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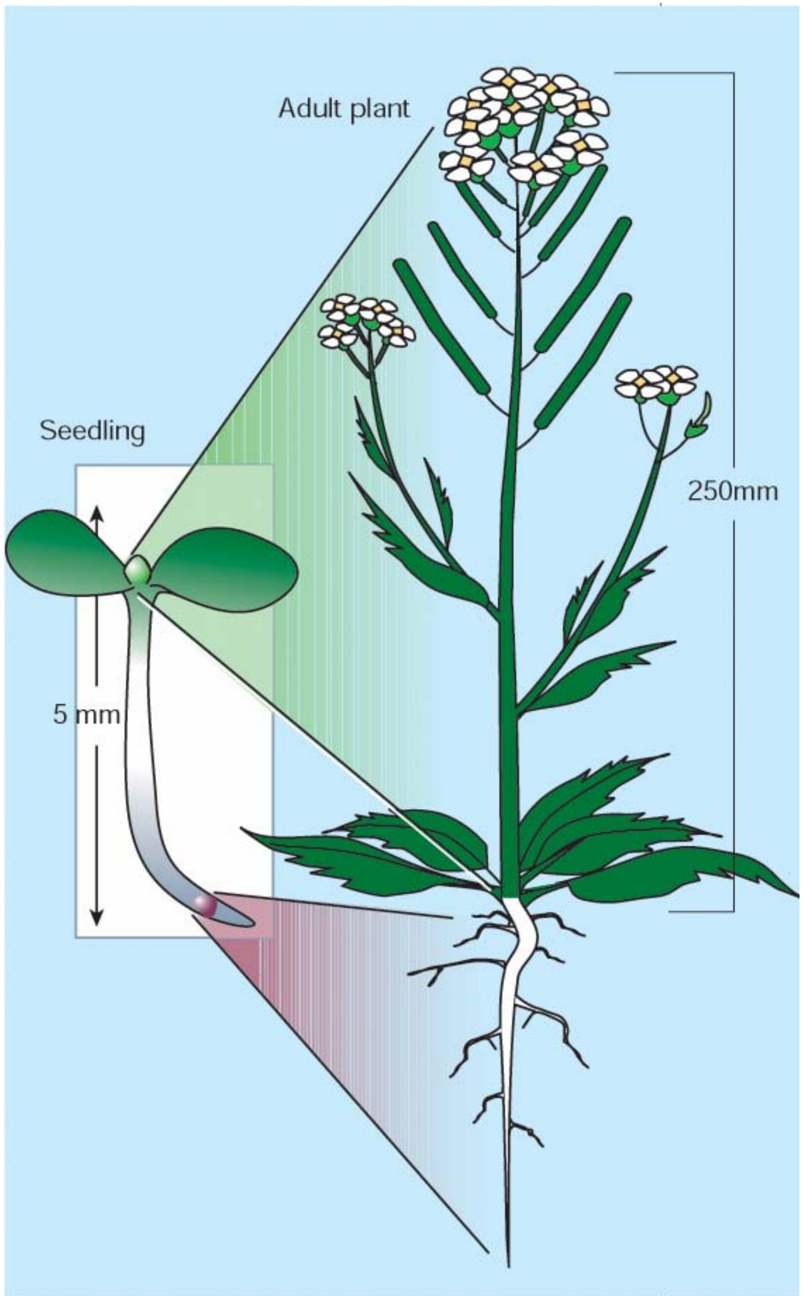
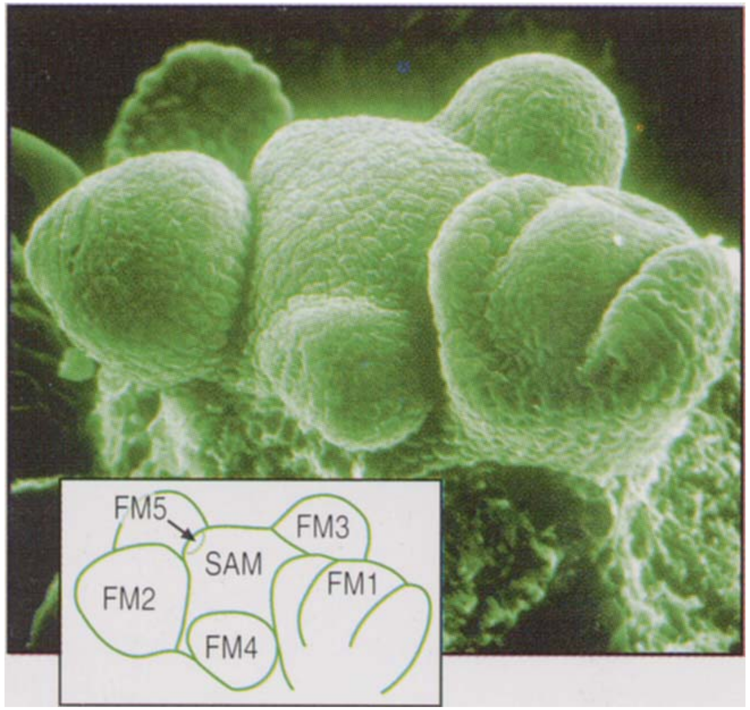
Forschung

Abt. Entwicklungsbiologie de Pflanzen

George Coupland

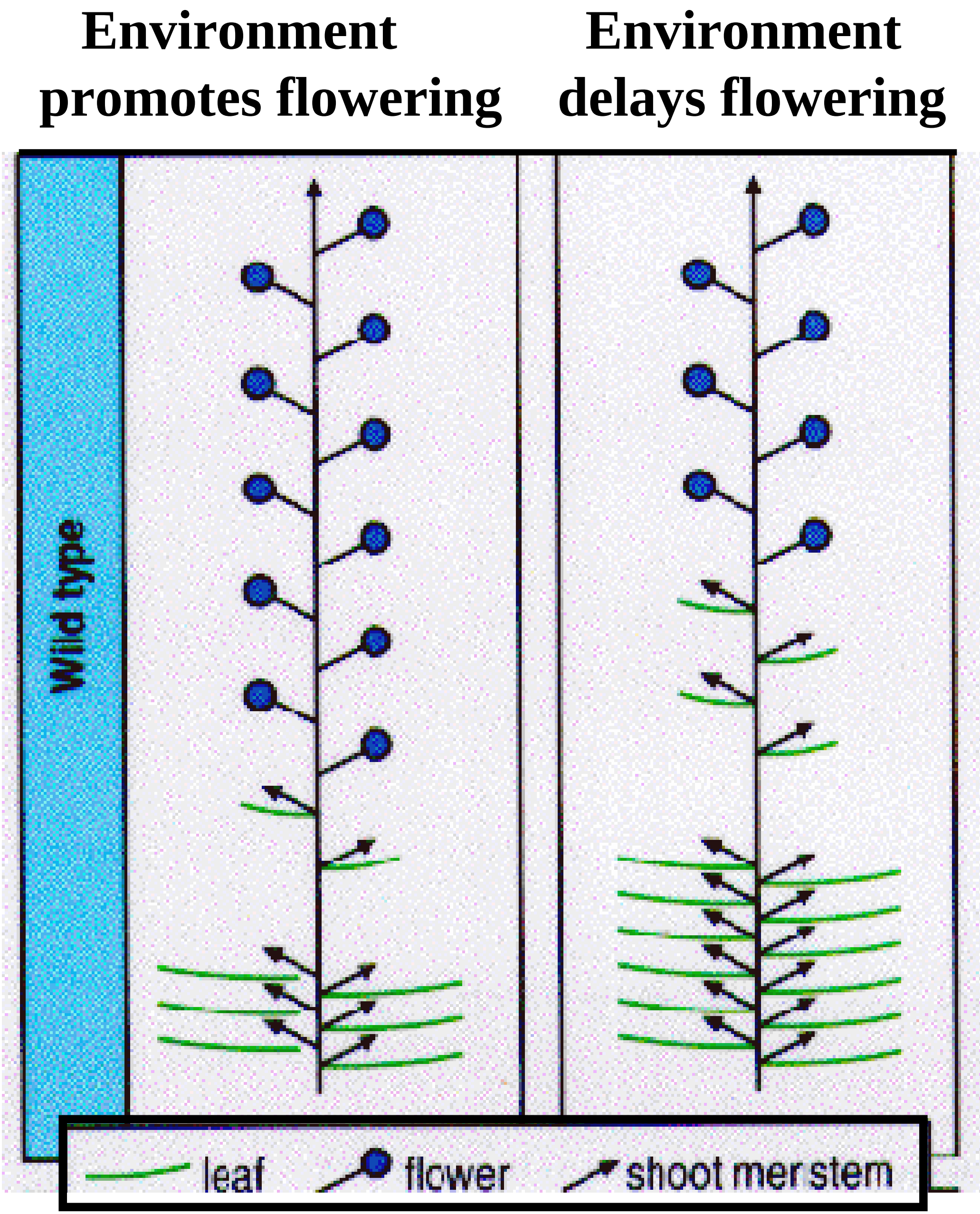




How is the transition from vegetative growth to flowering controlled ?

- How is it regulated by environmental conditions?

Environmental signals can influence the identity of the lateral organs formed at each node

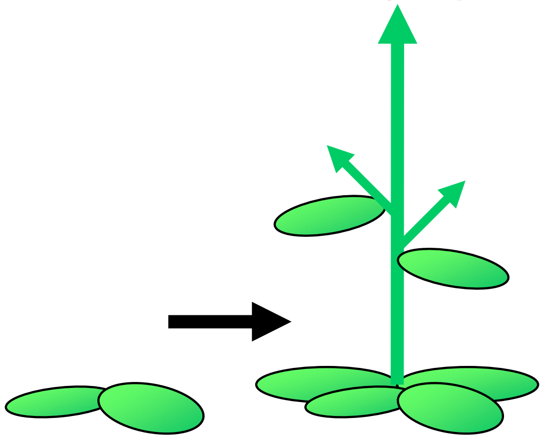


Environments that
Promote flowering
Of Arabidopsis are

-long daylengths,
photoperiod

-Long exposure to low
Temperature,
vernalization

Long-day plants flower when daylength exceeds a critical daylength



Examples:
Arabidopsis, wheat, barley, sugar beet

Long days	Flowering
Short days	No Flowering

Many mutations delay flowering of Arabidopsis

Wild-type ***constans***

Late flowering mutants can be placed in groups based on their responses to environmental conditions

Later flowering in long days, same as WT in short days
No response to vernalization *constans, gigantea, ft, cry2*

Later flowering in long days and short days
Flower faster after vernalization *fca, fpa, fy, ld*

Impair Gibberellic acid (GA) biosynthesis or response
Mainly later flowering in short days *ga1,*
gibberellic acid insensitive

