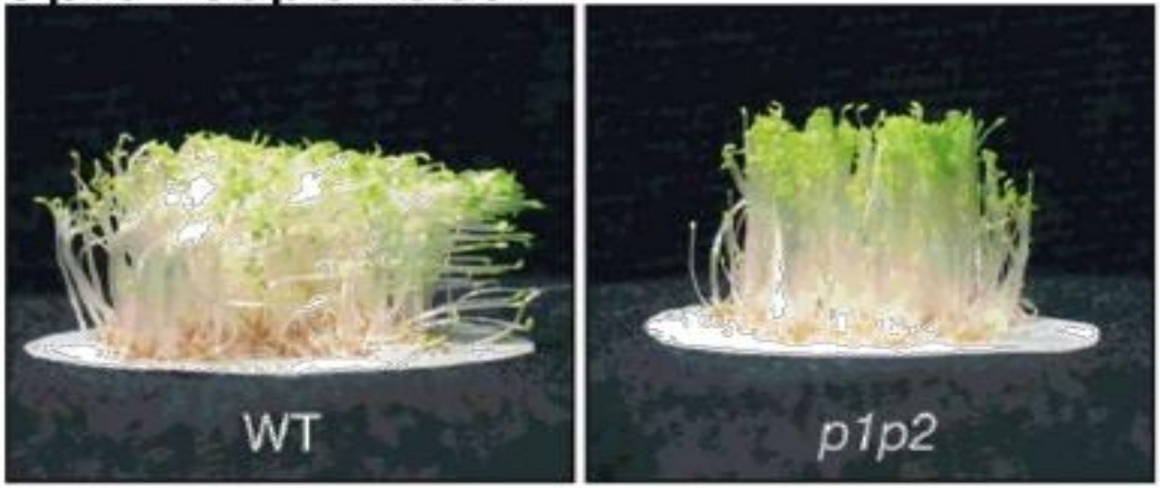
Plant Developmental Biology

PHOTOTROPINS

Main phototropins - ***PHOT1* and *PHOT2***

- *phot1* single mutent - no response in low light.
- *phot2* single mutant - as wild type.
- *phot1 phot2* double mutants do not show any phototropic responses.



← LIGHT

Phototropic response of wild-type *Arabidopsis* seedlings (WT) and a phototropin-deficient mutant (*p1p2*) irradiated with blue light from the right.

- The amounts of *PHOT1* and *PHOT2* present depend on the *age of the plant* and the *intensity of the light.*

- AT HIGH LIGHT INTENSITY

  -downregulation of *PHOT1* transcript

  -upregulation of PHOT2 transcript

- Phototropin expression levels change with the maturation of the leaves (chloroplast rearrangement) – maximise photosynthesis efficiency.

BLUE LIGHT PHOTORECEPTORS

1. PHOTOTROPINS : *phot1* and *phot2*

- **SERVE AS THE BLUE LIGHT PHOTORECEPTORS FOR PHOTOTROPISM, CHLOROPLAST MOVEMEMNTS, AND STOMATAL OPENING**
- **MUTANTS LACK BLUE LIGHT DEPENDENT PHOTOTROPISM, CHLOROPLAST MOVEMENTS, AND STOMATAL OPENING**
- **PHOTOTROPINS ARE FLAVOPROTEINS WITH SER/THR PROTEIN KINASES THAT AUTOPHOSPHORYLATE IN RESPONSE TO BLUE LIGHT**

