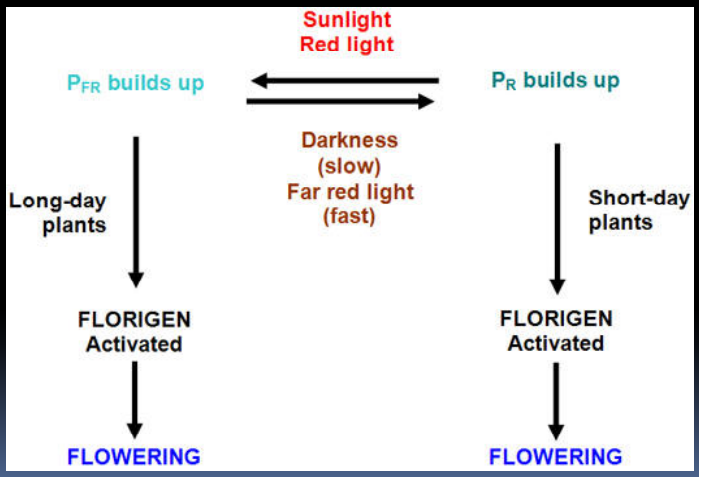
PHYTOCHROME

JOHNSON M
CPB – SXC - BOT

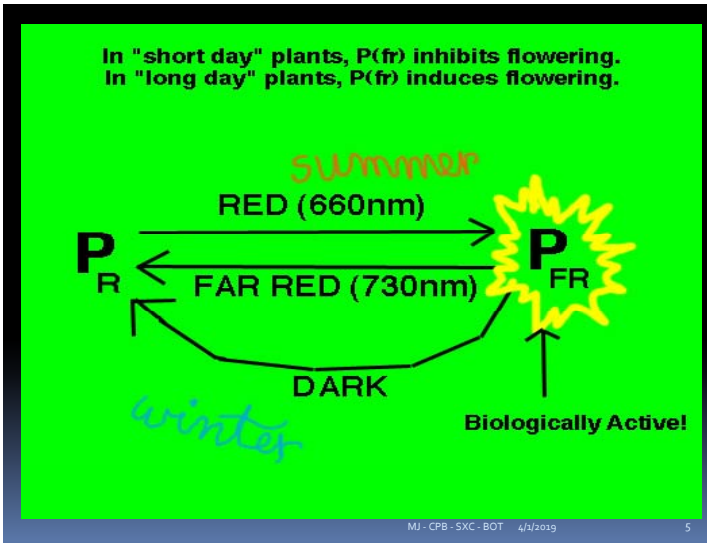


Phytochrome

- blue protein pigment - 125 kDa
- until 1959 - unique chemical species - technical difficulties in isolating and purifying the protein
- red light–induced morphogenic responses - seed germination *(650–680 nm)* - morphogenesis -reversed by a subsequent irradiation with light of longer wavelengths 710–740 nm- *far-red light*
- relation to stem and leaf growth -floral induction
- germination of lettuce seeds - stimulated by red light and inhibited by far-red light.
- a red light–absorbing pigment and a far-red light–absorbing pigment - act antagonistically in the regulation of seed germination

Phytochrome Can Interconvert between Pr and Pfr Forms

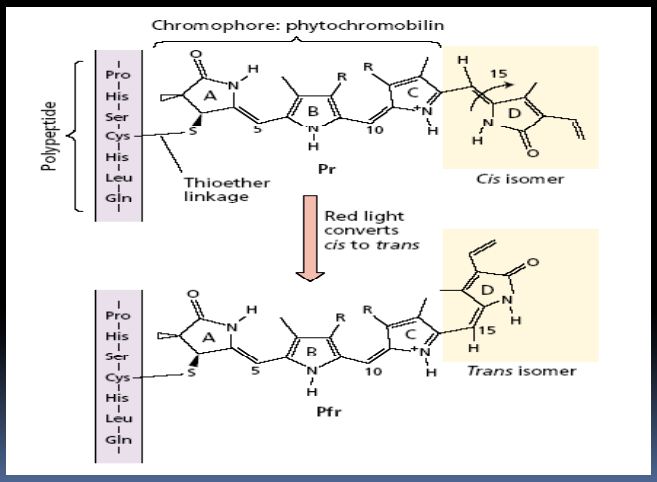
- Dark-grown or etiolated plants, phytochrome – present in a red light–absorbing form- **Pr – B/E – Synthesis – Blue (Human Eyes) -** converted by red light to a far-red light–absorbing form – **Pfr - blue-green.**
- **Photoreversibility -** distinctive property of phytochrome
- **Photostationary state –** Equilibrium



Pfr - Physiologically Active Form of Phytochrome

- phytochrome responses - induced by red light
- Native phytochrome - soluble protein with a molecular mass of about 250 kDa.
- Phytochrome - dimer made up of two equivalent subunits
- Each subunit consists of two components:
- a light-absorbing pigment molecule - **chromophore**
- polypeptide chain - the **apoprotein**
- apoprotein monomer -molecular mass of about 125 kDa
- the apoprotein and its chromophore make up the **holoprotein**

- In higher plants the chromophore of phytochrome - linear tetrapyrrole –**phytochromobilin**
- Only one chromophore per monomer of apoprotein-attached to the protein through a thioether linkage to a cysteine residue
- Pr form of phytochrome - electron microscopy and X-ray scattering
- The polypeptide folds into two major domains - "hinge" region.
- The larger N-terminal domain - approximately 70 kDa and bears the chromophore
- Smaller C-terminal domain – approximately 55 kDa and contains the site where the two monomers associate with each other to form the dimer