These three groups proposed to define genetic pathways

1. Double mutant analysis

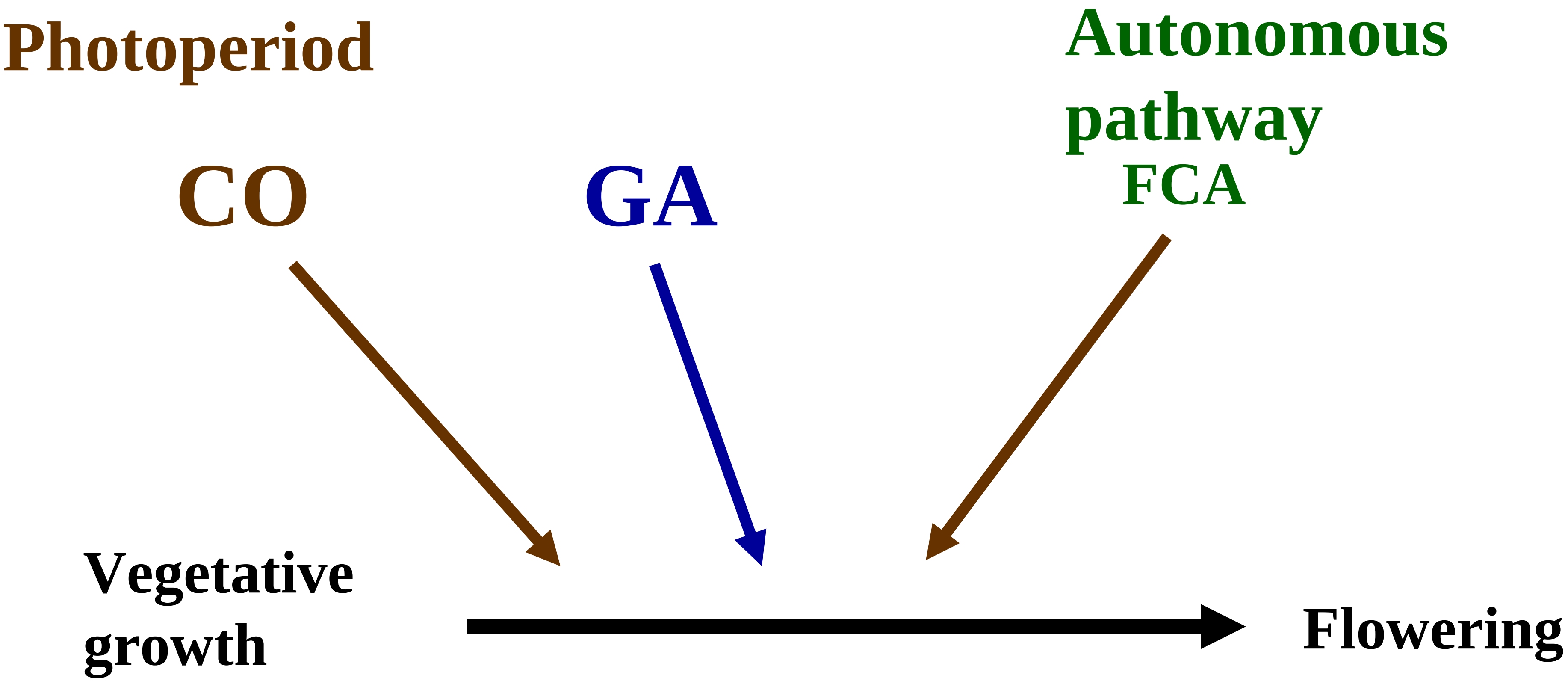
Combining mutants within groups causes no enhancement of phenotype. However, combining mutants between groups causes strong enhancement.

2. Clear groupings based on physiology.

Inactivating all three pathways prevents flowering

	LN in long days
WT	9.0
co	20.0
fca	31.0
ga1	16.0
co fca ga1	over 90 (never flowered)

Flowering time regulation in Arabidopsis involves three genetic pathways



Two classes of mutation reduce the response to daylength

Long days

Wild-type *constans*

Late-flowering in long days

No effect in short days

constans, gigantea, ft, cry2

Short days

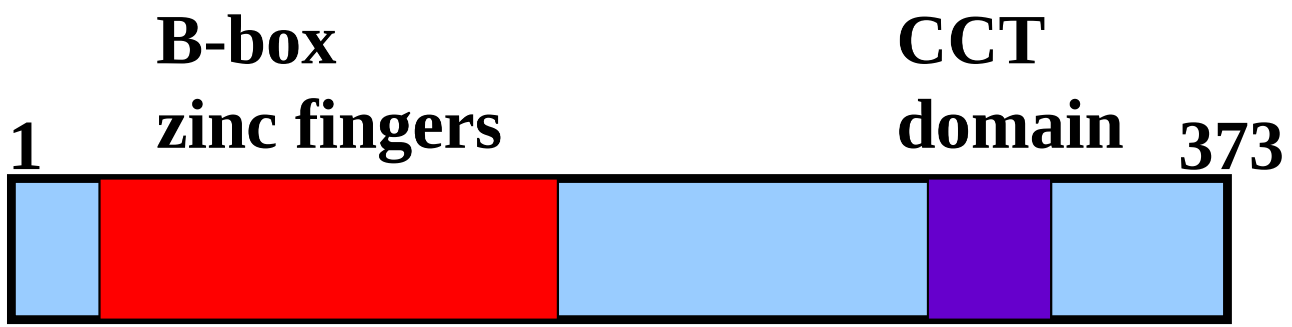
Wild-type *lhy-14*

Early-flowering in short days

No effect in long days

lhy, toc1

CONSTANS has two motifs that are required for its function

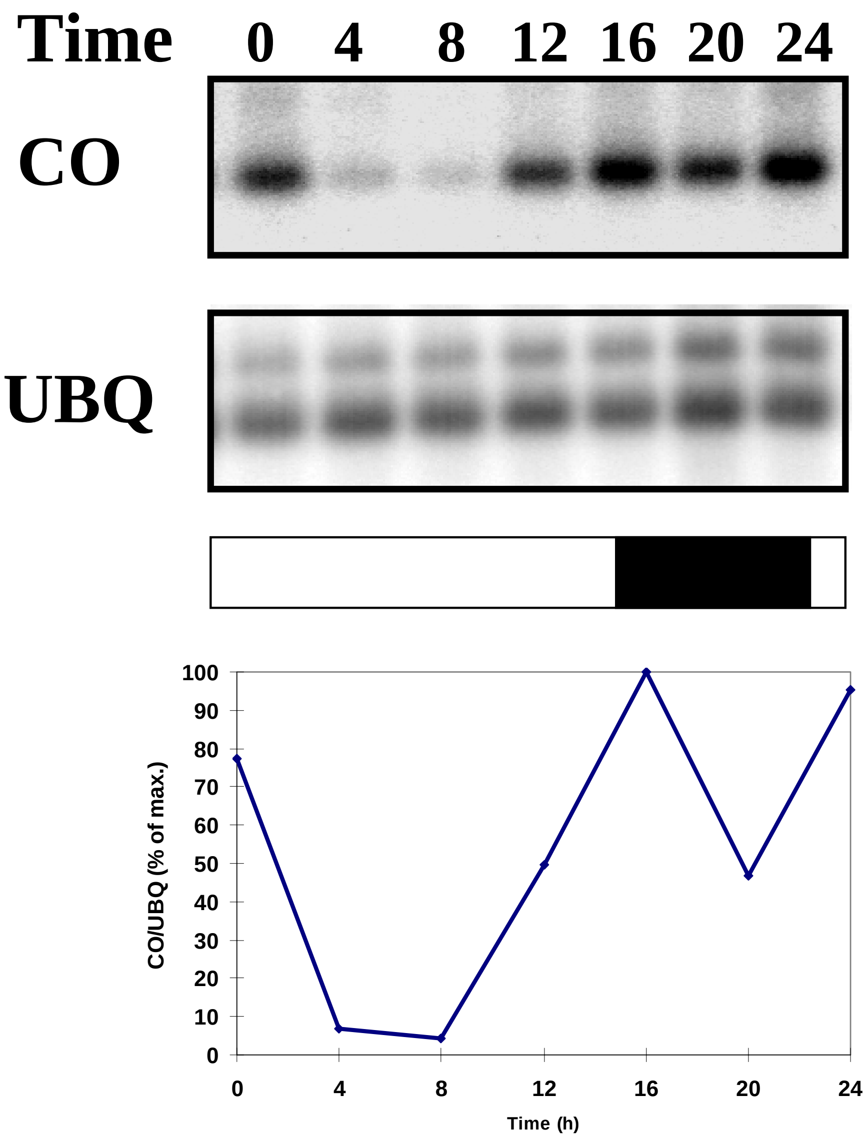


B-box proteins act in protein complexes that regulate transcription in animal cells

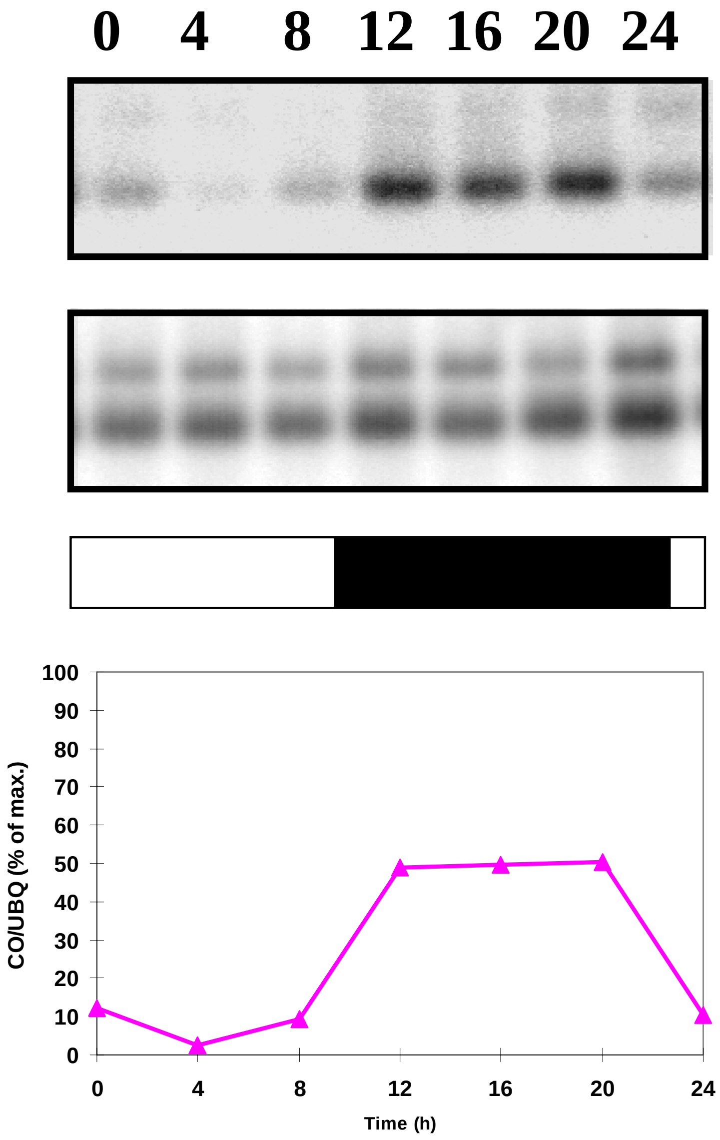
CCT is plant specific named after CONSTANS, CONSTANS-like and TOC1.

CO Expression Under Long and Short Days

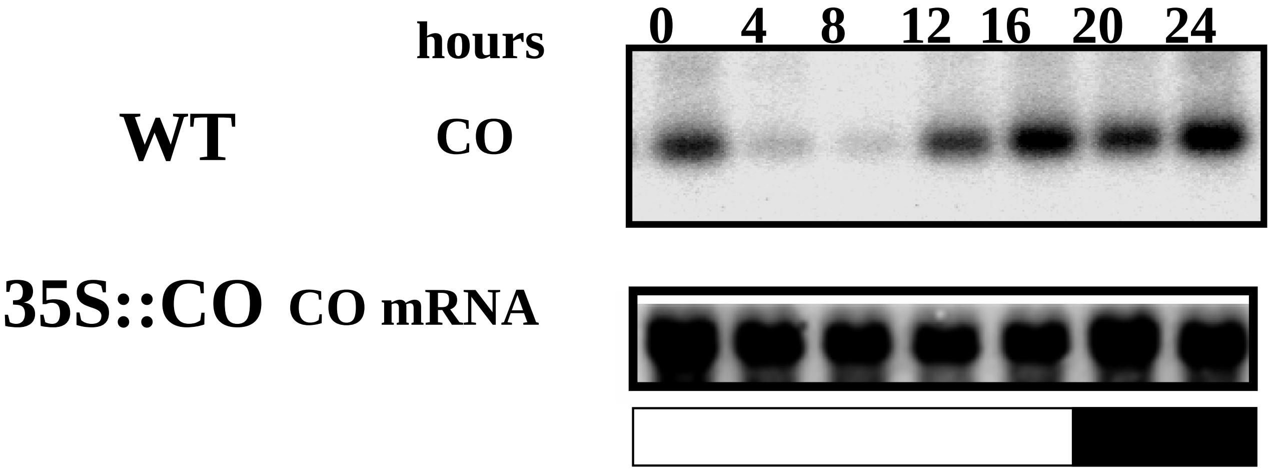
LONG DAYS



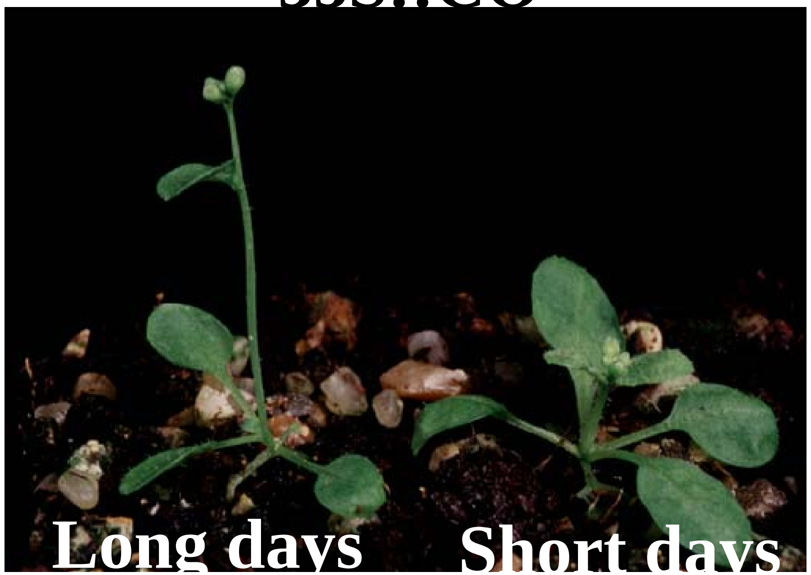
SHORT DAYS



CO mRNA is expressed throughout the day and at higher levels in *35S::CO* plants, and this causes early flowering in all daylengths