Phototropins and stomatal opening

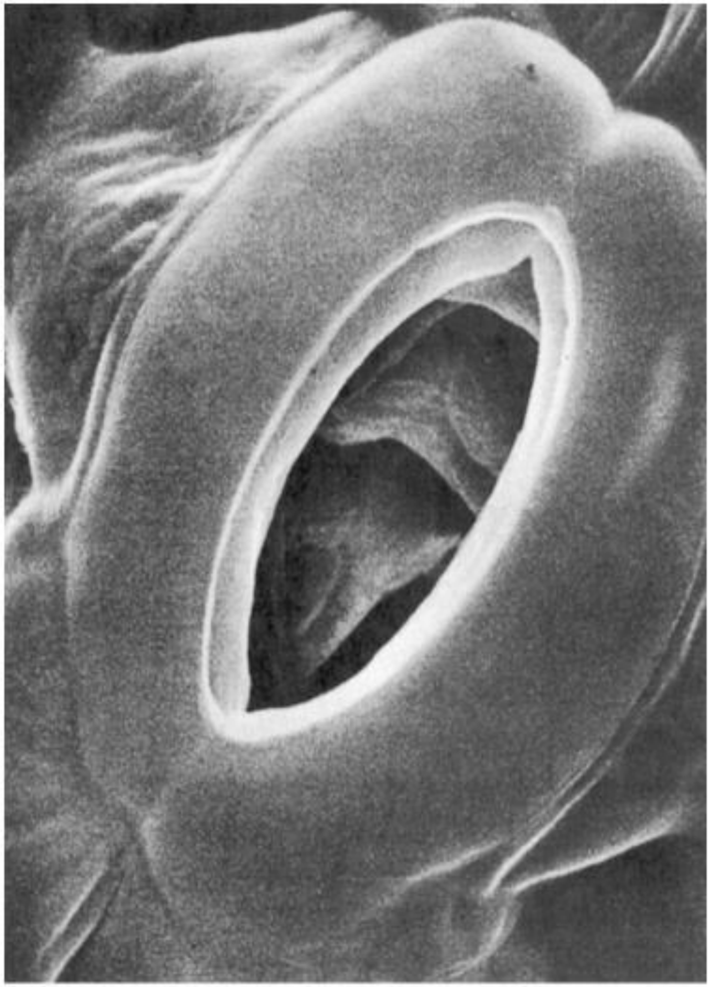


Fig. 11-9b, p. 170

Light affects the opening of stomata. In dim or no light, the stomata are closed; as the light intensity increases, the stomata open up to some maximum value.

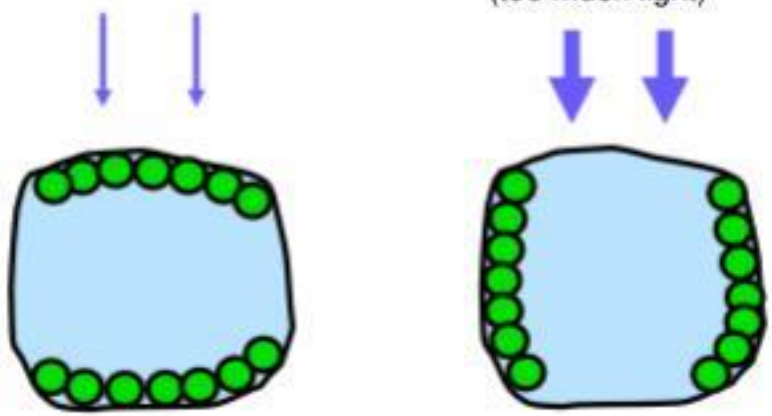
The blue part of the light spectrum is responsible for this response.

Blue light is perceived by phototropins that then promote the increase in solute concentration of guard cells starting with the conversion of starch into malic acid (see lectures on absorption and transportation) .

