For limiting magnitude $a - \Delta m$ the mean magnitude is

$$\mathbf{M}_{a-\Delta m} = \frac{(a - \Delta m)f_l + (a - \Delta m - 1)f_{l-1}\chi^{-1} + \ldots .}{F} = \frac{H - \Delta m \cdot F}{F}. \quad (9)$$

From (8) and (9) we have

$$\mathbf{M}_a - \mathbf{M}_{a-\Delta m} = \Delta m. \quad (10)$$

Thus the change in the mean magnitude equals the change in the limiting magnitude and is independent of both χ and the observational factors. If χ is only slightly greater than unity, the convergence in the series denoted as F and H will be slow, but in all data investigated thus far χ exceeds two. Thus in practice the series F and H converge rapidly.

[1] *H. B.* 895 (1934); *H. Ann.*, **105**, *Tercentenary Paper* 32 (1937); and unpublished
[2] Watson, *Proc. Am. Phil. Soc.*, in press.
[3] *Pub. Tartu Obs.*, **25**, no. 1 (1922); no. 4 (1923).

IS AUXIN PRODUCED IN ROOTS?[1]

BY J. VAN OVERBEEK

WILLIAM G. KERCKHOFF LABORATORIES, CALIFORNIA INSTITUTE OF TECHNOLOGY

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In 1933 Boysen Jensen[2] conclusively demonstrated that auxin is present in roots. When this problem was solved a new one arose: Is auxin produced in root tips, or is it merely accumulated there from elsewhere in the plant? Thimann[3] determined the amount of auxin which was given off by excised tips of Avena roots into dextrose-agar blocks and compared it with the amount of auxin that was obtained by ether extraction of such tips. In both cases he found the same amount of auxin and concluded that it is merely accumulated in the Avena roots and not actually produced by them. Other authors,[4] however, found that from the roots of Avena and other plants two to twenty times as much auxin could be obtained by diffusion as by extraction. They came to the conclusion that auxin is produced in roots. As we had obtained surprisingly large amounts of auxin from pea roots[5] it seemed of interest to compare the amounts of auxin obtained from excised root tips of germinating peas by diffusion and by extraction with improved techniques.

Tips 3 to 4 mm. long were cut from roots of "Alaska" peas which had germinated for two days in washed sand. These tips were placed on agar blocks ($1^1/_2$ per cent) containing 10 per cent dextrose, and were replaced each hour on fresh blocks. After from 6 to 9 hours no more auxin was given

off into the blocks (Fig. 1), not even if the tips were left on a single block for an additional period of ten hours. Yet at the end of such a prolonged diffusion experiment the tips still contained some auxin which could be demonstrated by ether extraction for 20 hours in a Soxhlet extractor (table). A similar set of roots as was used for the diffusion test was extracted with highly purified ether in a small Soxhlet extractor for 20 hours immediately after they were cut (Fig. 2). The amount of auxin obtained

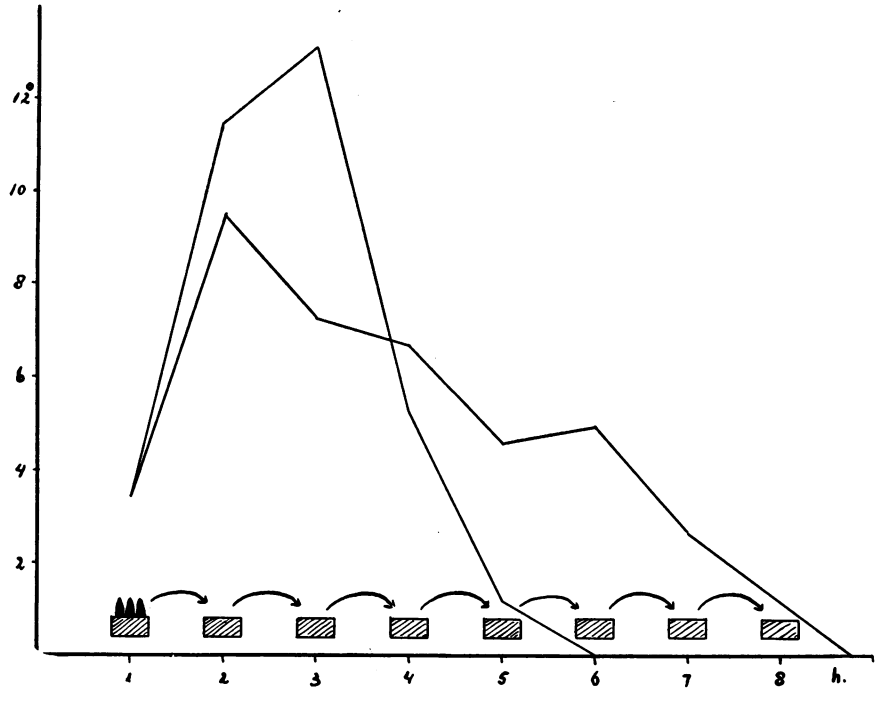

FIGURE 1

Amount of auxin (degrees of curvature in the Avena test) given off by 20 tips of pea roots during periods of 1 hour in 140 mm.^{3} agar ($1^1/_2$%) blocks containing 10% dextrose. (80923-28.)

in this way was practically equal to the sum of the amounts obtained in the diffusion test followed by extraction. It is interesting to note that diffusion yields less auxin than direct extraction, contrary to the results obtained by all previous investigators. It therefore seems that, under the conditions of our experiments, the auxin given off by *excised root tips of germinating peas* is auxin which was already present at the time the tip was cut off, and is not produced. Of further interest is the fact that in these root tips there is some auxin which apparently is not able to diffuse

out, but can be demonstrated by extraction only, which lends support to the view expressed by Thimann and Went[6] that auxin in the plants occurs in a bound and a free form.

