GENETIC FACTORS AFFECTING GROWTH AND DEVELOPMENT

- DNA directs growth and differentiation
  - Enzymes catalyze biochemical reactions
- Structural genes
  - Genes involved in protein synthesis
- Operator genes
  - Regulate structural genes
- Regulatory genes
  - Regulate operator genes

GENETIC FACTORS AFFECTING GROWTH AND DEVELOPMENT

- What signals trigger these genes?
  - Believed to include:
    - Growth regulators
    - Inorganic ions
    - Coenzymes
    - Environmental factors; e.g. temperature, light
    - Therefore . . .
      - Genetics directs the final form and size of the plant as altered by the environment

ENVIRONMENTAL FACTORS INFLUENCING PLANT GROWTH

- Light
- Temperature
- Water
- Gases

Signal transduction pathways link signal reception to response

- All organisms received specific signals/respond to them in ways that enhance survival/reproductive success
- Plants have cellular receptors that detect changes in their environment (molecule affected by stimulus)
  - *For stimulus to elicit response, certain cells must have appropriate receptor*
  - *Stimulation of receptor initiates specific signal transduction pathway*

(a) Before exposure to light

Tall, spindly stem/nonexpanded leaves (morphological adaptations called etiolation enable shoots to penetrate soil, including short roots due to little need for water absorption from little water loss by shoots)

Expanded leaves hindrance as shoots push through soil/chlorophyll waste of energy (underground)

(b) After a week's exposure to natural daylight

Begins to resemble typical plant w/broad green leaves, short sturdy stems, long roots (transformation begins w/reception of light by specific pigment, phytochrome) by undergoing changes (de-etiolation) by reception of signal (light) which is transduced into responses (greening)

ENVIRONMENTAL FACTORS INFLUENCING PLANT GROWTH

- Light
  - Intensity
  - Quality
  - Duration

ENVIRONMENTAL FACTORS INFLUENCING PLANT GROWTH

- Light (cont)

  narrow band affects plant photoreaction processes

  PAR (Photosynthetically Active Radiation)

  400-700nm

  stomates regulated by red (660nm), blue (440nm)

  - **photomorphogenesis** – shape determined by light
    - controlled by pigment **phytochrome**
    - phytochrome absorbs red (660nm) and far-red (730nm) but not at same time

ENVIRONMENTAL FACTORS INFLUENCING PLANT GROWTH

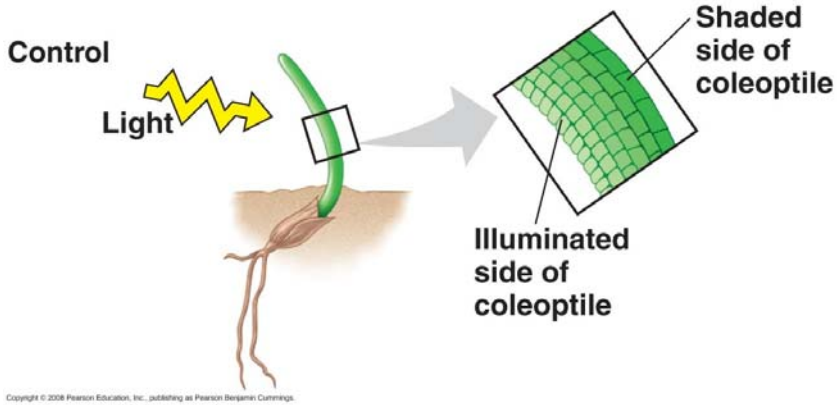
- Light (cont)
  - importance of phytochrome in plant responses
    - plants detect ratio of red:far-red light
    - red light – full sun
      - yields sturdy, branched, compact, dark green plants
    - far-red light – crowded, shaded fields/greenhouses
      - plants tall, spindly, weak, few branches; leaves light green

ENVIRONMENTAL FACTORS INFLUENCING PLANT GROWTH

- Light (cont)
  - **Phototropism** – movement toward light
    - hormone auxin accumulates on shaded side
    - cell growth from auxin effect bends plant
    - blue light most active in process
    - pigment uncertain