Blue light regulates chloroplast movement in leaf mesophyll cells

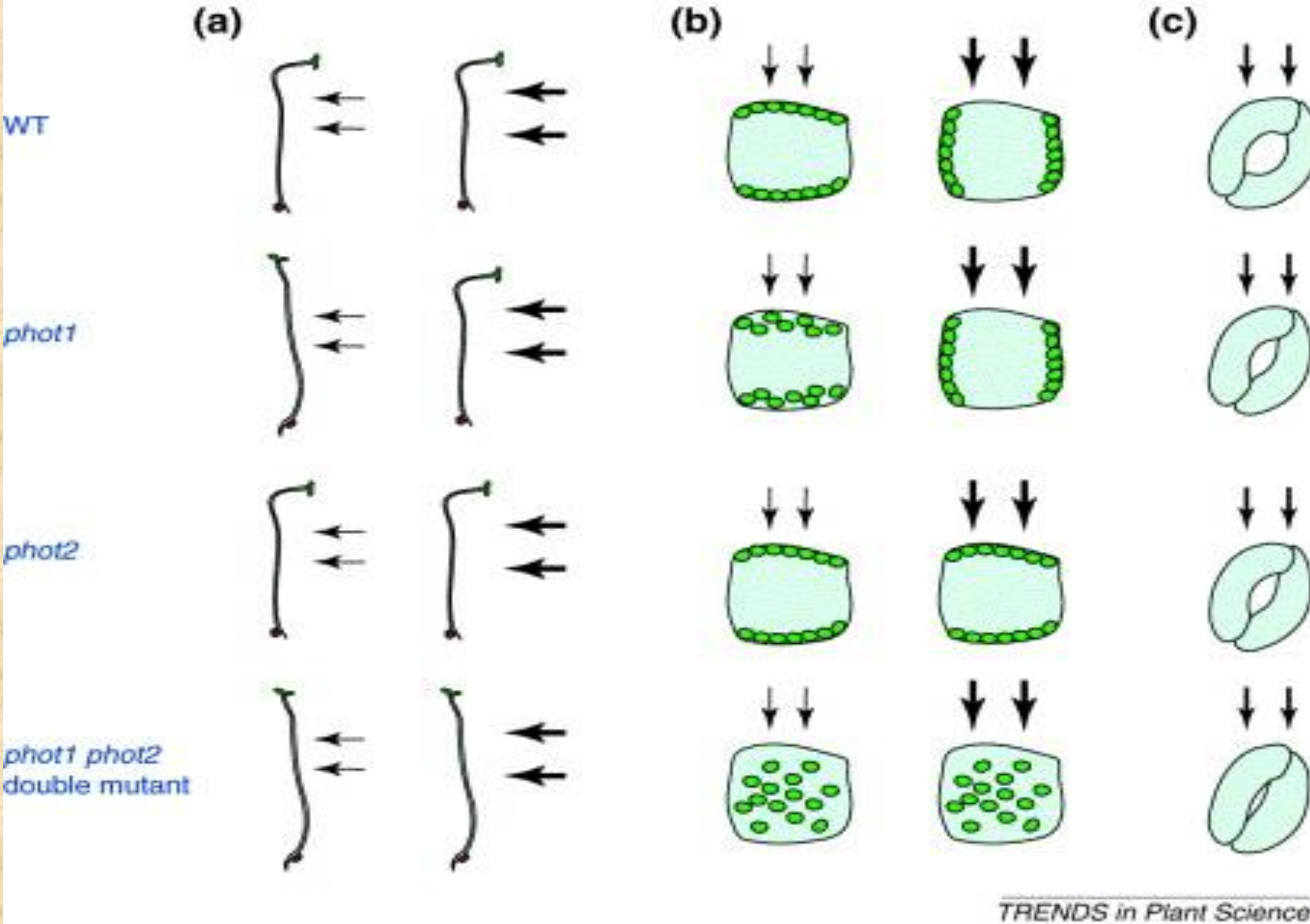
Low irradiance

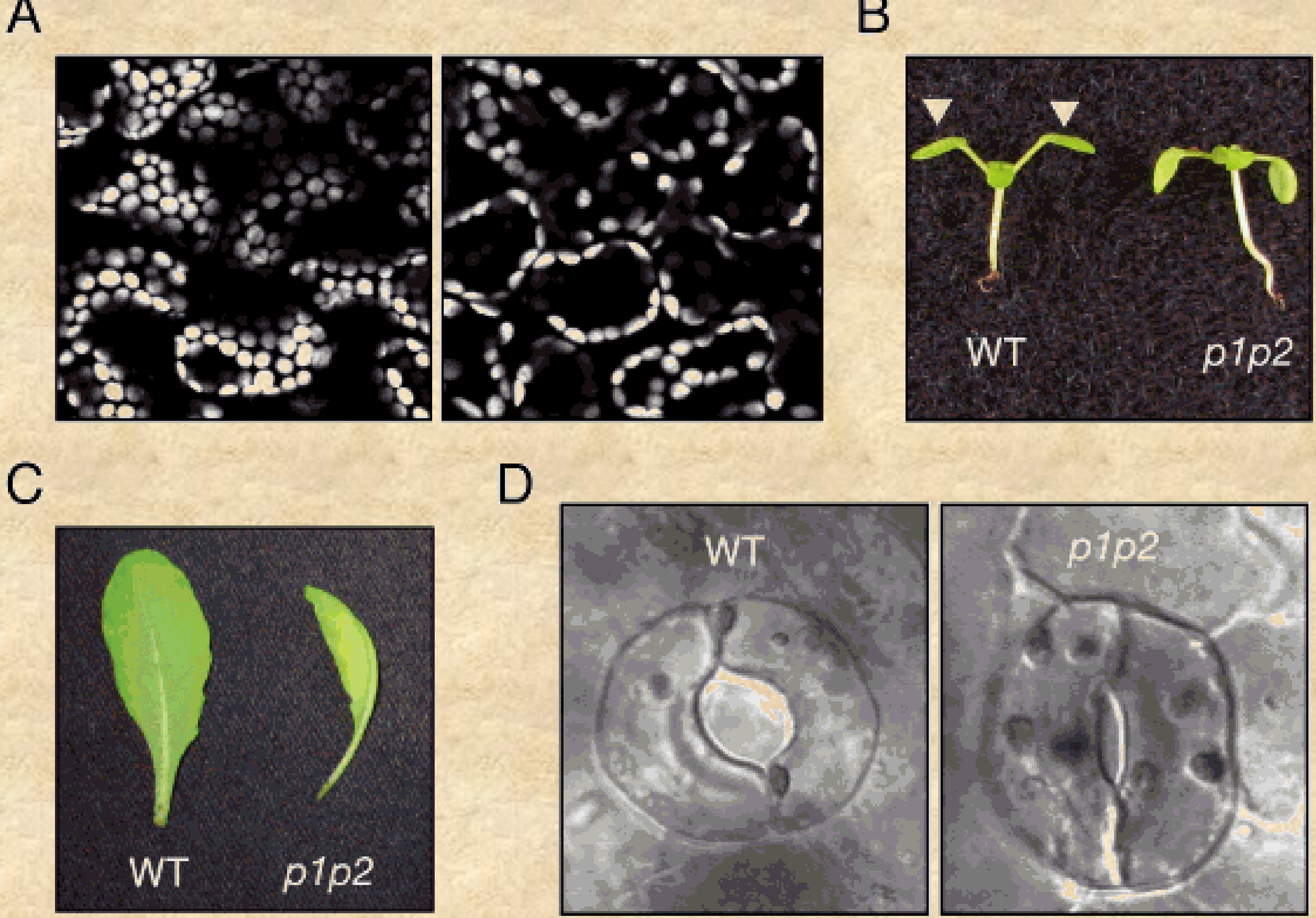
High irradiance (more energy reaches the leaf) (too much light)



