CONTROL OF GROWTH BY LIGHT
Overview: light controls plant growth in several ways.

**Photosynthesis**: provides energy for growth (red, blue wavelengths most effective)

**Phototropism**: guides direction of growth through auxin distribution (blue wavelengths most effective)

**Photomorphogenesis**: guides differentiation, morphogenesis, organogenesis (red, blue, ultraviolet wavelengths most effective, depending on response)

Differences in effective wavelength imply differences in receptor
An example of photomorphogenesis:

*De-etiolation*: compare bean seedlings grown in dark and light

Light: De-etiolated

No light: etiolated
Dark: hook closed

1 min red light: hook opens

1 min red, 5 min far-red: hook stays closed

1 min red, wait until hook opens; 5 min far-red, hook stays open, showing that far-red does not close the hook, just counteracts red signal

1 min red, 5 min far-red, 1 min red: hook opens, showing that the last signal is the effective one

Red, far-red reversibility suggests a unique receptor
Phytochrome

The red light receptor "phytochrome" is a protein (with tetrapyrrole pigment) with characteristics that explain the red, far-red response

Phytochrome has two forms: one (Pr) absorbs red light (and is transformed to the other form when it does); the other (Pfr) absorbs far-red light (and is transformed when it does)

In the dark, only the Pr form is made; in the (red) light, the Pfr form is created; the Pfr form is the active one
Other effects associated with phytochrome

Seed germination (stimulated, or inhibited)
Branching, tillering (grass branching)
Flowering (induction)
Senescence (induction)
Dormancy (induction, breaking)

There are several types of phytochrome, defined by several different genes; one is involved in de-etiolation; others involved in some of the responses listed above
Ecological effects of the red, far-red sensor

1) Light sensor

Pr is very sensitive to light
Seeds, seedlings detect very small amounts of Pfr
No Pfr synthesized without light
Thus, seeds, seedlings detect very small amounts of light
This allows them to determine how close they are to the surface of the soil

Some seeds germinate in light (or germinate and grow rapidly until they detect light) to start photosynthesis quickly; some seeds germinate in dark to assure themselves cover, better moisture supply
2) Color sensor

Ratio of Pr/Pfr depends on the ratio of far-red/red light
Ratio of far-red/red light depends on cover:

- sky: far-red/red ≈ 1
- under plant canopy: far-red/red > 1

Adult plants measure Pr/Pfr to limit branching, shoot
growth (less growth in low far-red/red light)

Phytochrome reactions serve to focus growth toward
maximizing photosynthesis
3) Seasonal sensor

Some plants time flowering to season:

“long-day plants” flower in winter, spring (days getting longer)

“short-day plants” flower in summer, fall (days getting shorter)

*Chrysanthemum* flowers in short days, long nights
Flowering is triggered by length of night; and phytochrome has a role in the timing/sensing mechanism.

This plant is called a “short-day” or “long-night” plant, because it flowers when the nights are long.
But it isn’t really that the nights are long—it is that they match the timing by an internal clock...

Plants have a “biological clock”, just as do people, insects, and fungi
Summary

Light controls many aspects of plant development: for instance, germination, growth rate, flowering

Phytochrome is one pigment-protein whose activity is influenced by light

A biological clock interacts with phytochrome to trigger flowering in seasonal plants