- ***Tropism**: any response resulting in curvature of organs toward or away from stimulus (often caused by hormones)*
  - Shoot of sprouting grass (enclosed in coleoptile) grows straight upward if seedling kept in dark/illuminated for all sides uniformly
  - *If illuminated form one side, grows toward light (results from differential growth of cells on opposite sides of coleoptile; cells on darker side elongate faster than those on brighter side)*
    - Postulated signal was transmitted from tip to elongating region

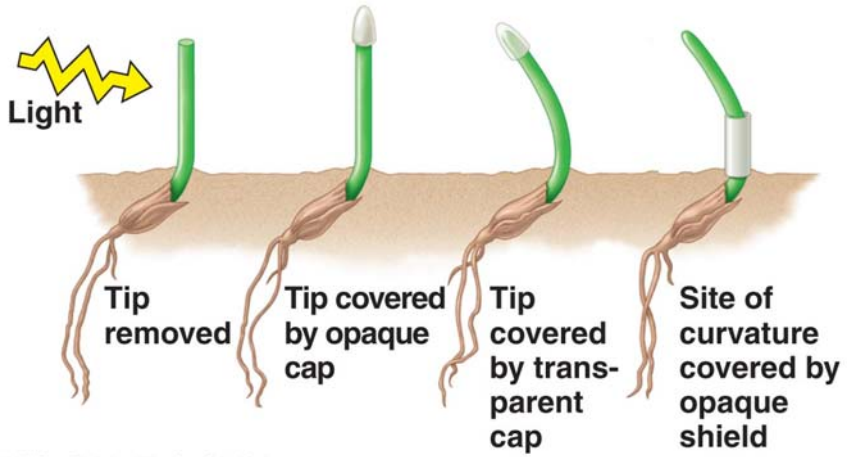
RESULTS



RESULTS

Darwin/Darwin: phototropic response only when tip is illuminated:

- **Only tip of coleoptile senses light**
- **Phototrophic bending occurred at distance from site of light perception (tip)**