Chloroplasts move towards the source of light (too maximalize light harvest)

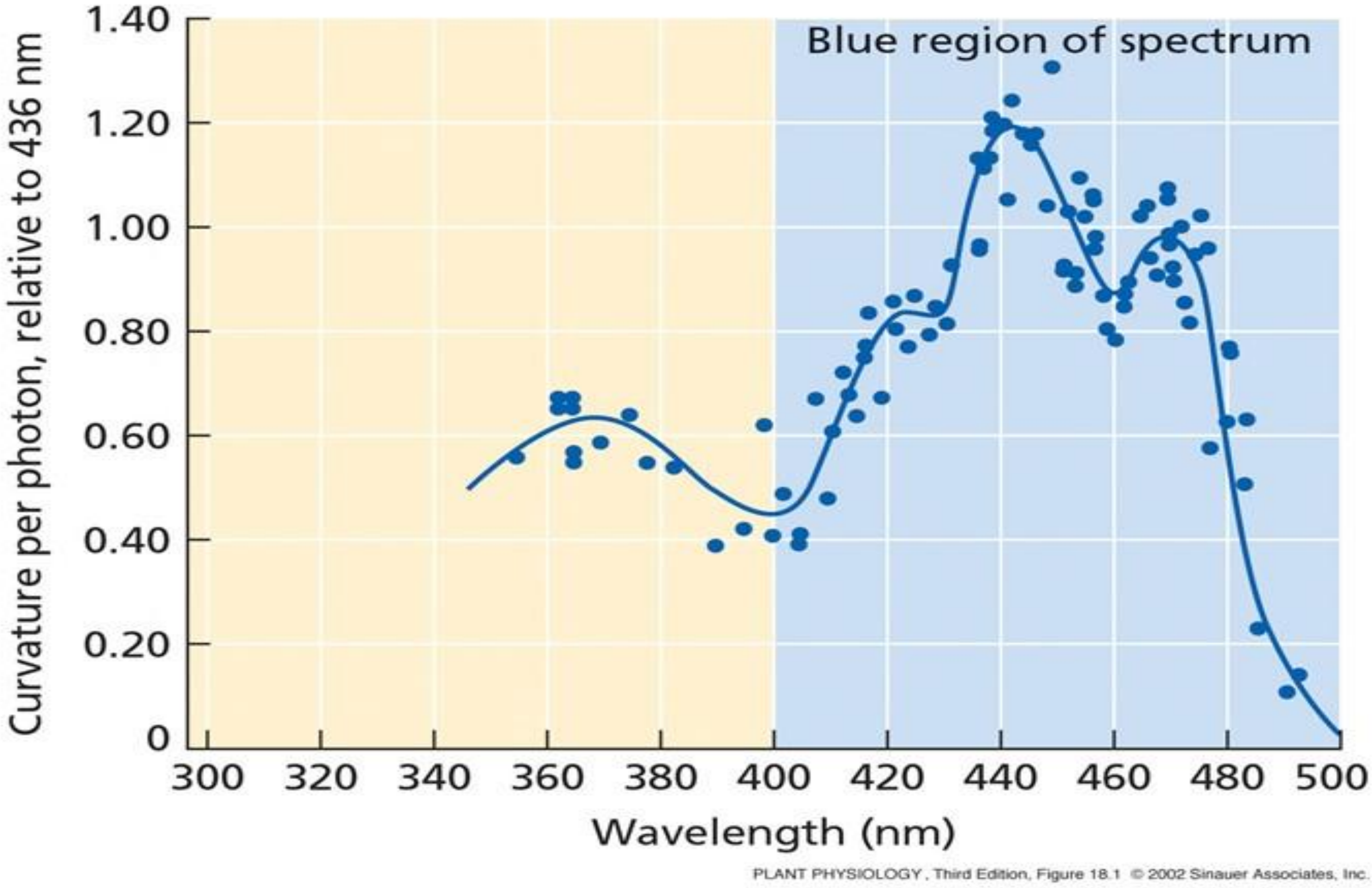
Chloroplasts move away from the source of light (to minimize damage by the excess light energy).


