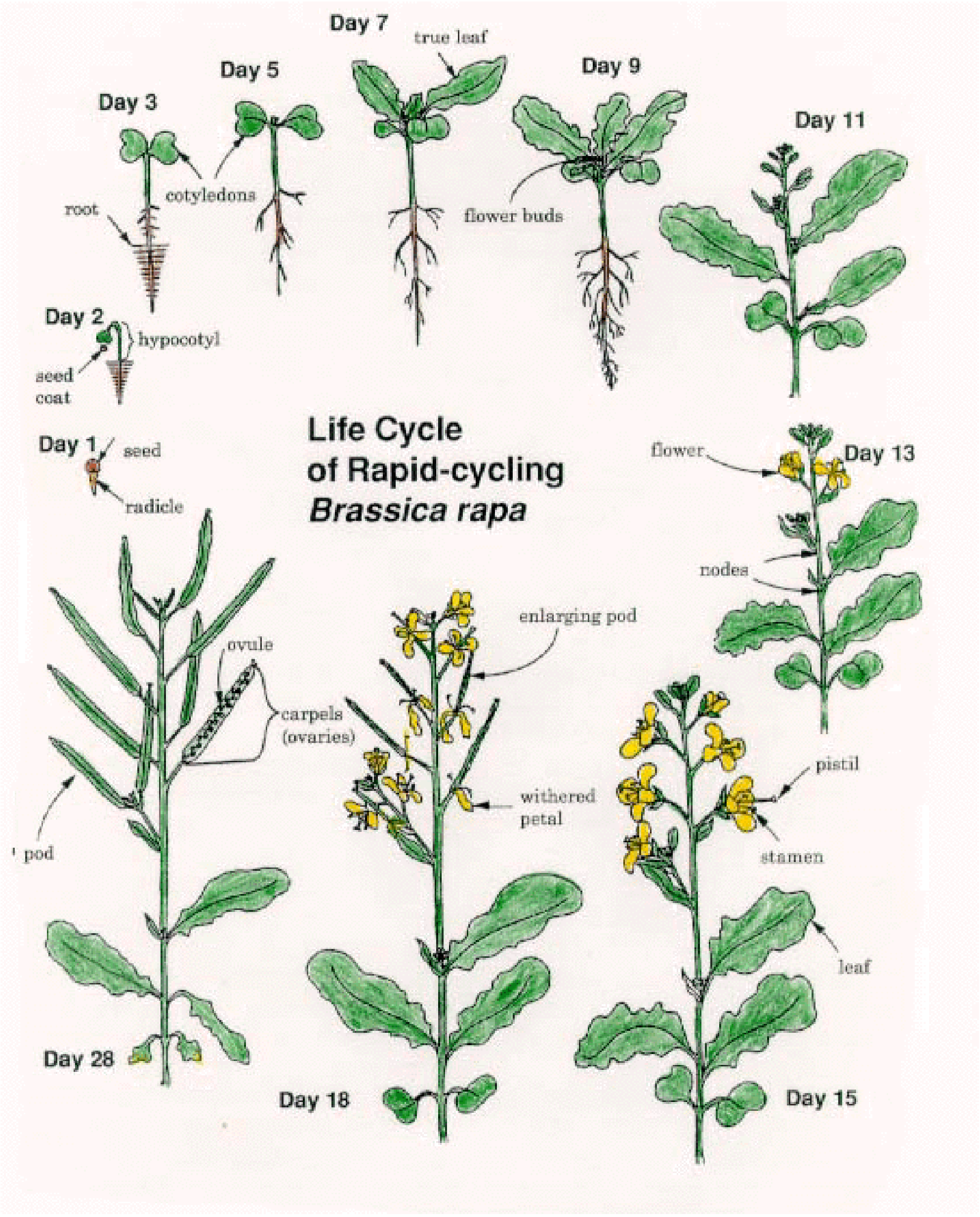
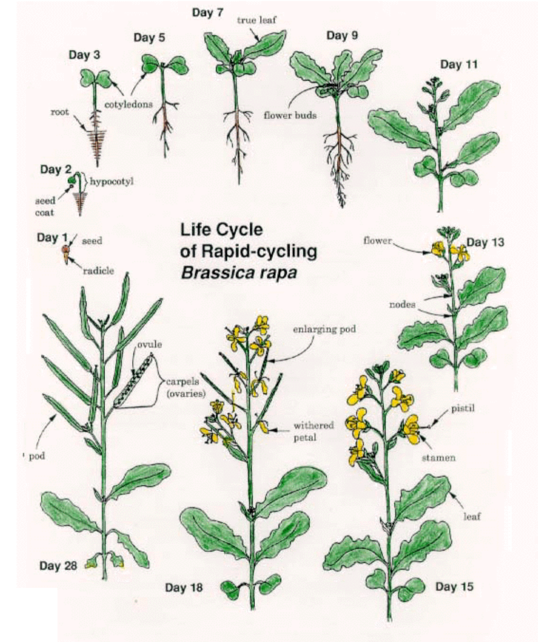
FLORACIÓN



Day 7
true leaf
Day 5
Day 9
Day 3
Day 11
cotyledons
root
flower buds
Day 2
hypocotyl
seed
coat
Life Cycle
of Rapid-cycling
Brassica rapa
Day 1
seed
radicle
flower
Day 13
nodes
enlarging pod
ovule
carpels
(ovaries)
pistil
withered
petal
pod
stamen
leaf
Day 28
Day 18
Day 15

FLORACIÓN … en la dispersión de plantas

FLORACIÓN


Life Cycle
of Rapid-cycling
Brassica rapa
Day 1
seed
radicle
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hypocotyl
seed
coat
Day 3
root
cotyledons
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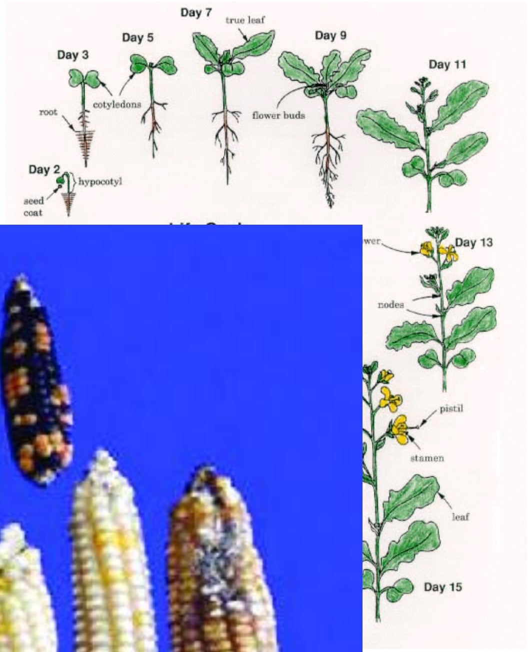
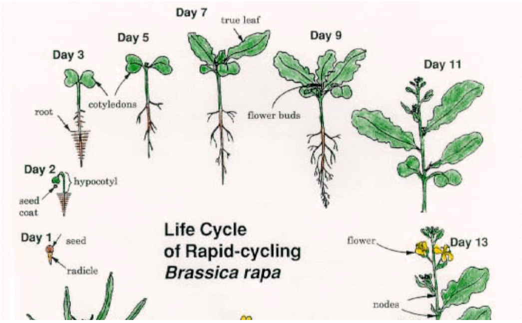
Day 13
flower
nodes
Day 15
pistil
stamen
leaf
Day 18
enlarging pod
withered
petal
Day 28
ovule
carpels
(ovaries)
pod

FLORACIÓN … y diversidad genèrica



FLORACIÓN … fecha òptima de floraciòn



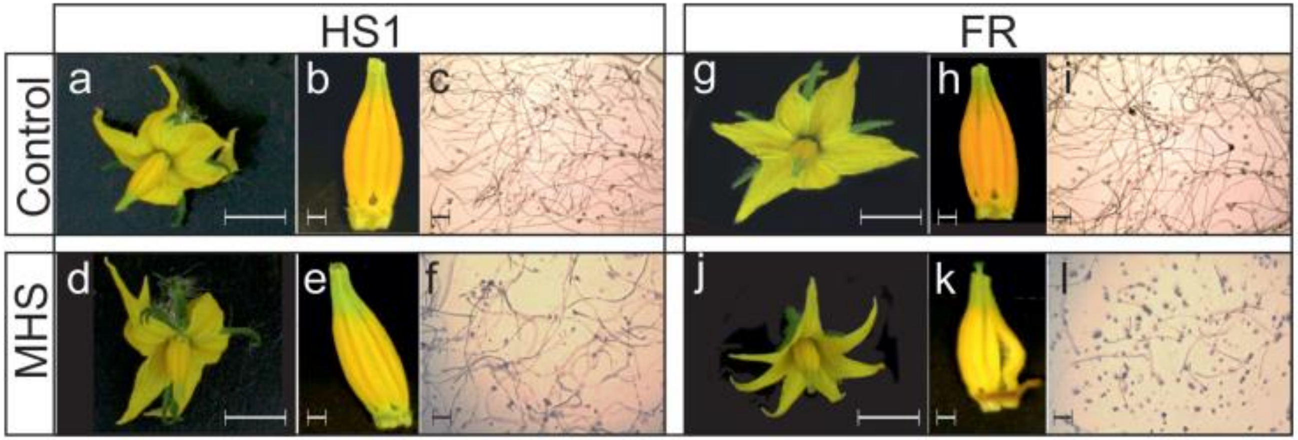
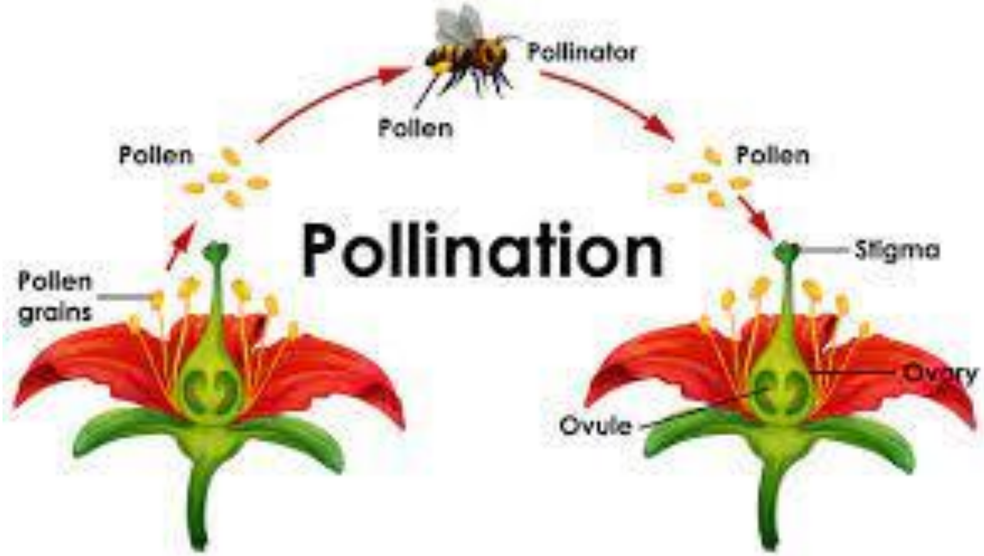
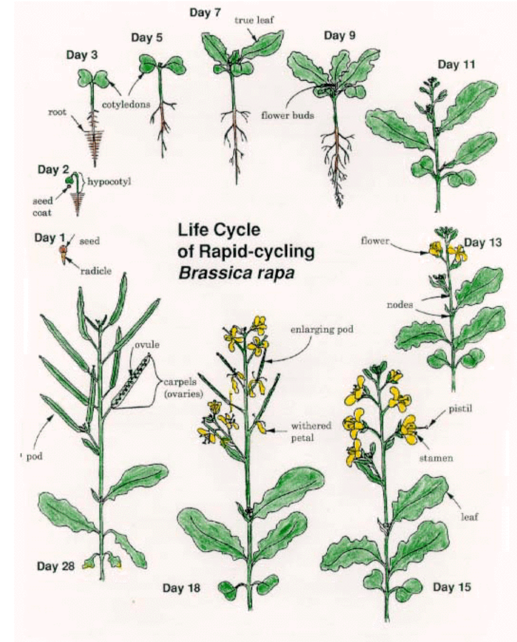
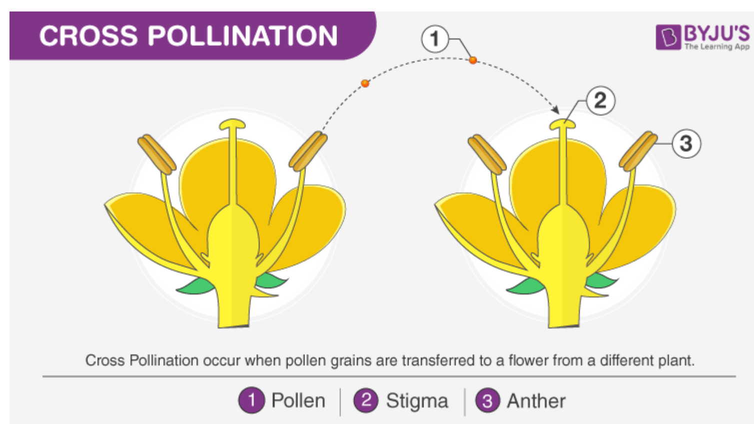


Figure 3 Tomato phenotypes under heat stress. Comparison of flower and anther development under control and MHS conditions (two weeks) in the tolerant genotype HS1 and the sensitive FR. Panels a, d, g, j: whole flowers; panels b, e, h and k: isolated anther cones; panels c, f, i and l: germinating pollen. Size bars represent 10 and 3 mm respectively.

