Photoperiod and Photoperiodis

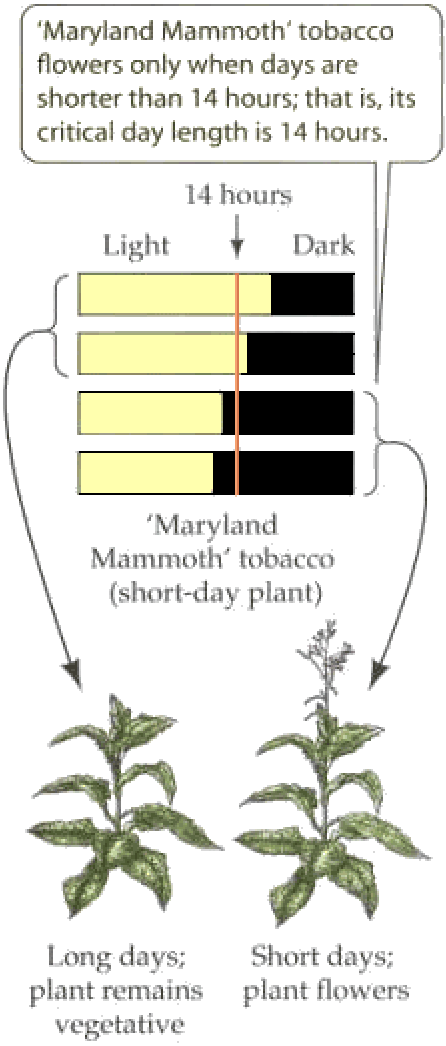
- **Photoperiod**
  - Word derivation:
    - *Photo*: light
    - *Period*: a specific length of time
  - Definition: the relative length of daylight and night
- **Photoperiodism**
  - Definition: the response of plants to changes in the photoperiod
  - Example: flowering
    - The timing of flowering in plants is determined by the relative length of daylight and night (photoperiod).
    - The seasons are controlled by the length of daylight.
      - Between December and June, in the northern hemisphere, the amount of daylight increases daily.
      - So, increased daylight indicates spring and summer are on the way.
      - Between June and December, the opposite occurs.

The Maryland Mammoth and the Discovery of Short-Day Plants

- **Researchers**: Garner and Allard at the USDA in the 1920s
- Worked with the **Maryland Mammoth**, a large tobacco plant that didn't flower in the summer when most tobacco plants bloomed.
- They discovered that the shortening days of winter stimulated flowering in the Maryland Mammoth.
  - Under controlled experiments, in light-tight boxes where they could manipulate the amount of light and dark, they discovered that flowering only occurred if the day length (amount of light) was 14 hours or less.
- They called the Maryland Mammoth a **short-day plant** because it required a light period *shorter* than a **critical length** to flower.

Short-day Plants

- Short-day plants flower when daylight is less than a critical length.
- They flower in the late summer, fall, or early winter.
- Examples: chrysanthemums (“mums”), poinsettias, some soybeans.



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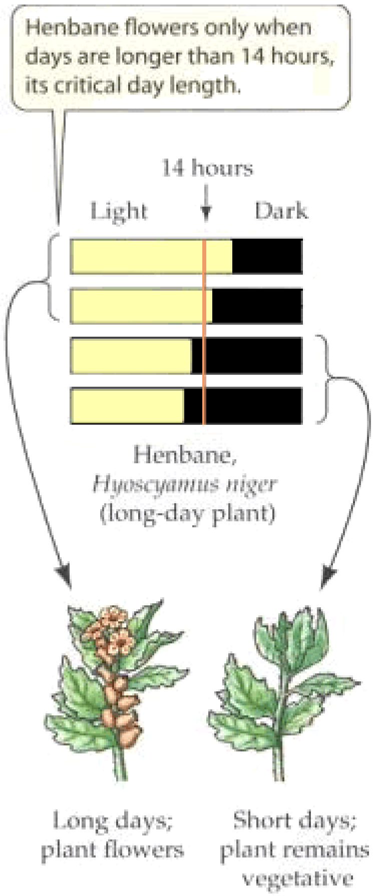
Long-day Plants

- Long-day plants flower when daylight is increasing.
- They flower in the spring and early summer.
- Examples: radishes, lettuces, irises, many cereal varieties.



