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SENSE ORGANS IN THE VEGETABLE KINGDOM.

Sinnesorgane in Pflanzenreich zur Perception mechanischer Reize. Von Dr. G. Haberlandt, o.ö. Professor an der Universität Graz. Pp. viii + 163; 6 plates. (Leipzig: Engelmann, 1901.) Price 9s. net.

MR. HUXLEY has truly said¹ that "perhaps the most remarkable service to the philosophy of biology rendered by Mr. Darwin is the reconciliation of teleology and morphology, and the explanation of the facts of both, which his views offer." Prof. Haberlandt is a devoted adherent to the school of evolutionary teleology; one of his earliest publications (in 1877) was a study of the protective adaptations of seedlings, and the desire to understand the meaning of every detail of plant-structure is still the key to his activity. It has led him, following the footsteps of Schwendener, to specialise in what he names physiological anatomy, which might with equal propriety be termed teleological or adaptive anatomy. Haberlandt's book,² in which he elucidates the minuter structure of plants from this point of view, is a recognised classic and is found in every botanical library in the world. The present work will, we think, only add to his reputation as an investigator.

The title of his book, "Sense Organs in the Vegetable Kingdom," &c., would by itself suggest the school of thought to which Haberlandt belongs, and on his first page he asserts that the plants have specific forms of irritability which are completely analogous to the senses of animals. This school, which puts side by side the reflex movements of plants and animals, dates (in its modern development) from the writings of Pfeffer and Sachs in Germany, and from the publication of "The Power of Movement in Plants" in this country,³ and is now generally accepted.

Haberlandt's book deals with the reflexes called forth by tactile stimulation, more especially with one branch of the subject, namely, the mechanism which localises and intensifies the touch. The means by which the disturbance, thus originated, is transmitted to the motor organs is for the moment of secondary importance with the author.

Haberlandt begins with the following definition:—

"Sense organs, or organs of perception, are those structural contrivances which contribute to the reception of an external stimulus, and show a more or less striking correspondence between structure and function."

According to this broad definition, the sense organ need not itself possess the quality of percipience. The essential characteristic is an arrangement for a sudden "deformation" of the ectoplasm in sense-cells. But certain plant-hairs and bristles are called sense organs, although they merely act like the vibrissæ of animals, that is to say like levers, the act of percipience occurring in the sensitive tissues in which they are imbedded. Haberlandt practically narrows his definition by applying the term

¹ "Life and Letters of Charles Darwin," ii. p. 201.

² "Physiologische Pflanzenanatomie." 1st Edit. 1884, 2nd Edit. 1896. (Leipzig: Engelmann.)

³ The earliest popular statement of this point of view was published by the writer of this notice in NATURE, 1878, vol. xvii. pp. 390, 411, &c.

Stimulator to the purely mechanical parts of sense organs, a terminology which seems to us of rather doubtful value, more especially as stimulators seem to graduate into sense organs in the narrower sense.

The simplest class of sense organs contains what the author calls *Fühlpapillen* or *Tactile-papillae*. These, as they occur in the stamens of *Opuntia*, &c., have been already described by Haberlandt in his "Physiologische Pflanzenanatomie"; the present book demonstrates the remarkable fact that tactile papillae occur in many different organs and in widely distinct natural orders—a state of things with which we are familiar in many adaptive structures, and which never fails to interest us. The tactile papilla in *Opuntia* consists of a small conical projection from an epidermic cell, into which runs a promontory of protoplasm. The fact that the papilla projects above the general surface renders it liable to be touched by the visiting insects, and the thin walls of the apical half of the papilla allow deformation to result from contact. The papillae in this instance are not, however, very sensitive to simple contact, for if the stamens are gently rubbed they curve but slightly, whereas if the filament is forcibly bent at the same time, as would be the case when an insect visited the flower, the reaction is greater. This is only one instance of the care with which Haberlandt has, throughout, distinguished the reaction due to contact that is produced by bending of the whole organ. In this case, and also in *Portulaca*, it seems that if the filament is merely stroked the needle slips over the papillae without seriously affecting them, but pressure at right angles to the filament deforms the wall of the tactile papilla and also bends the filament.

In the filaments of *Berberis*, the tactile papilla is of still simpler structure, being formed by the convex projection of the whole outer wall of an epidermic cell. The distribution of the cells corresponds with that of the region sensitive to contact, and here in contrast to *Opuntia* a slight touch, which produces no bending of the filament, is sufficient to call forth the reaction. It is true that forcible bending of the filament also has an effect, but the movement produced is incomplete; it is interesting that the motor machinery should respond less to direct deformation of its own constituent cells than to a minute change of form in the cells specialised as sense organs.

The tactile cells in *Berberis* differ from the non-sensitive ones in being richer in protoplasm, in containing orange chromoplasts and starch grains. The exposed projecting wall of the sense cells is not thin as in *Opuntia* or *Portulaca*; the disturbance produced by contact is apparently due to a curious thinning away of the outer wall where it meets the radial walls. This hinge-like mechanism must allow a localised deformation of the ectoplasm to occur; the cell is, in fact, like a box with strong but loosely fitting hinged lid, the hinges being the region where deformation especially occurs. The same type—a bulging epidermic cell with a hinged connection to the radial walls—occurs in *Abutilon* in a different natural order. The irritable stamens of *Helianthemum* are worthy of notice, from the absence of all definite sense organs. Haberlandt assumes that the delicacy of the epidermis renders superfluous any special arrangements; and he compares the filaments to those tendrils in which histological adaptations are absent.