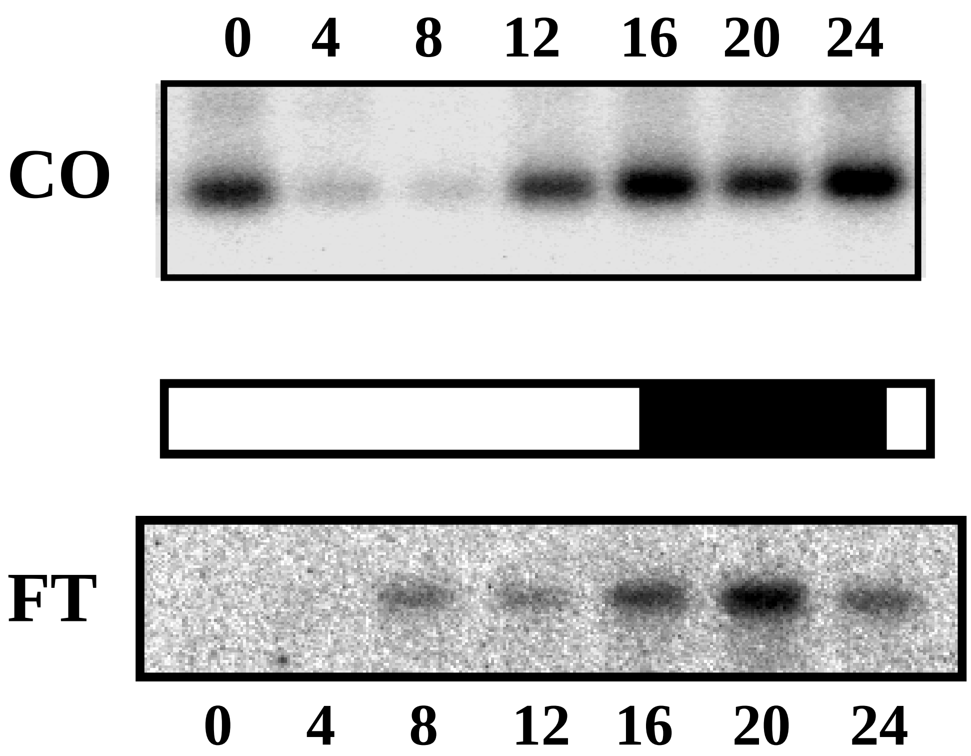


35S::CO



	Leaf Number
35S::CO	
Long Days	5.0
Short Days	4.8
Wild-type	
Long Days	8.6
Short Days	27.0

Comparison of diurnal rhythms in CO mRNA and mRNA of FT, a target gene of CO

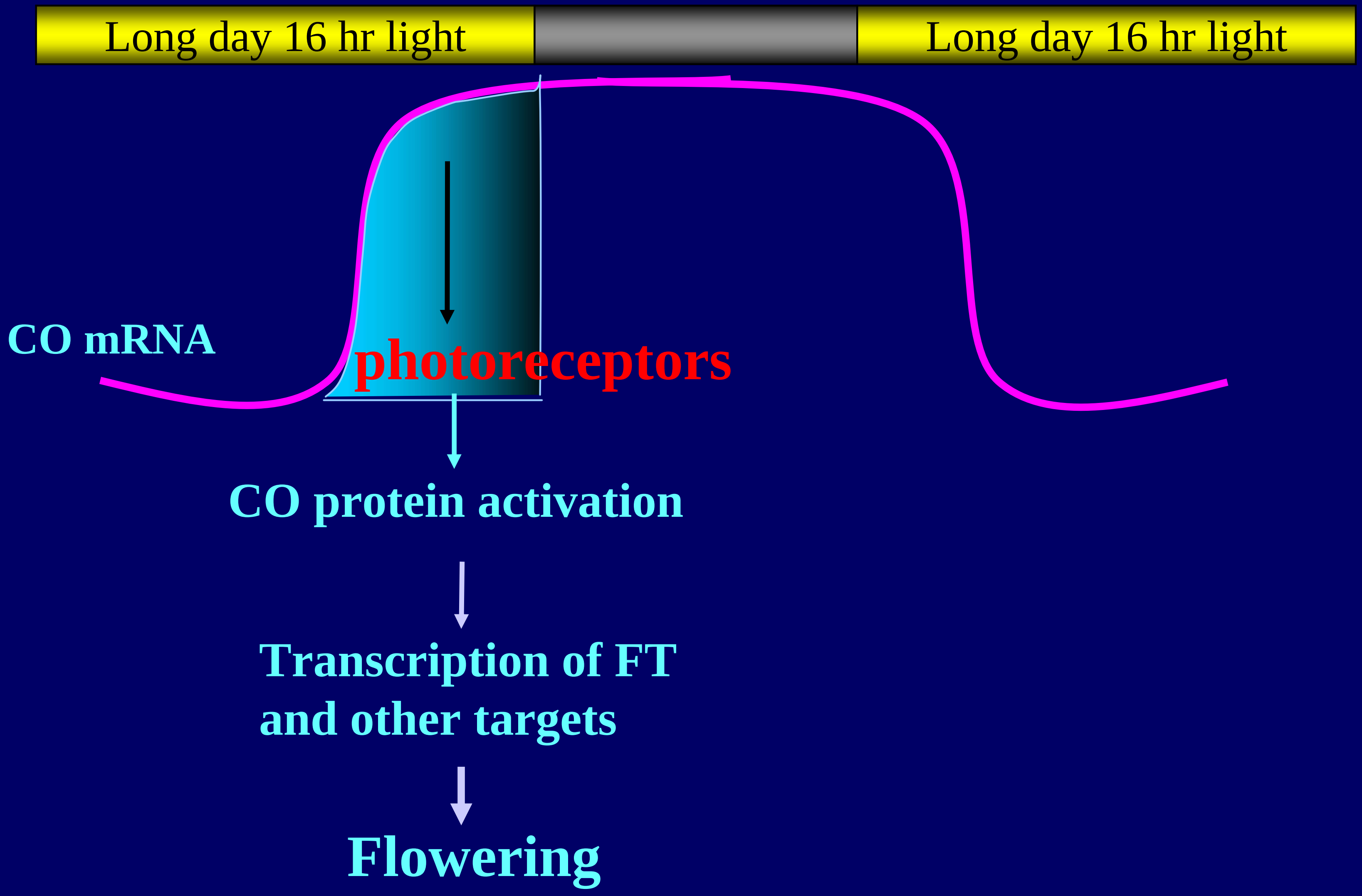


FT expression –

Reduced in co mutants
Reduced in short days
Overexpressed in 35S::CO

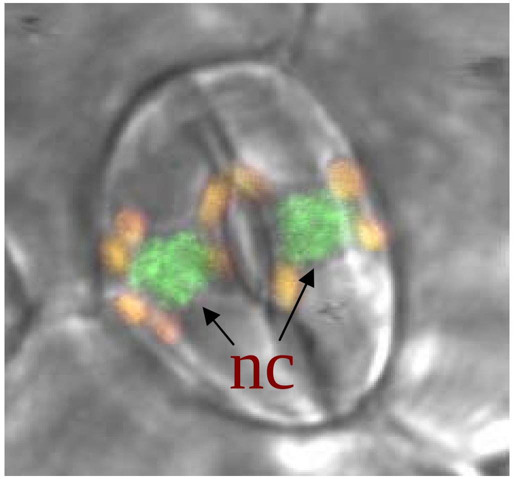
ft mutants similar phenotype to co mutants

A model for the response of Arabidopsis to daylength

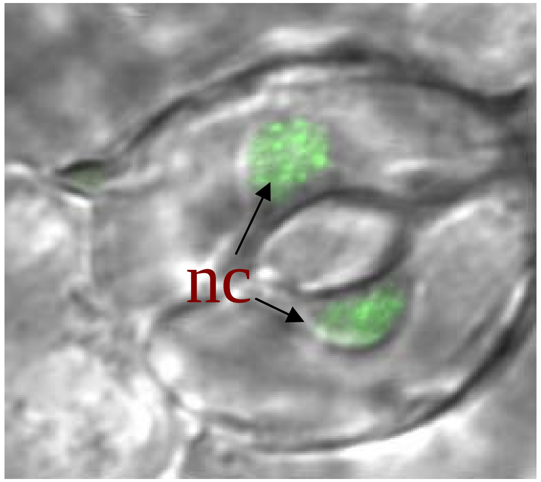


Exposure to light stabilises CO protein in the nucleus
35S::GFP:CO plants exposed to different light qualities

