

**Lecture 6: Phytochromes – Part II**  
**Ecological functions and Signal transduction**

Ecological significance of the R:FR ratio  
 Shade avoidance response

Subcellular localization of phytochrome

Phytochrome signal transduction  
 COP1  
 PIF3

Phytochrome functional domains

Factors known to be involved in phytochrome signaling

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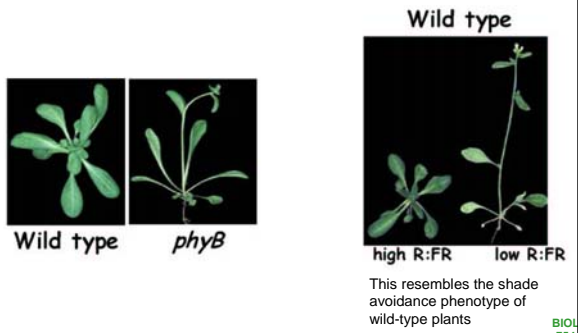
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**Light-grown *phyB* mutants are elongated and early flowering**



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**Phytochrome enables plants to adapt to changing light conditions**

**The R:FR ratio**

Presence of a red/far-red reversible pigment and the wavelengths of light provide plants information to adjust to the environment.

R:FR ratio varies in different environments!  $\frac{R}{FR} = \frac{\text{Photon fluence rate in 10 nm band centered on 660 nm}}{\text{Photon fluence rate in 10 nm band centered on 730 nm}}$

**Ecologically important light parameters**

	Photon flux density ( $\mu\text{mol m}^{-2} \text{s}^{-1}$ )	R/FR <sup>2</sup>
Daylight	1900	1.19
Sunset	26.5	0.96
Moonlight	0.005	0.94
Ivy canopy	17.7	0.13
Soil, at a depth of 5 mm	8.6	0.88

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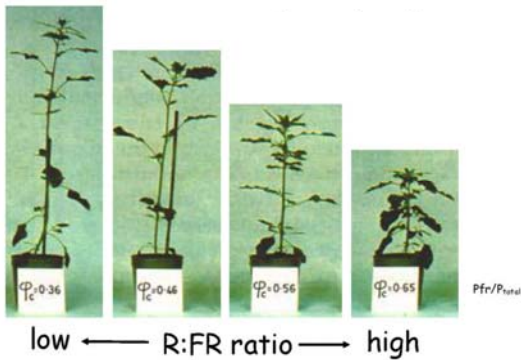
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**Red-light inhibition of stem elongation rate of light-grown pigweed (*Chenopodium album*)**



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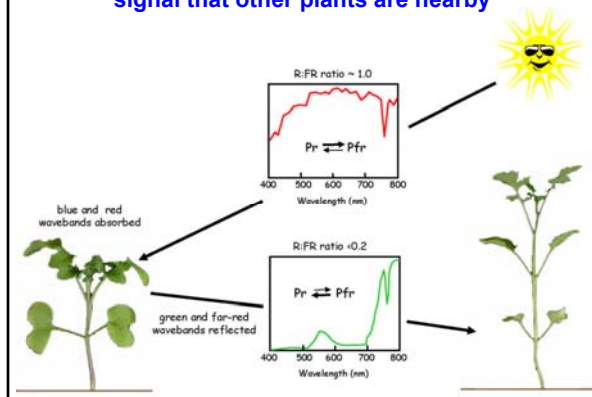
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**The reduced R:FR ratio of light acts as a signal that other plants are nearby**




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**Shade Avoidance Response**

Plants that increase stem extension in response to shading  
→ shade avoidance response ("sun plants")

**Rapid responses**

- Leaf hyponasty
- Increased internode extension
- Increased petiole extension

**Longer term responses**

- Reduced branching
- Reduced leaf area
- Reduced leaf thickness\*
- Reduced chlorophyll synthesis
- Accelerated flowering



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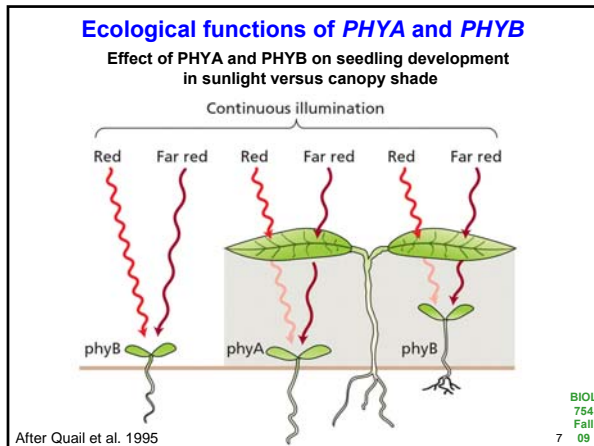
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### How does phytochrome mediate responses on the molecular level?

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### Phytochrome moves to the nucleus

- Phytochrome moves to the nucleus in a light-dependent manner.
- Movement detected by fusing phytochrome to green fluorescent protein (GFP).