FLORACIÓN … en especies alógamas







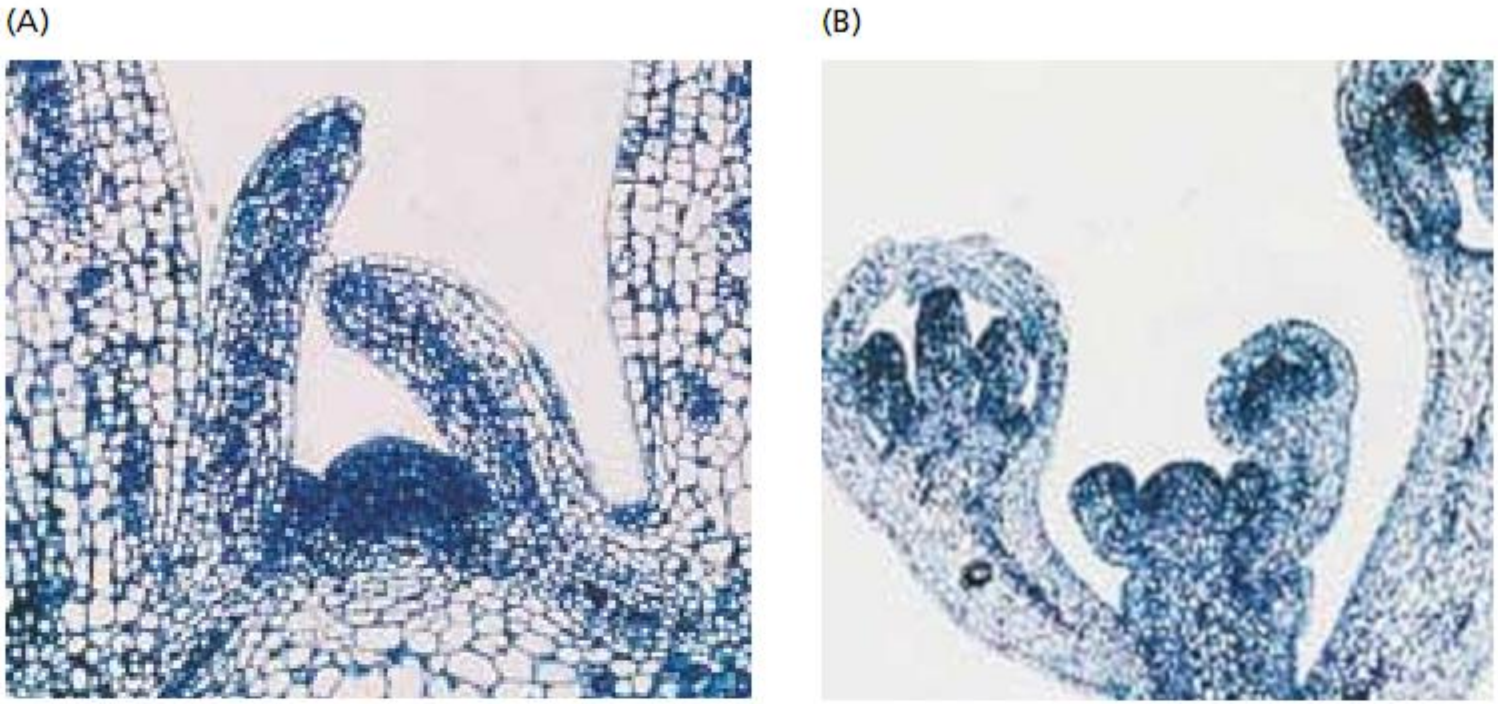


FIGURE 24.2 Longitudinal sections through a vegetative (A) and a reproductive (B) shoot apical region of *Arabidopsis*. (Photos courtesy of V. Grbić and M. Nelson, and assembled and labeled by E. Himelblau.)

Conceptos de desarrollo - FLORACIÓN

✓ **Juvenilidad**

Fotoperiodismo
Medición del fotoperíodo
Aspectos ecológicos
Vernalización
Control de la floración: integración

Juvenilidad

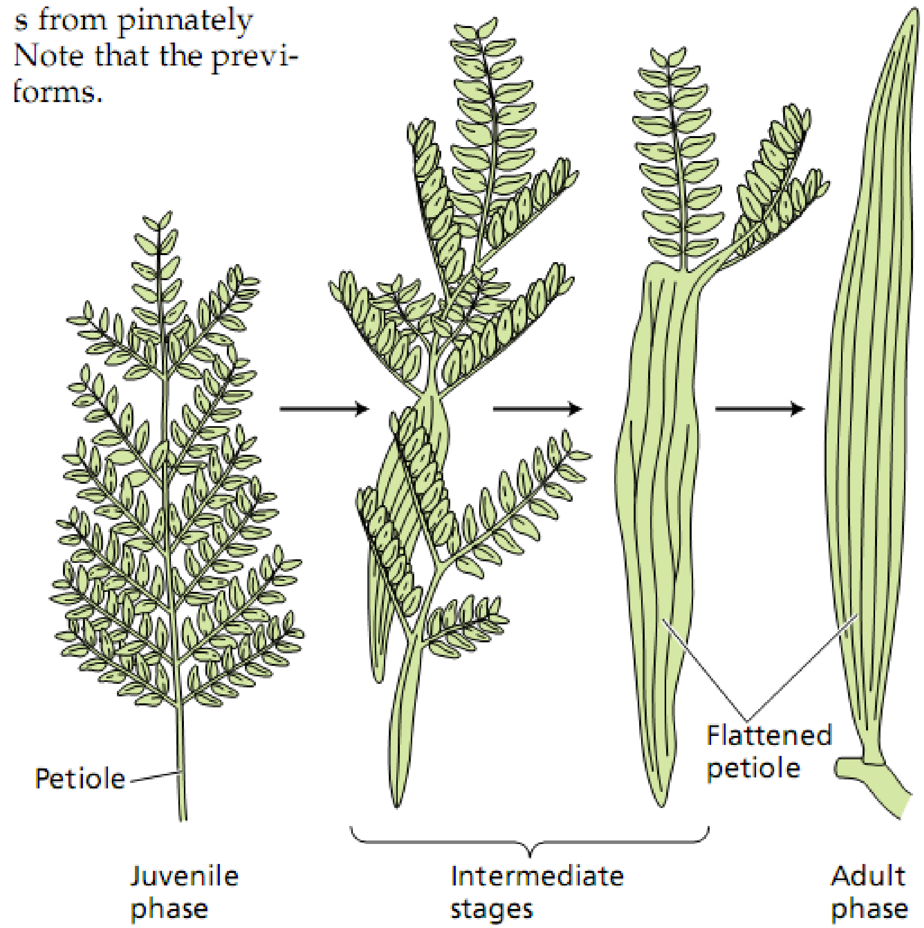
TABLE 24.1
Length of juvenile period in some woody plant species

Species	Length of juvenile period
Rose (*Rosa* [hybrid tea])	20–30 days
Grape (*Vitis* spp.)	1 year
Apple (*Malus* spp.)	4–8 years
Citrus spp.	5–8 years
English ivy (*Hedera helix*)	5–10 years
Redwood (*Sequoia sempervirens*)	5–15 years
Sycamore maple (*Acer pseudoplatanus*)	15–20 years
English oak (*Quercus robur*)	25–30 years
European beech (*Fagus sylvatica*)	30–40 years

Source: Clark 1983.

Juvenilidad

Acacia heterophylla



Juvenilidad

Fig. 1 The transition from juvenile (top left) to adult leaf shape (bottom right) along consecutive nodes of a branch of *Eucalyptus globulus* ssp. *globulus*. The first leaf illustrated grew at ≈1.5 m height. Juvenile leaves are sessile, opposite and glaucous, and grow transversely on quadrangular stems. Adult leaves are petiolate, alternate and shiny green, and are pendulous on cylindrical stems.

Juvenilidad: **heteroblastia y floración son fenómenos independientes**

Table 4 Genetic correlations of reproductive juvenility in *Eucalyptus globulus* ssp. *globulus* in the Massy Greene (MG), West Ridgley open-pollinated (WROP) and Latrobe (LA) trials with vegetative phase change traits in the Massy Greene trial

Stratum	Trial	Height to phase change	Vegetative juvenility
Family within locality	MG	0.00 ± 0.08	0.03 ± 0.09
	WROP	0.16 ± 0.08	0.06 ± 0.10
	LA	0.13 ± 0.08	0.01 ± 0.09

Conceptos de desarrollo - FLORACIÓN

Juvenilidad

✓ **Fotoperiodismo**

Medición del fotoperíodo
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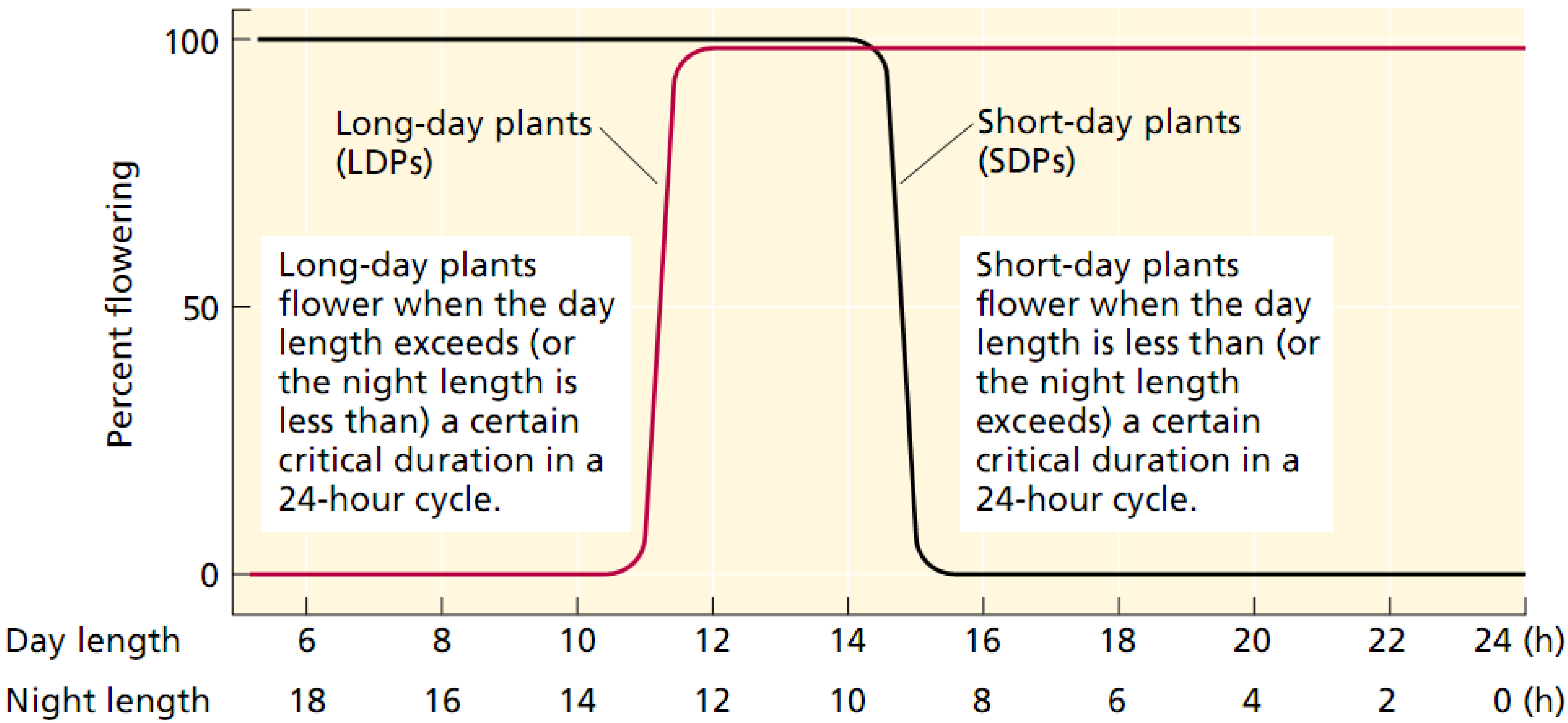
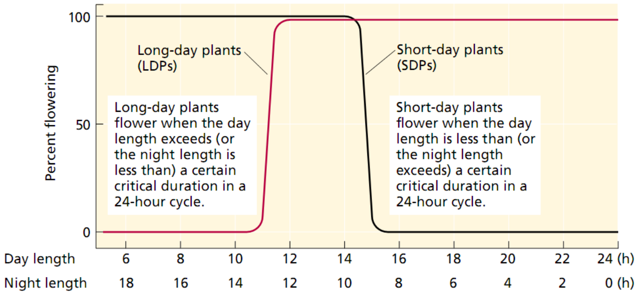


100
50
0
Percent flowering
Long-day plants
(LDPs)
Short-day plants
(SDPs)
Long-day plants flower when the day length exceeds (or the night length is less than) a certain critical duration in a 24-hour cycle.
Short-day plants flower when the day length is less than (or the night length exceeds) a certain critical duration in a 24-hour cycle.
Day length
6
8
10
12
14
16
18
20
22
24 (h)
Night length
18
16
14
12
10
8
6
4
2
0 (h)



Requerimientos:

- Cualitativos
- Cuantitativos

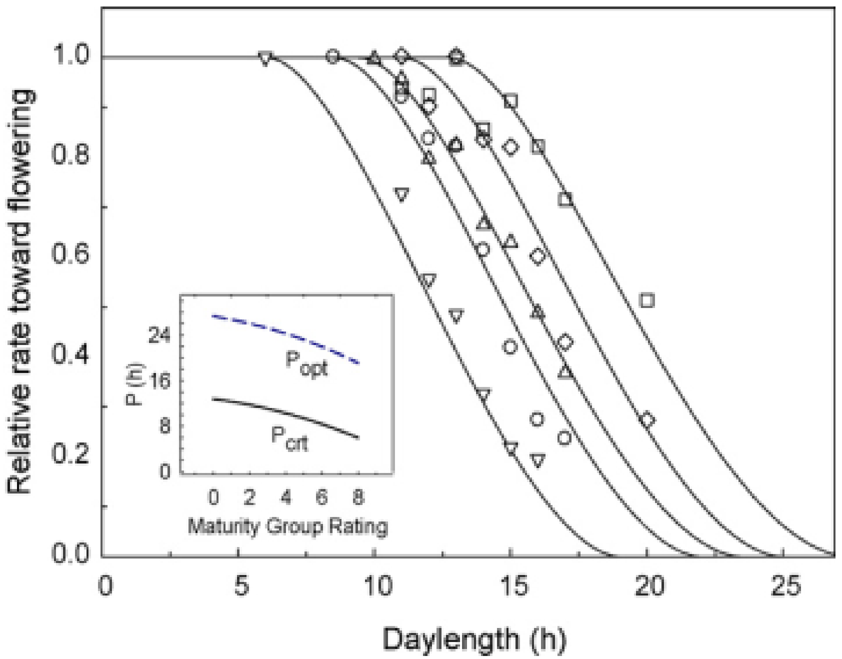


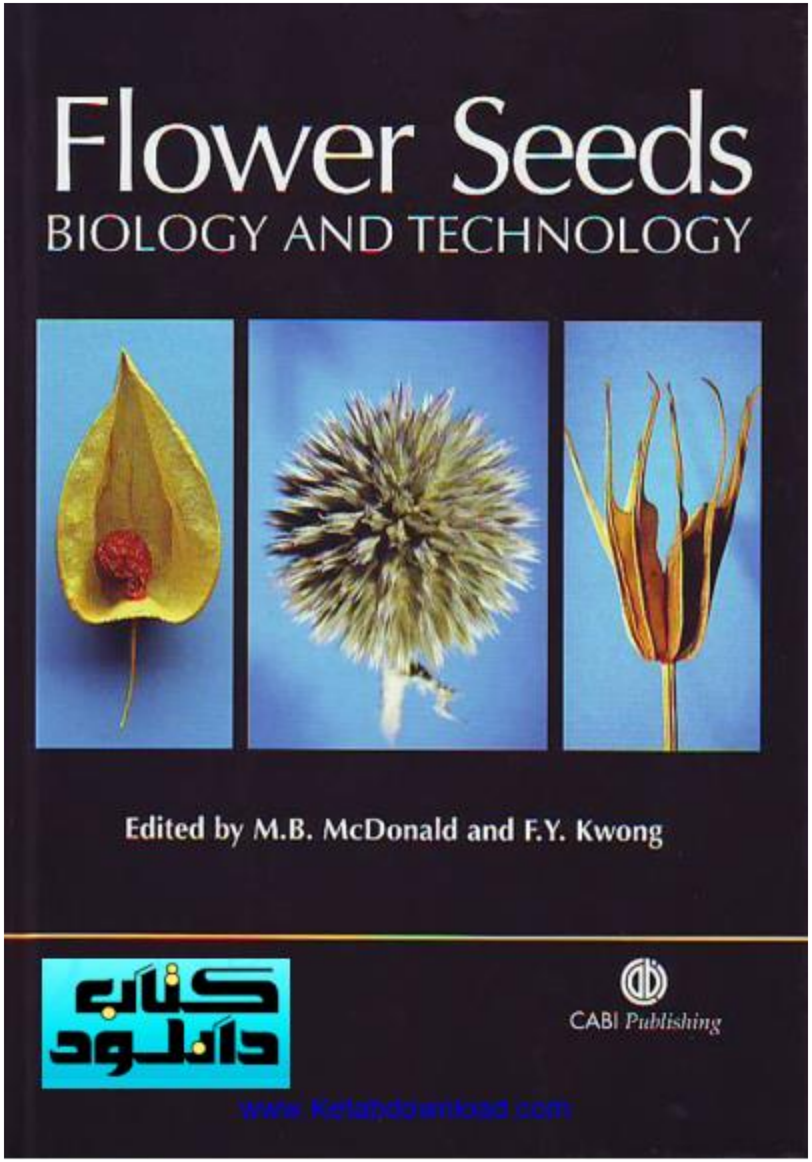
Fig. 4. Simulated and observed photoperiod response of the development rate toward flowering: (□), (◇), (△), (○), and (▽), indicate observed data from Cregan and Hartwig (1984) for MG 0, 3, 5, 6, and 8, respectively. Lines indicate simulated rate toward flowering for each of the maturity group ratings (MG) using beta function derived from Yin et al. (1995). Simulation is based on generalized parameters shown in the insert, where P_{opt} (optimum day-length) = 12.759 − 0.388 MG − 0.058 MG^2, and P_{crt} (critical day-length) = 27.275 − 0.493 MG − 0.066 MG^2.

The chart below may help you in selecting when to plant your particular crop:

Long Day Plants		Short Day Plants	Day Neutral Plants
artichoke	lettuce	black-eyed peas	apples
barley	oats	blueberries	apricots
beets	onions	cotton	Brussels sprouts
carrots	peas	mung beans	cabbage
cilantro	potatoes	raspberries	corn
clover	radishes	rice	cucumbers
dill	rye grass	soy beans	kale
fennel	spinach	sugar cane	peaches
flax	turnips	sweet potatoes	pears
lentil	wheat		tomatoes

Table 6.4. Photoperiodic and irradiance classifications are based on mean leaf nu open flower. Data presented below were primarily from the following references: Arn and Wilkins, 1999; Erwin and Warner, 2002; Motum and Goodwin, 1987a,b; Nordwi and Erwin 2004/5; Seeley, 1985; and Zanin and Erwin, 2003). Photoperiod classifica (facultative short-day plant); FLDP (facultative long-day plant); OSDP (obligate short (obligate long-day plant); DNP (day neutral plant). Irradiance classifications: 'FI' (fac response: supplemental irradiance hastened induction developmentally); 'II' (irradian response; increasing irradiance did not hasten flowering developmentally) (Erwin an Mattson and Erwin, 2003a,b). A question mark identifies an uncertain photoperiodic

Species	Photoperiod
Ageratum houstonianum L. 'Blue Danube'	FLDP
Alcea rosea	?LDP
Amaranthus hybridus L. 'Pygmy Torch'	DNP
Ammi majus L.	OLDP
Anethum graveolens L. 'Mammoth'	OLDP
Anigozanthos flavidus	FLDP
Anigozanthos manglesii	FSDP
Anigozanthos pulcherrimus Hook.	DNP
Anigozanthos rufus Labill.	DNP
Anisodontea × hypomandarum K. Presl.	FLDP
Antirrhinum majus L.	FLDP
Asclepias curassavica L.	DNP
Asclepias tuberosa L.	OLDP
Asperula arvensis L. 'Blue Mist'	OLDP
Begonia × hiemalis Fotsch	O/FSDP
Begonia tuberhybrida	OLDP
Begonia semperflorens	DNP
Bougainvillea spp.	FSDP
Calceolaria herbeohybrida	FLDP



6 Factors Affecting Flowering in Ornamental Plants

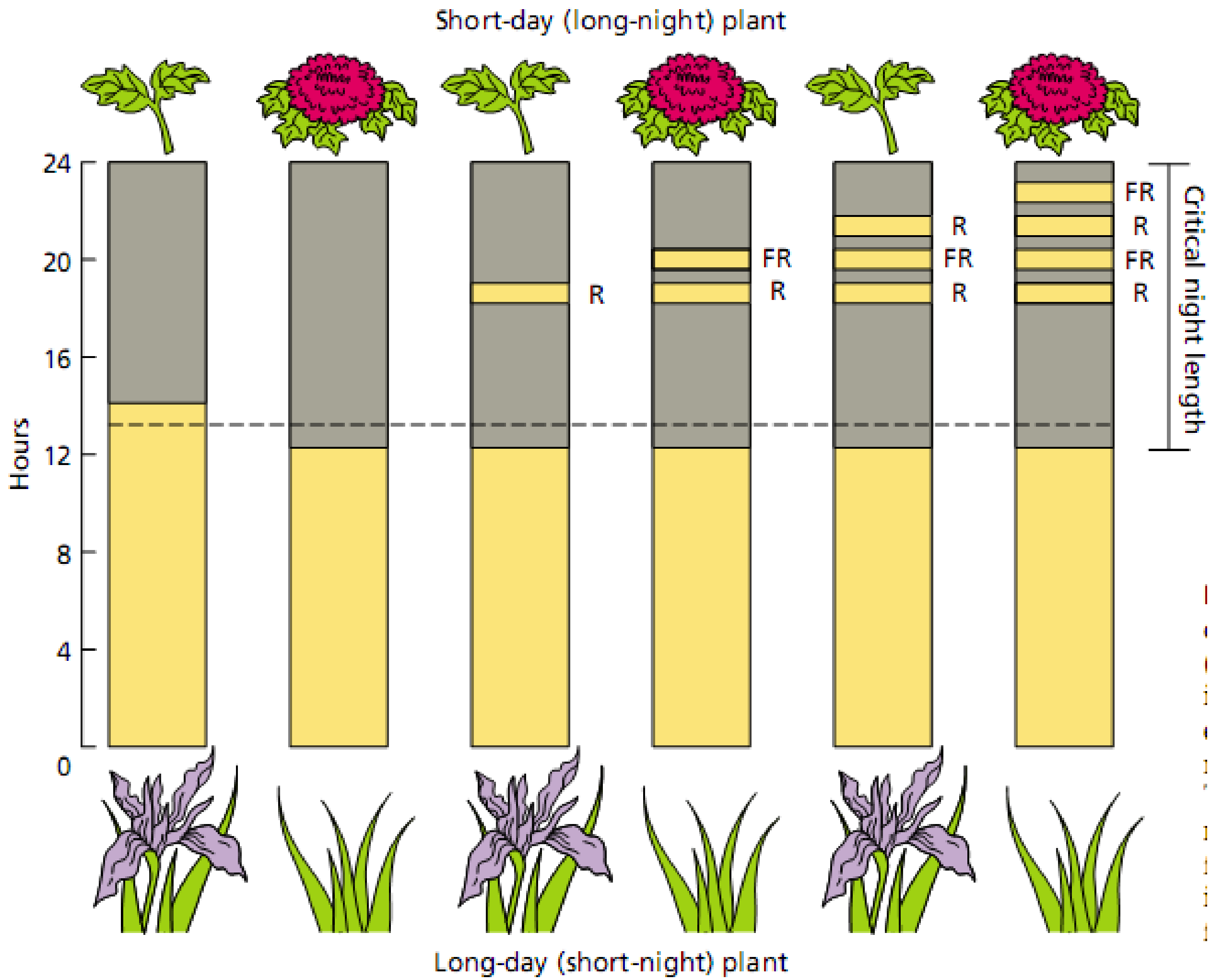
John Erwin
Department of Horticultural Science, University of Minnesota, 1970 Folwell Avenue, St Paul, MN 55108, USA

Conceptos de desarrollo - FLORACIÓN

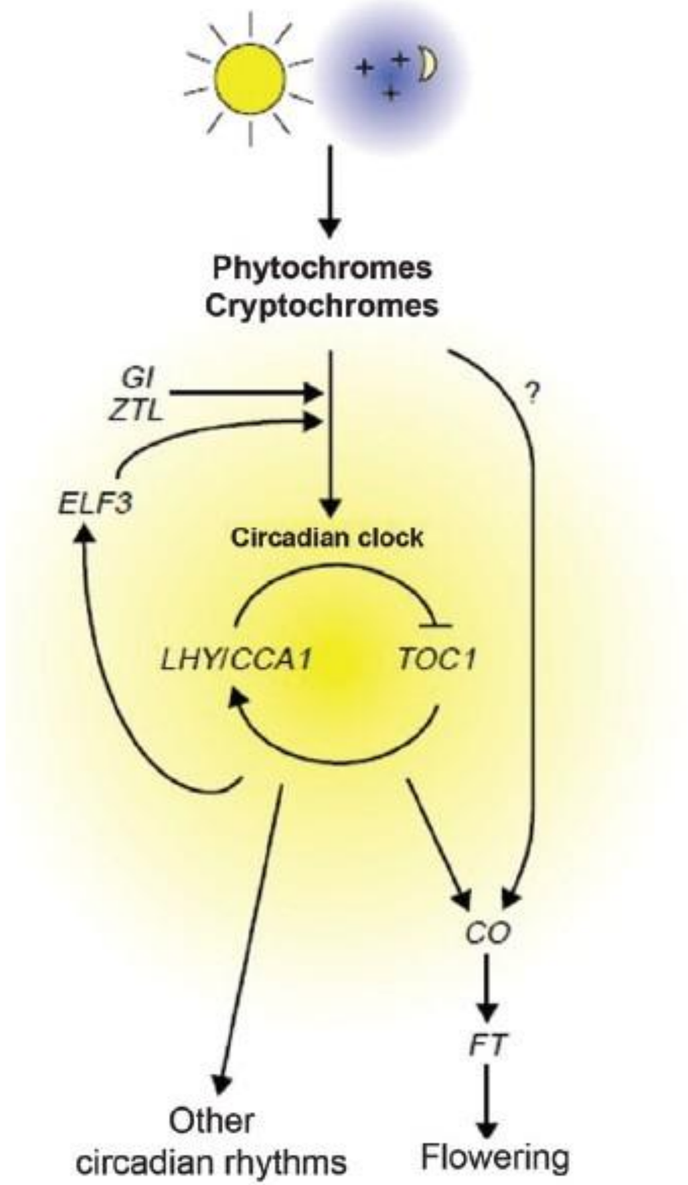
Juvenilidad
Fotoperiodismo

✓ **Medición del fotoperíodo**

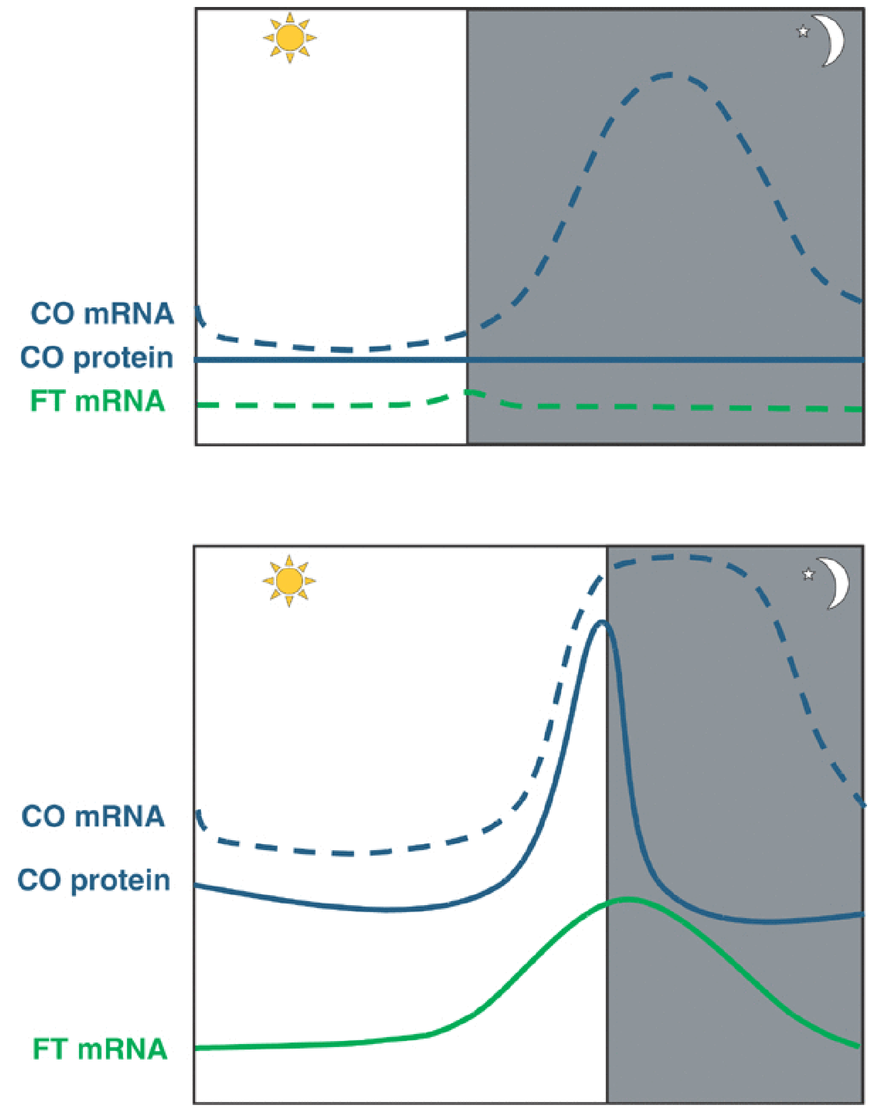
Aspectos ecológicos
Vernalización
Control de la floración: integración