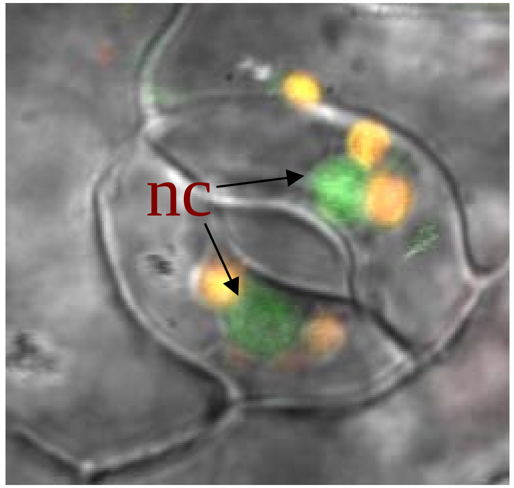
Light conditions in which CO is active



White

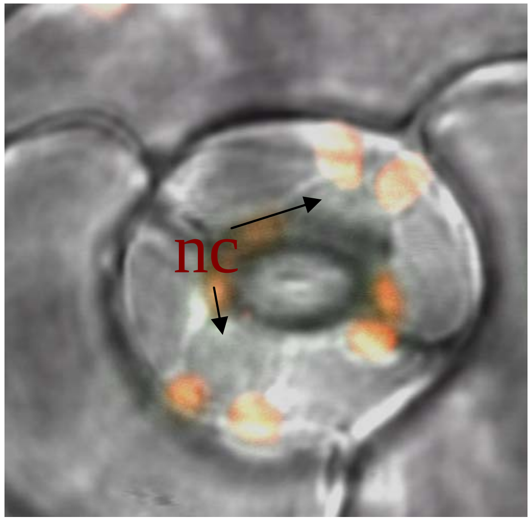


Blue

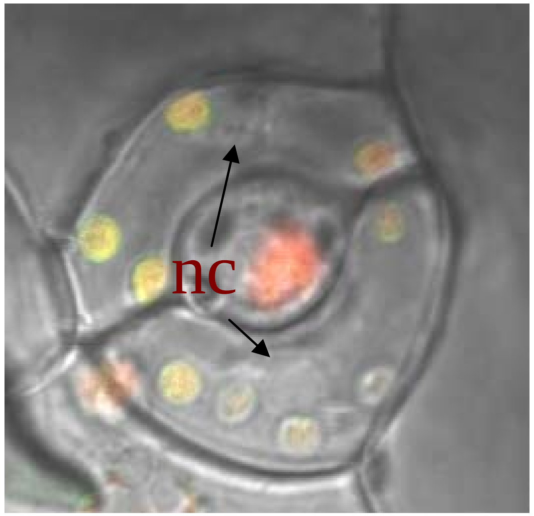


Far-red

Light conditions in which CO is inactive

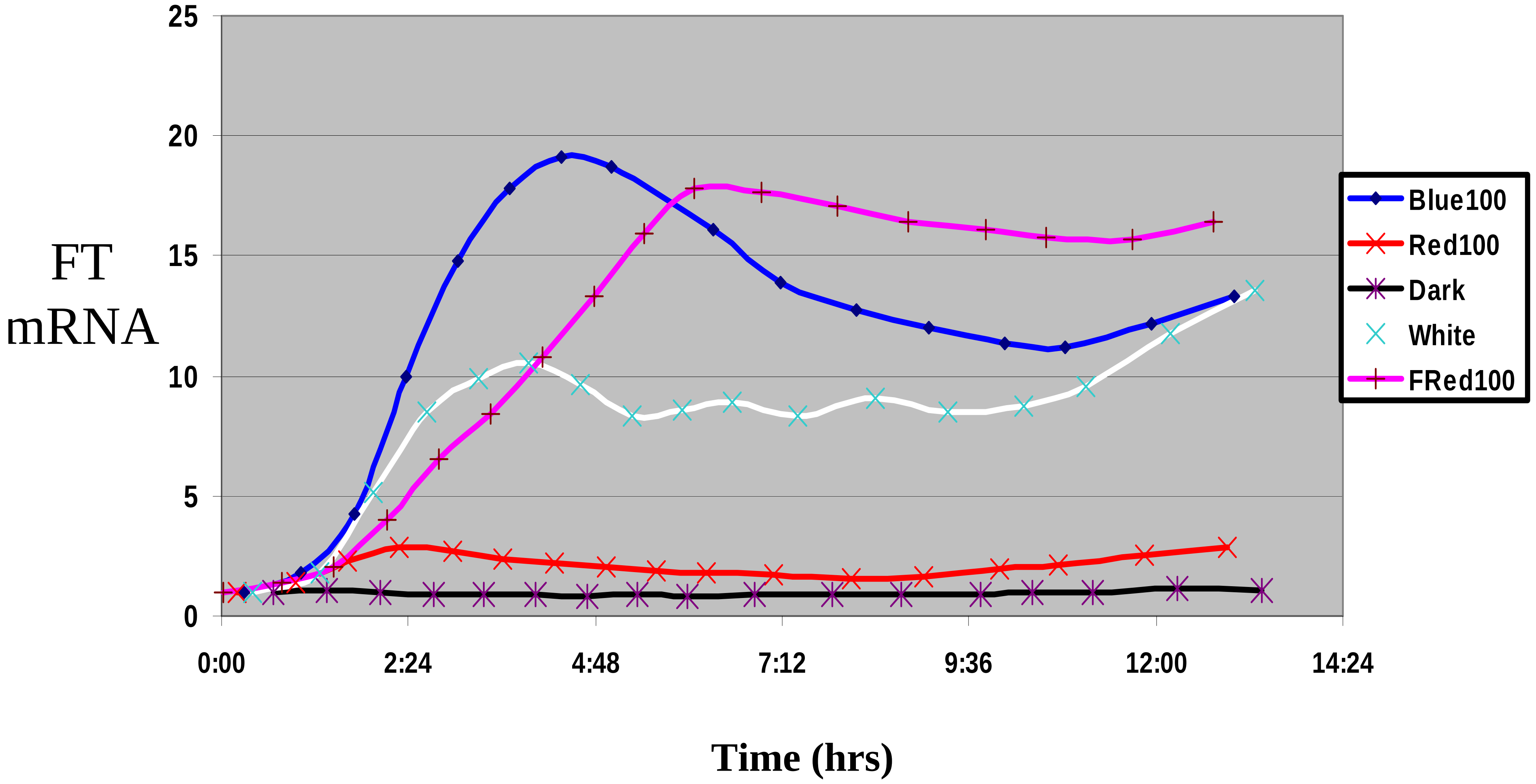


Dark

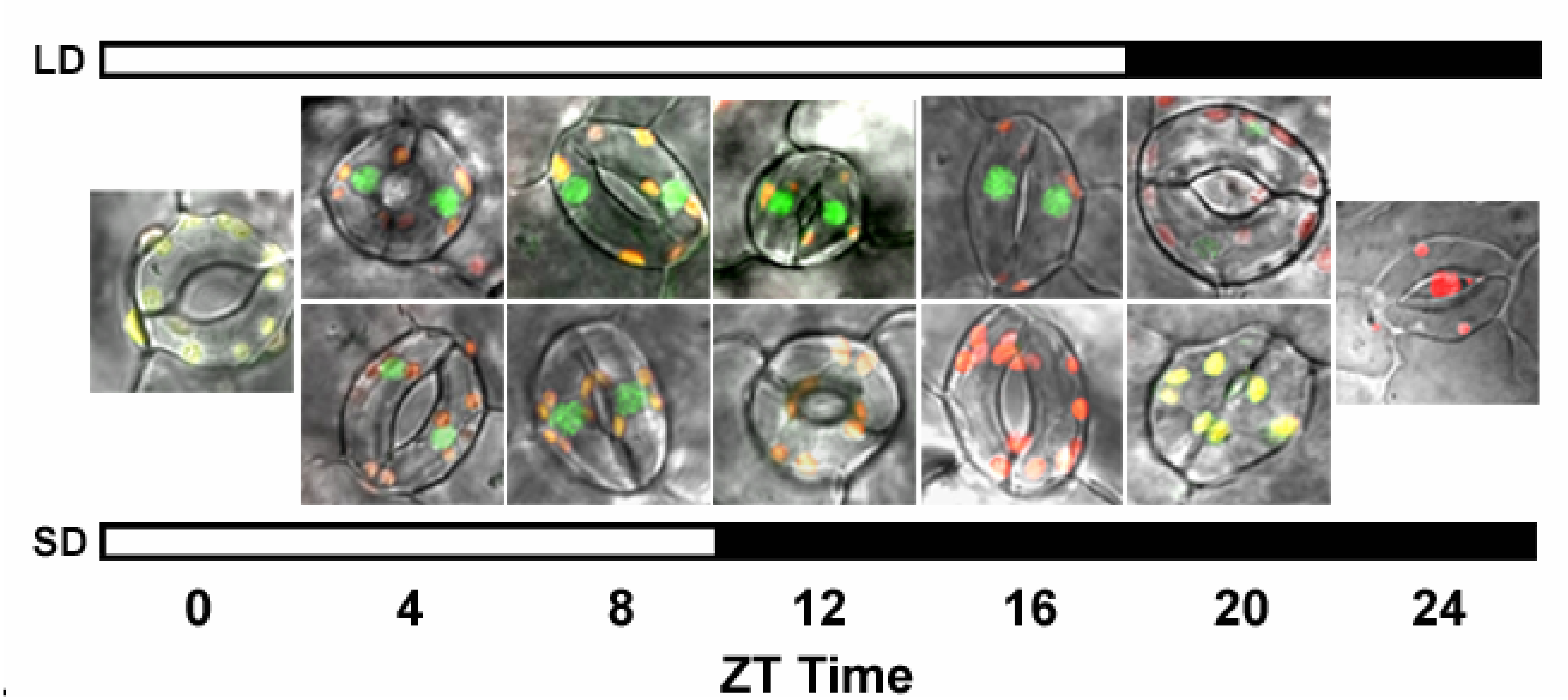


Red

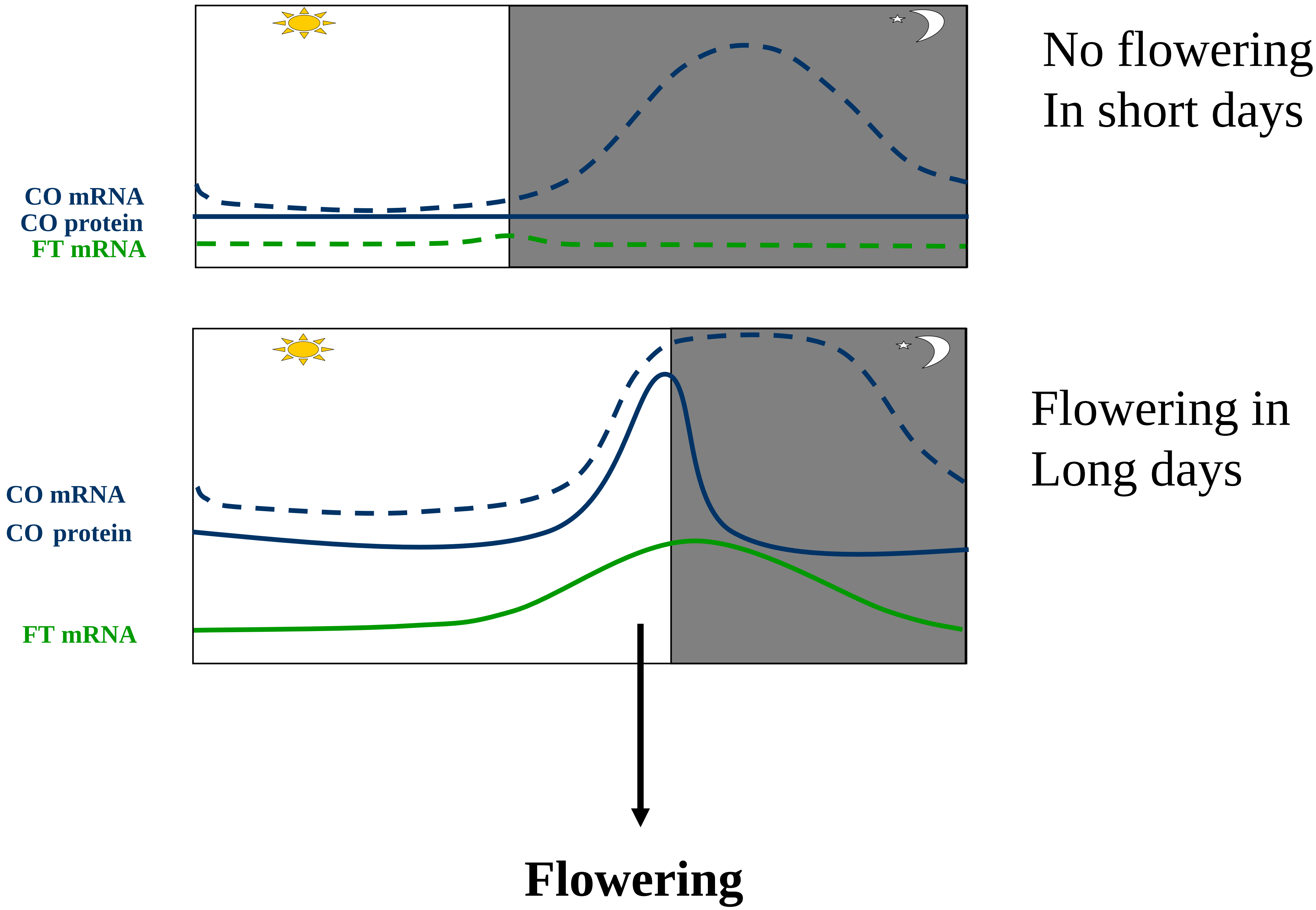
Activation of FT by 35S::CO occurs in blue and far-red light, but not red light