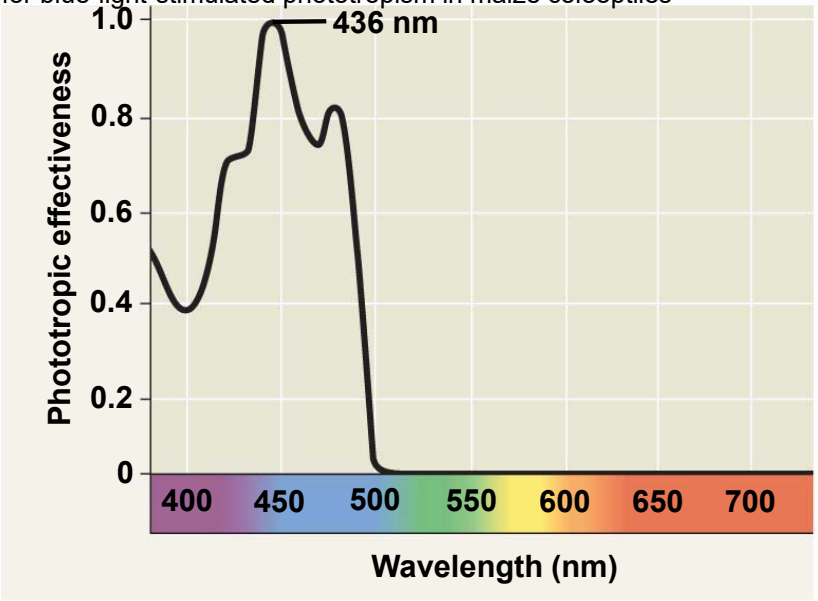


ENVIRONMENTAL FACTORS INFLUENCING PLANT GROWTH

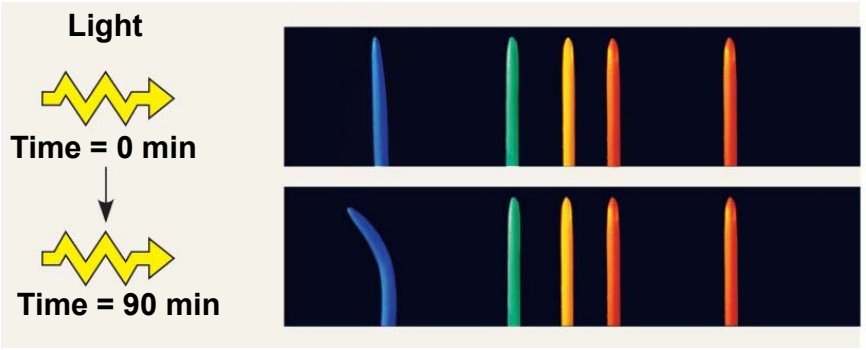
- Light (cont)
  - **Photoperiodism** – response to varying length of light and dark
    - shorter days (longer nights)
      - onset of dormancy
      - fall leaf color
      - flower initiation in strawberry, poinsettia, chrysanthemum
      - tubers/tuberous roots begin to form
    - longer days (shorter nights)
      - bulbs of onion begin to form
      - flower initiation in spinach, sugar beets, winter barley

- Plants detect not only presence of light but also direction, intensity, and wavelength (color)
  - Two peaks (red/blue light) for photosynthesis
  - Action spectra are useful in studying any process that depends on light (phototropism)
  - Two major classes of light receptors: **blue-light photoreceptors** and **phytochromes**

Fig. 39-16 Action spectrum for blue-light-stimulated phototropism in maize coleoptiles



(a) Action spectrum for blue-light phototropism



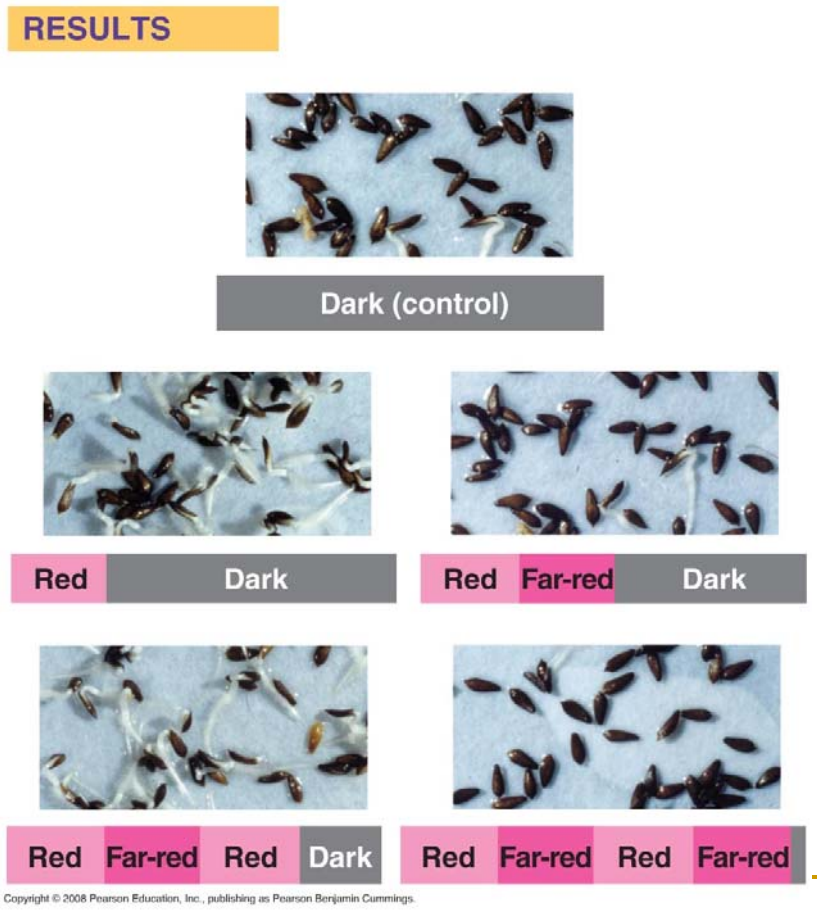
(b) Coleoptile response to light colors
Phototropic bending toward light controlled by phototropin (photoreceptor sensitive to blue/violet light, particularly blue light