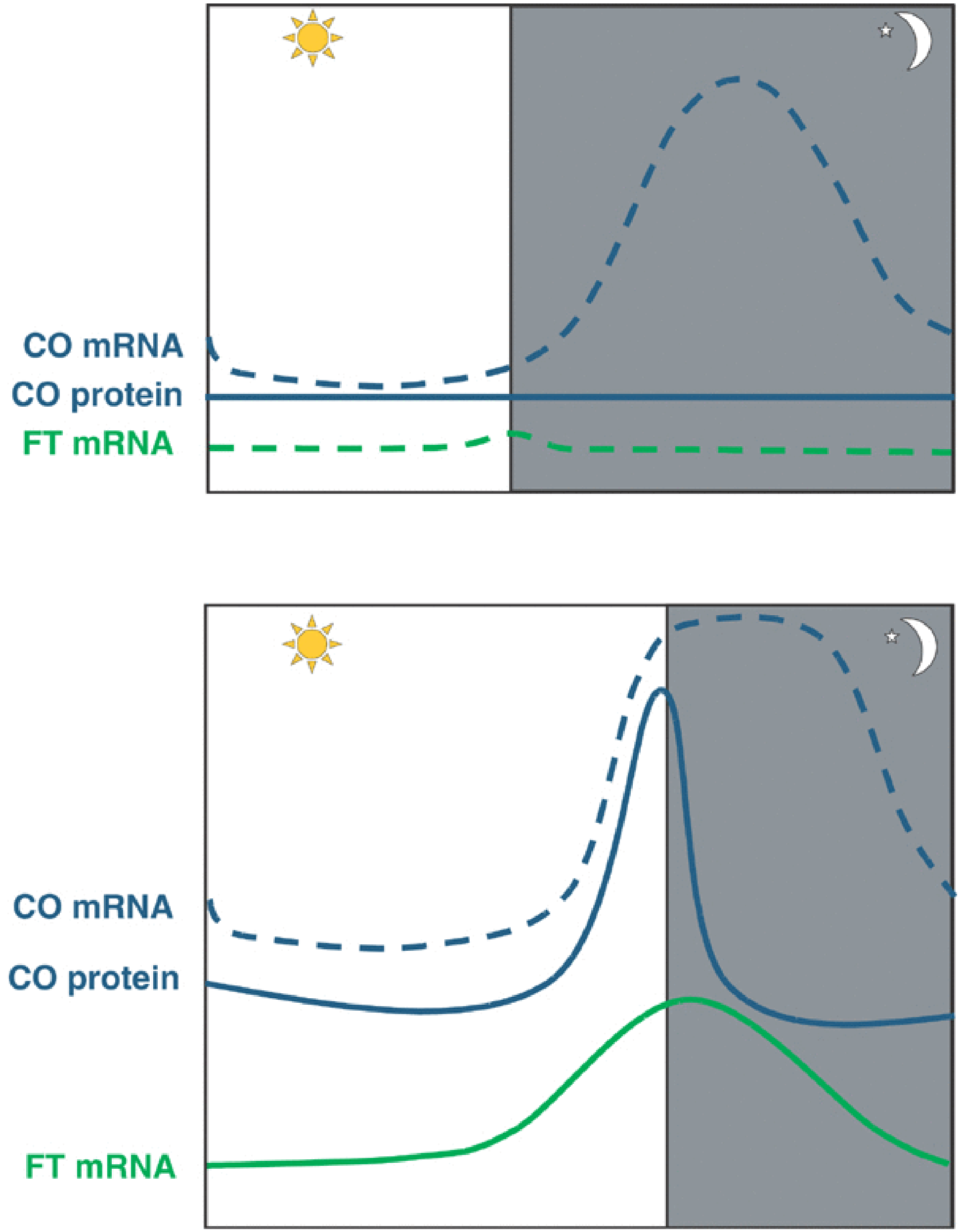


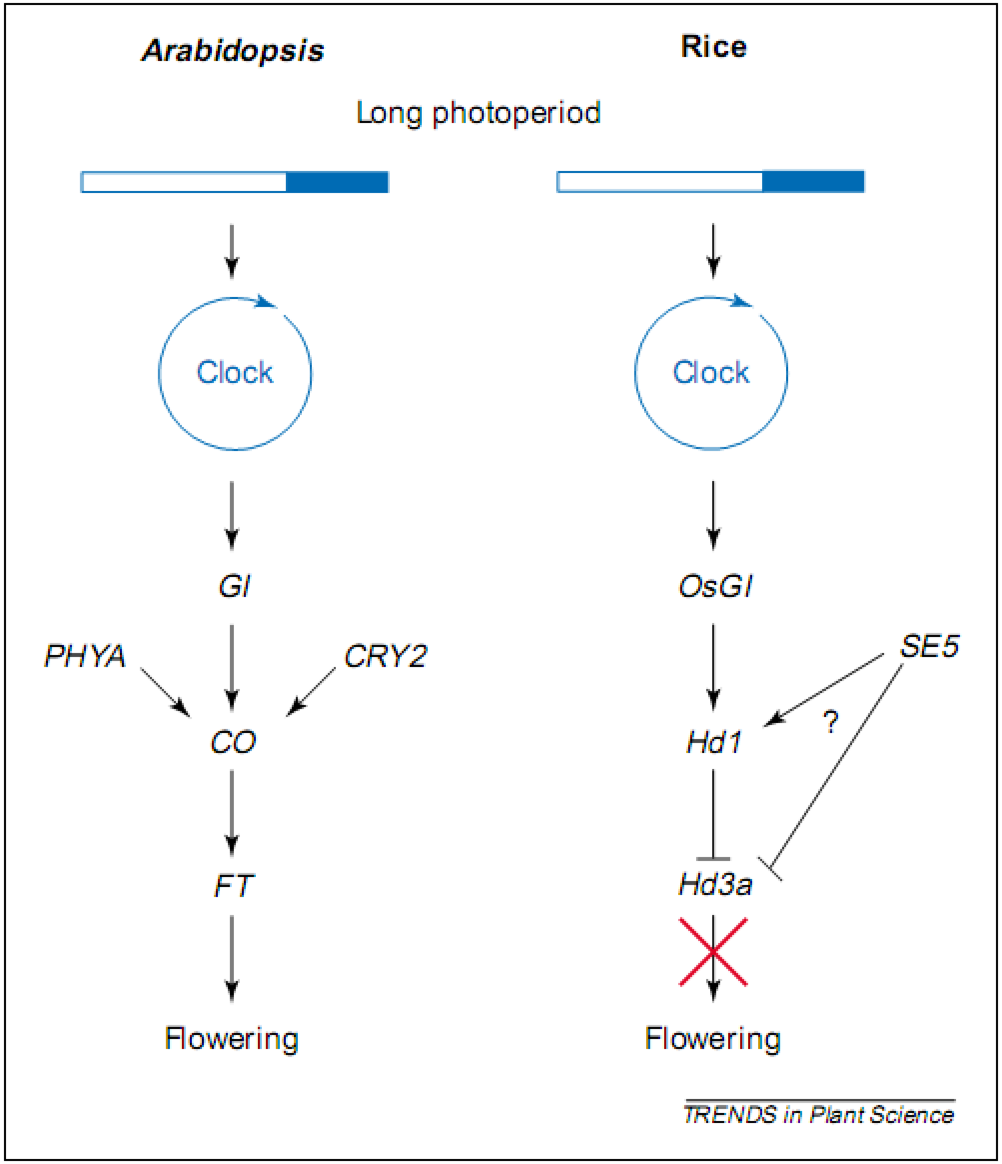
Short-day (long-night) plant
24
20
16
12
8
4
0
Hours
R
FR
R
R
FR
R
FR
R
FR
R
Critical night length
Long-day (short-night) plant



Current Opinion in Plant Biology




CO mRNA
CO protein
FT mRNA
CO mRNA
CO protein
FT mRNA



Arabidopsis
Rice
Long photoperiod
Clock
Clock
GI
OsGI
PHYA
CRY2
SE5
CO
Hd1
?
FT
Hd3a
Flowering
Flowering
TRENDS in Plant Science

Conceptos de desarrollo – FLORACIÓN

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Medición del fotoperíodo

✓ **Aspectos ecológicos**

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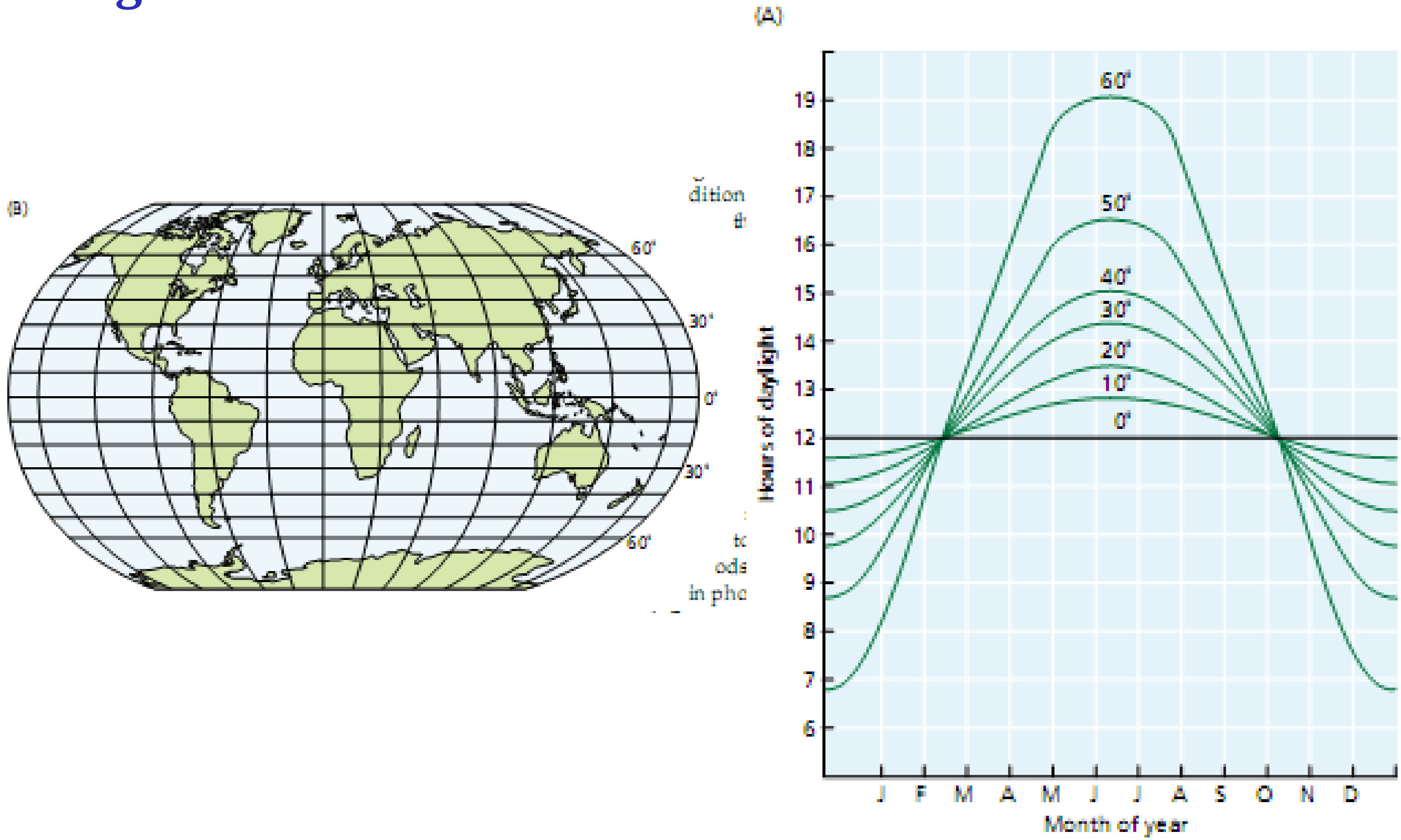
Variación anual del fotoperíodo según la latitud:



Distribución latitudinal de la soja:

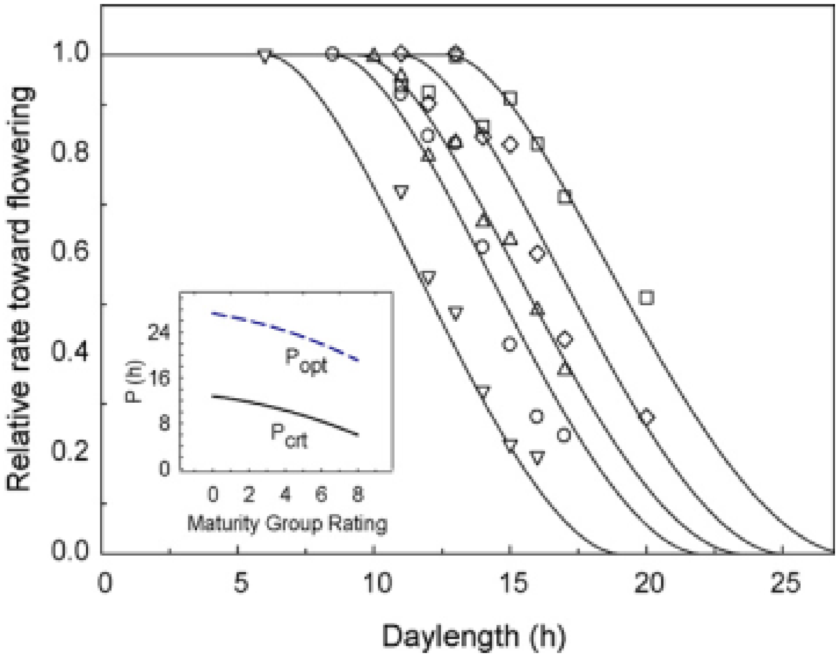
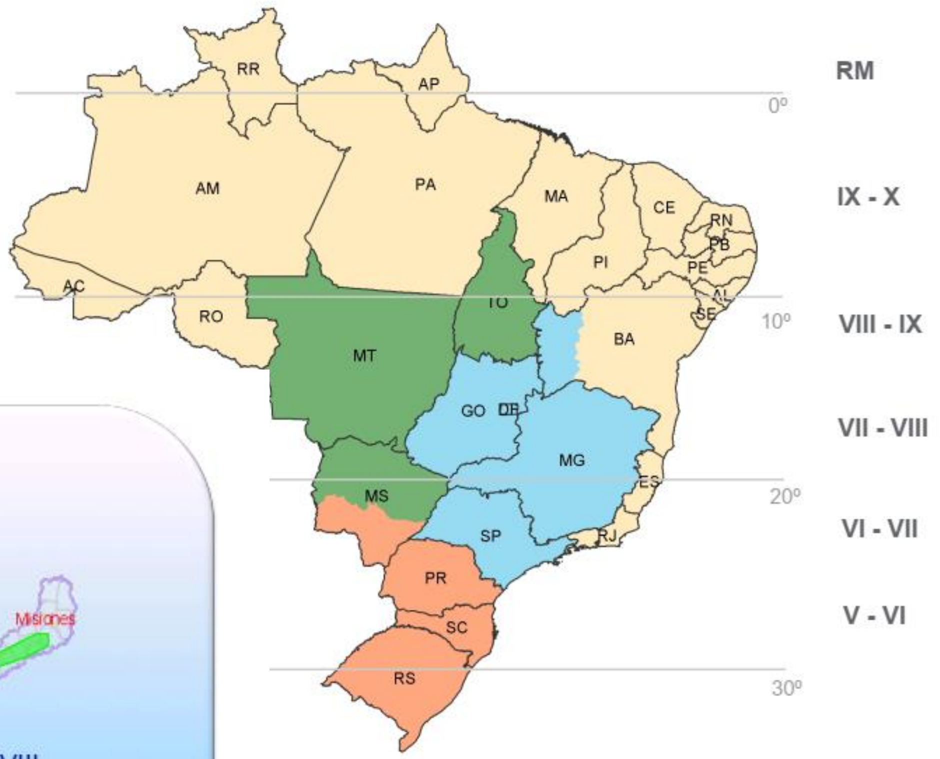
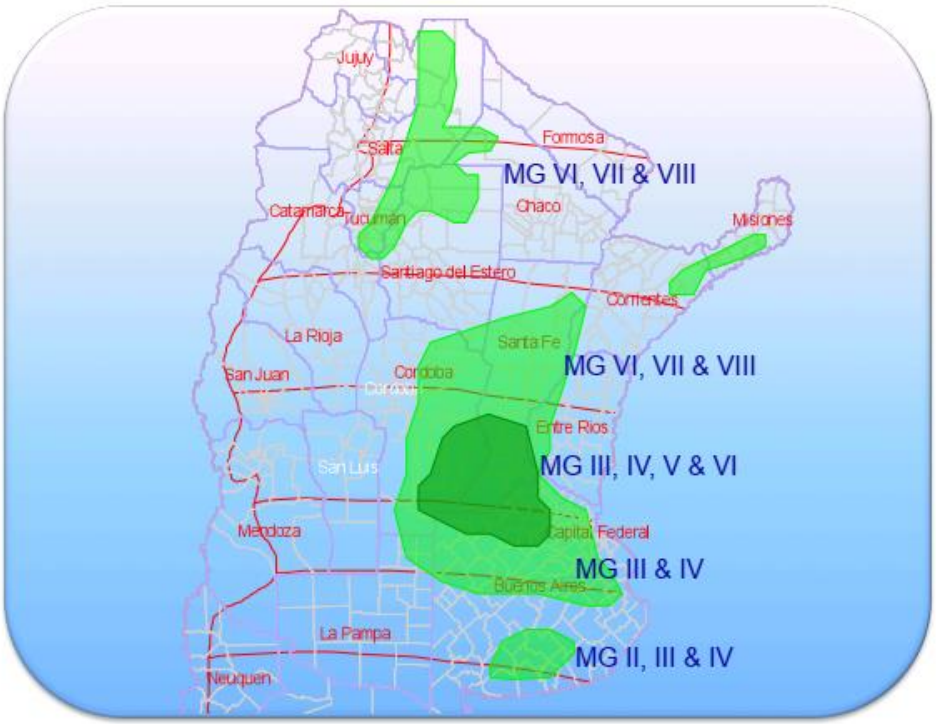