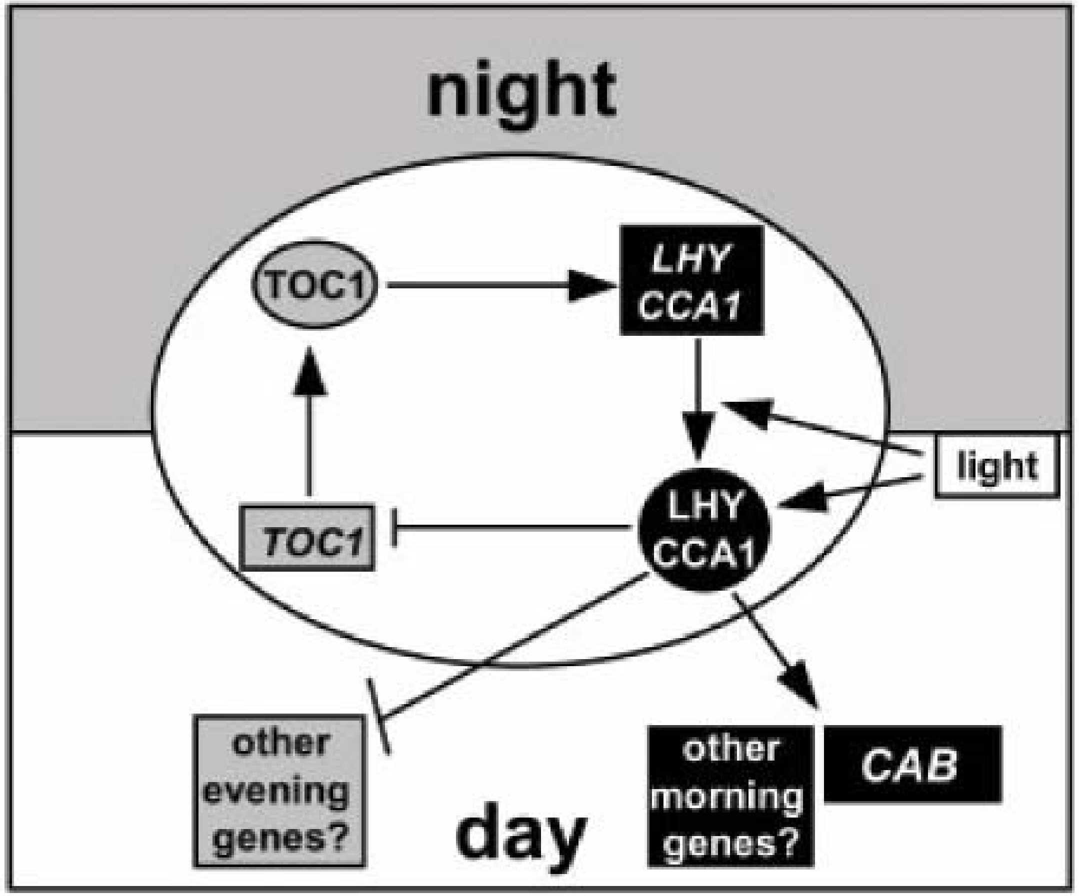
CO:GFP accumulates during the photoperiod in *35S::CO:GFP* plants



Coincidence of light and CO mRNA leads to stabilisation of CO protein and activation of FT under long days



The circadian clock of Arabidopsis is a negative feed-back loop regulating transcription

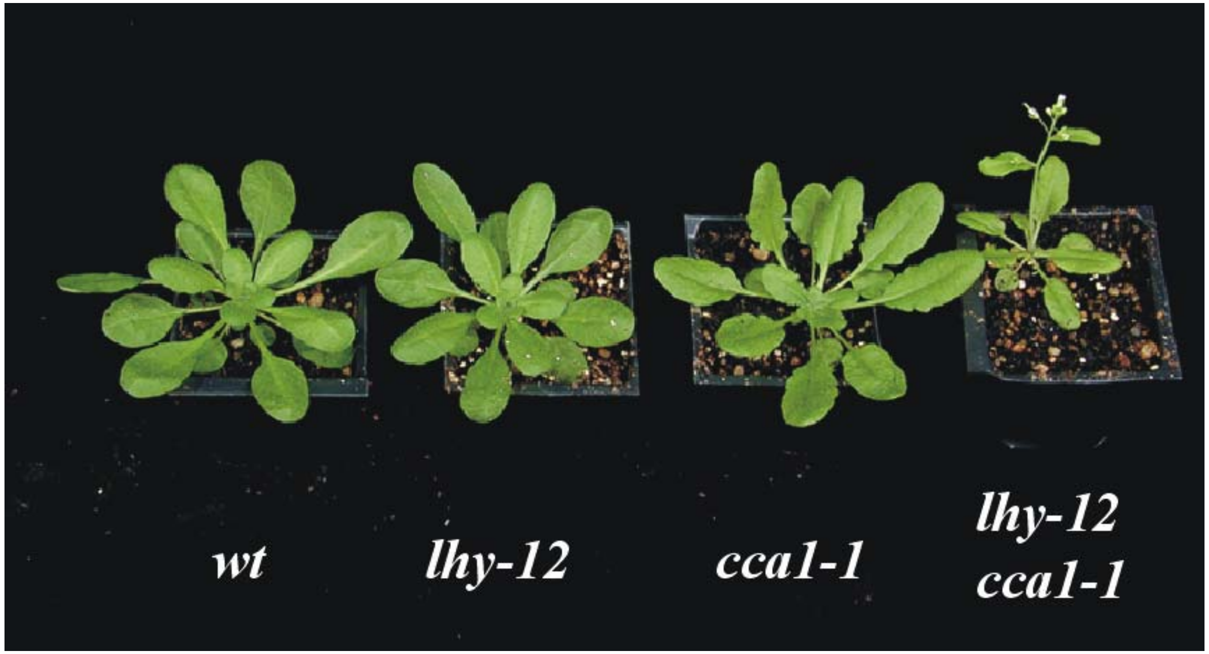


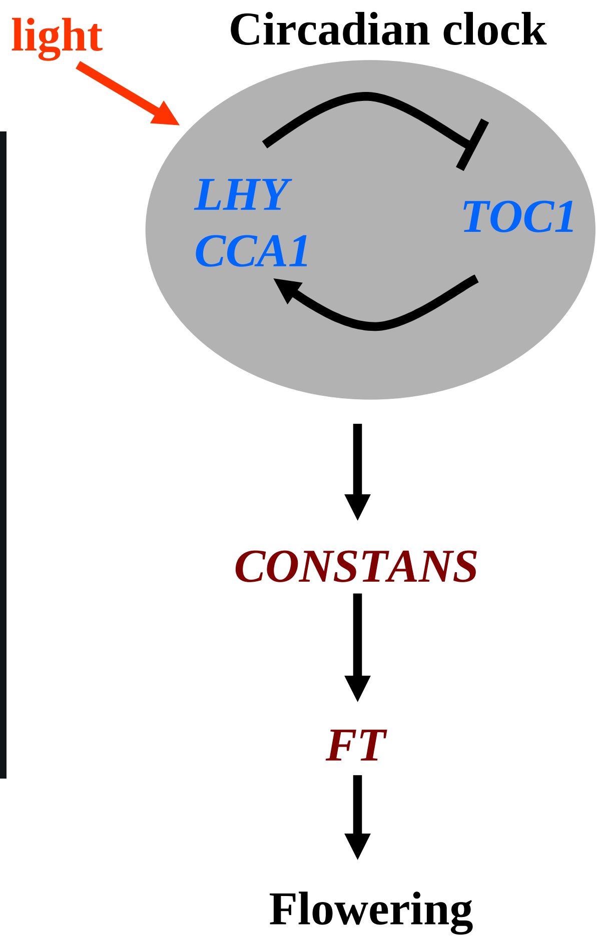
LHY/CCA1 – MYB
Transcription factors
Expressed in morning

TOC1 – similar to
Two component regulators
from bacteria. Expressed
in the evening

The circadian clock regulates 6% of Arabidopsis genes including CONSTANS

Mutations in circadian-clock components cause early flowering and this requires the CO and FT genes

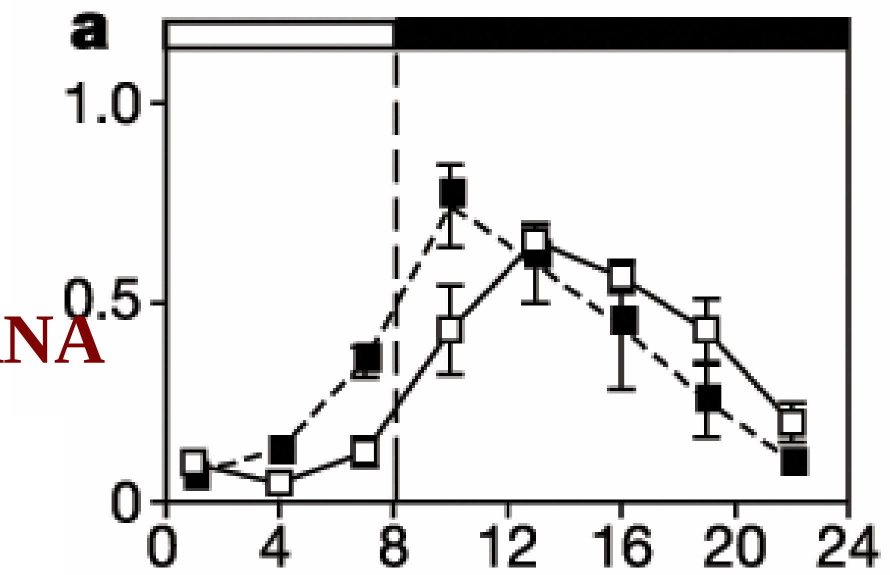




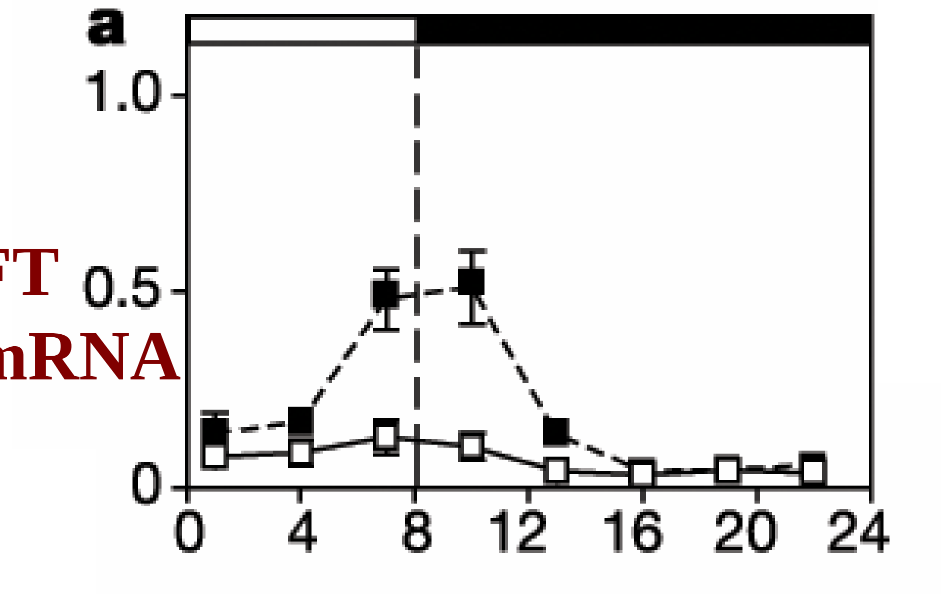
Mutations in lhy, cca1 or toc1 cause Early flowering under short days

Mutations in TOC1 change the timing in CONSTANS expression causing FT to be expressed under short days

CO mRNA



FT mRNA



■ **toc1 mutant**

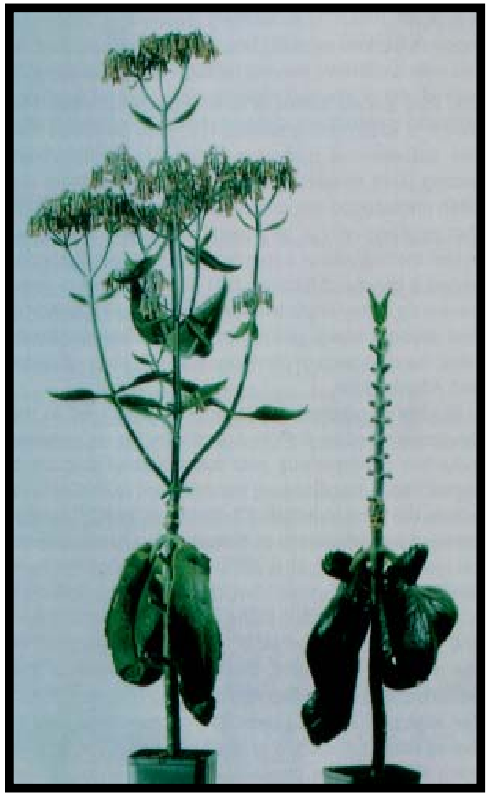
□ **WT plant**

A floral stimulus crosses a graft junction and induces floral development at the apex of the plant