TABLE

Total amount[7] of auxin obtained by:	
Diffusion from 50 tips	66.4° ± 2.6° (= 69% free moving auxin)
Ether extraction of residual auxin from same tips	29.6° ± 0.3° (= 31% bound auxin)
Total	96.0°
Direct ether extraction from 50 tips	91.4° ± 2.6°

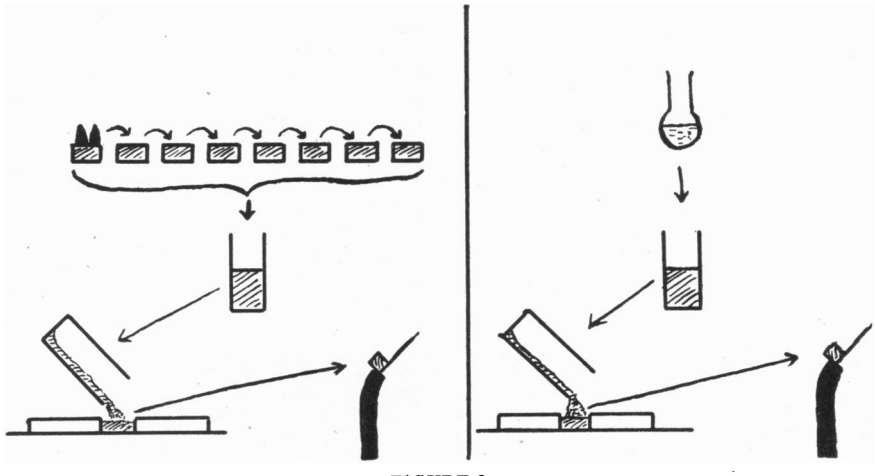

FIGURE 2

Scheme of the technique followed to obtain auxin from root tips of germinating peas. On the left the diffusion method consisting of: (1) the collection of auxin in dextrose-agar blocks, (2) melting of these blocks, in order to make the results obtained by this method strictly comparable to those obtained by the extraction method, (3) pouring of the agar into standard size blocks, (4) determination of the auxin content by means of the Avena test. On the right the extraction method which consists of: (1) the Soxhlet extraction, (2) the transfer of the extract into hot dextrose-agar (dextrose is used in order to make the extraction technique as comparable as possible to the diffusion method), (3) pouring of blocks of standard size, (4) the Avena test.

Although under the conditions described above (excised roots on dextrose-agar blocks), no evidence was found for auxin production, this does not necessarily mean that under natural conditions (intact roots) no production will take place. Recently there has appeared to be some evidence that excised pea roots grown *in vitro* under sterile conditions and in a

complete medium[8] (containing both vitamin B_1 and nicotinic acid) are able to synthesize auxin. Details will be published later.

[1] Report on work carried out with the aid of assistants supplied by the Works Progress Administration, Official Project Number 665-07-3-83, Work Project L-9809.

[2] *Planta*, **19**, 354 (1933).

[3] *Jour. Gen. Physiol.*, **18**, 23 (1934).

[4] Nagao, M., *Sci. Rep. Tohoku Imp. Univ.*, **10**, 721 (1936); Boysen Jensen, P., *Det. Kgl. Danske Vidensk. Sels., Biol. Medd.*, **13**, 1 (1936); Van Raalte, M. H., *Rec. trav. bot. néerl.*, **34**, 278 (1937).

[5] van Overbeek, J., and Bonner, J., *Proc. Nat. Acad. Sci.*, **24**, 260 (1938).

[6] Went, F. W., and Thimann, K. V., *Phytohormones*, Macmillan, New York, 1937.

[7] The amounts of auxin are expressed in degrees of curvature in the standard Avena test on the basis of 50 root tips and a volume of agar corresponding to 8 blocks (1120 mm.^{3}). All tests were done in quadruplicate and at the same time in order to avoid errors due to variation in sensitivity of the plants. If root tips are placed on plain agar blocks no auxin is found in them. Ether extraction of such tips that had been transferred to fresh plain agar blocks for a total period of 20 hours, yielded $46.6° \pm 1.6°$.

[8] Addicott, F. T., and Bonner, J., *Science*, **88**, 577–578 (1938).

CELL POLARITY AND THE DIFFERENTIATION OF ROOT HAIRS

BY EDMUND W. SINNOTT AND ROBERT BLOCH

DEPARTMENT OF BOTANY, COLUMBIA UNIVERSITY

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By means of a technique recently described by Sinnott[1] it is possible to observe the division and enlargement of cells in the living root tips of certain grasses, and to trace the history of these cells until differentiation is complete. In certain genera the cells which are to form root hairs (the trichoblasts) are sharply differentiated at the last cell division from those which are not, and the two develop very differently. In other genera differentiation of root hair cells is delayed for some time, and any cell, until rather late in its development, seems to have the capacity to form a root hair. A detailed comparison of these two types of differentiation throws light on the mechanism of root-hair determination. Root hair development was studied in *Phleum pratense*, *Poa trivialis*, *Chloris gayana* and *Sporobolus cryptandrus*.

In the genera *Phleum* and *Poa*, just before the last cell division (usually the fourth from the tip) in the surface layer or dermatogen, the apical end of the cell becomes more densely protoplasmic than the basal. The division which then follows is an unequal one, the apical (distal) daughter cell, which is the trichoblast and destined to produce a root hair, being