DISCUSSION

CHARLES DARWIN AND THE MODERN THEORY OF TROPISMS

PHOTOTROPIC and geotropic curvatures as well as other similar movements of plant organs are explained, as is known, by the unequal growth of their opposite sides. According to the modern view, the immediate cause of this phenomenon is that the growth hormone, *i.e.*, a substance formed in the plant itself and regulating its growth, accumulates on one side of the organ. This is a consequence of the polarization of tissues induced by the one-sided illumination, the action of gravity or some other external influence. The unilateral acceleration or retardation of growth depends on the concentration of the acting substance and the internal peculiarities of the plant organ which is acted on by light and other environmental factors.

This theory has played an important part in the development of the newest views on growth. It has stimulated the investigation of phytohormones (auxin, heteroauxin) which, as we now know, not only affect growth, but under certain conditions, also induce cell division and determine some morphogenetic processes. Therefore, they accomplish to some extent the same functions in the plant that the so-called organizers accomplish in the animal organism.

In view of the great theoretical and practical importance of all these questions, it is of interest to establish who first expressed the thought that tropic movements are connected with the physiological activity of a specific substance, produced by the cells of the plant and designated in modern physiology by the term "growth hormone."

Every one is familiar, of course, with the classical experiments of Charles Darwin which show that in many cases the action of the external agent (light, gravity, etc.) affects one part of the organ, whereas the motor reaction (phototropic, geotropic and other curvatures) occurs in another part which is often removed from the first by a distance of several centimeters. Whence Darwin concluded that in such cases a stimulus or influence is transmitted through the tissues of the plant. This conclusion has long been accepted by all and is now to be found in every textbook on botany.

Now the question naturally arises as to what Darwin imagined the mechanism of this transmission to be. The answer can not be found in any of the manuals on plant physiology nor even in any paper specially treating tropisms, growth or growth hormones. But whereas on page 486 of his work, "The Power of Movement in Plants" (1880), Darwin in summarizing his conclusions on the localization of phototropic sensitivity in the tip of *Phalaris* coleoptile, says: "These results seem to imply the presence of some matter in the upper part which is acted on by light, and which transmits its effects to the lower part."

This note leaves no doubt that Darwin considers the transmission of the phototropic stimulus in coleoptile tissues as the movement of a certain substance secreted by the phototropically sensitive tip of this organ.

Thus the priority of the basic idea of the modern theory of tropisms belongs to the great English biologist, whose merits in the physiology of plant movements seem not to be fully appreciated.

I consider it necessary to dwell on this subject because in a recently published book by P. Boysen Jensen, "Die Wuchstofftheorie" (Jena, G. Fischer, 1935), which has also been translated into English,[1] this question is incorrectly treated. The reader gains the impression that the idea of the material nature of the transmission of the phototropic stimuli was first advanced by Boysen Jensen himself in 1911. As we see, the real originator of this concept was Charles Darwin.

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EDWARD FREMY ON THE CONSTITUTION OF PECTOSE

IN a study of the original pectin literature one can not fail to be impressed by the remarkable understanding of the subject exhibited by the discoverer of the enzyme pectase and of pectose, the precursor of pectin, later renamed protopectin. Edward Fremy, some 90 years ago, differentiated the properties of various pectin modifications far more clearly than did any of the investigators during the subsequent fifty years, and in some respects more clearly than even some of the recent workers in the field.

It seems regrettable, therefore, that his views on the constitution of the precursor of pectin, as it exists in the plant, should be so generally misquoted, especially in English language publications. Fremy specifically pointed out that he had proof to the effect that pectose was a substance distinctly different from the pectin obtained from it by acid hydrolysis, and that it *could not be an insoluble calcium salt of pectin.* He says,[1] ". . . Je devais m'assurer que ce corps n'etait pas une combinaison insoluble de pectine avec la chaux ou avec

[1] P. Boysen Jensen, "Growth Hormones in Plants." Translated by G. S. Avery, Jr., and P. R. Burkholder. McGraw-Hill, 1936.

[1] E. Fremy, *Encyclopedia Chimique,* Vol. IX, p. 25, 1883. Also see *Ann. Chim. phys.* (3) 24 (1848)5.

le phosphate calcaire; les expériences suivantes ne me parassait lasser aucun doute a cet égard."

Nevertheless, v. Fellenberg in 1917[2] quoted Fremy as follows: "Deshalb vermutet Fremy, Pektose Könnte eine calciumverbindung des Pectins sein," and this seems to have become the generally accepted interpretation of Fremy's views pertaining to the constitution of pectose.

