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Phytochromes role in Plant Growth and Development

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Introduction

Phytochromes are photoreceptor molecules that absorb light, usually in the range 320 nm to 760 nm.The function of these pigments is to adjust the developmental program and behavior of plants to the prevailing environmental conditions (e.g. seasons and location)

Phytochromes

Phytochrome photoreceptors are present in higher plants like gymnosperms, angiosperms and lower plants like ferns, liverworts. They are almost certainly ubiquitous in green plants. The phytochromes absorb light with wavelength of 600-740 nm. They exist in two forms i.e. pfr and pr form.. Both the forms are inter convert able. The phytochrome molecule is the photoreceptor for red light responses. It exists in two forms, Pr and Pfr:

Discovery

A key breakthrough in the history of phytochrome was the discovery that the effects of red light (650–680 nm) on morphogenesis could be reversed by a subsequent irradiation with light of longer wavelengths (710–740 nm), called far-red light. This phenomenon was first demonstrated in germinating seeds, but was also observed in relation to stem and leaf growth, as well as floral induction The first clues regarding the role of phytochrome in plant development came from studies that began in the 1930s on red light–induced morphogenic responses, especially seed germination. Phytochrome was discovered by sterling Hendricks and harriesborthwicks at agricultural research institute in Maryland. Phytochrome, a blue protein pigment, was not identified as a unique chemical species until 1959, mainly because of technical difficulties in isolating and purifying the protein. The phytochrome pigment was identified using a spectrophotometer in 1959 by biophysicist Warren Butler and biochemist Harold Siegelman. Butler was also responsible for the name, phytochrome.

Pr form

- Absorbs at a peak of 666 nm

- Is the form synthesized in dark-grown seedlings
- When Pr absorbs red light, it is converted to the Pfr form

Pfr form

- Absorbs at a peak of 730 nm
- The Pfr form is the active form that initiates biological responses
- When Pfr absorbs far red light, it is converted to the Pr form
- Pfr can also spontaneously revert to the Pr form in the dark over time = dark reversion; Pfr is also susceptible to proteinases.
- Pfr absorbs some red light, so in red light, there is a balance of 85% Pfr and 15% Pr
- Pr absorbs very little far red light, so in far red light, there is a balance of 97% Pr to 3% Pfr

Phytochrome can interconvert between pr and pfr forms

Pr, which to the human eye is blue, is converted by red light to a far-red light–absorbing form called Pfr, which is blue-green. Pfr, in turn, can be converted back to Pr by far-red light.Known as photoreversibility, this conversion/reconversion property is the most distinctive property of phytochromes.

Pfris the physiologically active form of phytochrome

Because phytochrome responses are induced by red light, they could in theory result either from the appearance of Pfr or from the disappearance of Pr. In most cases studied, a quantitative relationship holds between the magnitude of the physiological response and the amount of Pfr generated by light, but no such relationship holds between the physiological response and the loss of Pr. Evidence such as this has led to the conclusion that Pfr is the physiologically active form of phytochrome. In cases in which it has been shown that a phytochrome response is not quantitatively related to the absolute amount of Pfr, it has been proposed that the ratio between Pfr and Pr, or between Pfr and the total amount of phytochrome, determines the magnitude of the response.

Phytochrome and the Circadian Clock in Plants

Photoreceptors and circadian clocks are universal mechanisms for sensing and responding to the light environment. In addition to regulating daily activities, photoreceptors and circadian clocks are also involved in the seasonal regulation of processes such as flowering. Circadian rhythms govern many plant processes, including movements of organs such as leaves and petals, stomata opening, stem elongation, sensitivity to light of floral induction, metabolic processes such as respiration and photosynthesis and expression of a large number of different genes.

Phytochrome in flowering

It is considered that during day time, the *Pfr*form of the pigment is accumulated in the plants which are inhibitory to flowering in short day plants but is stimulatory in long day plants. During critical dark period in short day plants, this form gradually changes into *Pr* form resulting in flowering. A brief exposure with red light will convert this form again into *Pfr* form thus inhibiting flowering. Reversal of the inhibitory effect of red light during critical dark period in SDP by subsequent far-red light exposure is because, the *Pfr*f orm after absorbing far-red light (730-354 nm) will again be converted back into *Pr* form. Prolongation of critical light period or the interruption of the dark period by red-light in long day plants will result in further accumulation of the *Pfr* form of the pigment, thus stimulating flowering in long-day plants.

Conclusion

Amazing progress has been made in recent years in elucidating phytochrome signaling mechanisms in higher plants, particularly in the model dicot *A. thaliana.*In addition, an integrated picture of light signaling crosstalk with temperature and various phytohormones is also emerging. Future studies will aim to tighten up the loose ends in phytochrome signaling and elucidate how phytochrome signaling intersects with various signaling pathways to coordinately regulate the diverse physiological responses and developmental processes.