PHYTOCHROME

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INTRODUCTION

- Phytochrome is a photoreceptor , a pigment that plants and some algae and fungi use to detect light.
- It is a sensitive to light in the red and far-red region of the visible spectrum.
- Biochemically phytochrome is a protein whit a billion chromophore.
- The pigment that controls growth and flowering in many plant.

HISTORY AND DISCOVERY

- The first important work in this field was conducted in 1930s by L.H. Flint and E.D. Mc Alister. In 1935 they reported that the seeds of lettuce (*Lactuca sativa*) did not germinate in dark but showed very good germination when exposed to wavelengths from 525 to 700 nm in the red region.
- H.A. Borthwick and S.B. Hendricks and other (1952) of the U.S. Department of Agriculture plant Industry Station in Beltsville, Maryland using large spectrograph confirmed the finding of Flint and Mc Alister.

DISTRIBUTION OF PHYTOCHROME

- Presence of phytochrome has been known in angiosperms , gymnosperms, liverworts, mosses, ferns and some green algae.
- Distribution of phytochrome in grass shoot is variable, but oat, rye and barley seedling all have high concentration in apical rigions of the coleoptile near the shoot apex and in the growing leaf bases.
- Phytochrome is present in most organs of all plants investigating, including roots.
- In green lower plants phytochrome is permanently localized in conformation in or near the plasma membrane.

CHARACTERISTICS OF PHYTOCHROME

- The action spectrum of the light needed for these responses shows a peak in the red at about 660nm.
- These responses can be reversed by an be application of far-red light soon after the red treatment.
- Sensitive spectrometers can measure a decrease in absorbance at 730nm when sensitive plant tissues are exposed to red light.

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- The change in absorbance is caused by the conversion of photoreceptor from one structural form to another.
- The red absorbing form changes to the far red absorbing from when it absorb red light and back again when it absorb far red light.
- Phytochrome has two different chemical structure that are inter-convertible the form are named by the color of light that they absorb maximally.

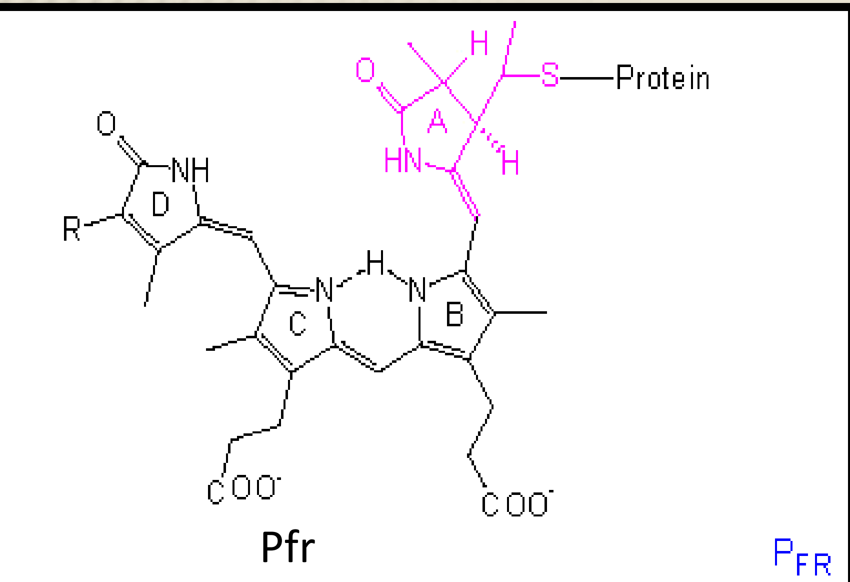
1] The Pr form and 2] The Pfr form

1] The Pr form:

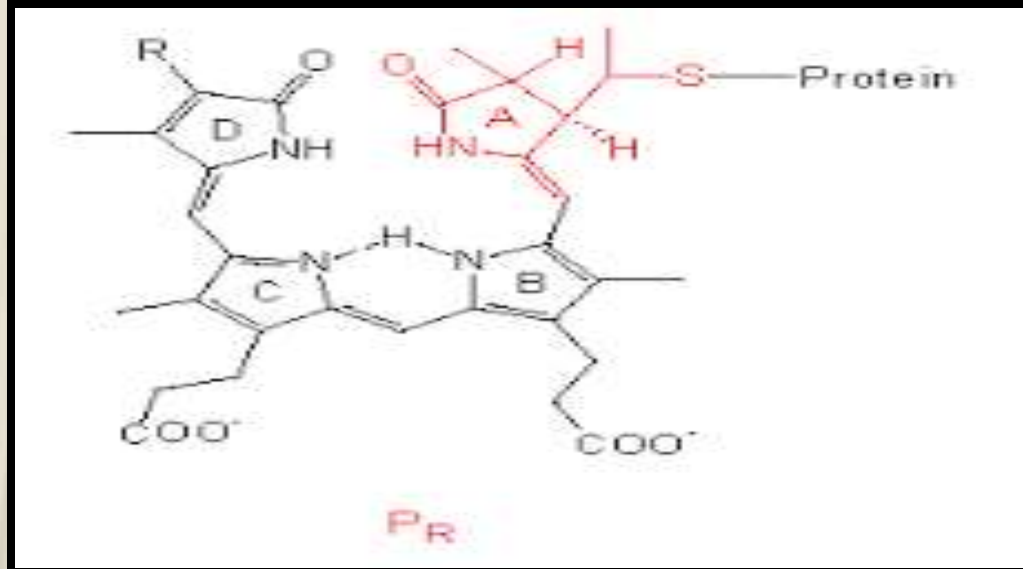
- Absorbs at a peak of 660nm
- Is the form synthesized in dark grown seedling.
- When Pr absorb red light, it is converted to the Pfr form.

2] The Pfr form:

- Absorb at a peak of 730nm.
- The Pfr is a active form that initiates biological response.
- When Pfr is absorb far red light it converted to the Pr form.



O
H
S—Protein
A
HN
H
O
NH
D
R
H
N
N
B
C
COO⁻
COO⁻
Pfr
PFR



R
O
O
H
S—Protein
D
NH
A
HN
H
H
N
N
C
B
COO⁻
COO⁻
PR

Pr
Pfr
Red Light (660 nm)
Quick conversion
Far-Red Light (730 nm)
Levels rise at night
Levels rise during day
Darkness
Slow reversion
(inactive)
(active)

CONT…

- Degradation of Pfr is known to occur by a highly process in which Pfr is first attached to small protein called ubiquitin.
- Attachment of ubiquitin to Pfr or to other protein targets them for degradation and carry out degradation's ATP and three enzymes are required.

1. **Protease :** recognize the protein
2. **Hydrolyase:** targeted the protein
3. **Release:** free ubiquitin

CHEMICAL NATURE

- Chemically, phytochrome is a homodimer of two identical polypeptide, each with a molecular weight of 120 kDa.

- Each polypeptide has a prothetic group call chromophore that is attached via a sulfur atom in a cysteine residue of the polypeptide. This chromophore is an open chain tetrapyrrole similar to the photosynthetic phycobilin pigment of red algae and cynobacteria.

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- The chromophore, Not the protein , That absorbs the light and causes phytochrome responses.

- When Pr is converted to Pfr by red light there is apparently a *cis-trans* isomerization in the chromophore . Alternation of the chromophore in phytochrome then cause several unidentified subtle changes in the structure of phytochrome portion.

