the equator until they terminate in latitude $\pm 80°$. The general trend of the spots is from latitude $\pm 35°$ to $\pm 5°$.

(3) At epochs of prominence minima (which are concurrent with sunspot minima) these centres of action are

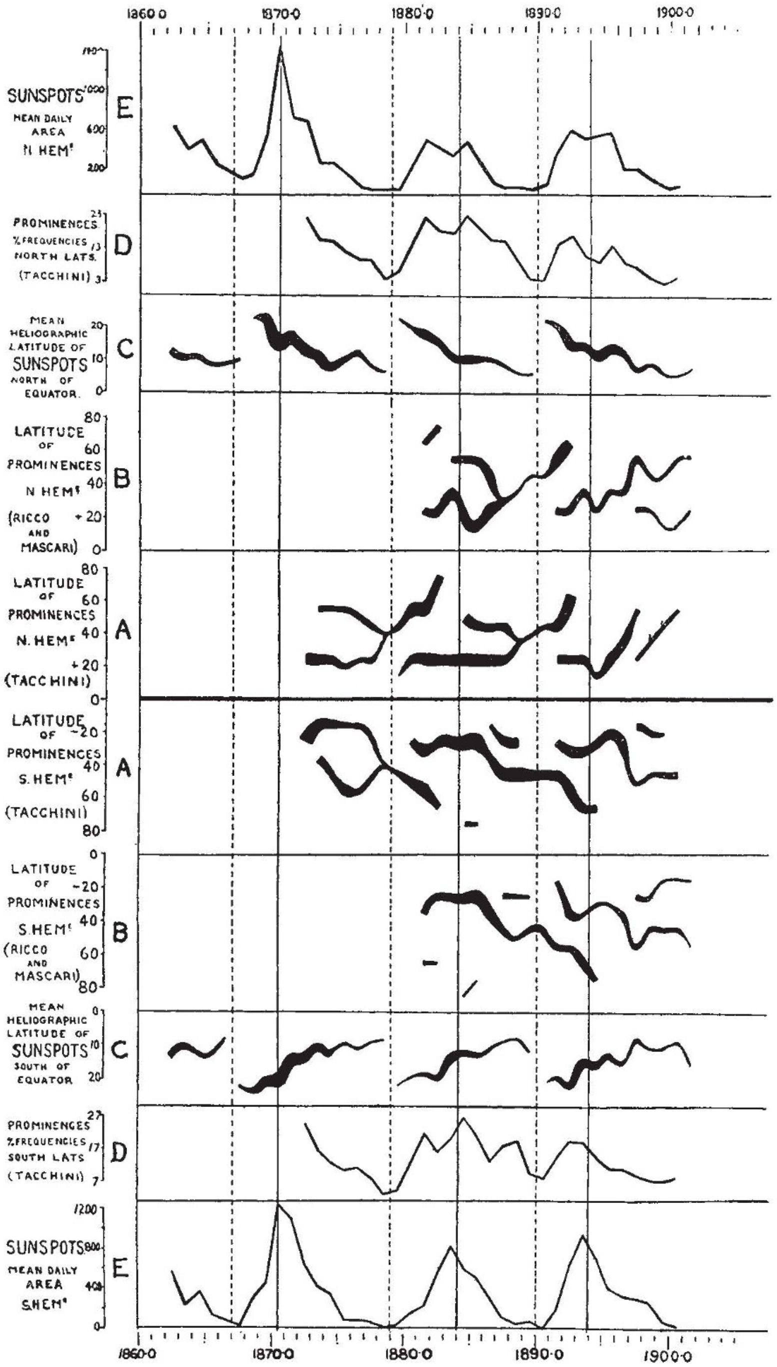

FIG. 2.—A comparison of curves illustrating the variations of the positions the centres of action of prominences (A and B) and spots (C), the percentage frequency of prominences (D), and the variation of spotted area (E). (The continuous and broken vertical lines indicate the epochs of sunspot maxima and minima respectively, the two hemispheres being taken together.)

restricted to one zone (about latitude $\pm 44°$) in each hemisphere, while those of the spots occupy two zones in each hemisphere.

Since the broken vertical lines in Fig. 2 represent the epochs of prominence and spot minima, it will be seen that these cut curves C when two zones of spots are in evidence, and intersect the curves A and B when there are only single zones of prominences.

(4) At nearly all other times these centres are apparent in two zones, while those of the spots occupy only one in each hemisphere.

This deduction is true if the curves C be taken as representing simply the phenomenon generally, but it should be borne in mind, as stated previously, that a new reduction of these spot zones, which is in hand, is necessary.

