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This Week's Citation Classic

Butler W L, Lane H C & Siegelman H W. Nonphotochemical transformations of phytochrome in vivo. *Plant Physiol.* **38**:514-19, 1963. [Agricultural Marketing Service and Agricultural Res. Service, US Dept. Agriculture, Plant Industry Station, Beltsville, MD]

Phytochrome was measured spectrophotometrically in cauliflower heads and in dark-grown maize seedlings. A dark transformation of the far-red absorbing form, P_{FR}, to the red absorbing form, P_R, was found in both types of tissue. In the seedling tissue, however, P_{FR} was also destroyed in an aerobic reaction which competed with the dark reversion. [The *SCI*® indicates that this paper has been cited over 155 times since 1963.]

Warren L. Butler
Department of Biology
University of California
La Jolla, CA 92093

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"During the decade of the 1950s there was an extensive search for the red-far-red pigment system which controls a wide variety of seemingly unrelated physiological responses in plants.[1] It was proposed on the basis of action spectroscopy on several of these responses that the pigment existed in two interconvertible forms, P_R and P_{FR}, with absorption maxima at 660 and 730 nm, respectively, and that red and far-red light caused transformations between the two forms.[2]

red

FR

far-red

Finally, in the summer of 1959, a pigment with these unusual photochemical properties was measured spectrophotometrically in intact tissue of dark-grown seedling plants and was isolated as a chromoprotein which retained the characteristic reversible, photochromic behavior.[3]

"In addition to the phototransformations of the pigment, dubbed phytochrome, dark reactions were also implicated in the physiology. A dark transformation of P_{FR} to P_R was postulated to be the basis of the timing mechanism by which photoperiodic plants reckon the length of the night and therefore the season of the year. The direct, spectrophotometric measurements of phytochrome *in vivo* afforded an opportunity to measure these proposed dark reactions.

"The measurements in the cited paper showed that there was, indeed, a dark transformation of P_{FR} back to P_R in the intact tissue. In tissue from cauliflower heads, the dark conversion of P_{FR} to P_R, following a brief irradiation with red light to form P_{FR}, occurred with a half-time of ~1 hour and with no loss of total phytochrome. In dark-grown seedling tissue, which was the primary source of material for isolating the pigment, P_{FR} also reverted to P_R but a major fraction of the P_{FR} was destroyed in the subsequent dark period. In continuous light which maintained a photostationary state of P_{FR}, phytochrome was destroyed almost completely in the seedling tissue and the rate of destruction saturated provided the light maintained a photostationary state of at least ten percent P_{FR}. However, approximately one percent of the phytochrome resisted destruction. It is this very low level of stable phytochrome which controls the photoresponses of mature green plants but the level is generally too low to be measured directly.

"This paper is cited probably for three reasons. 1) It was the first report of direct measurement of dark transformations of phytochrome *in vivo. 2)* It showed that prolonged irradiation with far-red light, which maintained a low photostationary state of P_{FR}, could act physiologically like red light. 3) It presented the dilemma that most of the phytochrome which could be measured in dark-grown seedling plants might not be physiologically active. This latter point has received considerable attention. To date, however, no differences have been found between the unstable and stable forms of phytochrome isolated from dark-grown and illuminated tissue. And we still do not know why dark-grown seedling plants have much higher levels of phytochrome than are required in the photomorphogenic control of mature plants."

1. **Borthwick H A.** History of phytochrome. (Mitrakos K & Shropshire J W, Jr., eds.) *Phytochrome.* New York: Academic Press, 1972. p. 3-44.
2. **Borthwlck H A, Hendricks S B & Parker M W.** The reaction controlling floral initiation. *Proc. Nat. Acad. Sci. US* **38**:929-34, 1952.
3. **Butler W L, Norris K H, Siegelman H W & Hendricks S B.** Detection, assay, and preliminary purification of the pigment controlling photoresponsive development of plants. *Proc. Nat. Acad. Sci. US* **45**:1703-8, 19S9.