Fig. 4. Simulated and observed photoperiod response of the development rate toward flowering: (□), (◇), (△), (○), and (▽), indicate observed data from Cregan and Hartwig (1984) for MG 0, 3, 5, 6, and 8, respectively. Lines indicate simulated rate toward flowering for each of the maturity group ratings (MG) using beta function derived from Yin et al. (1995). Simulation is based on generalized parameters shown in the insert, where P_{opt} (optimum daylength) = 12.759 – 0.388 MG – 0.058 MG^2, and P_{crt} (critical daylength) = 27.275 – 0.493 MG – 0.066 MG^2.

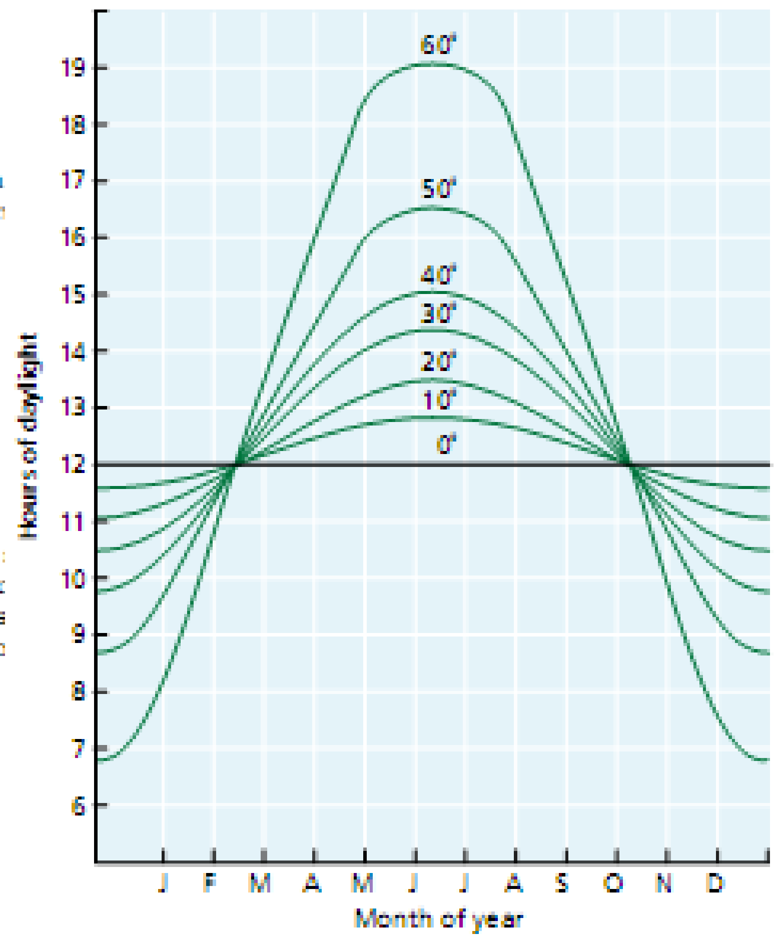
Distribución latitudinal de la soja:



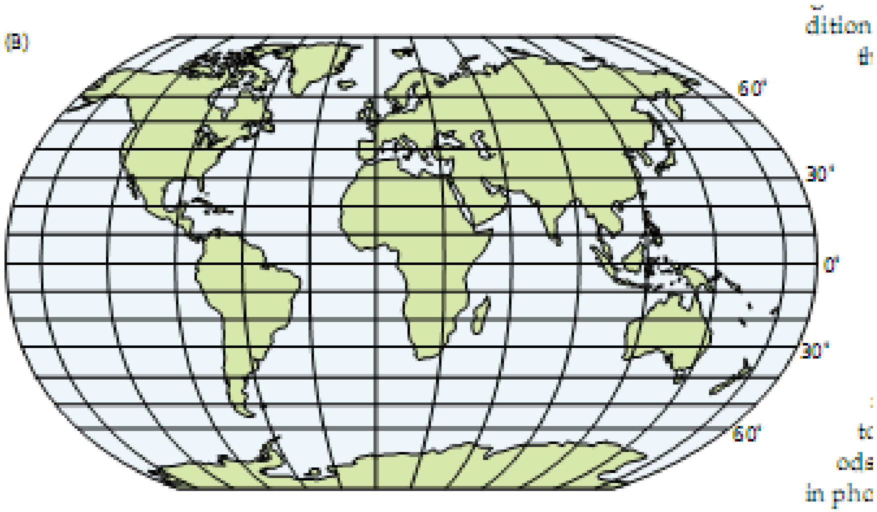


Variación anual del fotoperíodo según la latitud:

(A)



(B)



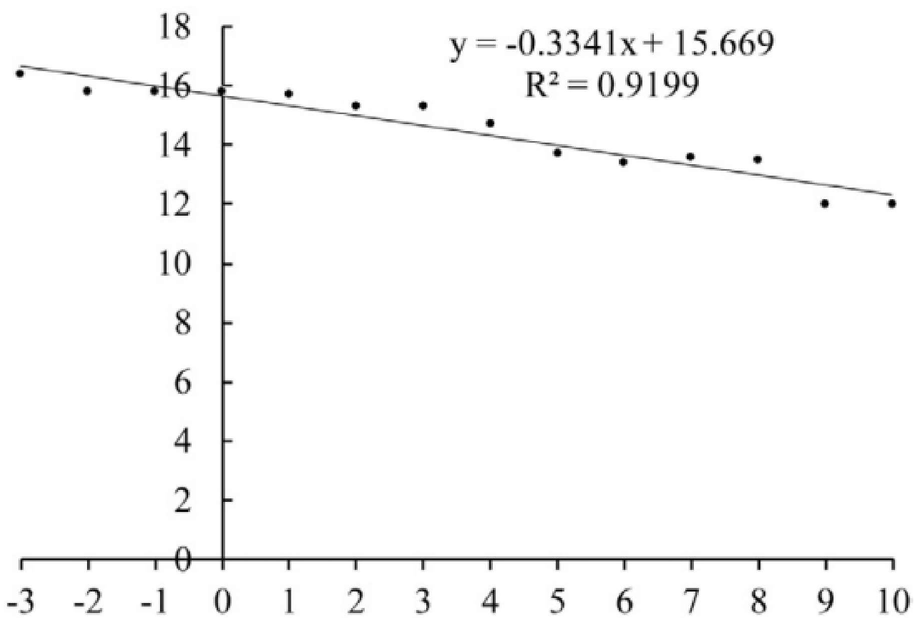
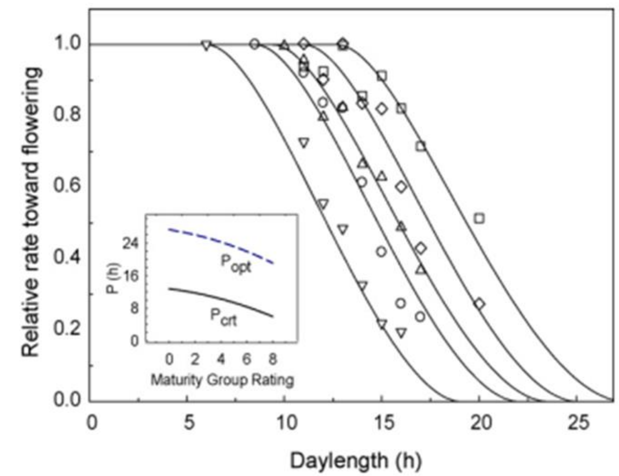


Fig. 2. Linear regression of the association between the critical photoperiod of soybean cultivars and maturity groups. RMG, relative maturity group. Note: –3, –2, and –1 represent MG 0000, MG 000, and MG 00, respectively.



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Conceptos de desarrollo - FLORACIÓN

Juvenilidad
Fotoperiodismo
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Aspectos ecológicos

✓**Vernalización**

Control de la floración: integración

Vernalización en trigos invernales

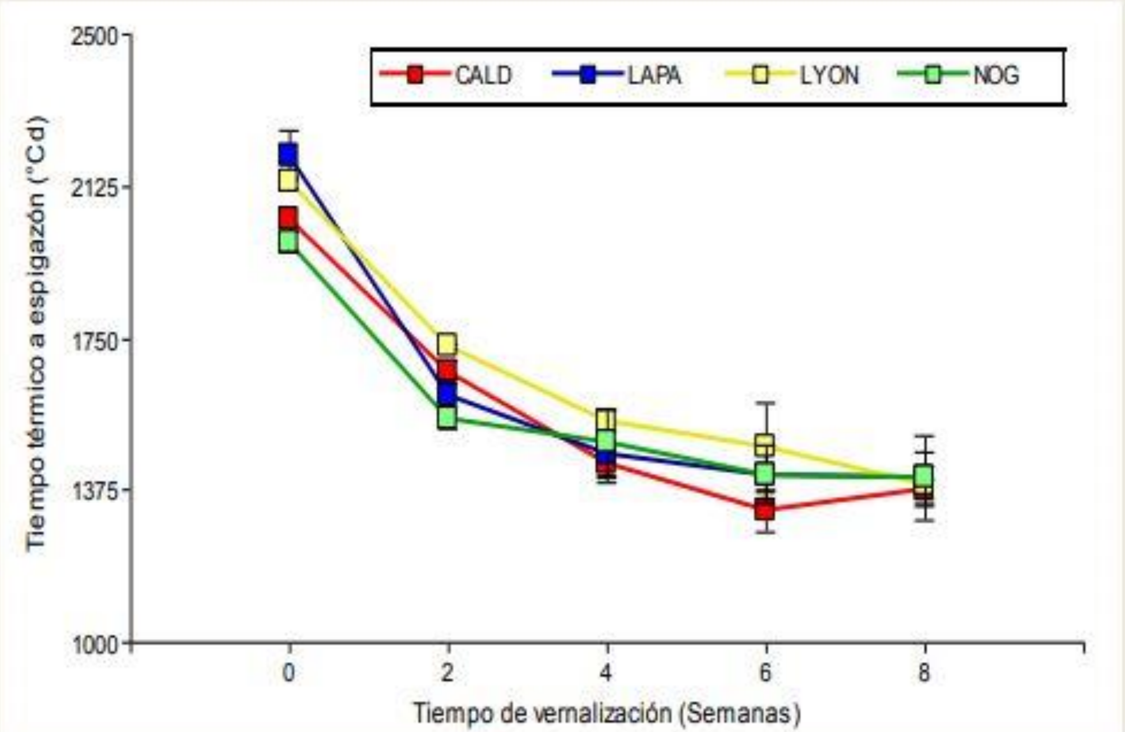
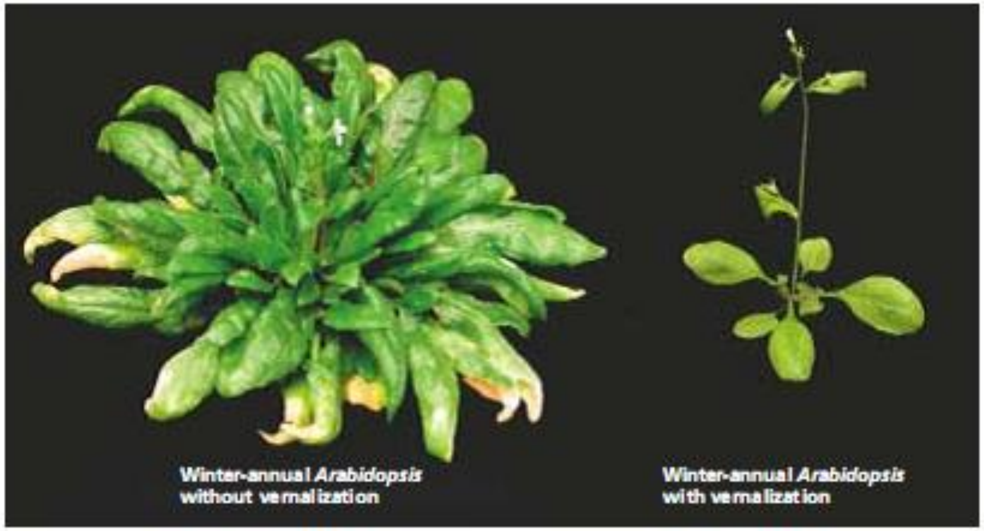


Figura 1. Duración de ciclo trasplante espigazón (°Cd), para las cuatro variedades invernales de menor requerimiento de frio (CALD= Caldén, LAPA= Lapacho, LYON= Lyon y NOG= Nogal), en función del tiempo de vernalización (semanas).