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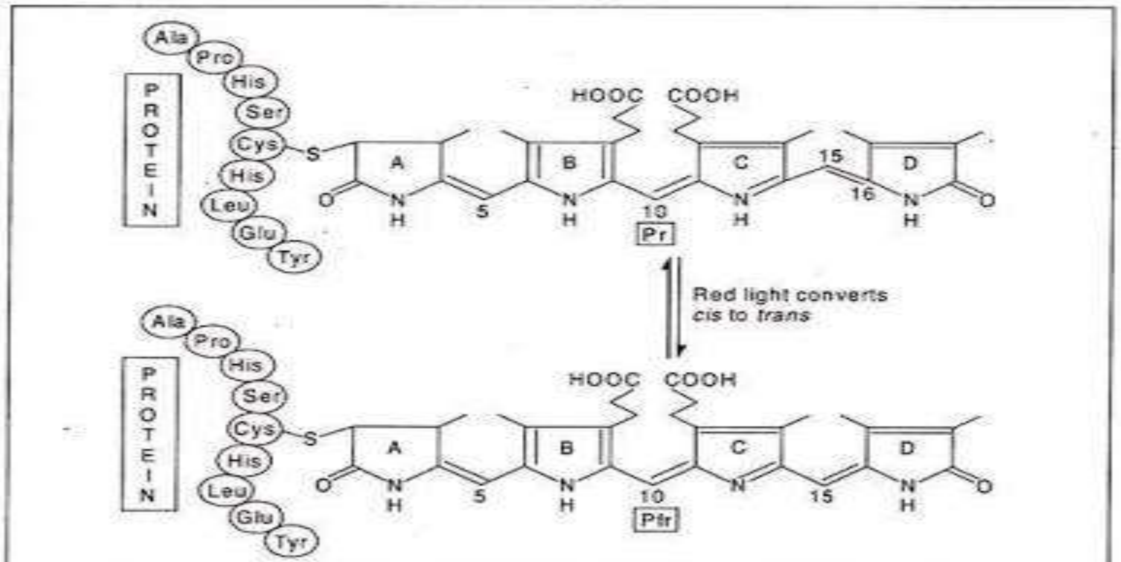
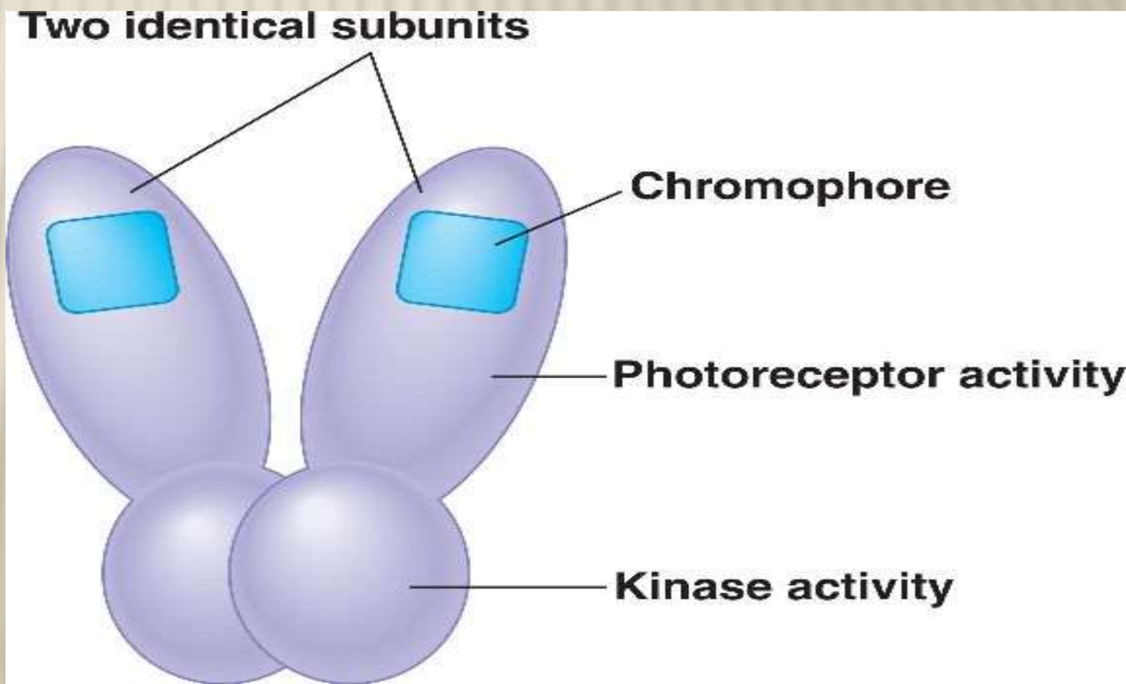
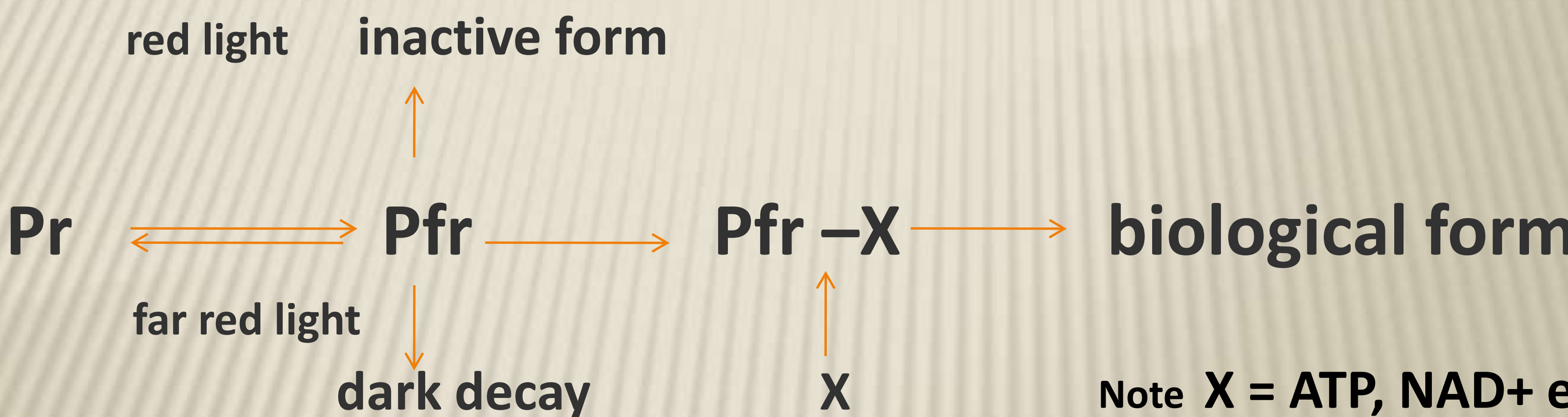