(a)
(b)
(c)
WT
phot1
phot2
phot1 phot2
double mutant
TRENDS in Plant Science


A
B
WT
p1p2
C
WT
p1p2
D
WT
p1p2

Phototropins and Blue Light Sensing

Light is one of the most important environmental cues controlling plant development, and is achieved through a suite of photoreceptor proteins. Like photoreceptors associated with our vision, plant photosensors can detect the presence, intensity, direction and color of light, and in turn, utilize this information to direct their growth. A small family of proteins known as the phototropins, which are activated specifically by UV/blue wavelengths of light. The photoactivation of these proteins stimulates a range of processes that ultimately optimize the photosynthetic efficiency of plants, including phototropism, after which they were named. For instance, phototropins direct the movement of chloroplasts (Greek for "green maker"), which represent the heart of the photosynthetic machinery as their position within the cell can greatly affect the efficiency of energy production. Likewise, chloroplasts reside in leaves, which can be viewed simply as solar panels. Leaf positioning and expansion is also directed by the phototropins . Additionally, phototropins control the opening of stomata (Greek for "mouths") pores in the leaf epidermis, which regulate gaseous exchange (Figure D). Stomatal opening is important for energy production, as it allows CO2 uptake for photosynthesis. Collectively, these responses serve to enhance the photosynthetic performance of plants and maximize their growth potential. Many plant species are able to track the movement of the sun by a process known as heliotropism (Greek for "towards sun"). This photomovement response is also likely mediated by phototropins.



Action spectrum of Avena Coleoptile curvature, a 3 peak or 3 fingure Denotation. Original recording of Thimann and Curry, 1960

A sunfleck in a patch of *Oxalis oregana*. A gap in the shade exposes this forest floor herb to full sunlight. The fleck will move across the plants as the sun moves, causing the plants to experience two widely different light environments on a short time scale (minutes). Photograph courtesy of Dr. Olle Bjorkman.

The processes of photomorphogenesis integrate and respond to information about the light environment in parallel with the time scales of the changes described. The photosensory systems used in photomorphogenesis can couple the absorption of photons to visible responses within seconds, as in the case of phototropism in the fungus Phycomyces, or light signals can be integrated over days, as in most cases of photoperiodic induction of flowering.

Two different types of phototropism, first described by Charles and Francis Darwin (Darwin and Darwin, 1880), illustrate this distinction. The form the Darwins described as heliotropism, now conventionally thought of as phototropism, is a permanent differential growth towards light.