Notices of Books and Memoirs.

The Movements of Plants. By CHARLES DARWIN, LL.D., F.R.S., assisted by FRANCIS DARWIN. London: John Murray.

A LATE notice of such a book as this is justified by the names of the authors: no writings bearing the name of Darwin admit of rapid or superficial reading. In 'The Movements of Plants' we are led to reflect upon past knowledge of certain well-known slight motions on the part of the higher phanerogams, besides being introduced to new and startling facts in the revelations of movements hitherto undescribed; but the crowning of the whole is the ingenious application of the facts to support the well-known views of Darwin. Having demonstrated that certain peculiar variations or periods occur in the growth of small tracts of cells, and that these result in slight movements of the tissues built up by the cells, we have the foundation for series of phenomena produced by modifications of the original movement, by the action of physical and other agents of different kinds, and if the movements thus rendered are advantageous they may be amplified by natural selection. The chief object of the present work is to describe and connect together several large classes of movement common to almost all plants.

After a short introduction, partly occupied with clear definitions of useful terms, the authors at once plunge into a series of detailed observations, proving that the radicles, hypocotyls, and epicotyls of the young seedlings of numerous plants are normally engaged in circumnutation; the clever way in which each part is made to write an approximate history of its own movements, either with a bristle, &c., on smoked glass plates, or with a ray of light on the retina of the observer, will repay careful attention by any student. Not only in the patient observations themselves, but in the clear descriptions and frank statements of partial failures, do we learn how to experiment and record.

A large and varied number of seedlings of phanerogams, one Fern, and one Selaginella are proved to be in constant circumnutation; and we may probably safely accept the conclusion that the same is true for all plants, some more and some less. In Chap. ii. we are led to imagine the way in which the motion proceeds, and to see that some benefit may accrue to the infant plant, as its radicle seeks to screw and wriggle its tip into the soil; the insumation becoming completed by the force of growth in length and breadth. The authors even attempt to measure this force, and succeed in conveying the idea that a penetrating radicle exerts considerable pressure on the surrounding particles of soil. On the other hand, the writhing of the upper portions of the seedling (commonly arched to give more purchase, and to withdraw the cotyledons with as little abrasion as possible) lifts up the load of soil above, and wriggles through to light and air. We cannot dwell on the several other advantageous acquirements of seedlings, but pass on to consider the important discoveries enunciated in Chap. iii. When the tip of a radicle meets a solid obstacle, it does not obstinately press upon it and try to force itself through to its own destruction, but, as the authors observed, "the delicate root-cap, when it first touched any directly opposing surface, was a little flattened transversely; the flattening soon became oblique, and in a few hours quite disappeared, the apex now pointing at right angles to its former course. The radicle then seemed to glide in its new direction over the surface which had opposed it, pressing on it with very little force." The authors did not think this due to mere mechanical resistance, for the pressure was too slight; and it is known that the growing tip of a radicle is more rigid than the parts just above, which have ceased to grow. Besides, a very yielding object—*e. g.*, thin tin-foil—will deflect the rigid tip of the radicle. The effects could not be due to a mere slowing of growth at the point of contact, since the curvature produced was not confined to that part, but extended 8–10 mm. above: thus was arrived at the idea that the extreme tip of a radicle is *sensitive* to touch, and may *transmit* an influence to the upper parts, causing them to bend away from the touching object, carrying the tip away at the same time. It was shown by Sachs some years ago that the radicle is sensitive to contact at a region some mm. above the apex; but in this case the radicle turns *towards* the touching object, and curves round it as a tendril does round a stick.

Then follow experiments of an exhaustive nature, carefully recorded and with those frank admissions of difficulty which render the whole work so instructive and charming. Minute objects, carefully attached to the side of the extreme apex, cause the radicle to bend away from the touching body, against the action of gravitation, and even in opposition to innate forces as well.