Most likely Fellenberg referred to views expressed by Fremy in 1839 when he made his first report on pectin to the Society of Pharmacy.[3] At that time he had not yet named the substance, because, as he says, it might well be that it would turn out to be nothing but pectin combined with lime. As noted above, he later satisfied himself that this view was not tenable, that pectose was in fact a new substance.

Because of its wide use for reference purposes it is especially regrettable that the first paragraph of the generally excellent review which M. H. Branfoot published in 1929[4] contains the following: "From this behavior Fremy concluded that pectose was probably an insoluble salt of calcium or potassium, giving rise to free pectin and bases when acted upon by acids." Probably because of being well acquainted with the above review T. N. Morris, on page 12 of his "Principles of Fruit Preservation," published in 1933,[5] states that "pectose was first recognized in the plant tissues by Fremy, who considered that it was an insoluble salt of calcium or potassium which gave rise to free pectin and bases when extracted with acids."

Meyers and Baker[6] in 1929 said "Chodnew, Payen, Fremy and other early investigators considered protopectin to be an insoluble calcium compound." Sloep (1928)[7] properly reports the views of Fremy, but unfortunately her thesis is printed in Dutch, and is therefore not so readily available to the general reader in this country.

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THREE RETURNS OF A BANK SWALLOW

SINCE 1923, Mrs. Stoner and I have banded in Iowa and New York State 5,576 young and adult bank swallows, *Riparia r. riparia.* Of these, 2,829 have been banded in the Oneida Lake, New York, region since 1928. Among the total of 147 returns that we have obtained from our bandings, only one individual has been recovered as many as three times, an interval of at least eight months having passed between each recovery.

A brief history of this bird, so far as it is known, is herewith offered as a contribution to the biology of this species.

Incubating adult bank swallow No. F 55924 was banded from a burrow in the south bank of Fish Creek about three miles east of Oneida Lake, New York, on June 2, 1932.

On May 26, 1934, this swallow was recovered (Return-1) as an incubating individual in the same colony and from a burrow a few yards north of the one occupied in 1932. Its body temperature registered 104.6° Fahr. and its weight was 14.4 grams. The burrow was 34 inches deep and 14 inches below the turf. This bird was now at least three years old.

On May 21, 1935, No. F 55924 was again recovered (Return-2) in the same colony as before and in a burrow a few feet from the one occupied by it in 1932. Its body temperature registered 106.0° Fahr. and its weight was 14.6 grams. Another adult occupying the burrow at the same time escaped us. The burrow was 18 inches deep, 6 inches below the turf and contained an unlined grass nest. This swallow was now at least four years old. Two days later it was recaptured from the same burrow, when its temperature registered 106.8 degrees and it weighed 17.0 grams. At this time also its mate, obviously a female, was captured and banded. Evidently, therefore, F 55924 was a male.

On May 22, 1936, No. F 55924, along with its *unbanded* mate, was recovered (Return-3), dead, in the same colony as before and in a burrow a few feet from the site of the one occupied by it in 1934. This burrow was 36 inches deep, 12 inches below the turf and contained an unlined nest.

The bodies of the dead swallows were first discovered on directing into the burrow, by means of a small hand mirror, a beam of light reflected from the sun. The nest and the remains of the birds were then removed with a long bent wire. Most of the fleshy parts as well as the crania and their contents had been devoured by a house rat not long before our arrival, for the remnants of the rodent's feast were fresh. We also discovered the remains of eight other adult bank swallows which had met a similar fate in this colony within a few hours preceding our visit. The culprit was observed in one of the burrows actually feeding upon the body of a swallow, but it successfully eluded our efforts to capture or kill it.

The essential known facts regarding bank swallow F 55924 may be briefly summarized as follows: Its known age at the time of death was 10 days less than five years; it had made at least five round-trip jour-

2 *Biochem. Zeits.*, 85: 119, 1918.
3 *Jour. Pharm.*, (2) 26: 591, 1840.
4 "Food Investigation Special Report," No. 33, London: 1929, p. 1.
5 Van Nostrand Company, 1933, p. 12.
6 Bull. No. 160, Del. Agr. Expt. Sta., June, 1929, p. 3.
7 "Onderzoekingen over Pectinstoffen en hare Enzymatische Ontleding." Delft, 1928, p. 21.