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.