

Lecture 16:

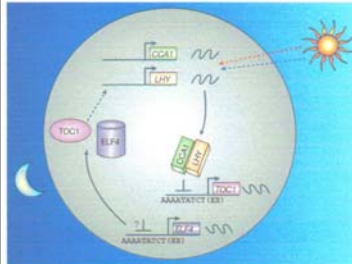
Photoperiodism –

The ability of an organism to detect day length

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Molecular interactions that shape the plant circadian oscillator

The circadian clock constitutes the timing mechanism of seasonal responses



Circadian rhythms are based on transcriptional feedback loops in which some proteins negatively control their own expression by antagonizing the action of positively regulating transcription factors

Yanovsky and Kay 2003
Nat Rev Mol Cell Biol 4: 265-75

Arabidopsis mutants with aberrant circadian rhythms

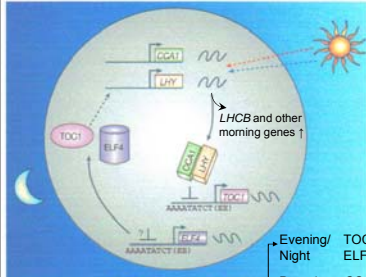
elf3/elf4 – early flowering 3/4; mutation causes no circadian rhythm in light, but rhythm is maintained in constant dark

toc1 – timing of *cab* expression 1 (pseudo-response regulator*); mutations shorten photoperiod

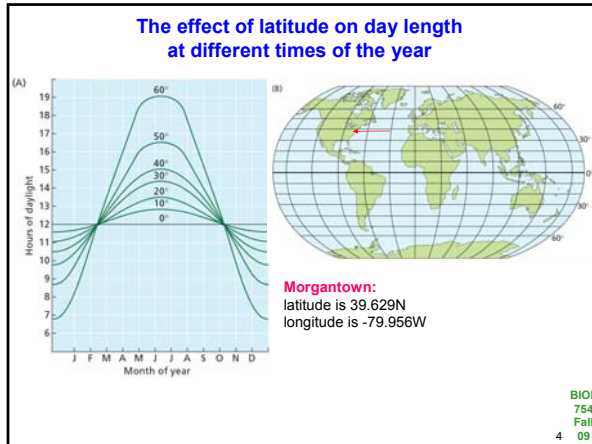
lhy (late elongated hypocotyl), *cca1* (circadian clock associated 1) – MYB-related putative transcription factors -> mutations abolish circadian regulation of genes 2

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Molecular interactions that shape the plant circadian oscillator



Evening/ Night	TOC1 ↑ ELF4 ↑	⇒ Activate expression of CCA1, LHY
Dawn/ Day	CCA1 ↑ LHY ↑	⇒ Repress TOC1, ELF4 transcription
Day	TOC1 ↓ ELF4 ↓	⇒ CCA1 ↓ LHY ↓
Dusk/ Evening	Release of inhibition of TOC1, ELF4	⇒ TOC1 ↑ ELF4 ↑



Plants can be classified by their photoperiodic responses

Wild type tobacco (*Nicotiana sylvestris*) (left) and **Maryland Mammoth** cv. of tobacco (*Nicotiana tabacum*) (right), which fails to flower in the summer, but flowers in winter under natural light

Gallard & Allard, 1920, USDA Beltsville, MD

Nicotiana tabacum = short-day plant
Nicotiana sylvestris = long-day plant

MARYLAND MAMMOTH locus is a recessive gene in *N. tabacum* that confers short-day behavior (Allard, 1919; Lang, 1948).

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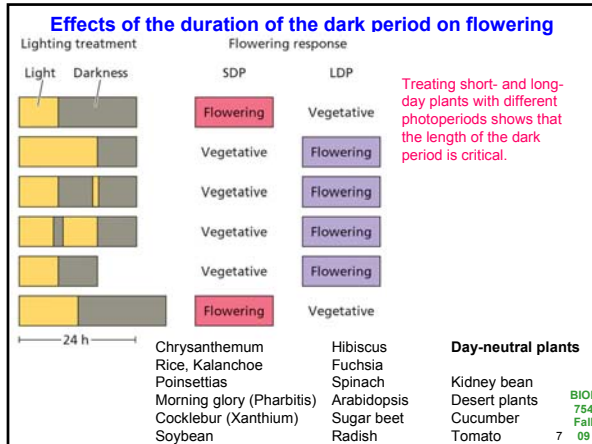
Photoperiodic regulation of flowering