INTA Marcos Juarez

Vernalización:
Frío percibido por el meristema
Cambios epigenéticos



Conceptos de desarrollo - FLORACIÓN

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Fotoperiodismo
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Vernalización

✓ **Control de la floración: integración**

Arabidopsis thaliana **PDL**

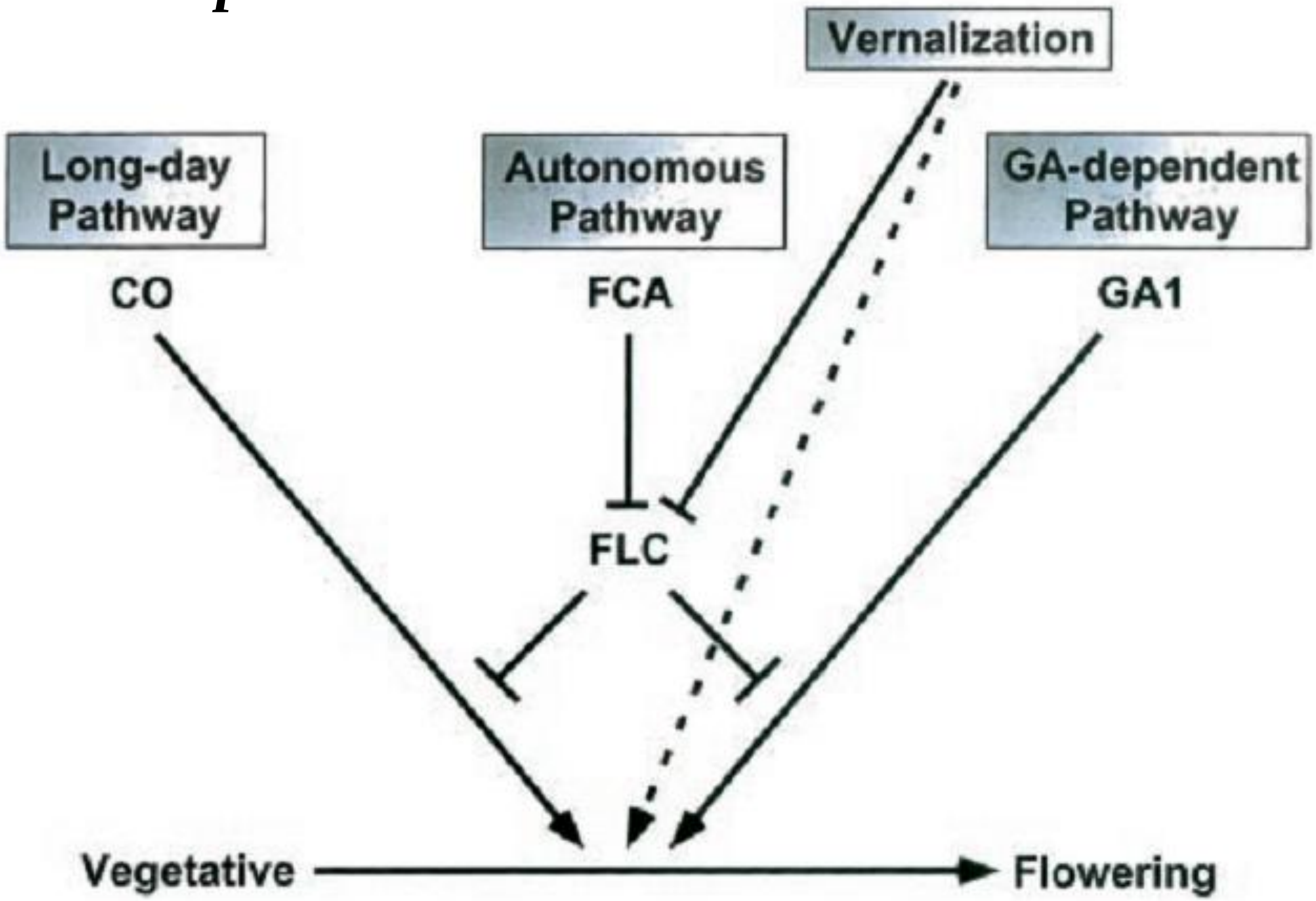


Table I. *The flowering time of wild-type and single, double, and triple mutant combinations of co-2, fca-1, and gal-3*

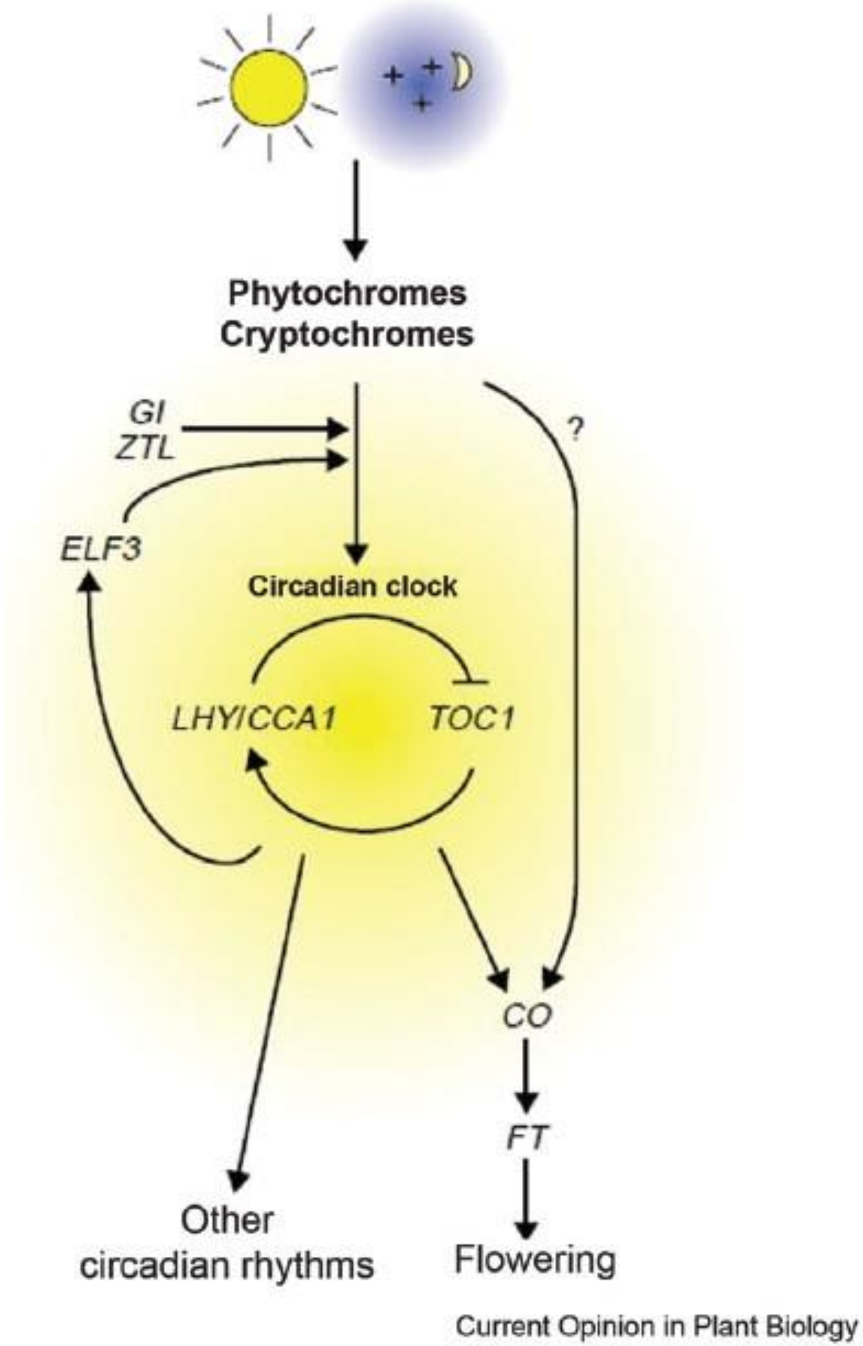
Genotype	Long Days			Short Days		
	Rosette leaves	Cauline leaves	Total leaf no.	Rosette leaves	Cauline leaves	Total leaf no.
La-*er*	5.6 ± 0.6	3.8 ± 0.7	9.4 ± 1.2	25.3 ± 4.4	9.4 ± 2.3	34.6 ± 6.1
co-2	13.4 ± 1.1	6.3 ± 1.3	19.7 ± 2.2	22.6 ± 2.2	8.3 ± 1.8	30.9 ± 3.5
fca-1	23.4 ± 2.6	7.4 ± 1.3	30.8 ± 3.4	48.5 ± 4.3	10.0 ± 2.1	58.5 ± 5.3
gal-3	–	–	15.5 ± 1.0	–	–	68.8 ± 7.5
co-2 fca-1	32.8 ± 1.8	14.3 ± 1.3	47.0 ± 2.6	44.0 ± 5.6	10.4 ± 1.0	54.4 ± 6.1
co-2 gal-3	–	–	67.9 ± 13.8 (70%)	–	–	89.0 ± 14.2 (50%)
fca-1 gal-3	–	–	35.3 ± 3.0	–	–	91.0 ± 6.7 (50%)
co-2 fca-1 gal-3	–	–	>90	–	–	>100
co-2 fca-1 gal-3 (+vernalization)	–	–	50.0 ± 7.6	–	–	N.D.[a]

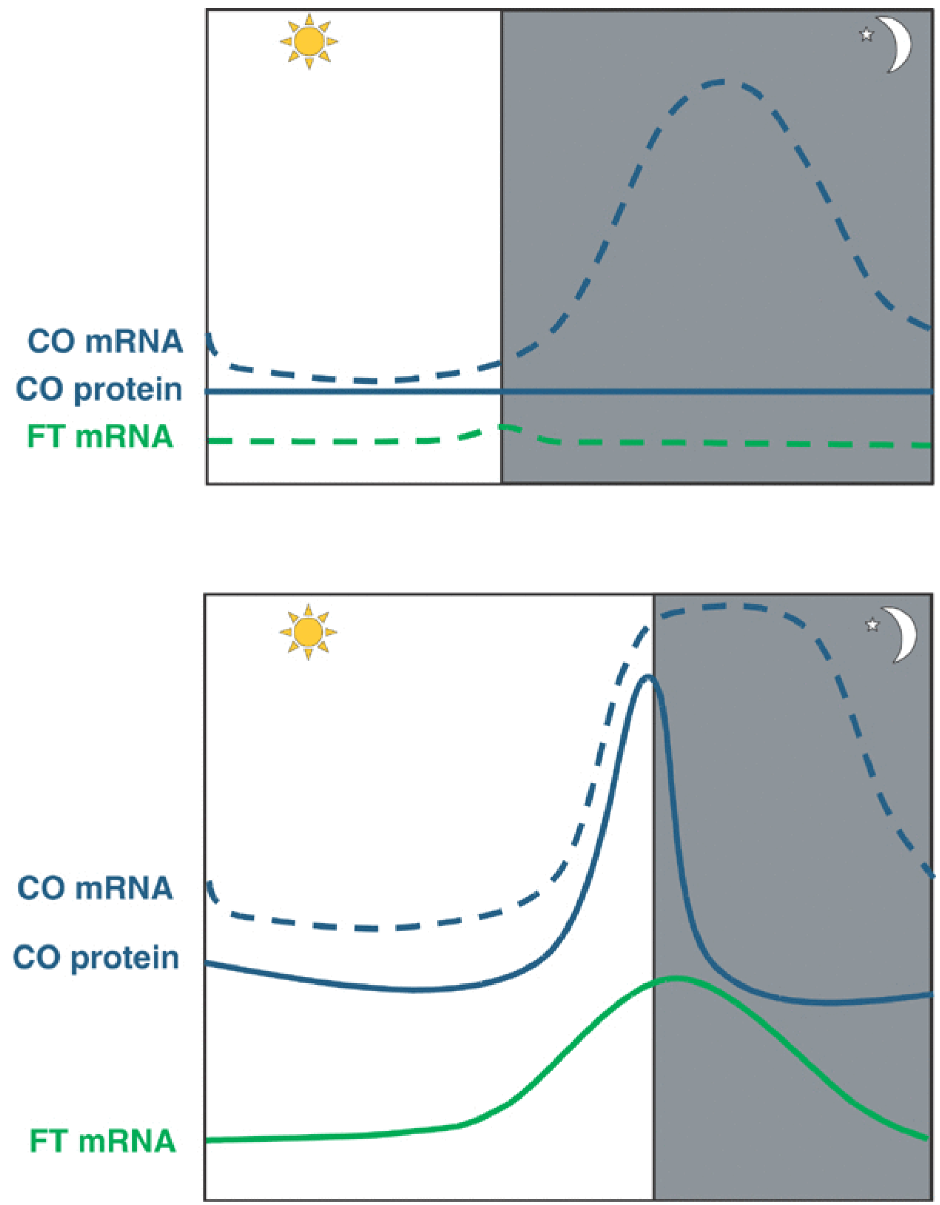
[a] N.D., Not determined.

