CC/NUMBER 40
OCTOBER 4, 1982

This Week's Citation Classic

Bünning E. Die endonome Tagesrhythmik als Grundlage der photoperiodischen Reaktion. (Endogenous daily rhythms as the basis of photoperiodism.)
Ber. Deut. Bot. Ges. 54:590-607, 1936.
[Botanisches Inst., Univ. Jena and Univ. Königsberg, Germany]

There are qualitative differences in light sensitivity of the individual phases of endogenous daily rhythms, resulting in variable effects on flower formation. Similarities between the genetics of photoperiodism and of endogenous rhythms are pointed out and the possible role of coincidence in external and internal rhythms in plants and animals is discussed. [This paper has been cited in over 135 publications since 1961. Based on *SCI*® data for 1961-82, it proved to be the most-cited paper ever published in this journal.]

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August 20, 1982

"Before the first symposium on biological clocks[1] most of the biologists interested in photoperiodism did not believe in the existence of endogenous daily rhythms (now called circadian rhythms). Between 1950 and 1960 only a few authors found it worthwhile to criticise my photoperiodism hypothesis. They believed that I had 'invented' endogenous rhythms in order to explain photoperiodism. The contrary is true. I was searching for something like photoperiodism in order to find an adaptive value for those rhythms and thus to explain their evolution without evoking Lamarck.

"Endogenous daily rhythms were observed before 1936. Darwin believed them to be 'to a certain extent inherited' as a consequence of the long-lasting influence of the external rhythms. Nevertheless, around 1900, observations on such rhythms served as an argument for the inheritance of acquired characteristics. The lack of evidence for an adaptive value for endogenous daily rhythms favored this explanation. Several opponents of these disciples of Lamarck tended to doubt the endogenous nature of these rhythms. They proposed that unknown external factors were responsible for the observations of Darwin and others. It was also suggested that endogenous rhythms might not be due to inheritance but to long-lasting modifications.

"This was the challenging background against which I started my experiments in 1928. These experiments proved that certain rhythms were not only endogenous but also inherited. These findings compelled me to look for the adaptive value of the endogenous rhythms. I speculated in 1932[2] that the degree of coincidence between external and internal daily rhythms might be important for the fitness of organisms. Reviewing the literature on photoperiodism up to 1932 led me to believe that I might find there the phenomena which are controlled by the special quantitative relations between the physiological and the external rhythms. Thus it was this study of the literature which resulted in the experiments reported in the 1936 paper.

"The interest in this publication and in later publications from my laboratory increased after the Cold Spring Harbor Symposium.[1] There was a flood of research from many laboratories. Not all of the publications supported my ideas, but there is now a general agreement concerning the role of 'external coincidence' in the fitness and the development of plants, animals,[3] and human beings.[4] The time problems of shift work and of jet flights stimulated this interest in studying the relations between external and physiological rhythms. These were reasons enough to go back to earlier reports, such as my 1936 paper.

"That 1936 publication and my further work in this field were the major reasons for my receiving the following honors: honorary doctoral degrees from the Universities of Glasgow (UK), Freiburg (FRG), and Erlangen (FRG); foreign associate, US National Academy of Sciences; member or corresponding member of six other academies; foreign member of the American Philosophical Society; honorary member of the Japanese and corresponding member of the American Botanical Societies; and Charles Reid Barnes Life Membership of the American Society of Plant Physiologists."

1. Biological clocks. (Whole issue.) *Cold Spring Harbor Symp.* 25, 1960. 524 p.
2. **Bünning E.** Über die Erblichkeit der Tagesperiodizität bei den *Phaseolus*-Blättern. *Jahrb. Wiss. Bot.* 77:283-320, 1932.
3. **Follett B K & Follett D E.** *Biological clocks in seasonal reproductive cycles.* Bristol, UK: Scientechnica, 1981. 292 p.
4. **Moore-Ede M C, Sulzman F M & Fuller C A.** *The clocks that time us.* Cambridge, MA: Harvard University Press, 1982. 448 p.