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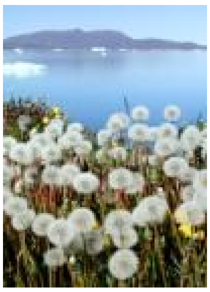
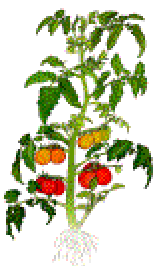
Day-neutral Plants

- Day-neutral plants do not flower in response to daylight changes.
- They flower when they reach a particular stage of maturity or because of some other cue like temperature or water, etc.
- This is the most common kind of flowering pattern.
- Examples: rice, dandelions, tomatoes, etc.





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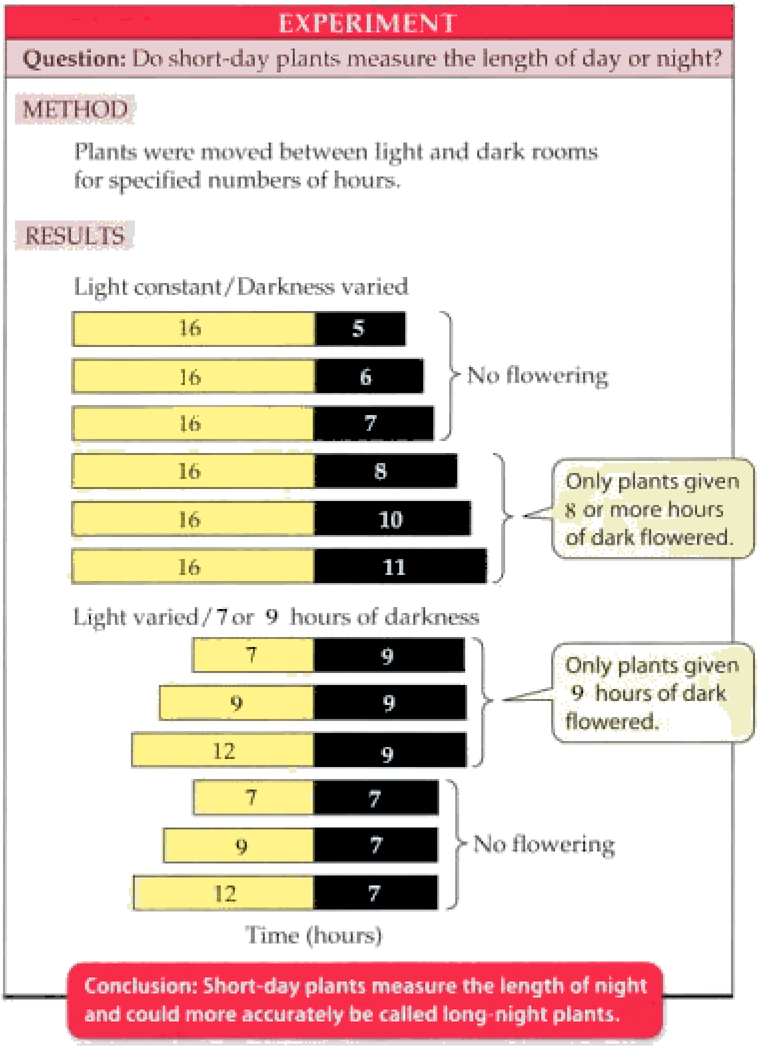
Surprise!

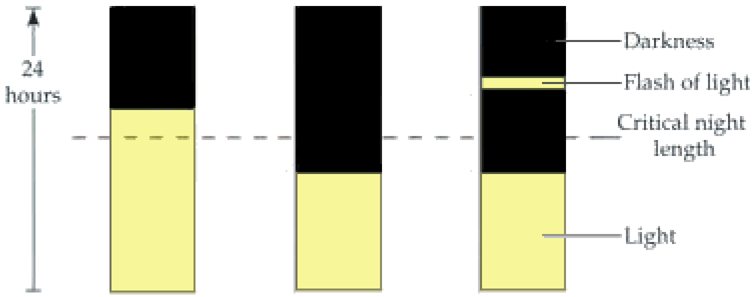
- In the 1920s, when they first did their research on the Maryland Mammoth, they thought it was all about **critical day length**.
    - For twenty years this was the prevailing understanding about how flowering was initiated.
    - All the biology books printed during these years talked about short-day plants and long-day plants.
- But, in the 1940s, researchers discovered it was **night length** rather than day length that determined flowering.