(5) The subsidiary maxima exhibited by the curves representing the percentage frequency of prominence activity for each entire hemisphere are due to the presence of two well-developed centres of prominence activity in each hemisphere.

To make the comparison the subsidiary peaks on the curves D should be compared with the curves A and B, and in every case the former are accompanied by two zones of prominences.

Before concluding this article it may be mentioned that other observers, and among them Father A. Fényi, S.J., have studied this question of prominence distribution, but their discussions have been restricted to only comparatively short intervals of a few years; their results are, however, in harmony with those described here.

It is important finally to state that the deductions here made may be partially incomplete owing to the difficulty of determining sometimes whether a new centre of action has been formed or the position of an old one changed. Further, account must be taken of the fact that the material discussed does not represent the record of the percentage frequency of prominences determined from observations made on the disc of the sun (now rendered possible by the Jannsen-Hale-Deslandres method), but one obtained from observations of the phenomena occurring only at the limb of the sun. The close agreement between the observations of the different observers shows nevertheless that this latter method is of great value.

WILLIAM J. S. LOCKYER.

THE STATOLITH THEORY OF GEOTROPISM.[1]

THE paper deals with the modern theory[2] of the mechanism by which plants are enabled to regulate their line of growth by means of the force of gravity. When an upright flower-stalk is forcibly subjected to a change of position, for instance by laying the flower-pot on its side, it responds by geotropic curvature, and finally regains the vertical. The statolith theory is not concerned with the mechanism of curvature, but merely with the question how horizontality can originate a stimulus, in other words, how the plant perceives that it is no longer vertical. It is known that in some animals, for example the Crustacean Palæmon, the faculty of spacial orientation depends on statoliths (otoliths) which serve as guides by pressure on the internal surface of the otocyst. This theory has now been applied

[1] A paper by Mr. Francis Darwin, read at the Royal Society, March 12.

[2] Published simultaneously by Haberlandt and Němec in vol. xviii. of the *Berichte d. Deutschen Bot. Gesell.*; see also *Pringsheim's Jahrb.*, vols. xxxvi., xxxviii.

to plants; the function of statoliths is believed to be performed (in Phanerogams, at least) by starch grains which are free and movable, and thus fall to the lower end of the cell. So long as the plant is vertical, the starch grains rest in a layer on the basal walls of the cells. If the plant is placed obliquely or horizontally, the falling starch grains rapidly take up a different position, and, by pressing on a new region of the cell walls, can be conceived to originate a stimulus.

The fact that the power of being gravitationally stimulated occurs in certain definite regions (*e.g.* the root-tip) suggests the existence of that type of physiological machine which we call a sense-organ. Now falling starch grains supply the physical conditions which are known, in the case of animals, to supply a sense-organ for orientation. Therefore, when we find in the root-tip groups of specialised cells provided with falling starch grains, such grains being absent in the parts of the root which have no power of geotropic perception, we have strong *a priori* evidence for the statolith theory.

This general line of argument has been fully and convincingly developed by Haberlandt and Němec, who have also supplied direct experimental evidence. Some of the latter is not quite so satisfactory. Thus Němec succeeded in destroying the starch in bean roots by embedding seedlings in gypsum, when such roots were found incapable of geotropic curvature. Němec not unnaturally put down his results to the loss of an integral part of the sense-organs. But I have shown that grass seedlings, the starch of which has been largely removed by exposure to high temperatures, not only fail to respond normally to gravitational stimulus, but also to the stimulus of light. The loss of starch must be looked at as a symptom of general inability to respond to stimulation rather than as a loss of special sense-organs.

In the autumn of 1901, feeling the unsatisfactoriness of the available methods of attacking the problem, I devised what was then a new method.[1] My point of view was that if gravitational sensitiveness is a form of contact-irritability (which must be the case if the pressure of the statoliths on the plasmic membrane is the critical event), then it might be possible to intensify the stimulus by vibration. I hoped, by applying vibration in a vertical plane to a horizontal seedling, to make the starch grains dance on the lateral walls, and by such repeated blows on the protoplasm to produce a more active geotropic response.

The result was as I expected, the seedlings which had been kept horizontal for from eight to ten minutes,[2] on a tuning-fork vibrating in a vertical plane, showed about 44 per cent. more curvature than the control specimens.

In order to make sure that the tuning-fork did not act by merely increasing the *general* irritability of the seedlings, the experiment was repeated with vertical specimens exposed to lateral illumination. In this case it was found that the curvature of the vibrated plants was only 5 per cent. more than that of the control specimens. We may therefore conclude that vibration increases the geotropic reaction, but does not materially affect heliotropism. This is precisely what might be expected on the hypothesis that geotropism is the result of tactile stimulation of the plasmic membranes lining the lateral cell walls by means of starch grains. So far as it goes, the method is therefore clearly confirmatory of the statolith theory.