This work is well done, and we venture to think that it opens up a splendid field for discovery; indeed, the authors would probably be the readiest to admit that it commences rather than concludes an investigation. Their own researches on the influence of temperature are surprising, so far as they go; instead of the tip being more sensitive at higher temperatures, the reverse is the case. They failed to decide whether simply cold or hereditary effects of season, &c., affected other trials. Changes in growth, density, slight electrical disturbances, &c., will have to be understood, we venture to think, before this part of the subject is exhausted. The nature of the "sensitiveness" itself offers a deep problem to the molecular physicist, and we seem to be brought face to face with a property of protoplasm in its simplest form. The object of the writers, however, is to establish the facts of the movements resulting from the stimuli, and the firm basis of experimental evidence established enables us to proceed with confidence. We must even accept that the tip of the radicle can "distinguish between harder or more resisting and softer substances," since it becomes deflected from a piece of sand-paper, even if a piece of thinner paper be at the same time affixed to the opposite side. The tip of the radicle is drawn *towards* moist air, and the authors adduce experiments to prove that the sensitiveness here also resides in the apex; hence, what with circumnutation (primarily a phenomenon of growth), geotropic, and innate tendencies to plunge straight down, sensitiveness to the touch of a harder body driving the tip to one side, and a sensitiveness to moisture attracting it in an opposite direction, there is a complex and beautiful problem before one who attempts to picture the insinuation of a radicle into the soil.

We are not quite convinced of the accuracy of the conclusions as to the causes which render secondary rootlets and branches capable of replacing primary ones, when the latter are destroyed or injured; in normal cases it would be very difficult to strike the balance between even the external forces which direct a branch or rootlet into that portion of the available space which is least traversed by other air- and light-, or water- and food-seeking organs of like nature.

The circumnutating movements of stems, leaves, &c., in mature plants are described in Chap. iv., and convince us still further of the generality of these phenomena; one of the most instructive of the illustrations—that of the strawberry runner—brings clearly before the reader the mode by which a creeping stem wriggles its way amongst dense herbage, and at the same time aids him in imagining the microscopic writhings of the rootlets beneath.

Some of the *periodic* movements of leaves have been known for many years, and in some cases for centuries; but the authors bring vividly before us the fact that so many leaves describe more or less elongated elliptical figures, that we must believe that all leaves circumnutate—not always regularly, but more or less decidedly. In a large number of examples the swing of the leaf is increased periodically with the waning light of evening, or as the sun rises in the morning; the leaf moves its apex towards the zenith in the evening, and falls towards the horizon next morning. But some leaves describe figures approaching the circle, and all stages of transition are found.

Some climbing plants are typical of the one extreme, their stems swinging in nearly circular sweeps; certain leaves are so far modified towards the other extreme, that, except for certain irregular loops and zigzags, we might not trace the connection between their vertical sweeps in one plane and the elongated ellipses which these courses really consist of. The reason that the circumnutation of climbing stems has become so regular and circular is, that the sweeping internodes may swing over a larger area and stand a better chance of meeting with a support. But what reason can we assign for the long drawn up and down movements of leaves? The authors answer, because there is some benefit derived by the leaf from a vertical position at night, as opposed to a more or less horizontal position during the day. If they can demonstrate this, we have to admit that such modifications of circumnutation might be increased by natural selection.

And thus we are introduced anew to that beautiful phenomenon, alike admired by poet and philosopher—the "Sleep of Plants." Since the days of Linnæus, the nyctitropic movements of plants have been a wonder of the vegetable world; we are now brought suddenly to meet an explanation of them in terms of utility, and it is pleasing to find that they lose nothing when examined in the fierce glare of modern thought—the exploded wonder simply reveals deeper and yet more charming marvels.

Careful experiments and observations have convinced the Messrs. Darwin that if a sleeping leaf is prevented from assuming its normal position on a clear, chilly night, by being fastened so that the upper surface is exposed to direct radiation, a certain amount of injury follows, varying in different cases—in some experiments proving fatal. The upper surface suffers more than the lower; and the upper surface is usually carefully protected. This is not explained; may we suggest that possibly the fact of the lower looser parenchyma having much air entangled between the cells has to do with the diminished liability of the lower side to suffer from chilling ?

Various and complicated movements are undergone by the sleeping leaves or leaflets; many simply stand vertically, others twist on their axes through several, even 90°. Many leaflets twist and fold over one another ; or a terminal leaflet revolves, and then falls vertically between two others, the three forming a compact flat bundle exposed with the edges up and down. Writing, as we do, from the tropics, we have abundant examples of the most complex of these phenomena. Certain plants which are especially cultivated on hot hill-sides sometimes suffer severely from chilling by radiation when grown on flats; their leaves do not sleep, in the sense here referred to, and the rapid radiation from the flats may cause the most serious damage to leaves; while trees on the slopes do not so suffer, though at a higher elevation. We must believe that such a plant would be better able to grow on exposed flats if the leaves stood vertically at night.