Blue-Light Photoreceptors
Phytochromes as Photoreceptors

- Various blue-light photoreceptors control hypocotyl elongation, stomatal opening, and phototropism
- **Phytochromes** are pigments that regulate many of plant's responses to light throughout its life
  - These responses include seed germination and shade avoidance

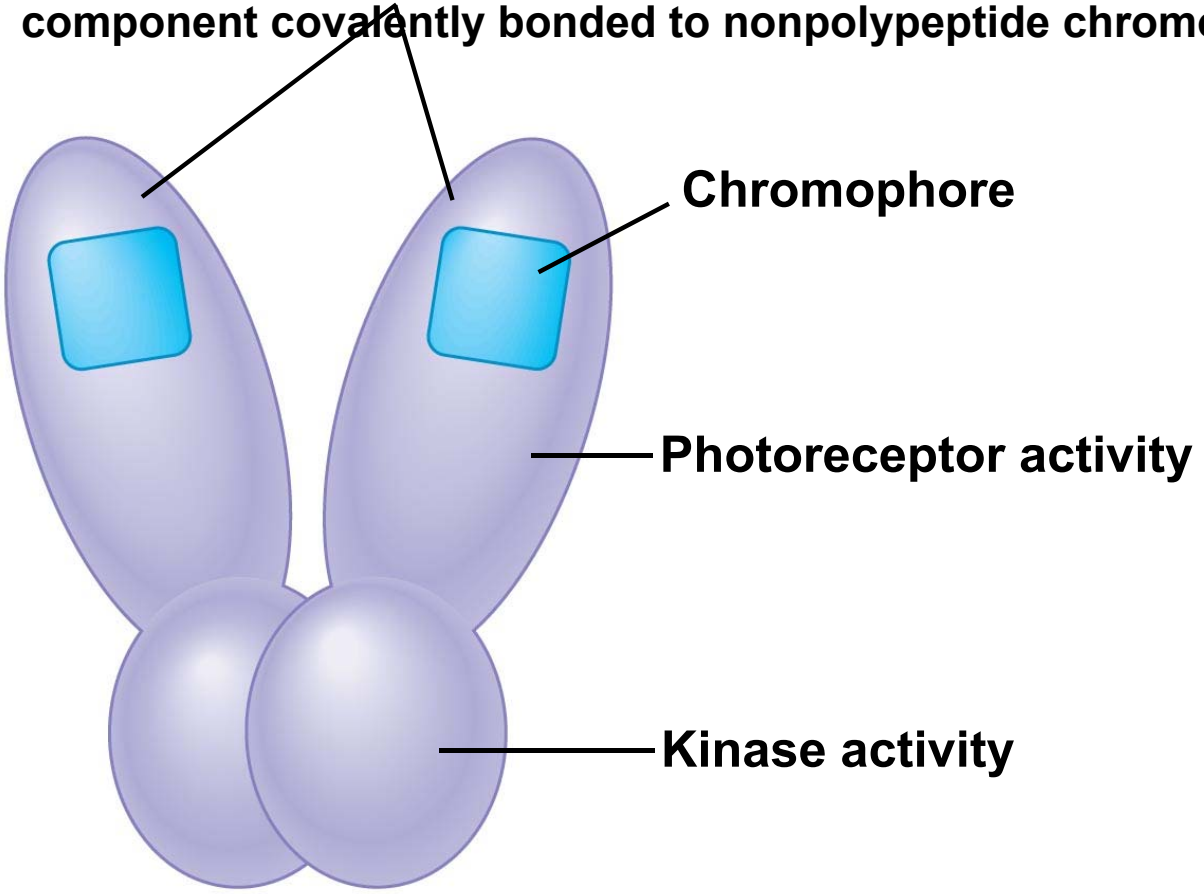
Phytochromes and Seed Germination

- Many seeds remain dormant until light conditions change
  - Red light increased germination, while far-red light inhibited germination
  - Final light exposure was determining factor
  - Effects of red/far-red light reversible