Grafting approaches

Noninduced shoot

Induced stock

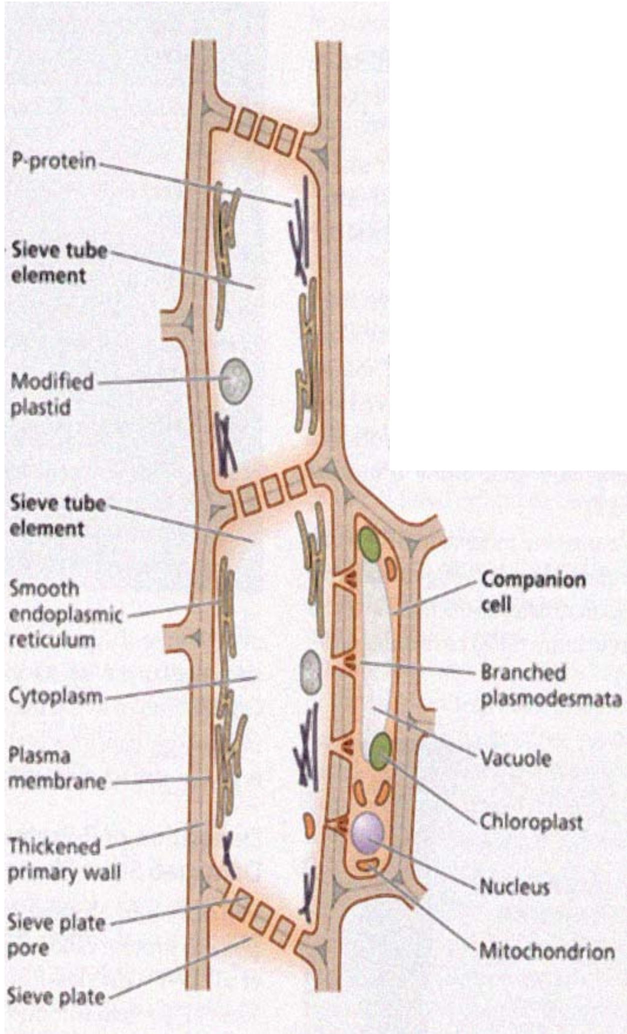


Noninduced shoot

Noninduced stock

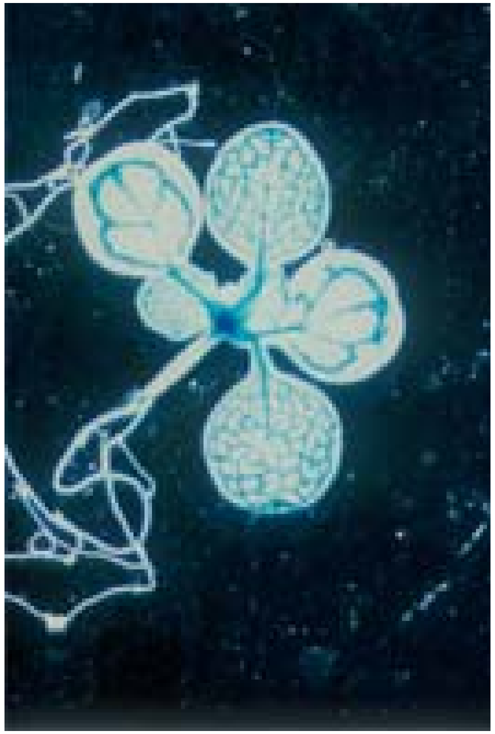
Bryophyllum diagremontianum

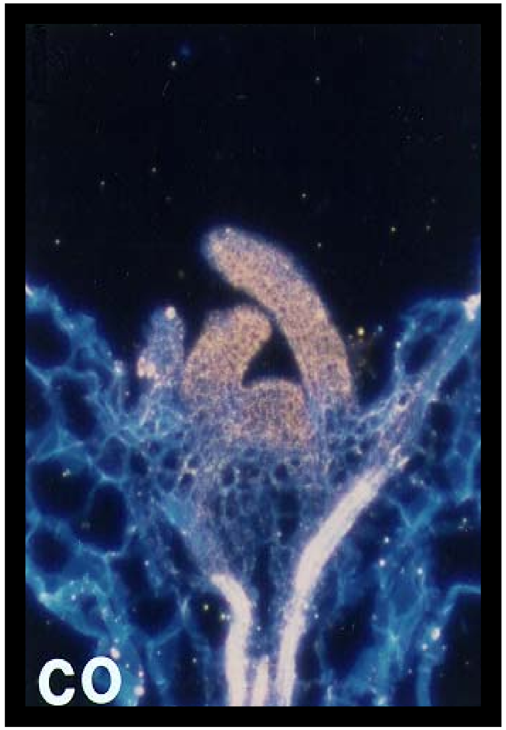
J. Zeevaart, MSU



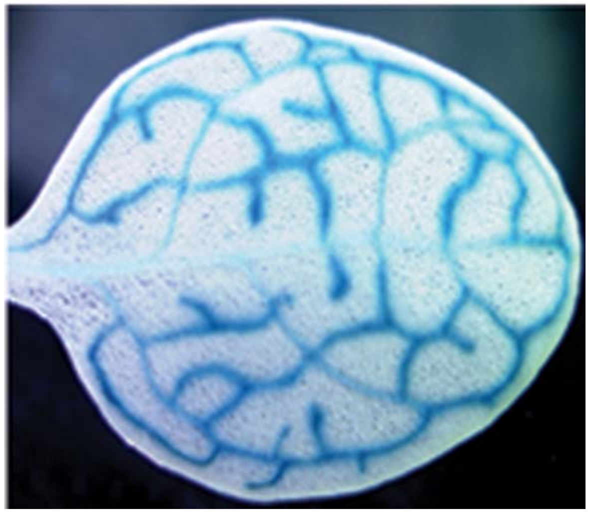
Phloem sieve elements transport photosynthate as well as some proteins and RNAs from the leaf to the apex of the plant

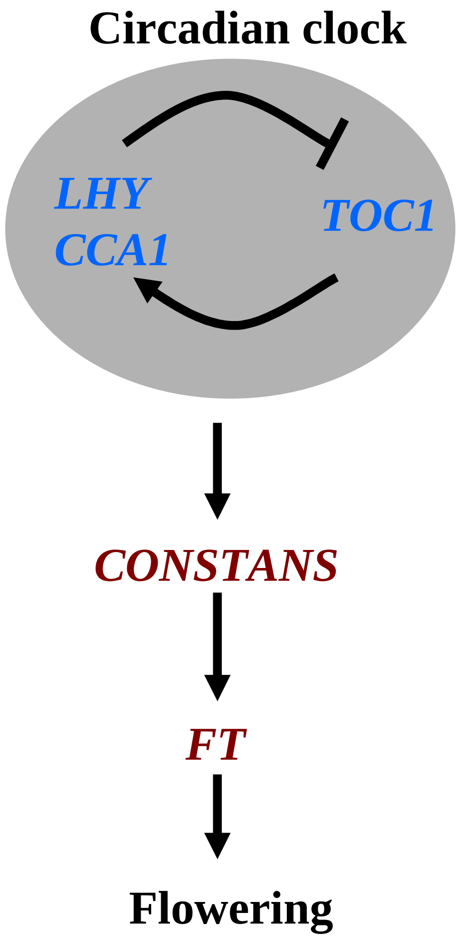
CONSTANS shows a wide expression pattern in the leaf vascular tissue and the meristem



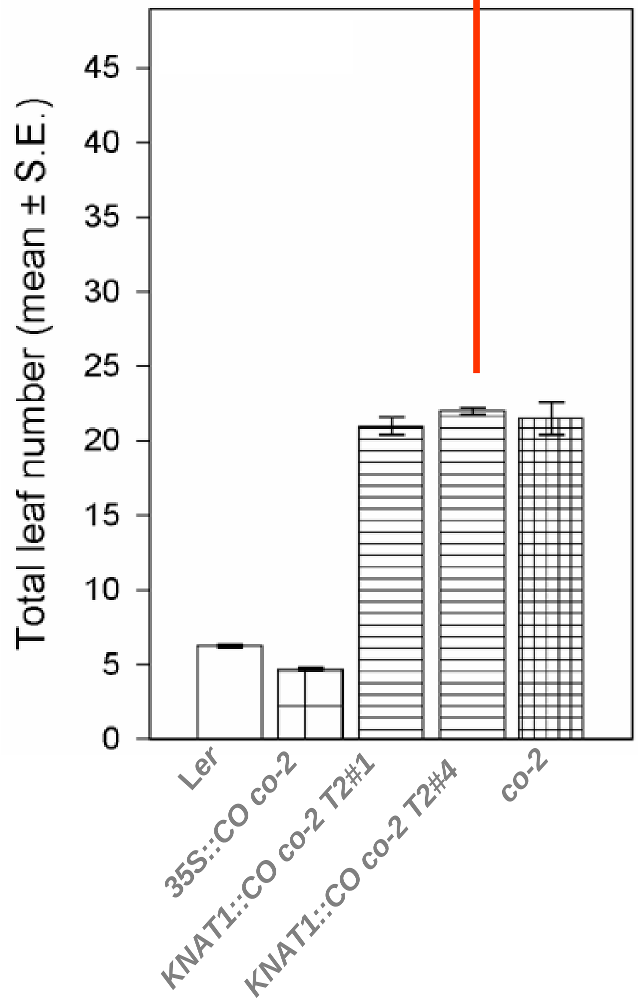


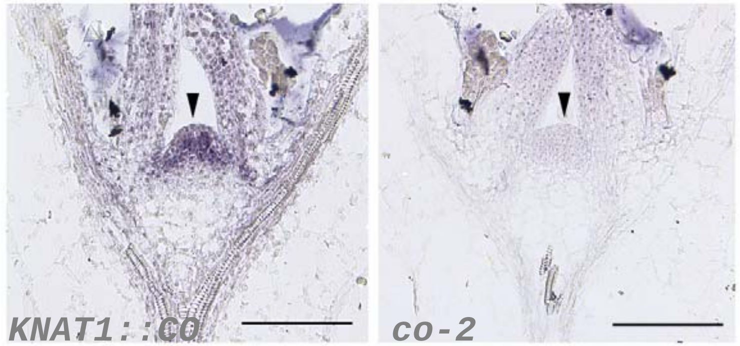
CO mRNA *in situ* hybridisation on an 8-day-old