Cotyledons sleep; not always in the same way as the leaves of the same plant; and many plants with sleeping cotyledons do not place their older leaves in nyctitropic positions; while others have sleeping leaves, but their cotyledons do not sleep. We can verify the statement that the cotyledons of *Mimosa pudica* are placed vertically upwards, and face to face at night, though the first leaf drops its rachis like a semaphore, and folds its leaflets forwards in an imbricate manner, as do older ones.

Besides sleeping movements, the authors enter into the description and discussion of two other forms of modified circumnutation; those caused by the *direction* of incident light,—nyctitropic movements being determined by changes in the *intensity* of surrounding light,—and those due to the action of gravitation. Chapters viii. and ix. are occupied with the important subject of heliotropic movements. If it is of advantage to a seedling to turn its little green assimilating organs to the light as soon and as conveniently as possible, we may see how the attracting stimulus of bright light tends to amplify those parts of the normal circumnutating movement which drives the stem or leaf in its direction; some organs still try to return on their course, but in others the superior advantages gained by obeying the new impulse have, so to speak, eliminated this tendency to rebel, and circumnutation has become modified into a straightforward movement towards the source of light.

All degrees of obedience to the new impulse seem to be exhibited, and marvellous examples are given of the power of discrimination possessed by certain plants between the slightly more and slightly less powerful source of light. We must reluctantly pass over the delicate and interesting experiments tending to show that this sensitiveness to light resides in the tips of the organs; many difficulties suggest themselves, and some parts of the very complex problems to be dealt with cannot be considered solved. The student will gain a deep insight, however, into the conflict which a young seedling enters upon when first it raises its green organs to the light. Gravitation excites positive or negative movements, as does light, on various parts of plants; and in Chaps. x. and xi. of the 'Movements of Plants' we are placed in possession of the results of many observations. Geotropic movements cannot be controlled to the extent possible with others, but the authors have ingeniously overcome many difficulties. Here again the influence of gravitation is considered to be especially effectual in modifying the direction and amount of a movement already present; if the modification acts for the benefit of the organ, it will be preserved, and even increased. We should run the risk of doing injustice if we attempted to review shortly this complex part of the work; it is no easy task to see one's way through the various and varying influences which are at any time determining the position of a young stem or root, and the authors of the present book are to be congratulated on the clearness of their exposition of so difficult a subject. But again they go further, and localise the sensitiveness to gravitation in the tip of the radicle; undoubtedly the illustration given, of a horizontally-extended radicle which did not curve geotropically within 1 to 1½ hours, but did curve some time afterwards,—although the tip had been cut off at the end of the 1½ hours,—seems inexplicable on any other obvious supposition than that the influence of gravitation had acted long enough while the tip was on, to cause the necessary changes for curvature at a later period.

But we must conclude this imperfect survey of an immense work. We should like to learn more of the exact effects of cutting or cauterising so delicate an organ as the tip of a radicle, of which the thin walled cells contain dense and actively dividing protoplasm; we should also welcome more knowledge on the exact influence of the heat rays, and possibly others in the more delicate experiments on localised sensitiveness to light. But the authors are not con-concerned with these problems; not only is this work a valuable addition to the ever-growing library of "Darwinism," but it is in itself a store of well-observed and well-recorded facts of independent utility. It will aid the student to avoid that too-common error of regarding the cell and the plant as mechanism very crudely worked by simple physical agents, and yet will effectually warn the careful reader against imagining that because the phenomena are complex they are necessarily beyond the range of scientific investigation. Modern vegetable physiology is daily learning to appreciate more and more, in the complicated phenomena of heredity and so-called innate impulses, that the action of physical agents during past ages must be taken into account; and although we avoid the worn-out terminology of a vicious dualism, the life of an organism depends on deeply-involved actions and reactions not to be revealed entirely by our present means. We do not know what causes the alternate rushes of fluid and solid particles in certain tracts of cells, nor do we know how physical agents really act on the particles. Sensitiveness to stimuli is placed amongst the remarkable "properties of protoplasm," and we can dimly picture how complex must be the changes called forth by a successful stimulus; but here our knowledge stops, and heartily welcome must be any earnest endeavours to apply the simpler result of physical science to the complex problems of Biology. W.