FRANCIS DARWIN.

ENTOMOLOGY AT OXFORD.[3]

THE second volume of the "Hope Reports" contains the papers published by the workers in the entomological department of the University of Oxford during the years 1897–1900, and it is a cause for much congratulation to see this evidence of the very interesting and important work that is being done under the direction of Prof. Poulton with the valuable collections of tracheate arthropods possessed by the University.

In the first paper, on mimetic attraction, by Dr. Dixey, there is an important contribution to the subject which seems to be a favourite one with the Oxford entomologists, namely, the evolution of the patterns of the wings of those butterflies that form Müllerian associations. The whole theory underlying the work of Dr. Dixey and his colleagues has, it is well known, met with considerable opposition from several well-known entomologists who have studied Lepidoptera in tropical countries, and it is therefore a very satisfactory feature of this volume to find included in it a good report of the discussion that took place at the Entomological Society in 1897 at the conclusion of Dr. Dixey's papers.

The two papers on mimicry, by Prof. Poulton, which follow contain many additional facts of importance, but as they are not illustrated, they are rather difficult to follow for those who have not a special acquaintance with the butterflies; but Prof. Poulton's interesting communication to the Linnean Society entitled "Natural Selection, the Cause of Mimetic Resemblance," illustrated by five plates and several figures in the text, is an important contribution to knowledge which any zoologist may read with advantage. The volume also contains some reports on the experimental inquiry into the struggle for existence in certain common insects, and the colour-relation between pupæ of several species of butterflies and the surroundings of their larvæ.

The third volume is mainly devoted to the investigations of Mr. Guy Marshall and Prof. Poulton on the bionomics of South African insects. In South Africa entomologists have found several excellent examples of those forms of mimicry which are known as "Batesian" and "Müllerian" mimicry respectively. It was clearly important to test experimentally the value of the colours of these insects as a protection from their enemies. This Mr. Marshall has done with results which are as interesting as they are remarkable. The fact that Mantidæ and spiders exhibit unmistakable signs that certain species of Lepidoptera are distasteful to them, but are unaffected by colours whether warning or cryptic in character, suggests that birds and other vertebrates are the principal enemies which have caused the evolution of the colour patterns of these insects. The experiments with living kestrels and the results of an examination of the contents of the crops of a large number of wild birds go a long way towards a proof of the importance of the colours of both Lepidoptera and Coleoptera as a protection from their avian enemies. These and other investigations of a similar character, excellently illustrated by several plates, make up a paper of singular interest. The opponents of the evolution theory as applied to the colours of insects have a difficult task before them when they attempt to explain away the results of the experiments that are here recorded.

Space does not permit us to refer more fully to the other papers which appear in these volumes, but enough has been said to show that a very important work is being carried on in Oxford. The rows and rows of insects that the labours of entomologists in many countries have brought together in the Hope Museum are not only ticketed and arranged in systematic order, but they are made to yield up facts which, when intelligently studied, have an important bearing upon the current theories of evolution. But this is not all. Work that is done in a museum only, valuable as it may be, is of little account unless it stimulates to, and is supplemented by, experimental work in the field. That this is what museum work does lead to in Oxford is one of the most pleasing features of these volumes.

S. J. H.

MAGNETIC WORK IN MARYLAND, U.S.A.

IN a second report on magnetic work in Maryland (Maryland Geological Survey, special publication, vol. v. part i. pp. 23–98, the Johns Hopkins Press, Baltimore, 1902), Dr. Bauer gives the results of the survey which he commenced in 1896. In the earlier years the work was done mainly under the direct auspices of the Maryland Geological Survey, but subsequent to May, 1899, when Dr. Bauer took charge of the magnetic department of the U.S. Coast and Geodetic Survey, the Geodetic Survey contributed materially to it. The result, in Dr. Bauer's words, is that "Maryland now possesses the most detailed magnetic survey of any country, with the exception of Holland," there having been on the average one station to each 100 square miles.

1 Practically the same method has meanwhile been made use of by Haberlandt, who has published the results in *Pringsheim's Jahrb.*, 1903.

2 After being subjected to vibration, the plants were placed on a klinostat to prevent further gravitational stimulation. The curvature was measured after several hours slow rotation.

3 "Hope Reports," vols. ii., iii., 1900, 1902. Edited by Edward B. Poulton. Oxford: Printed for private circulation by Horace Hart, 1901, 1903.)