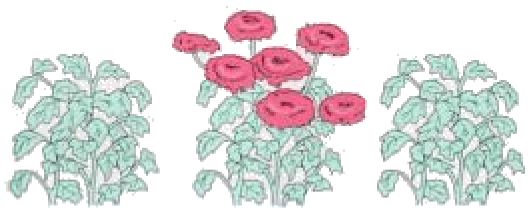
It's All About Night Length, *Not* Day Length!

- Key discovery: **photoperiodism** has nothing to do with day length—it is completely dependent on a **critical night length**.
- Summary of research using the cocklebur plant:
    - The critical night length for the cocklebur is 8 hours: as long as the cocklebur plant has at least 8 hours of **continuous darkness**, it will flower.
    - What was originally called a **short-day** plant is actually a **long-night** plant.
    - If the night is punctuated by light for a few minutes, then it will not flower!

The Experimental Results





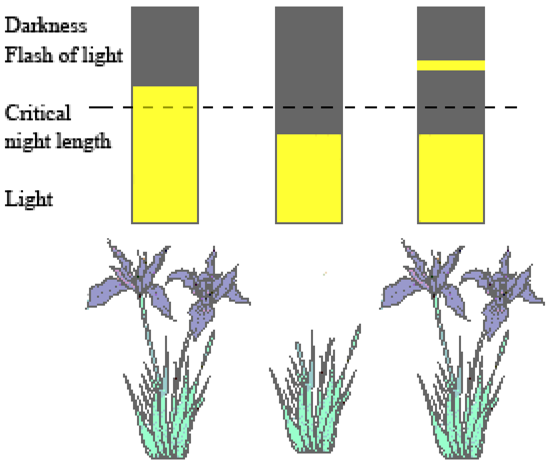


Short-day (long-night) plants

Unknown source; part of figure 39.16, page 766, Campbell's *Biology, 5th Edition*; unknown source

Long-day Plants are Actually Short-night Plants!

- Similarly, what were once thought to be **long-day** plants are actually **short-night** plants: they flower only when the night is shorter than a critical length.
- A few minutes of light during the night will shorten the night length, therefore causing flowering to occur!



Part of figure 39.16, page 766, Campbell's *Biology, 5th Edition*

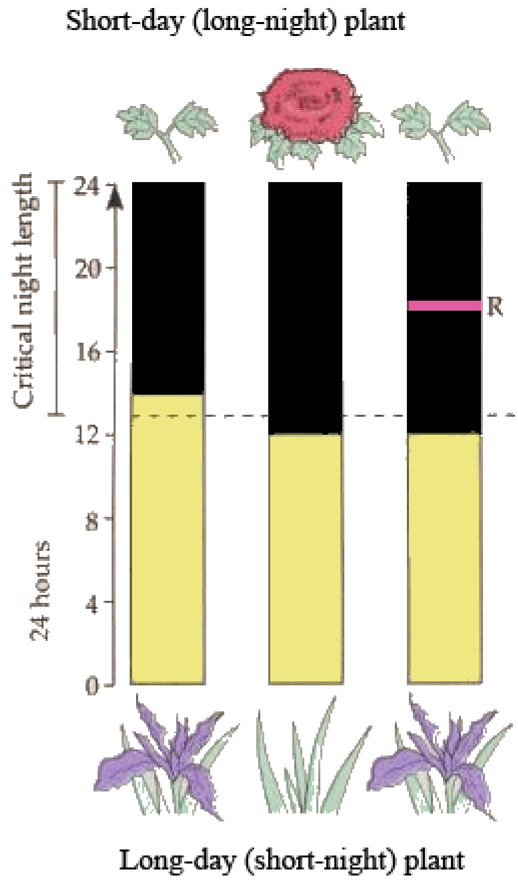
Flower Growers Use Knowledge About Photoperiodism to Make Money!