Fig. 14.2 : Structure of the phytochrome chromophore and its binding to the apoprotein. The chromophore is covalently linked to the protein at cysteine residue via a thioether bond. The chromophore undergoes *cis-trans* isomerization at carbon 15 in response to red and far-red light



MODE OF ACTION OF PHYTOCHROME

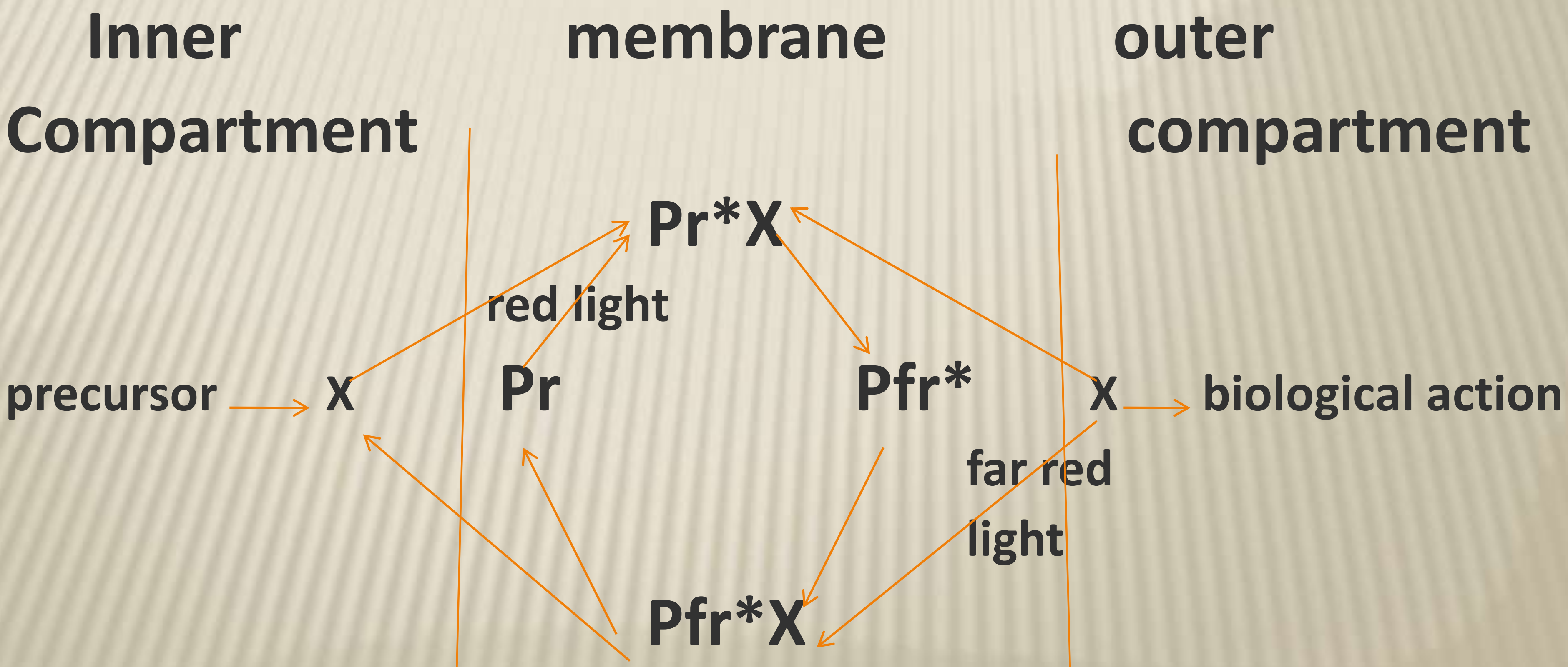
1] Hartman, the German physiologist has proposed a scheme of phytochrome action