PHYA:GFP PHYB:GFP

Nucleus Speckles

Continuous far-red light White light

- Can move in Pr or Pfr form
- fast transport (~ 15 min)
- maximal transport under continuous FR light (HIR)
- Moves only in Pfr form
- Slow transport (several hours)
- Requires R for transport; inhibited by FR
- Under circadian control

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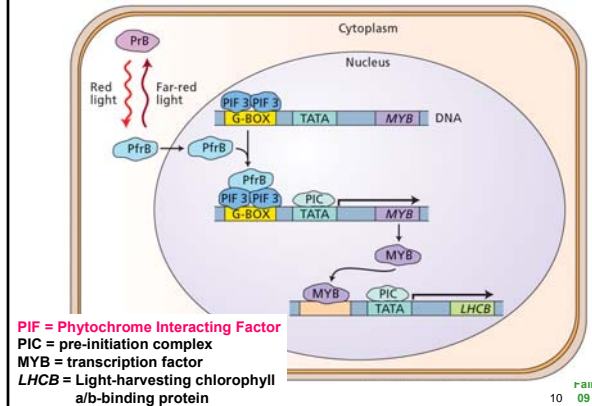
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### What happens when PHYA/B move into nucleus?




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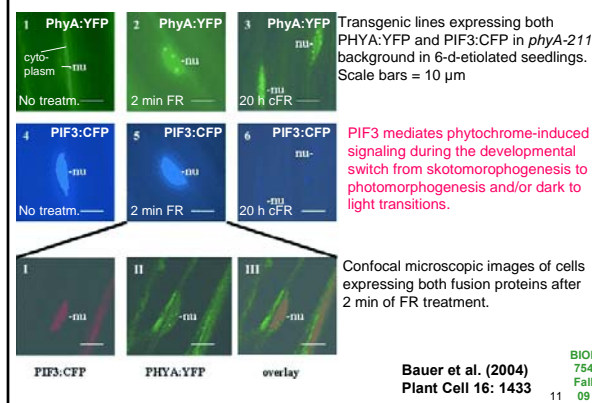
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### PIF3 co-localizes with PHYA in the nucleus




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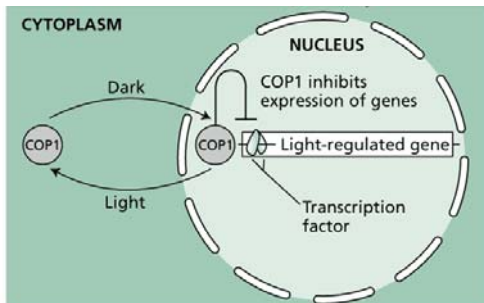
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### Genes that suppress photomorphogenesis

Mutants that block response to darkness (*skotomorphogenesis*):  
*cop* = constitutive photomorphogenesis  
*det* = de-etiolated




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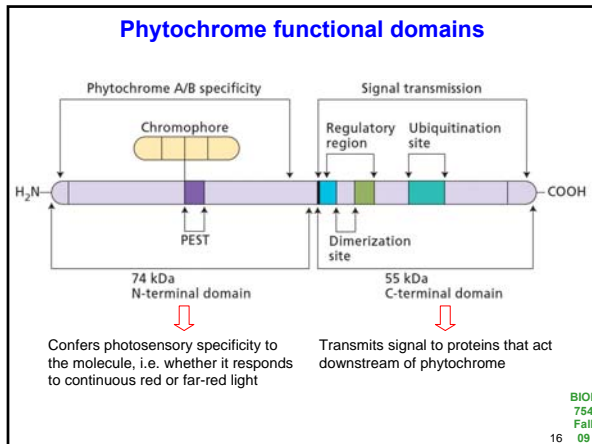
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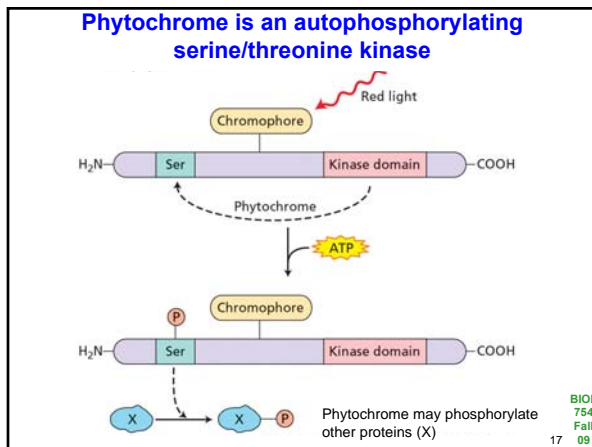
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### Phytochrome - Summary

Mediates the plants' response to light → photomorphogenesis  
R exerts the strongest effect, which is reversed by FR

Exists in red-light absorbing Pr form and far-red light absorbing Pfr form

Synthesized in the Pr form

Pfr considered to be the physiologically active form

Encoded by gene family: PHYA, B, C, D, E

PHYA and PHYB move into the nucleus

Regulate transcription of genes involved in greening, e.g. small subunit of RUBISCO, LHCB (mediated by PHYA and B)

VLFR, LFR, HIR

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## Physiological functions of phytochromes

### Phytochrome A (phyA)

Mediates VLFR (e.g. seed germination, gene expression etc)  
Mediates HIR (e.g. inhibition of elongation growth, gene expression etc)  
DOES NOT mediate LFR

### Phytochrome B (phyB)

Mediates LFR (e.g. seed germination, gene expression, inhibition of elongation etc)  
Mediates responses to R:FR ratio  
DOES NOT mediate VLFR or HIR

### Phytochromes D and E (phyD and phyE)

Act redundantly with phyB

### Phytochrome C (phyC)

Weak red light sensor and may modulate phyB action in control of hypocotyl elongation

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