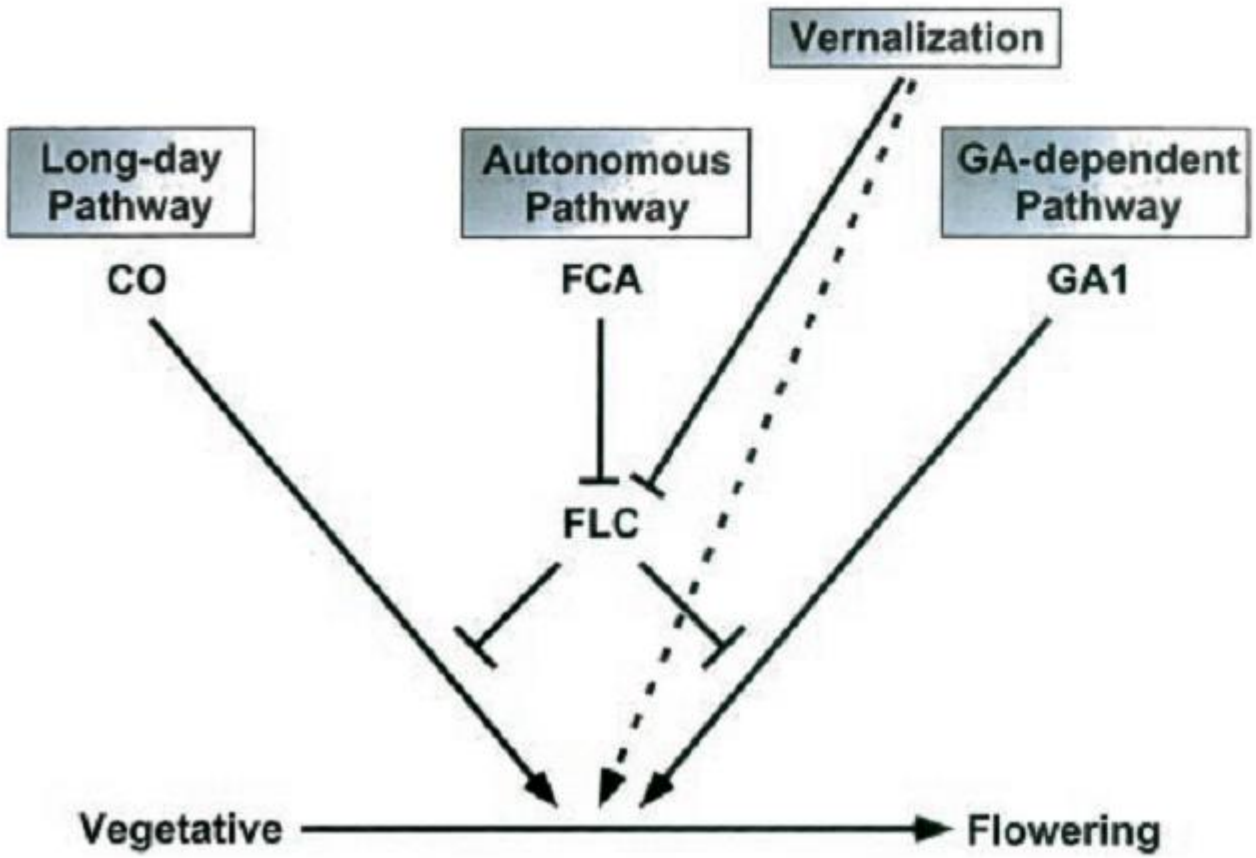
Table I. *The flowering time of wild-type and single, double, and triple mutant com*

Genotype	Long Days		
	Rosette leaves	Cauline leaves	Total leaf no.
La-*er*	5.6 ± 0.6	3.8 ± 0.7	9.4 ± 1.2
co-2	13.4 ± 1.1	6.3 ± 1.3	19.7 ± 2.2
fca-1	23.4 ± 2.6	7.4 ± 1.3	30.8 ± 3.4
ga1-3	–	–	15.5 ± 1.0
co-2 fca-1	32.8 ± 1.8	14.3 ± 1.3	47.0 ± 2.6
co-2 ga1-3	–	–	67.9 ± 13.8 (70%)
fca-1 ga1-3	–	–	35.3 ± 3.0
co-2 fca-1 ga1-3	–	–	>90
co-2 fca-1 ga1-3 (+vernalization)	–	–	50.0 ± 7.6

[a] N.D., Not determined.


Phytochromes
Cryptochromes
GI
ZTL
?
ELF3
Circadian clock
LHY/CCA1
TOC1
CO
FT
Other
circadian rhythms
Flowering
Current Opinion in Plant Biology


CO mRNA
CO protein
FT mRNA
CO mRNA
CO protein
FT mRNA


Vernalization
Long-day Pathway
Autonomous Pathway
GA-dependent Pathway
CO
FCA
GA1
FLC
Vegetative
Flowering

Conceptos de desarrollo - FLORACIÓN

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Control de la floración: integración

✓**FLORÍGENO**

FLORÍGENO

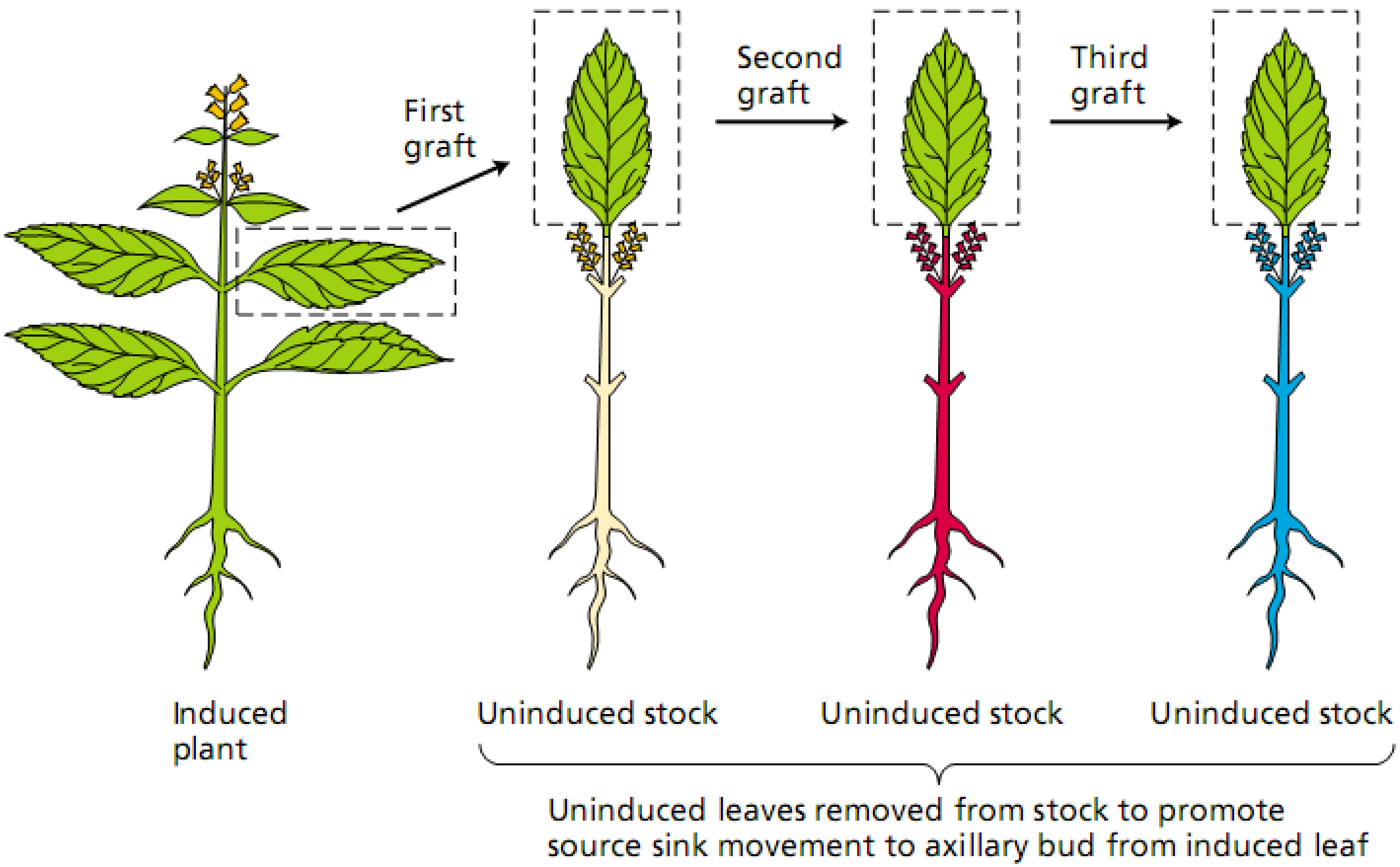
Xanthium strumarium (1 DC !!)

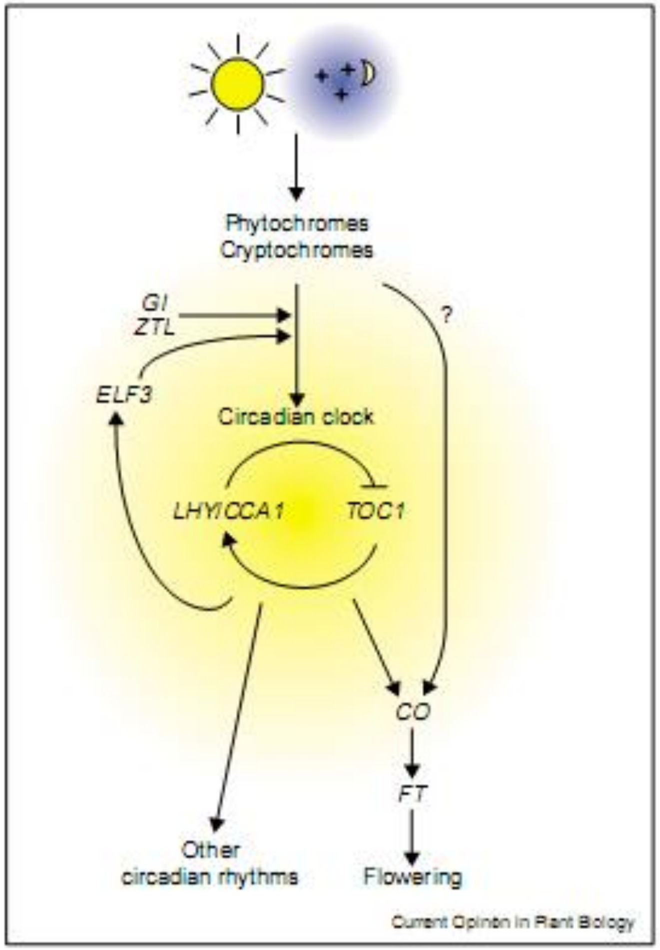
Induced
graft donor

Uninduced
graft donor

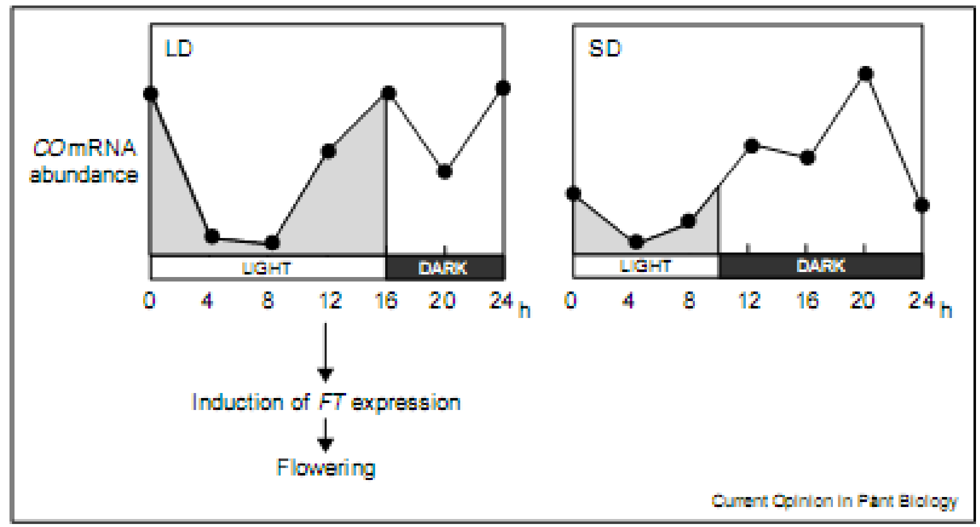
FIGURE 24.29 Successful transfer of the floral stimulus between different genera: The scion (right branch) is the LDP *Petunia hybrida*, and the stock is nonvernalized *Hyoscyamus niger* (henbane). The graft combination was maintained under LDs. (Photo courtesy of J. A. D. Zeevaart.)

“Florígeno”: proteína o mRNA móvil en el floema!!