Note X = ATP, NAD+ etc…

2] According to Borthwick and Hendricks Pr and Pfr follow several alternative reaction paths since only that could explain the apparently contradictory observations made from time to time.

3] H. Smith (1970) assumes the phytochrome to be present in the membrane.



Smith hypothesis for phytocrome action

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4] Jaffe's hypothesis is also entirely speculative. He assumes that phytochrome perhaps causes changes in permeability of the membrane and acts through acetylcholine(Ach).

5] Evans (1975) says that Pfr (or PfrX) "control the flow of reactive substances into several linked and compecting synthetic pathways."

MECHANISM OF PHYTOCHROME ACTION

- Phytochrome is believed to act in following ways :

1]According to Galston and coworkers hydroxylation of flavonoid compound is affected by phytochromes. Mohr, however suggests that radiation infuences some 'basic metabolic change in the cell' responsible for many different effects and influences on flavenoid hydroxylation pattern presumably represent only one such change.

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2] works of K.V. Thimann and coworkers suggest that phytochrome action involves the synthesis of nucleic acids and enzymes which may be responsible for the physiological changes. Mohr and others have found evidence to suggest that phytochrome effects are medicated by activation of genes that code for specific messenger RNA molecules which in their turn code for specific enzymes.

3] their are certain responses due to red or far – red light which are too fast to be explain by the gene activation or repression hypothesis.

PHYTOCHROME MEDIATED PHYSIOLOGICALE RESPONSES:

- **Phytochrome has been found to control a number of physiological responses of the plant. e.g. spore germination, chloroplast movement, elongation, bud dormancy, root development,..etc.**
- **Numerous plant responses are mediated by phytochrome hence, for convenience of study , they have been divided in to positive, negative and complex responses or as developmental and repaid responses.**

1] Positive responses:

characterized by initiation or increase of biosynthetic or growth processes e.g. phytocrome mediated anthocynin synthesis.

2] Negative responses:

those involving inhibition of growth processes or other physiological processes like translocation of substance e.g. inhibition of hypocotyls elongation by light.

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3] complex responses;

Those which are characterized by initially an inhibition and later promotion of the responses as compared to corresponding dark control e.g. light controlled regulation of oxygen uptake by cotyledons.

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DEVELOPMENTAL AND RAPID RESPONSES

A] **Developmental responses:** those responses which are mediated by phytochrome but also involve other physiological processes like growth, differentiation certain periodic phenomenon and longer time for production of the responses e.g. photoperiodism and germination

B] **Rapid responses :** those which are detectable within a very short period after germination irradiation and do not apparently interact with complex physiological processes e.g. closing of mimosa leaflets.

PHYTOCHROME IS A PIGMENT SYSTEM: SOME EVIDENCES

- There are similarities in the absorption spectra of phytochrome and the action spectra of plant responses is one important evidence suggesting that phytochrome is the pigment causing such responses.
- The response caused by red light are, always nullified by an immediate subsequent exposure to red light.
- Only low irradiance levels of either red or far red light that are capable of inter converting phytochrome from one form to another cause these responses.

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- In leaves and stem , light absorbed by chlorophyll alters both the action spectra for phytochrome response caused by Pfr and the amount of light required for the response.
- Both Pr and Pfr absorb violate and blue light, but low irradiance levels of these wevelengths are much less effective then red or far red light for the physiological processes.

ROLE OF PHYTOCHROME

- Many flowering plants use it to regulate the time of flowering based on the length of day and night (photoperiodism) and to set circadian rhythms.
- It also regulates other responses including the germination of seeds, elongation of seedling, the size, shape and number of leaves the synthesis of chlorophyll and the straightening of the epicotyl or hypocotyl hook of dicot seedlings.

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Thank You