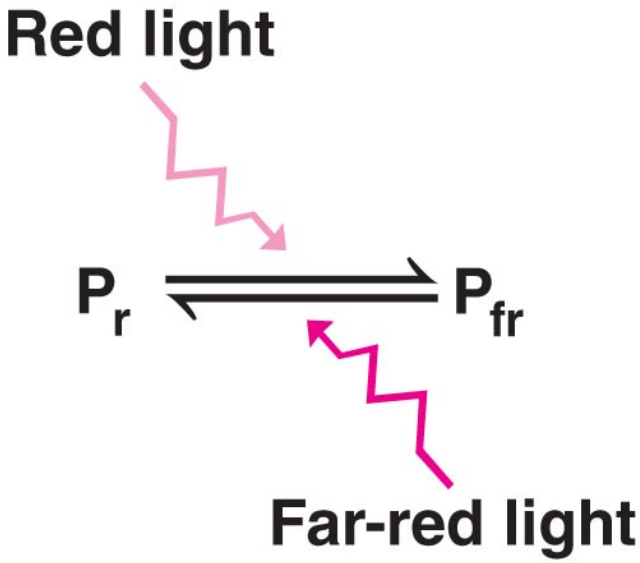


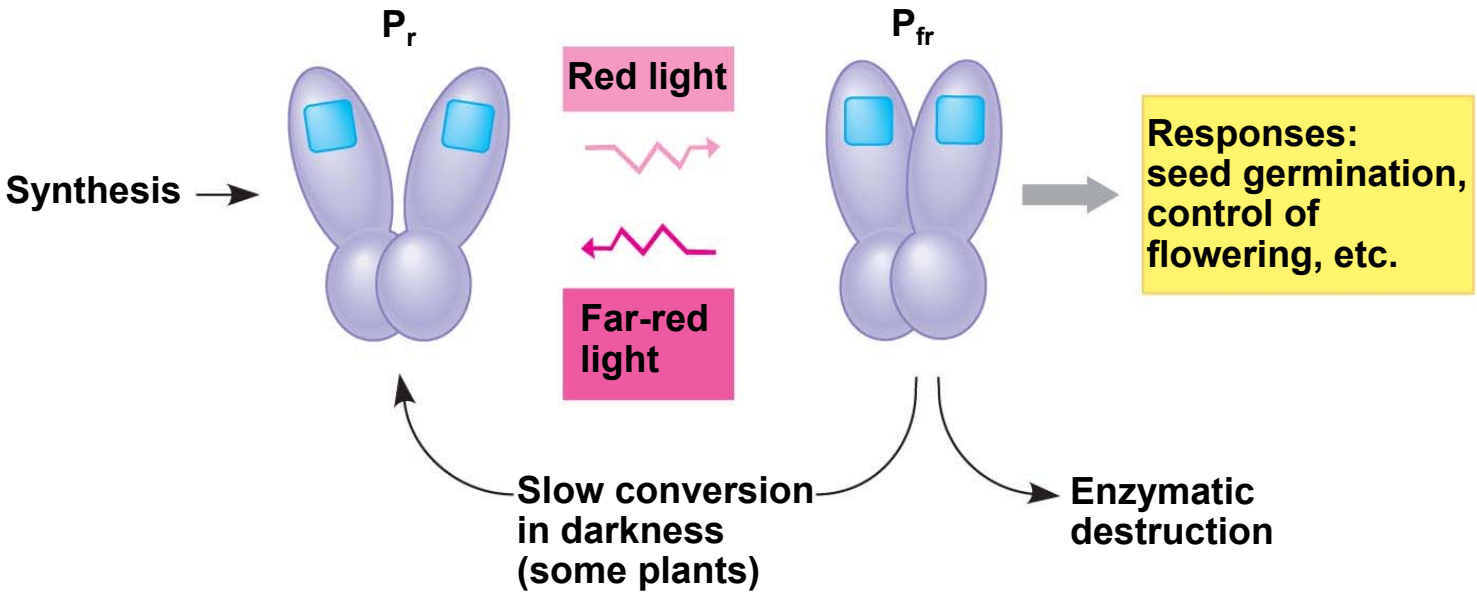
Photoreceptor responsible for opposing effects of red/far-red light are phytochromes