Simple tactile papillæ occur in stigma lobes of *Golfussia anisophylla*; they are not highly sensitive, and a pressure on them sufficient to bend the lobe is required, but whether or no the deformation of the motile tissue acts as an accessory stimulus is not easily decided. In his section on irritable styles and stigmas, Haberlandt describes the curious movements of the style of *Arctotis* (Compositæ), which was discovered by D. Müller in 1853, but has, until recently, received too little attention. Like the filaments of *Helianthemum*, it has no special sense organs, and Haberlandt suspects that the reaction is called forth by the style being forcibly bent rather than irritated by touch.

In Darwin's "Fertilisation of Orchids" the mechanism by which *Catasetum* shoots out its pollen-masses was for the first time described. Haberlandt has now shown that in *C. Darwinianum* and *macrocarpum* the "antennæ" which receive the stimulus, and transmit an influence to the rostellum, are provided with sense organs. His drawings (especially Taf. iii. Fig. 7) fully confirm his remark that the tactile papillæ bear a striking resemblance to those on the filaments of *Opuntia* and *Portulaca*.

In an undetermined species of *Catasetum* a most remarkable divergence from the type occurs. Tactile papillæ are wanting, and the antenna is converted, by the development of mechanical tissues, into a vibrissa or lever; it is capable of bending near the base, and obviously functions like filaments in *Dionæa*,¹ where the movement of the stiff apical part deforms the percipient joint or hinge near the base.

Allied to the tactile papillæ are the *Fühl-tüpfeln* or tactile pits discovered by Pfeffer in certain tendrils, inasmuch as by their means the protoplasmic prolongations which fill the pits are brought close to the free surface, and in such a position that they are liable to deformation by contact. Haberlandt describes these structures in detail in a variety of genera, and gives drawings of several, including the cases where a relatively large crystal is included in the pit, an arrangement which must have the effect of a stone in a man's shoe in increasing the sensitiveness to contact.²

For the interesting account of the minute tactile pits in the tentacles of *Drosera*, the reader is referred to the original. The remaining sense organs described by Haberlandt may be placed together, although by the author they are subdivided into tactile hairs, tactile bristles, stimulators, &c. Their essential character has already been referred to in describing an unnamed species of *Catasetum*; it is the occurrence of a stiff terminal part the movement of which deforms either the base or the tissues from which it springs. A simple example occurs on the contractile stamens of *Centaurea montana*; here the sense organs consist each of a simple, strongly built hair, the movement of which acts on the thin-walled basal joint. Other organs of the same essential type have been described³ in *Aldrovanda*, but here the sensitive joint is not at the base, but in the middle of the hair.

One of the most interesting points in the book is the discovery of similar organs in *Mimosa* and *Biophytum*.

¹ Haberlandt, "Physiologische Pflanzenanatomie," Edit. ii., p. 481.

² See also Haberlandt, "Physiologische Pflanzenanatomie," Edit. ii., 1896, p. 478.

³ Haberlandt, "Physiologische Pflanzenanatomie," Edit. ii., 1896, p. 480.

The sensitive lower surface of the pulvinus of *Mimosa pudica* bears a number of obliquely lying bristles, and Haberlandt finds that the familiar reaction follows a touch applied to one of these. To convince himself of the fact the observer must, it seems, select a plant not in the highest condition of irritability; with a slightly sluggish plant it is easy to convince oneself that the bristles are the most sensitive part of the surface. The bristles are of several types, of which the most interesting is described as the "cork-squeezer" pattern.

In the angle between the bristle and the surface of the pulvinus is a projecting mass of cells, which will necessarily be squeezed when pressure is applied to the end of the bristle. The same mechanical contrivance is found among the *Oxalidæ* on the leaves of *Biophytum*, the lever being in this case a stiff hair instead of a bristle. The author points out (p. 80) that the discovery of these organs throws light on the question of the biological meaning of the irritability of *Mimosa*. Their existence does not seem compatible with Sachs' view that the response to contact is useful as a protection against sudden violent hail- or rain-storms. On the other hand, it lends support to Pfeffer's theory that the movement of the leaf stalks serves to warn off small creeping insects, &c. In Java and Singapore, where *Mimosa pudica* is an introduced weed, Haberlandt has seen the leaves react to visitors of this type.

The book concludes with a short section on the comparison of the tactile organs of plants with those of animals, in which the interesting point is brought out that in insects the lever-like or hinged hairs bear a distinct resemblance to corresponding structures described by the author in plants.

FRANCIS DARWIN.

A NEW TREATISE ON THE CALCULUS.

An Elementary Treatise on the Calculus, with Illustrations from Geometry, Mechanics and Physics. By George A. Gibson, M.A., F.R.S.E., Professor of Mathematics in the Glasgow and West of Scotland Technical College. Pp. xix + 459. (London: Macmillan and Co., Ltd., 1901.) Price 7s. 6d.

AMONG several notable characteristics possessed by this work, the most prominent appears to be the severity of its logic. In one important respect it differs also from the usual English mathematical treatise—it seems to speak to the student, warning him against too probable error and giving him advice. This is a feature which should be encouraged. The aim of the writer of a text-book should be to educate his reader, frankly recognising the imperfections of human nature, and not merely to set forth a work of unassailable art full of unimpeachable truths.

While applied mathematics is the great field for the exercise of such a method of treatment—since erroneous views on the part of students are at once more probable and more numerous in this domain than in others—the calculus is probably, in the field of pure mathematics, the subject in which a student most needs the anticipation of errors and difficulties; and the really philosophical student will find in Prof. Gibson's treatise a work which