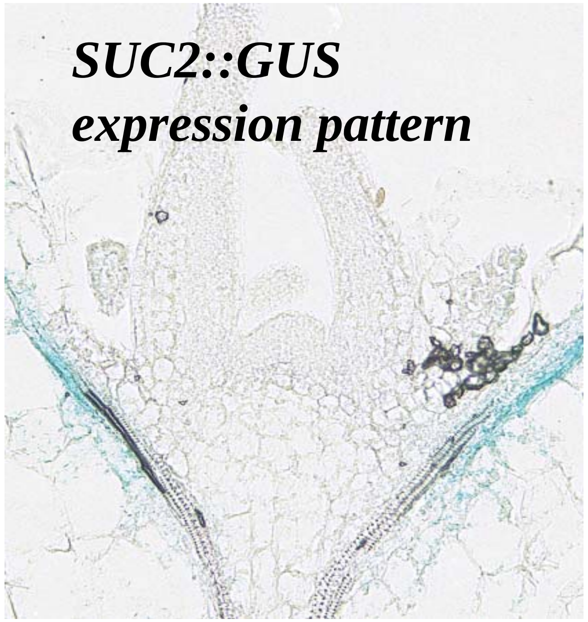


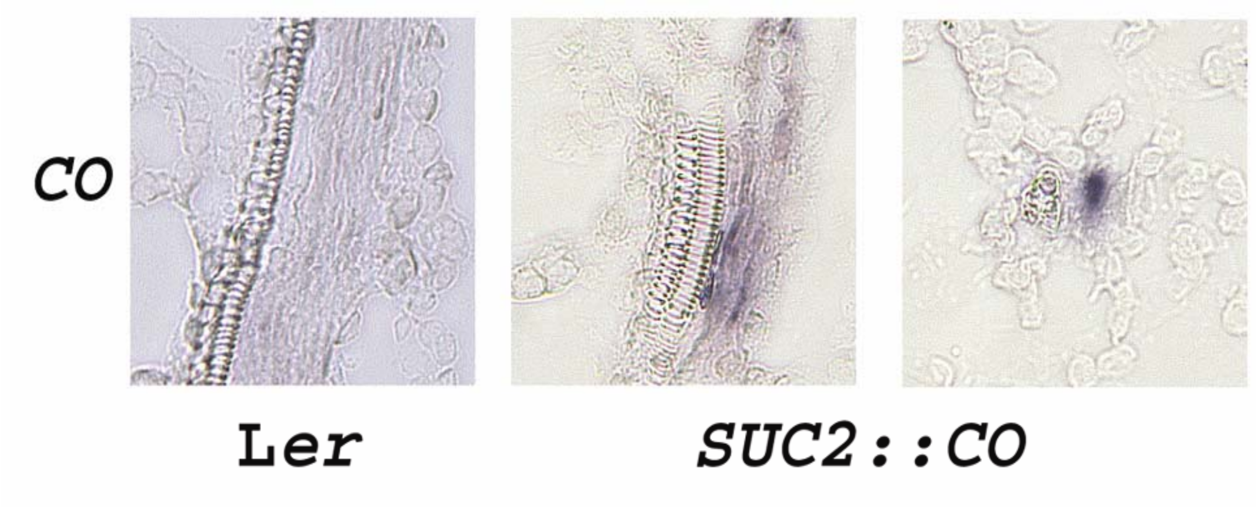
CO does not promote flowering when expressed in the SAM



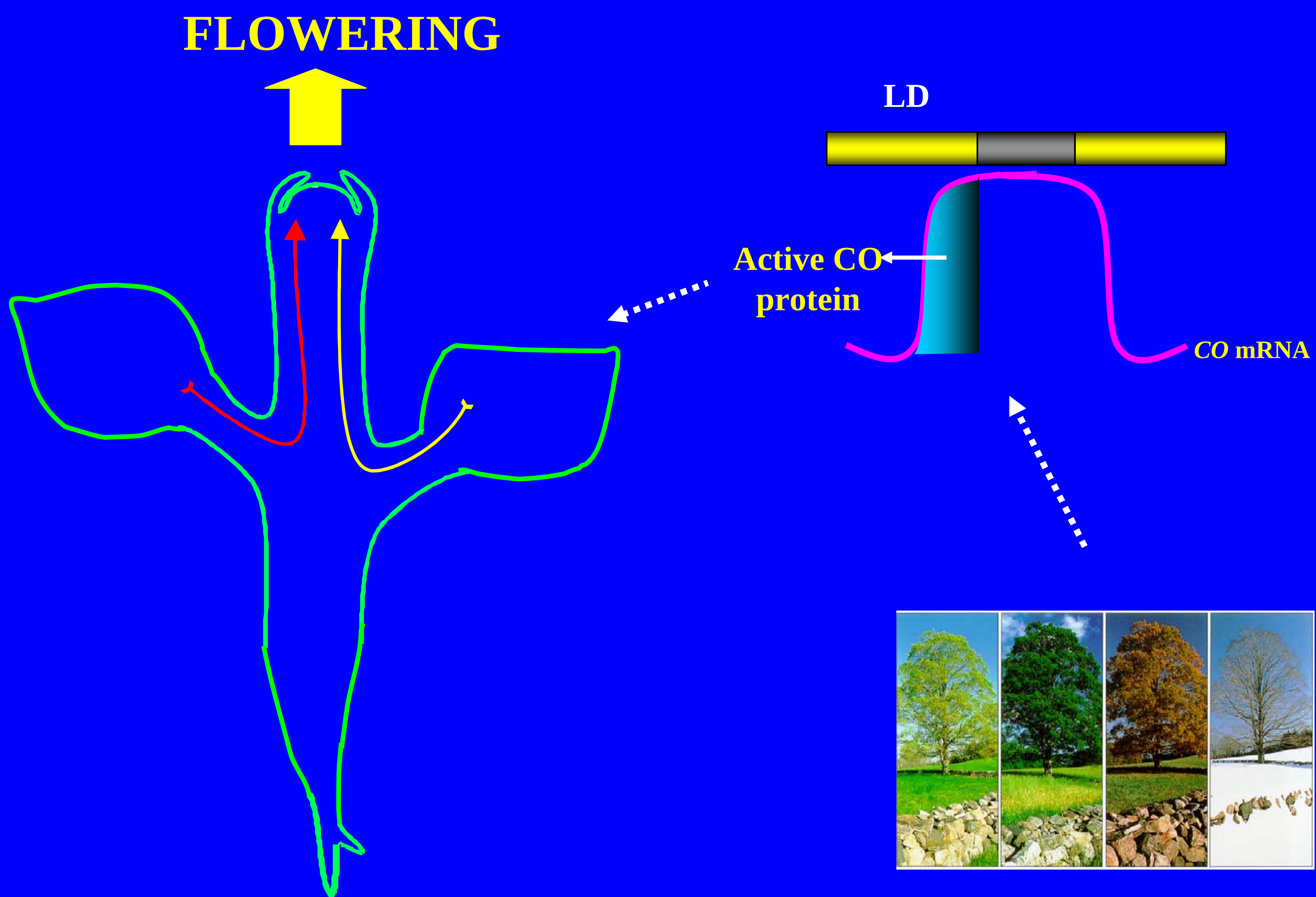


CO acts in the phloem to trigger flowering

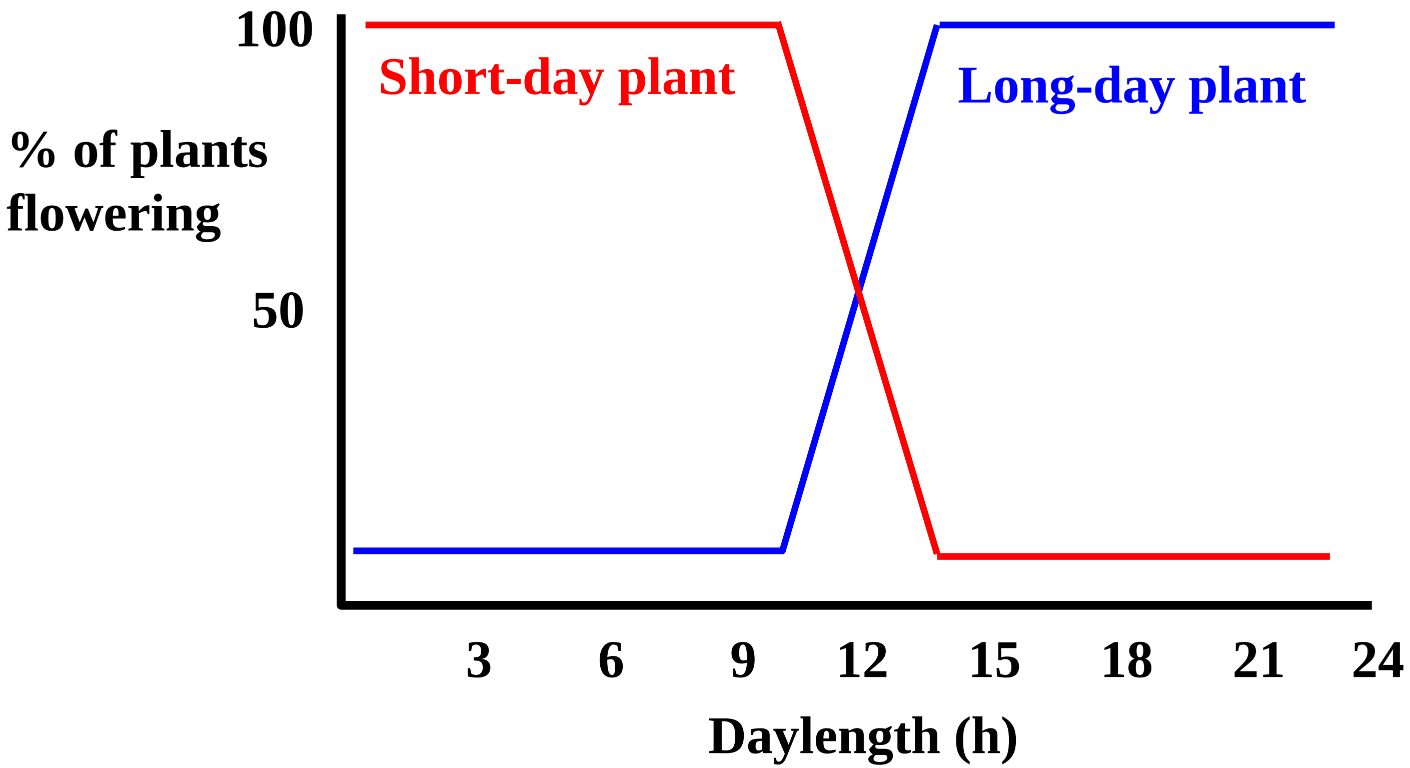


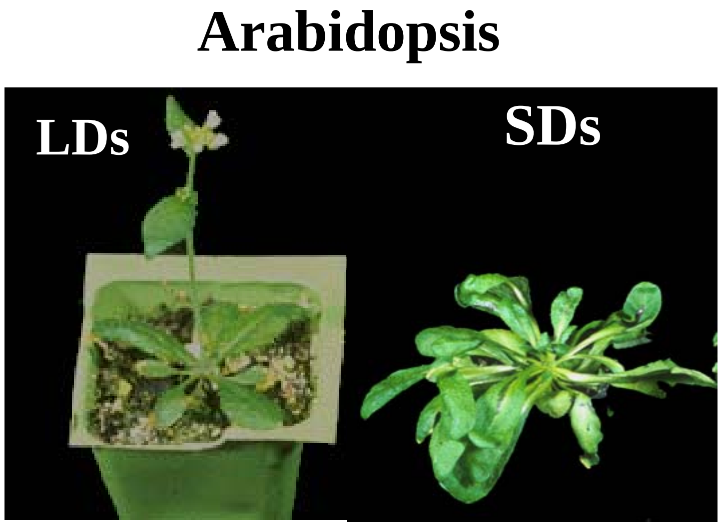


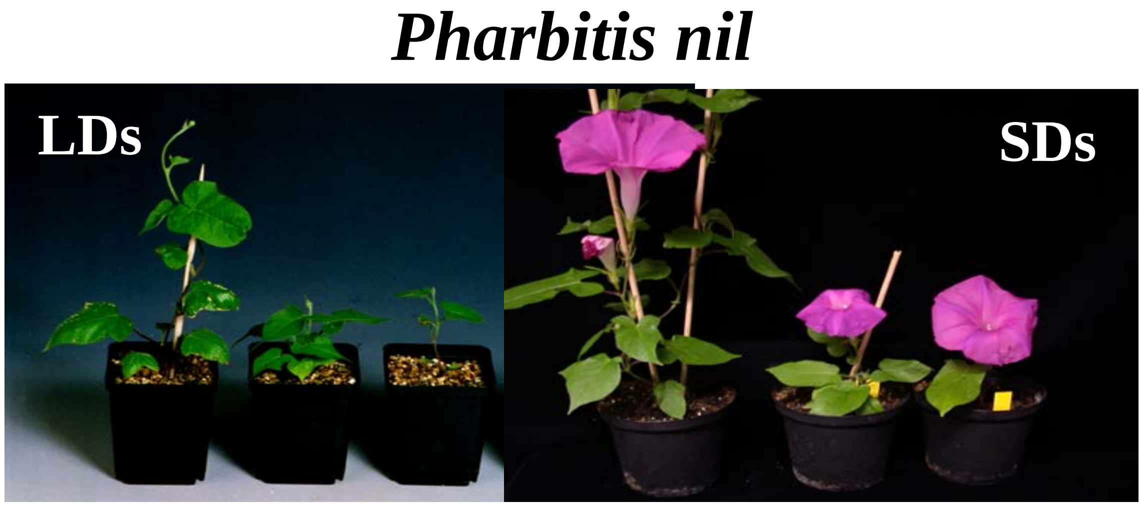
Control of flowering in response to photoperiod in *Arabidopsis thaliana*