Phytochromobilin

- **Synthesized in Plastids**
- phytochrome apoprotein alone cannot absorb red or far-red light
- Light - absorbed only when the polypeptide -covalently linked with phytochromobilin to form the holoprotein
- derived from 5-aminolevulinic acid via a pathway - branches - chlorophyll biosynthetic
- Leak out of the plastid into the cytosol by a passive process
- Assembly of the phytochrome apoprotein with its chromophore – **autocatalytic**
  - purified phytochrome polypeptide - mixed with purified chromophore

- **Both Chromophore and Protein Undergo Conformational Changes**
  - the chromophore absorbs the light, conformational changes in the protein - initiated by changes in the chromophore
- the Pr chromophore undergoes a *cis–trans isomerization of the double bond* between carbons 15 and 16 and rotation of the C14–C15 single bond
- During the conversion of Pr to Pfr, the protein moiety of the phytochrome holoprotein - undergoes a subtle conformational change
- Type I and Type II phytochromes
- Type I – 9 times more abundant than Type II in dark-grown pea seedlings;
- In light-grown pea seedlings - amounts of the two types - about equal
- *PHY, -PHYA, PHYB, PHYC, PHYD, and PHYE.*

Phytochrome Responses

- Rapid biochemical events
- Slower morphological changes, including movements and growth

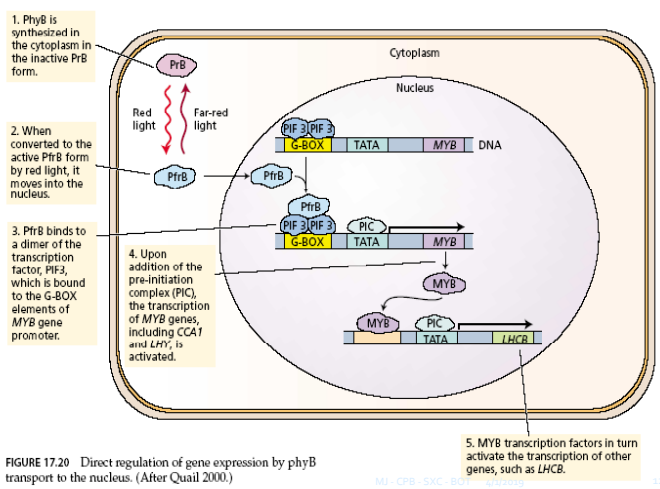
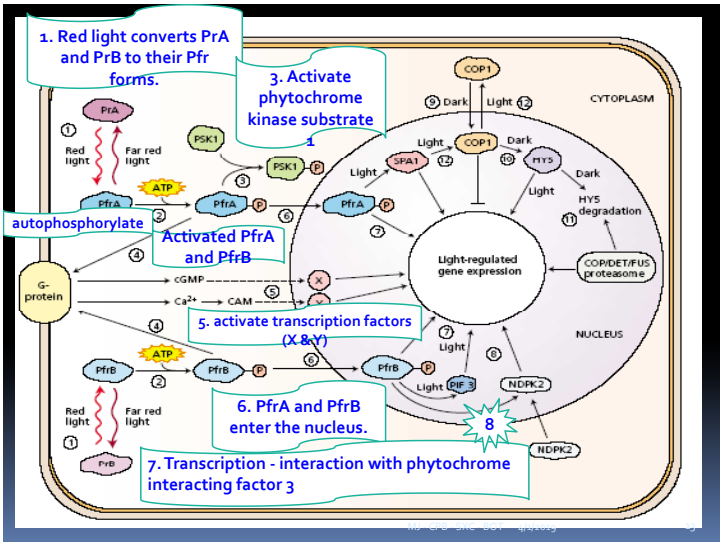
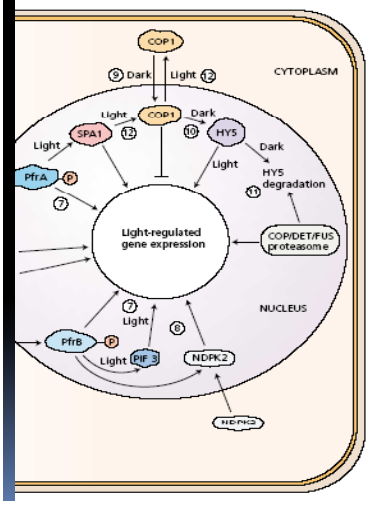


FIGURE 17.20 Direct regulation of gene expression by phyB transport to the nucleus. (After Quail 2000.)





- In the dark, COP1 enters the nucleus and suppresses light-regulated genes.
- In the dark, COP1, an E3 ligase, ubiquitinates HY5.
- In the dark, HY5 - degraded with the assistance of the COP/DET/FUS proteasome complex.
- In the light, COP1 interacts directly with SPA1 - exported to the cytoplasm.

cryptochrome

- hy4 protein-**cryptochrome**
- **1 (cry1), - a blue-light photoreceptor** mediating the inhibition of stem elongation.
- Photolyases -pigment proteins that contain a flavin adenine dinucleotide and a pterin.
- **Pterins - light-absorbing, pteridine derivatives -** function as pigments in insects, fishes, and birds

Phototropins

- **Involved in Phototropism and Chloroplast Movements**
- *nph1* ((*nonphototropic Hypocotyl) gene - renamed phot1* - protein it encodes - **phototropin**
- lacks a phototropic response in the hypocotyl
- normal blue light–stimulated inhibition of hypocotyl elongation