- As your book mentions, the flower-growing industry uses this knowledge about how photoperiodism works to produce flowers out of season.
- Chrysanthemums are short-day (long-night) plants that normally bloom in the fall.
    - Their blooming can be stalled until Mother's Day in May by exposing the plants to a little light during the long evenings.
    - This effectively shortens the night below the critical night length!

The Details

- Red light, of wavelength 660 nm, is the most effective in interrupting night length.
- Experimental results have confirmed this fact:
    - **Short-day** (long-night) plants experiencing a long night will *not* flower if exposed briefly to 660 nm light sometime during the night.

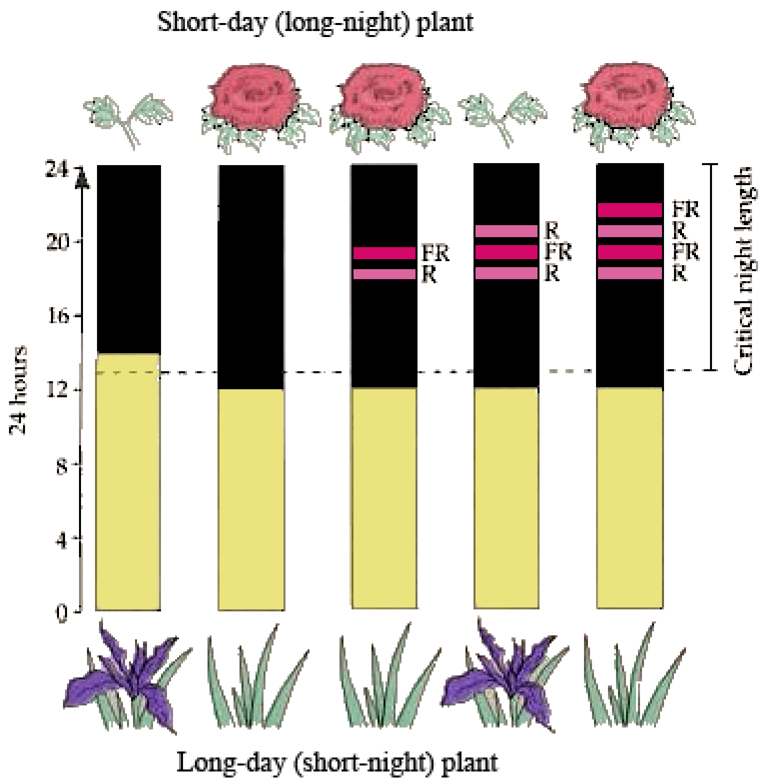
- **Long-day** (short-night) plants exposed briefly to a 660 nm light *will* flower even if the total night length exceeds the critical number of hours.



Part of figure 39.18, page 768, Campbell's *Biology, 5th Edition*

Far-red Light Cancels the Effect of Red Light

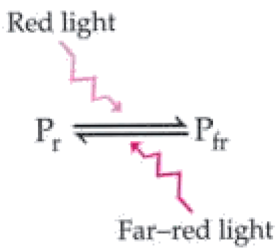
- Shortening of night length by **red light (R)** can be negated by a flash of **far-red light (FR)** of 730 nm.
- When this occurs, the plant perceives no interruption in night length.
- No matter how many times red light is flashed, as long as it is followed by far-red light the effects of red light are canceled.
- This works in both short-day and long-day plants.



Part of figure 39.18, page 768, Campbell's *Biology, 5th Edition*

How Does This Work?

- Light-sensitive proteins called **phytochromes** are partially responsible for the timing of flowering.
- The phytochrome proteins come in two different forms: P_r and P_{fr}.
- These phytochromes act as photodetectors that tell the plant what kind of light is present.
- The absorption of light causes them to convert to the other form:
    - P_r absorbs **red light** to become P_{fr}.
    - P_{fr} absorbs **far-red light** to become P_r.
- The presence of P_{fr} switches on physiological and developmental changes in plants.
    - Not only does it influence flowering, but also triggers other responses to light such as seed germination.