Two identical subunits, each consisting of polypeptide component covalently bonded to nonpolypeptide chromophore



- Phytochromes exist in two photoreversible states
  - Depend on color of light provided
  - Converts P_r (inhibits germination) to P_{fr}, which triggers many developmental responses (germination)
  - Though light contains both red and far red light, conversion to P_{fr} faster than conversion to P_r so ratio of P_{fr} to P_r increases in light, triggering germination





Phytochromes and Shade Avoidance

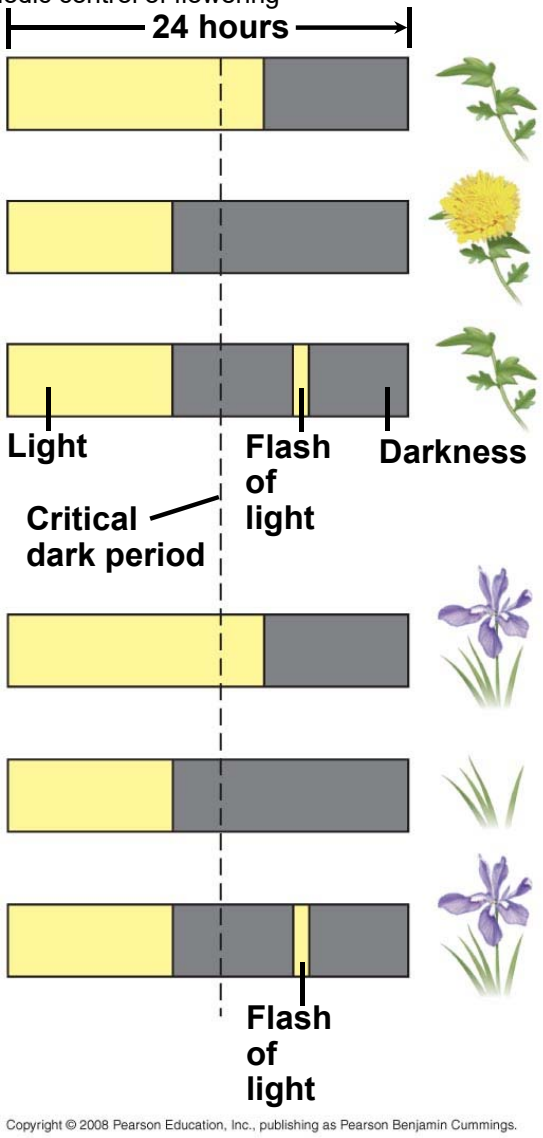
- During day, $P_r \rightleftarrows P_{fr}$ interconversion reaches dynamic equilibrium, with ratio of two phytochrome forms indicating relative amounts of red/far-red light

- Allows plants to adapt to changes in light conditions

  - Shaded plants receive more far-red than red light
    - In **"shade avoidance" response**, phytochrome ratio shifts in favor of P_r when tree is shaded, inducing tree to allocate more resources to growing taller

