NOTE.

GEOTROPISM AND THE WEBER-FECHNER LAW.—Some recent experiments having demonstrated the truth of a statement made by the writer at the Newcastle meeting of Section K of the British Association that the perception of gravity in plants was purely a protoplasmic phenomenon and as such conformed to the Weber-Fechner Law, it has been considered advisable to make a preliminary statement of the work. All details with a description of the apparatus used will be published shortly.

The main points are these :

1. In 1905 Fitting¹ suggested that the Weber-Fechner Law might explain the results he obtained in an investigation with the oblique intermittent klinostat of the minimal angle-differences perceived by the epicotyl of various plants at varying angles to the vertical. He did not, however, develop the suggestion.

2. In 1906 Darwin² repeated the suggestion with reference to Fitting's observations on the differences in the presentation times required at varying angles to the vertical, but he did not develop the suggestion.

3. As the Weber-Fechner Law holds good within certain limits for the perception by animals of most stimuli, such as weight, light, sound, &c., and as protoplasm is the only substance common to the various organs involved in the perception, it occurred to the writer that the perception of gravity by plants involved *only* a protoplasmic change. Changes in permeability seemed the most probable mechanism, and such changes involve changes in the electrical resistance of the tissue.

4. Waller³ has pointed out certain divergences from the logarithmic curve of the Weber-Fechner Law which convert that curve into an $\int$ or sigmoid curve.

5. The writer has examined Fitting's observations on the difference in presentation time required at varying angles and finds that the results give a sigmoid curve.

6. The writer has also examined Fitting's observations on the minimal angle-differences perceived at varying angles to the vertical and finds that, on the hypothesis that 3.6 per cent. is the minimal angle-difference perceived by the plant, forty-eight of the fifty-eight experiments recorded by Fitting give a correct result, and of the ten results not in accordance with this hypothesis two are almost correct and six were repeated by Fitting and the results of the repeated experiments are in accordance. According to Weber the minimal difference in weights which is perceived by man is 3.3 per cent.

7. The writer has investigated, by measuring the changes in electrical resistance of the second millimetre of one side of the root-tip, the changes in permeability

¹ Fitting, H., *Jahrbüch. f. wiss. Botanik*, Bd. xli, 1905.

² Darwin, F., *New Phytologist*, 1906.

³ Waller, A. D., *Brain*, 1895.

produced in the root of *Vicia Faba* on exposure to varying angles, and finds that the permeability increases with the angle to the vertical according to the Weber-Fechner Law, showing the same divergences as found by Waller for the physico-chemical changes in retina, muscle, and nerve in response to various stimuli.

8. The permeability of the cortical cells of both upper and under sides of the root-tip increases, but that of the under side does so to a greater extent. The consequent relatively greater turgidity of the cells of the upper side explains the curvature. The increased permeability, giving decreased turgor, on both sides of the root explains the retardation of elongation of the axis shown by Sachs¹ to take place during curvature.

9. If statoliths or other bodies acted at all their effect would be dependent on four factors:

- a. The size of the grains.
- b. The number of grains.
- c. The angle of the plant.
- d. The viscosity of the medium.

Alone, these four factors could never give a resultant which would conform to the Weber-Fechner Law, and if they acted in conjunction with the changes in permeability their effect would be to distort the sigmoid curve considerably. Statoliths are present in considerable numbers in the root-tip of *Vicia Faba*, but the curve is always what would be expected if the excitation due to gravity were a purely protoplasmic phenomenon.

10. The negative geotropism of the shoot is explained by the obvious fact that if the protoplasm has the property of producing 'stem' cells it is different from that which produces 'root' cells, and another of its properties is to react to gravity by changes in permeability which are the reverse of those which take place in the root.

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¹ Sachs, J. v., *Physiology of Plants* (Eng. trans.), 1887.