bean, it begins to revolve in a narrow little ellipsis. But this is immediately modified by the attraction of gravity, and rendered "geotropic," or earth reaching, as the German botanists, with their wonted genius for inventing new words which look at first sight like new facts, style the familiar tendency of rootlets. The radicle supposing the seed to be lying on the surface of the ground—instantly bends down and begins revolving, the tip, which is the sensitive part of the rootlet, transmitting some influence to the adjoining parts, causing them to bend. If the soil is soft or friable, the tip, protected by the root cap, enters it; but if the surface is compact delay ensues, and the revolving movement seem to aid the act of penetration. Thus, unless the seed falls into a crevice where it can get what a sailor would call "a purchase," the circumnutating movements lift it off the ground. But in the latter case another curious arrangement comes into play. From the upper part of the rootlet an immense multitude of extremely fine hairs are protruded. These stick themselves to particles of earth or stone, and thus hold the upper part firm while the lower is endeavouring to penetrate the soil, though most probably the real reason why these hairs are emitted is to bring the rootlet into closer contact with the particles of the soil, in order to be enabled to absorb the layer of water surrounding them, together with any dissolved matter. This function of the hairs on the roots of plants was well known prior to the publication of Mr. Darwin's book, but their anchoring power so as to aid the circumnutating movements of the tip is a fine illustration of that teleology which the Evolutionists so affect to despise. Once wedged in the earth, the tip will probably be prevented from circumnutating, but should it enter a crack, or a burrow made by a worm or larva, or a drill that strange revolving, almost "perpetual" motion begins afresh. The root has not the power of bending away from any hard object, and this excessive sensitiveness enables it to "follow with unerring skill a line of the least resistance." The rootlet tip Mr. Darwin, indeed, compares to the brain. It does for the plant what that great nerve centre does for the animal, enabling it in some mysterious manner, though without nerves, to transmit information from cell to cell of what is going on at the furthest extremity of its body corporate. "Geotropism" also aids the radicle to penetrate downwards. But this is a feeble power compared with circumnutation, and the sensitiveness which the rootlet possesses to air which contains more moisture on one side than on the other. To this side they bend, and hence, in spite of geotropism, it is probable that the roots will be deflected from their downward course to any source of moisture in the soil. Again, nearly all radicles are slightly sensitive to light, and hence bend from it. In like manner, the secondary rootlets which are given off from the main one resemble it in the respects described. It is, of course, well known that many different organs of plants in breaking through the ground take the form of an arch, thus leading us to believe that this must in some way be highly important to them. Probably it serves to protect the tender-growing top, though, as Mr. Darwin shows, circumnutation also plays its universal part here. Once the seedling is enabled to send up a stem above the soil, "each shoot, petiole, sub-petiole, and leaflet is constantly describing small ellipses." The flower stalks are also continually circumnutating. If we could 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." The long runners of plants like strawberries also circumnutate, and are thus sided in their passage between and over surrounding obstacles. Circumnutation in a modified form also causes leaves, which when first unfolded stand in a vertical position, to gradually bend down as they grow older. It tends to depress flower stalks after the flower has withered, to raise up others, and to cause various other minor familiar phenomena. These are affected, not, as Mr. Darwin is careful to point out, by a

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* "The Power of Movement in Plants." By Charles Darwin, LL.D., F.R.S., assisted by Francis Darwin. London: John Murray, 1880.

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