  - Direct sunlight stimulates branching/inhibits vertical growth

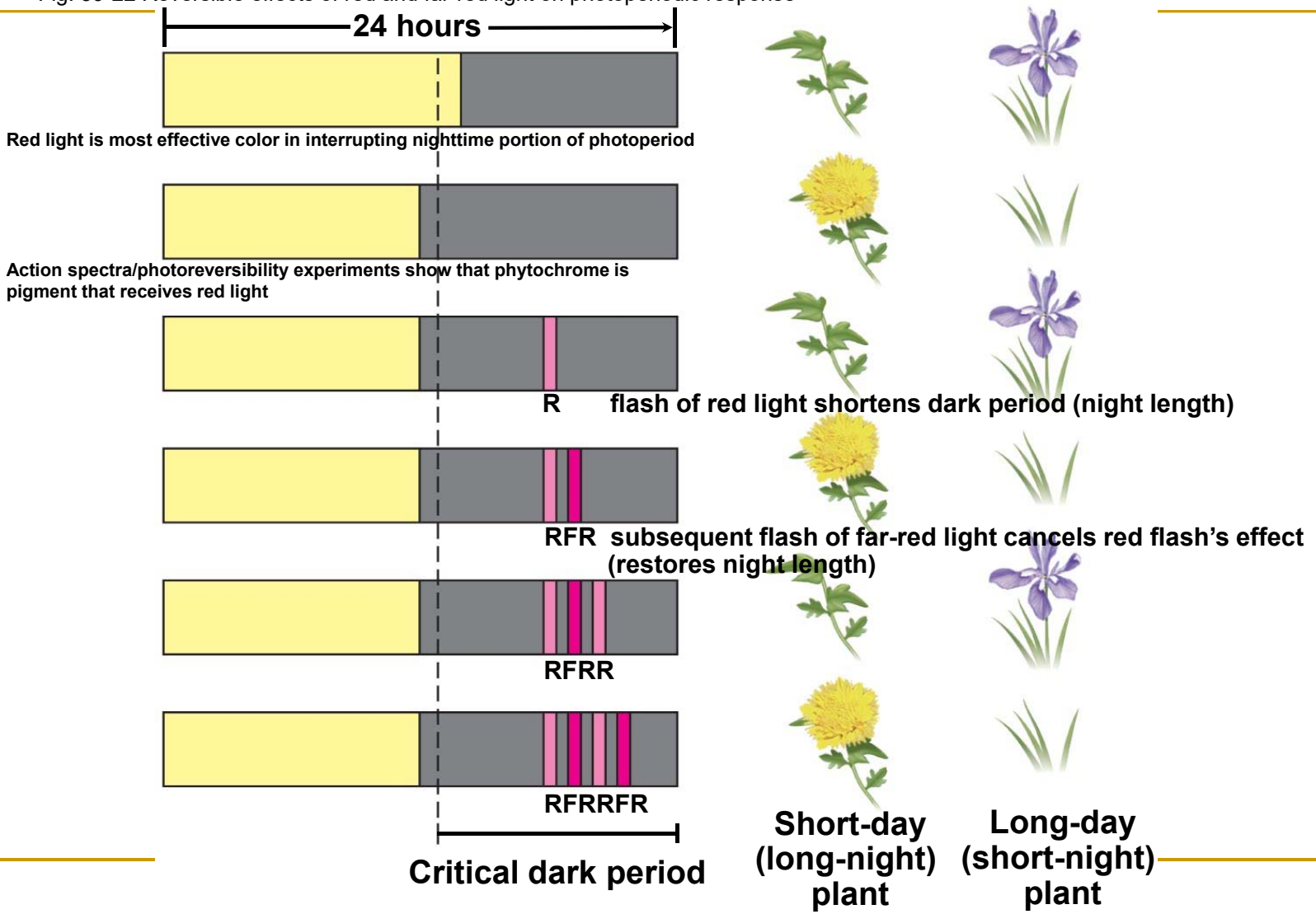
Fig. 39-21 Photoperiodic control of flowering



(a) Short-day (long-night) plant, P_{fr} inhibits flowering

(b) Long-day (short-night) plant, P_{fr} induces flowering

Fig. 39-22 Reversible effects of red and far-red light on photoperiodic response



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