Darwin on Movement in Plants.*

The purpose of Mr. Darwin's latest work is to give a detailed account of a great number of experiments on the movements of different parts of growing plants, together with a general *résumé* of what is known of these movements and their causes. The accounts of the experiments are, of necessity, extremely technical, and are intended for the use of botanical investigators rather than for the general reader. The discussions and conclusions which accompany them will, however, interest every one who has the slightest curiosity in regard to the actions of "our brother organisms, the plants." These parts of the work, "to save the reader trouble," have been printed in larger type than the more technical portions.

A few of the more interesting facts developed by Mr. Darwin's investigations may be here briefly summarized. First of these must be placed the central idea of the book—that of the "circumnutation," or perpetual squirming, of the growing parts of all plants. It is known to every one that the stems of the various twining vines wind about other objects, bending successively to all points of the compass so that the tip revolves. Thus, if the tip of such a plant at a certain time bend toward the north, it will afterwards "be found gradually to bend more and more easterly, until it faces the east; and so onward to the south, then to the west, and back again to the north. If the movement had been perfectly regular, the apex would have described a circle — or, rather, as the stem is always growing upwards, a circular spiral." But the figure described is always irregularly oval or elliptical, because this motion is never perfectly uniform for all sides.

This phenomenon of the revolution of the apices of plants is called by Mr. Darwin "*circumnutation*." It is shown in the present

*The Power of Movement in Plants. By Charles Darwin, LL.D., F.R.S., assisted by Francis Darwin. With illustrations. New York: D. Appleton & Co.

work that circumnutation is not peculiar to twining plants, but that in a greater or less degree all growing parts of every plant—the roots, branchlets, and leaves—have the same motion. Moreover, the various movements of plants are nearly all simple modifications of circumnutation.

"The great sweeps made by the stems of twining plants and by the tendrils of other climbers, result from a mere increase in the amplitude of the ordinary movement of circumnutation. The position which young leaves and other organs ultimately assume is acquired by the circumnutating movement being increased in some one direction. The leaves of various plants are said to sleep at night, and it will be seen that their blades then assume a vertical position through modified circumnutation, in order to protect their upper surfaces from being chilled through radiation. The movements of various organs to the light, or from it, are all modified forms of circumnutation—as, again, are the equally prevalent movements of stems, etc., toward the zenith and of roots toward the centre of the earth. If we look, for instance, 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. * * If we could look beneath the ground, and our eyes had the power of a microscope, we should see the tip of each rootlet endeavoring 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 growth of young seedlings and the motions of the different parts of the young plant are the subjects of a majority of the experiments made. The very tip of the root is its most sensitive part, and it alone controls the direction taken by the descending axis. Wherever it goes, the growth of the root must follow; hence it is very important to the plant that from the first the root-tip should follow the best possible path. The natural direction of the root is downward, following the impulse of gravitation (*geotropism*); the tip, if the soil permits, pursuing a spiral or corkscrew-like direction downward. The root-tip, moreover, is sensitive to contact with different substances, and chooses the direction of least resistance: it is sensitive to moisture, turning generally in the direction of the greatest dampness: and to the action of light, usually turning away from it.

"Authors seem generally to look at the bending of a radicle toward the centre of the earth as the direct result of gravitation, which is believed to modify the growth of the upper or lower surfaces in such a manner as to induce curvature in the proper direction. But we now know that it is the tip alone which is acted on, and that this part transmits some influence to the adjoining parts, causing them to curve downwards. Gravity does not appear to act in a more direct manner on a radicle than it does on any lowly organized animal, which moves away when it feels some weight or pressure.

"A radicle may be compared with a burrowing animal, such as the mole, which wishes to penetrate perpendicularly into the ground. By continually moving his head from side to side or circumnutating, he will feel any stone or other obstacle, as well as any difference in the hardness of the soil, and he will turn from that side; if the earth is damper on one than on the other side, he will turn thitherward as a better hunting-ground. Nevertheless, after each interruption, guided by a sense of gravity, he will be able to recover his downward course and to burrow to a greater depth."

In a remarkable degree, the action of the sensitive and almost sensible root-tip is analogous to that of the brain of some of the lowest animals. The circumnutation of leaves is an upward and downward motion, by which are described very narrow ellipses. The "sleep" of the leaves of certain plants—that is, the assumption of a direction at night different from that taken during the day-time—is shown by Mr. Darwin to be a modification of the motion of circumnutation. The leaves, both when awake and when asleep, are continually in motion, the motion being most rapid at the periods of transition between light and darkness. The sleeping leaves or leaflets place themselves with the axes more or less nearly vertical, some by turning upwards, others by turning downwards. The purpose of sleeping is conclusively shown to be the reduction of the amount of radiation of heat from the leaf:—to prevent it from becoming chilled at night. The tender seed-leaves of very many plants, whose leaves do not "sleep," assume this vertical position at night. Mr. Darwin observes:

"It is impossible not to be struck with the resemblance between the foregoing movements of plants and the actions performed unconsciously by the lower animals. With plants an astonishingly small stimulus suffices; and even with allied plants one may be highly sensitive to the slightest continued pressure and another highly sensitive to a slight momentary touch. The habit of moving at certain periods is inherited both by plants and animals; and several other points of similitude have been specified. But the most striking resemblance is the localization of their sensitiveness, and the transmission of an influence from the excited part to another which consequently moves. Yet plants do not, of course, possess nerves or a central nervous system; and we

may infer that with animals such structures serve only for the more complete transmission of impressions, and for the more complete intercommunication of the several parts."

This book is characterized by the same freedom from dogmatism and the same patient attention to details which have marked all the works of the greatest naturalist of our time. A theory is worth little until it becomes a natural inference from known facts; and the best models of the investigations which furnish these facts have been given us by Mr. Darwin. Hence the superior vitality of "Darwinism" as compared with all other theories of the origin of species. DAVID S. JORDAN.