Unlabeled figure, page 768, Campbell's *Biology, 5th Edition*

Circadian Rhythms

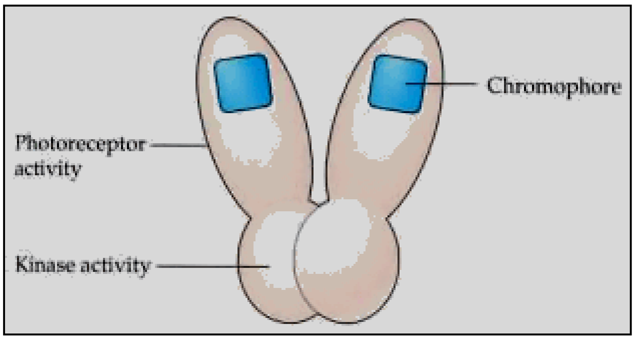
- Most plants and animals exhibit what are called **circadian rhythms**.
    - Word derivation:
        - *Circa*: approximately
        - *Dies*: day
        - "About a day"
    - Circadian rhythms are patterns of physiological change that follow a 24-hour cycle, day after day.
    - These 24-hour cycles can be seen in a variety of physiological responses and are very predictable:
        - Pulse
        - Blood pressure
        - Temperature
        - Rate of cell division
        - Metabolic rate
        - Stomata opening and closing
- The big question in biology is whether these changes are controlled externally (by environmental cues) or whether they are controlled internally (endogenously).
    - The answer seems to be that they are controlled internally.
    - Scientists have put people and plants in darkness for days, and they still exhibit the 24-hour cycle.
    - However, the 24-hour cycle is no longer synchronized with the outside world—it drifts.
- Take-home message: biological clocks exist, but they can drift.

The Phytochrome System Is a Way to Maintain the Circadian Rhythm

- Since ordinary daylight has both red and far-red light, how does this system work?
    - The phytochrome is a **homodimer** (a quaternary protein with two identical halves), bonded to a non-protein light absorbing pigment called a **chromophore**.
    - The P_r form is constantly being synthesized by the plant.
    - When exposed to daylight, some of the P_r is converted to P_{fr}, but some P_{fr} is converted to P_r as well.
        - Eventually, equilibrium is reached and maintained during the day.
    - Degradative enzymes destroy more of P_{fr} than P_r.
- In the dark, P_{fr} is converted to P_r.
    - At sundown, and throughout the night: P_{fr} begins to disappear and P_r accumulates.

- At sunrise: P_{fr} levels suddenly increase, and P_r levels decrease.
- Thus **night length** is responsible for resetting the circadian rhythm clock.

Figures 39.19 page 769,



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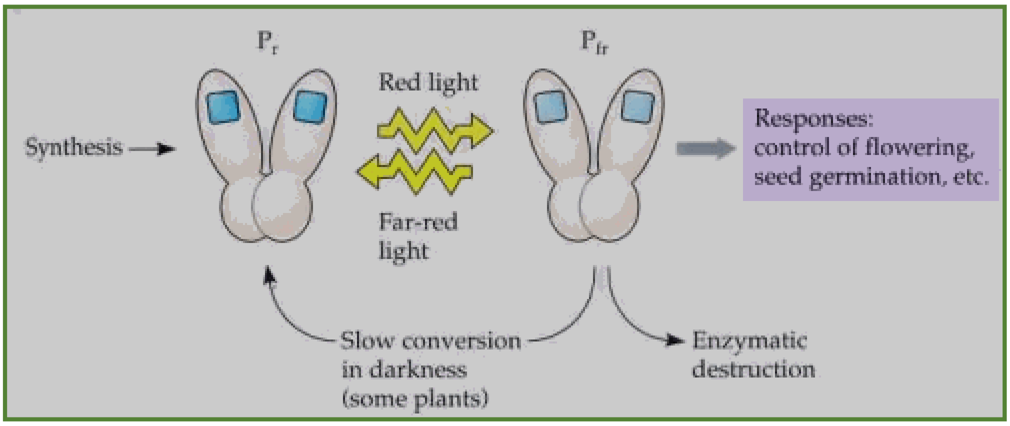

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