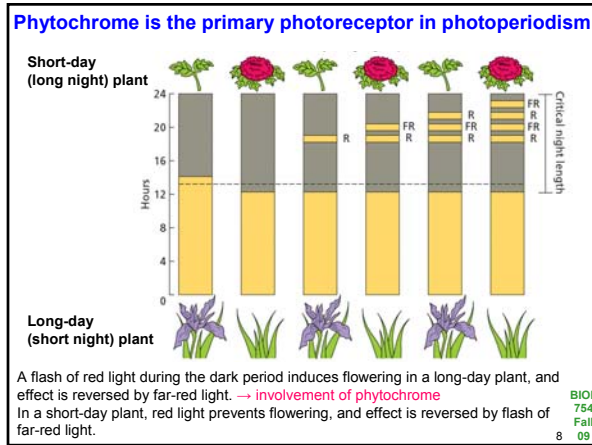
Short-day plants flower when the day length is less than (or the night length exceeds) a certain critical duration in a 24-h cycle.

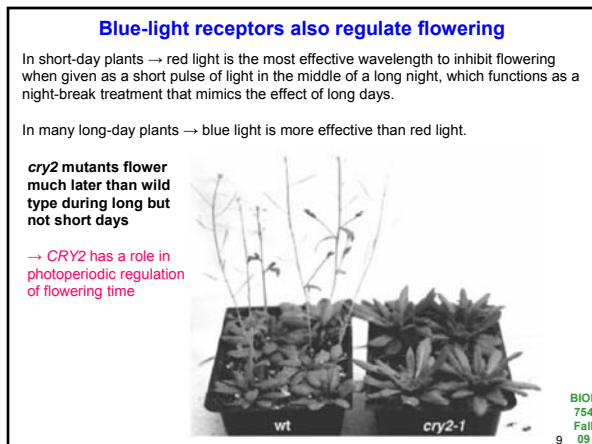
Short-day (long-night) plants flower when night length exceeds a critical dark period. Interruption of the dark by brief light treatment prevents flowering.

Long-day plants flower when the day length exceeds (or the night length is less than) a certain critical duration in a 24-h cycle.

Long-day (short-night) plants flower if the night length is shorter than a critical period. In some long-day plants, shortening the night with a night break induces flowering.

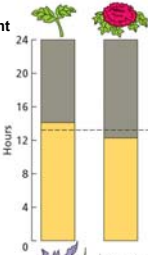






How does an oscillation with a 24-h period measure a critical duration of darkness?

Short-day (long night) plant



Example:

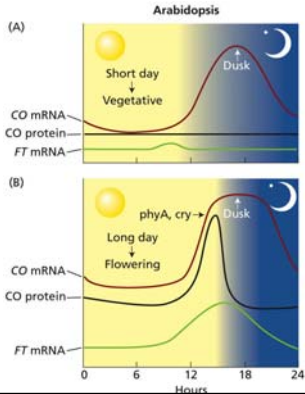
How does Chrysanthemum "know" that it needs 10-12 hrs to induce flowering?

Long-day (short night) plant



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A physiological model of photoperiodic time measurement
Molecular basis of the external coincidence model



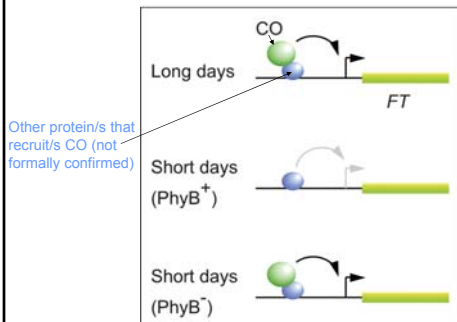
Coincidence model: Plants are sensitive to light only at certain times of the day-night cycle.

CONSTANS (CO)
=> zinc finger transcription factor
=> promotes flowering under LD
=> stimulates expression of FT (FLOWERING LOCUS T)

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Red light promotes degradation of CO, delaying flowering

A. thaliana



Kobayashi and Weigel 2007 Genes Dev 21: 2371-2384

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