Botany. — "*The inadmissibility of the statolith theory of geotropism, as proved by experiments of* Miss. C. J. PEKELHARING. By Professor F. A. F. C. WENT.

The statolith theory as formulated by HABERLANDT and NÊMEC in order to explain the perception of gravitational force by plants, has led to a whole series of papers in which the authors have attempted to advance arguments for and against the theory. It is not my intention to discuss these here, it may suffice to say that none of them have led to a definite conclusion concerning the question and have at most induced HABERLANDT (NÊMEC did not occupy himself any further with the matter) to modify the theory several times in order to bring it into line with newly discovered facts.

The adherents of the statolith theory suppose that the perception of gravitational stimuli takes place in the plant cell in consequence of the pressure exerted by starch grains on the protoplasm. We may consider it an entirely open question, whether in this case we should postulate that the starch grains change their place when the orientation of the cell with regard to the perpendicular is changed, but in any case we may demand, that the faculty of perceiving gravitational stimuli should go together with the presence of starch grains. Hence it is intelligible that both HABERLANDT and NÊMEC tried to make the starch disappear from the sensitive parts, the former with the aid of low temperatures, the latter by imbedding the objects in plaster of Paris. They were successful in this; the power of perceiving gravitational force disappeared with the starch and returned when the starch was regenerated. These experiments did not, however, furnish a conclusive proof, because it was uncertain whether the treatment which brought about the disappearance of the starch, did not also affect adversely the reactivity of the protoplasm.

A detailed discussion of these experiments seems superfluous, on account of what follows. In experiments on the perception of gravitational stimuli Miss C. J. PEKELHARING attempted in my laboratory to bring about the disappearance of the starch from the geotropically sensitive parts by a different method from that employed hitherto. In so doing she obtained important results of which I wish to give here a preliminary outline.

An investigation of FLURI [1]) had shown that by means of aluminium salts it is possible to eliminate starch from living cells, both from

[1]) M. FLURI, Der Einfluss von Aluminiumsalzen auf das Protoplasma, Flora, Bd. 99, p. 81, 1908.

leaf veins and from Algae. This suggested to Miss PEKELHARING that in this way it might also be possible to remove starch from the root cap of living roots. It was at once found, however, while experimenting with the rootlets of *Lepidium sativum*, that aluminium salts are poisonous. The roots generally react with an abnormal growth in thickness and traumatotropic curvatures, by means of which they turn away from the aluminium solution.

Experiments have of late been made with solutions which are so called physiologically balanced, i.e. in which the toxicity of one metallic ion is annulled or at least compensated for by another metal; these experiments led to attempts to counteract the toxicity of the aluminium, an object, which was more or less achieved by using K-ions.

If the roots of *Lepidium* are grown in a solution containing 1 gram of potash-alum in 4 litres of tap-water, it is found that there are a number of roots which become very long and thin and retain their starch, while others thicken in a more or less abnormal manner and lose their starch. Of the latter there are always some which show the above mentioned traumatotropy and which are therefore unsuitable for further experimentation. If these are cut away, a certain number always remain, which are free from starch and straight. If the solution is a little weaker, the traumatotropic rootlets indeed disappear, but the starch then persists; in stronger solutions the curvature is so general, that the material becomes useless.

The presence or absence of the starch can be ascertained by means of chloral-iodine; in the transparent rootlets of *Lepidium* it is then possible to see at once by small magnification, whether or not starch is present; increased certainty is obtained by making longitudinal sections. In order to be absolutely sure, however, a series of microtome sections were made in certain cases, and each section was examined separately for starch; it was thus found that the chloral-iodine test is sufficiently reliable.

The experiment was now carried out in such a way, that the seeds were soaked in water for a day and then placed on gauze which was stretched over a lamp chimney. The chimney-glass was placed in the solution of potash alum in such a way, that the level of the liquid was $^1/_2$ cm. below the gauze. After a few days the rootlets which had grown through the gauze, had attained a suitable length. Those with traumatotropic curvatures were then removed, and the lamp-glass was placed horizontally in order to expose the roots to the stimulus of gravity. All experiments were carried out in the dark, in order to exclude the action of light.

It was now clearly shown, that a number of rootlets, which had curved geotropically, were completely free from starch. Whatever views we may adopt with regard to the harmful action of the aluminium on the plant, or with regard to the fact that by no means all roots were free from starch, the fact, established with certainty, that roots, the tip of which had become starch-free, nevertheless curved geotropically, proves conclusively that the perception of the stimulus of gravity can take place *without* statoliths.

At most the protagonists of the statolith theory may still maintain, that the starch grains could in any case accelerate the perception of gravity. On this point a conclusive answer could only be obtained by determining the presentation time for geotropism in roots with and without starch. This determination was unsuccessful, for two reasons: In the first place the harmfulness of the solution and the tendency to traumatotropic curvature make it necessary to stimulate somewhat longer in order to get curvatures which can be readily observed and secondly these water cultures cannot be placed on a clinostat during the latent period, a condition which is necessary in the case of this object, in order to obtain definite curvatures with the presentation time.

Utrecht, October 1909.

Physics. — "*The degree of completeness of the circular polarization of magnetically divided lines.*" By Prof. P. ZEEMAN.

1. A luminous gas placed between the poles of an electromagnet observed along the lines of force, gives in the simplest case, two spectral lines of different wavelengths. These lines are situated at both sides of the original line. In accordance with LORENTZ's elementary theory my observations so far published tend to show almost perfect polarisation of the lines of this doublet, the polarization being right-handed for one, left-handed for the other of its components. If the direction of the field is reversed the sign of the polarization becomes opposite.

Corresponding to the doublet, observed parallel to the field, a triplet is seen when the light emitted at right angles to the field is analysed. The components of this triplet are linearly polarized.

LORENTZ as early as 1898[1]) showed that some conclusions concerning the polarization of the components of magnetically divided

[1]) LORENTZ. These Proceedings June 1898. p. 113. The Theory of Electrons. Teubner. Leipzig. p. 149. 1909.