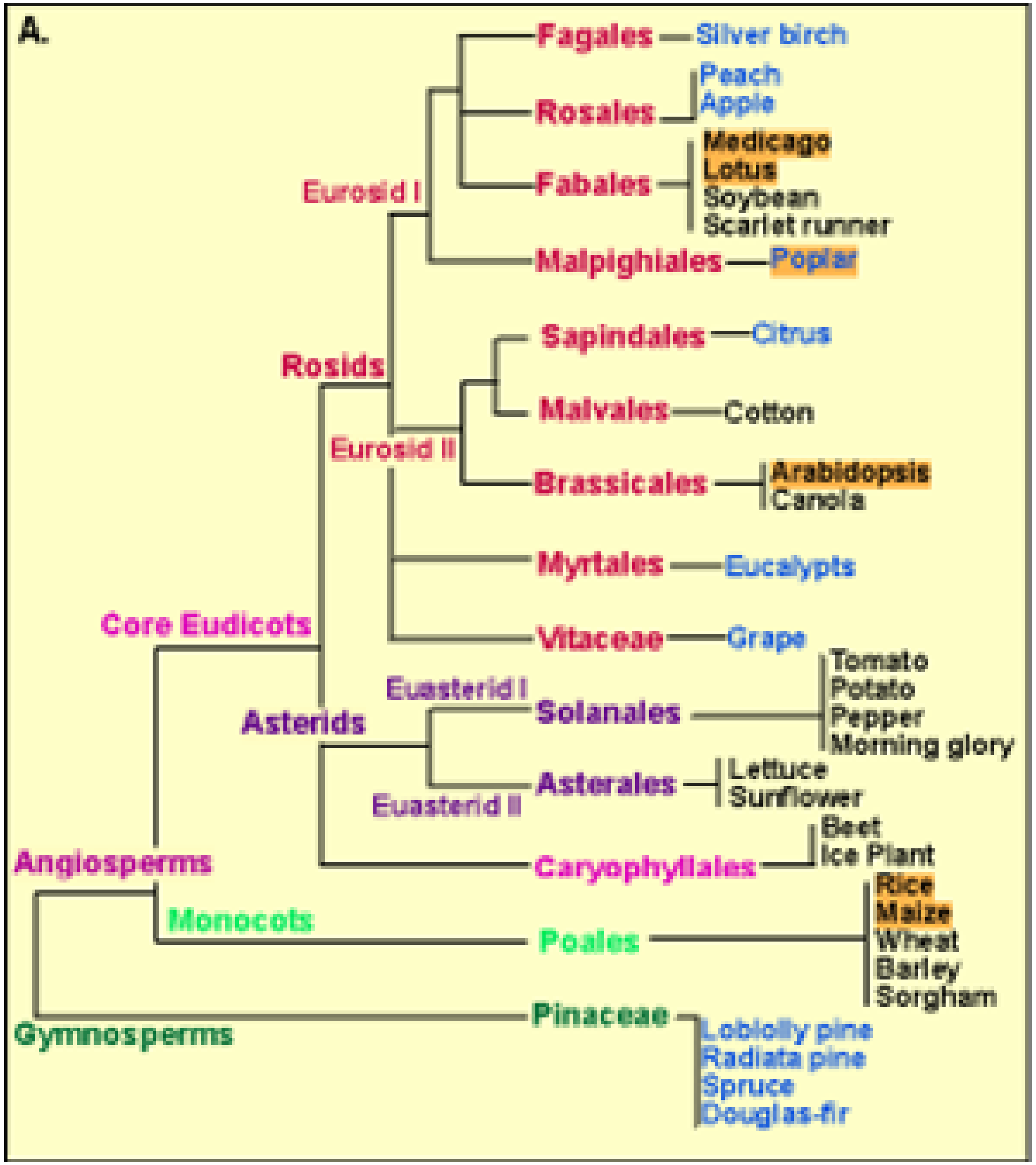
Distinct response types: long and short-day plants



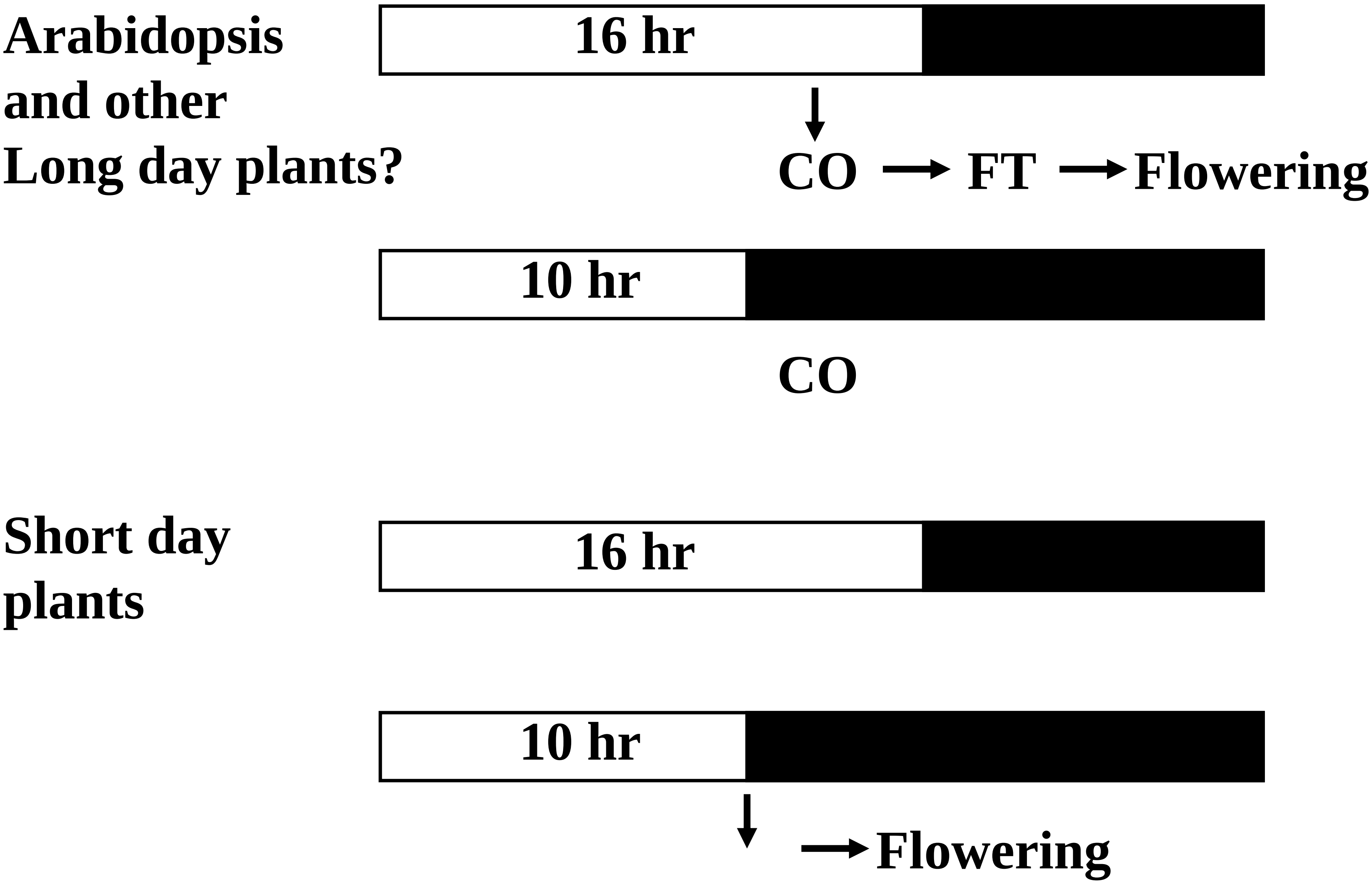




Long-day and short-day responses have evolved independently in different families of flowering plants



Contrasting long and short-day responses

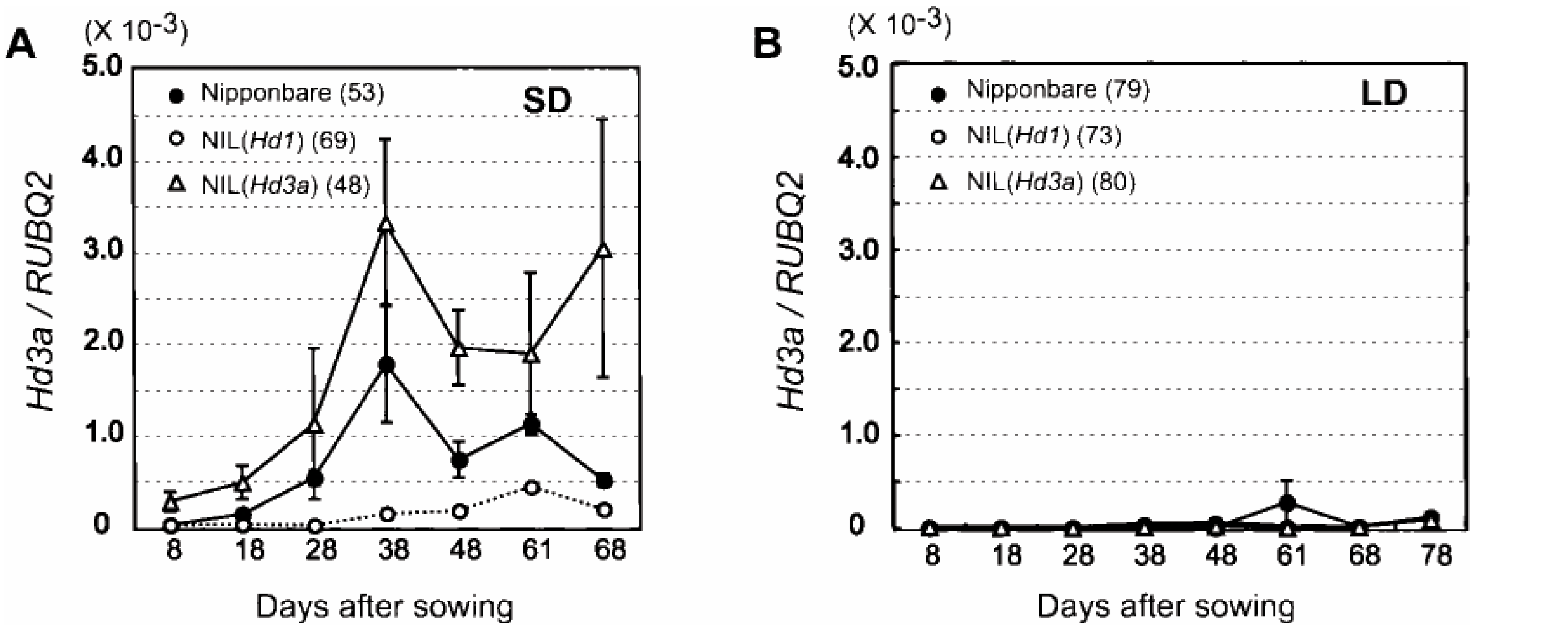


Conservation of sequence and expression pattern of Arabidopsis flowering genes in rice

CO rice orthologue – HEADING DATE 1

FT rice orthologue – HEADING DATE 3

HD3 – expressed in short days, but not long days.
Reversed compared to Arabidopsis



A conserved flowering-time pathway in rice and Arabidopsis confers the opposite effect to day length

Arabidopsis	*Rice*
Long days	Long days
↓	↓
GI	*OsGI*
↓	↓
CO	(*OsCO*) *Hd1*
↓	⊥
FT	(*OsFT*) *Hd3*
Promotion of flowering	Inhibition of flowering

Rice data from:
Hayama et al. (2003)
Nature 422, 719

In rice flowering occurs under short days because CO represses FT under long days