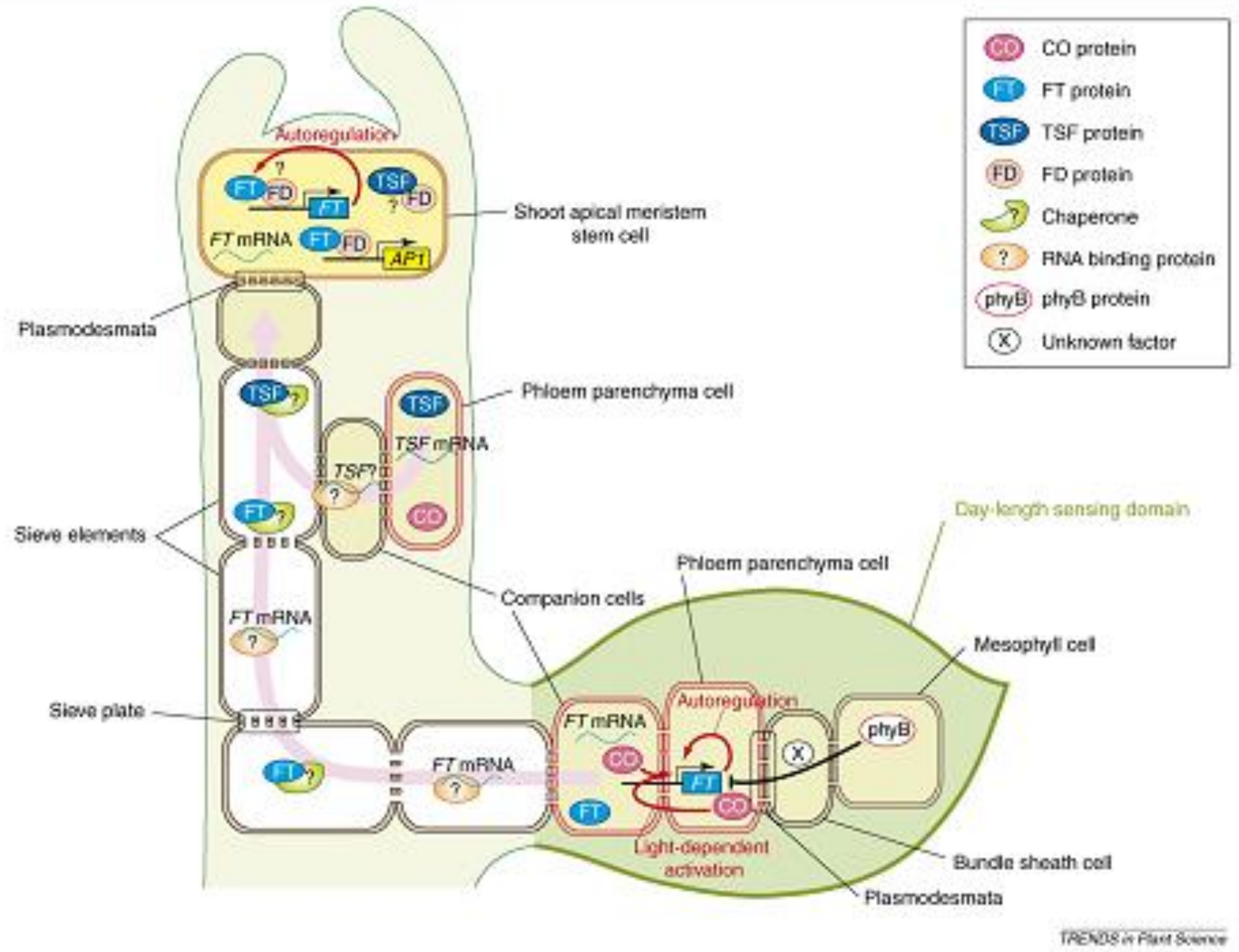


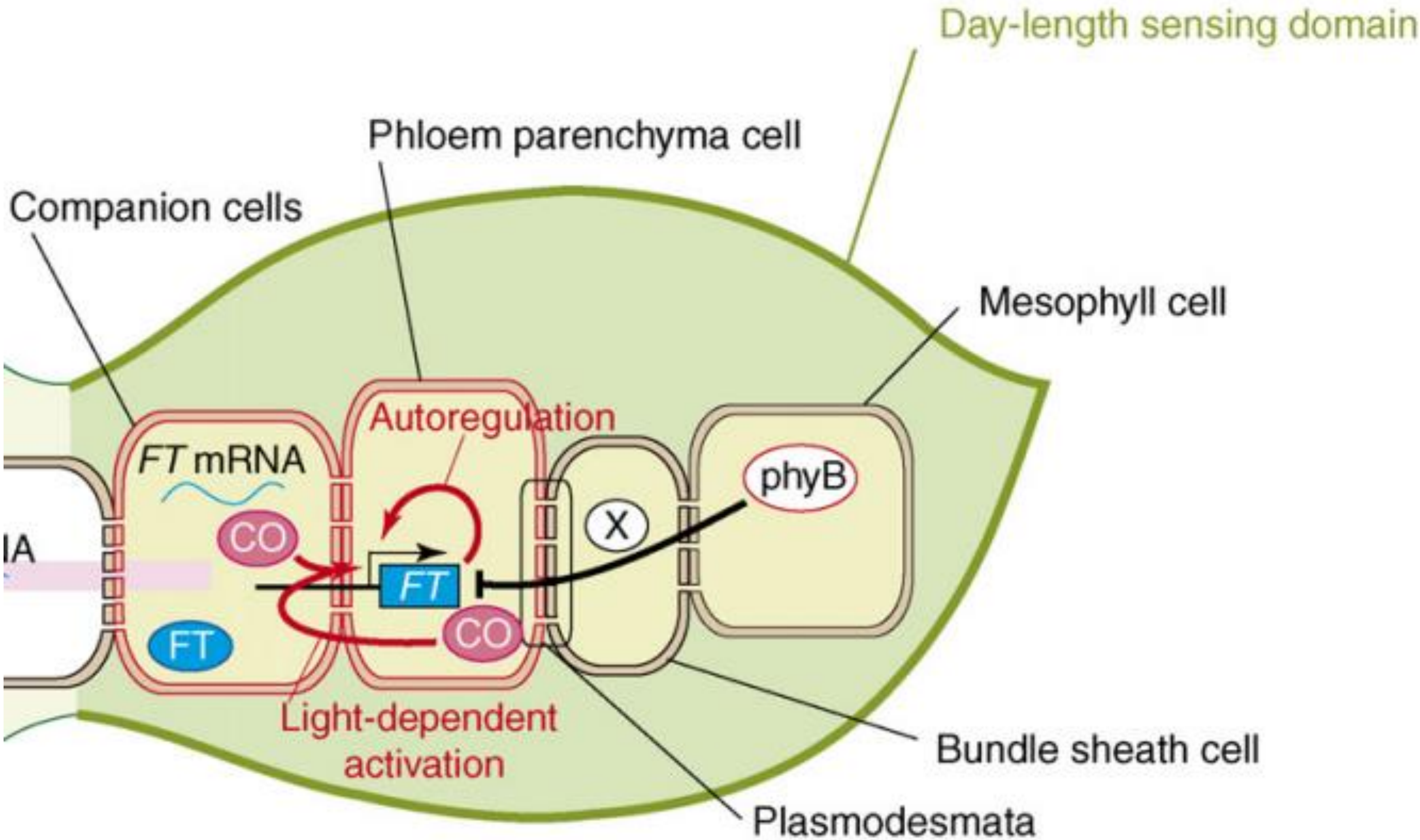
Phytochromes
Cryptochromes
GI
ZTL
?
ELF3
Circadian clock
LHY/CCA1
TOC1
CO
FT
Other
circadian rhythms
Flowering
Current Opinion in Plant Biology



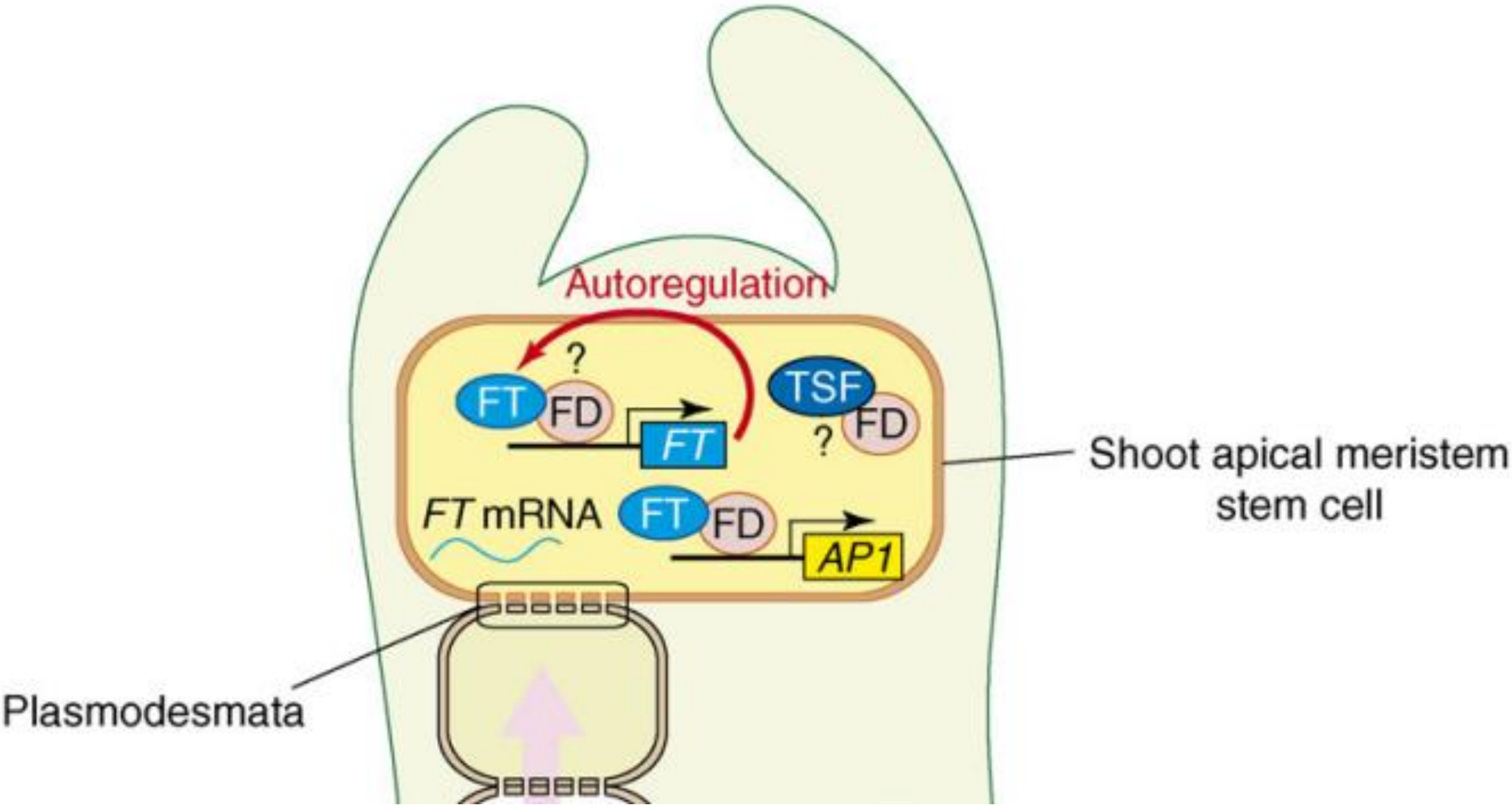
LD
SD
CO mRNA
abundance
LIGHT
DARK
0
4
8
12
16
20
24 h
Induction of FT expression
Flowering
Current Opinion in Plant Biology

“Florígeno”: proteína o mRNA correspondiente al gen FT





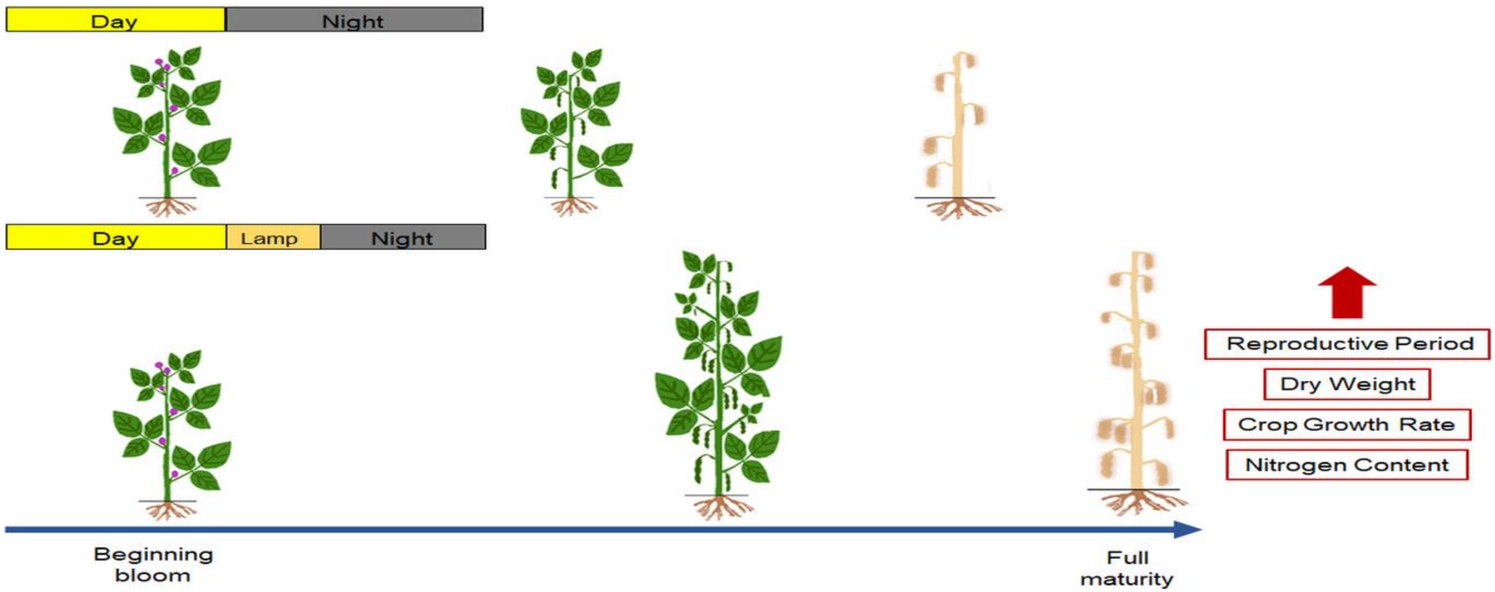
Day-length sensing domain
Phloem parenchyma cell
Companion cells
Mesophyll cell
Autoregulation
FT mRNA
phyB
X
CO
FT
CO
FT
Light-dependent
activation
Bundle sheath cell
Plasmodesmata

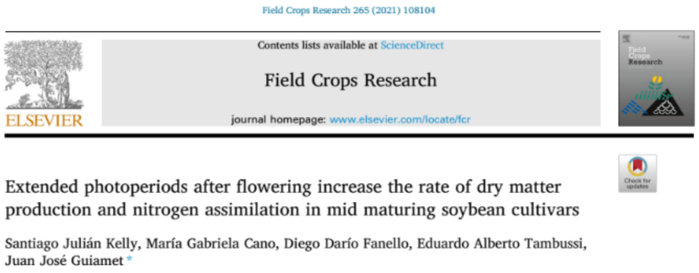


Autoregulation
?
FT
FD
FT
TSF
FD
?
Shoot apical meristem
stem cell
FT mRNA
FT
FD
AP1
Plasmodesmata

Regulación de otros procesos por el fotoperíodo

Regulación de otros procesos por el fotoperíodo: desarrollo reproductivo tardío





Field Crops Research 265 (2021) 108104

Contents lists available at ScienceDirect

Field Crops Research

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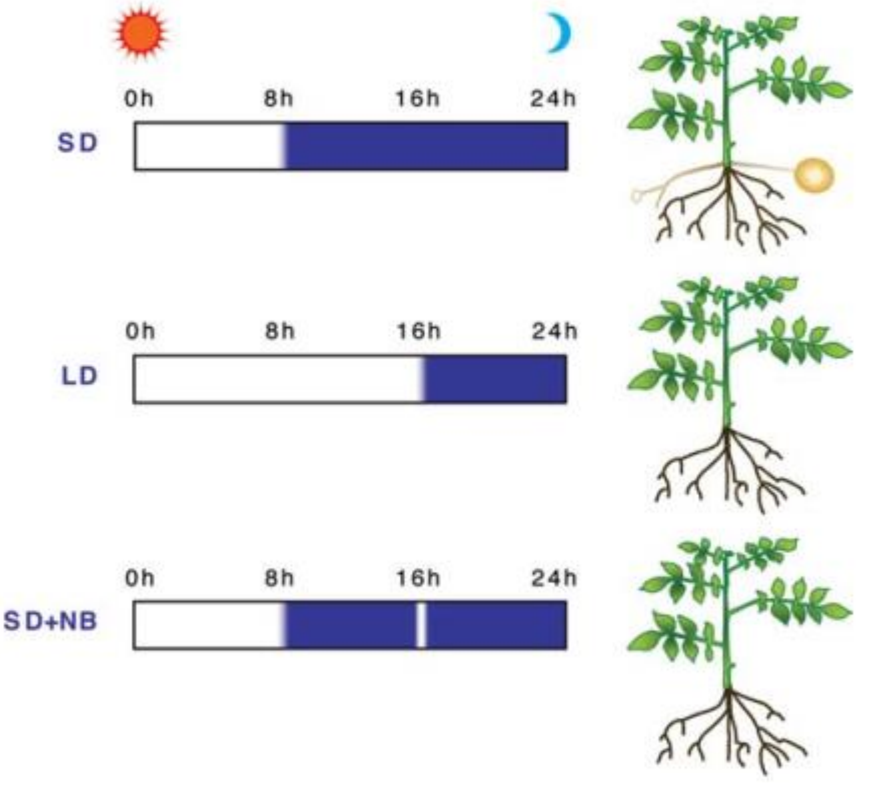
ELSEVIER

Extended photoperiods after flowering increase the rate of dry matter production and nitrogen assimilation in mid maturing soybean cultivars

Santiago Julián Kelly, María Gabriela Cano, Diego Darío Fanello, Eduardo Alberto Tambussi, Juan José Guiamet *

Regulación de otros procesos por el fotoperíodo: tuberización



Tuberización inhibida por altas temperaturas.
Características compartidas con floración: fotoperíodo percibido en las hojas, estímulo transmitido por injertos. Ortólogos de CO y FT.

Regulación de otros procesos por el fotoperíodo: brotación y dormición de yemas en especies leñosas.

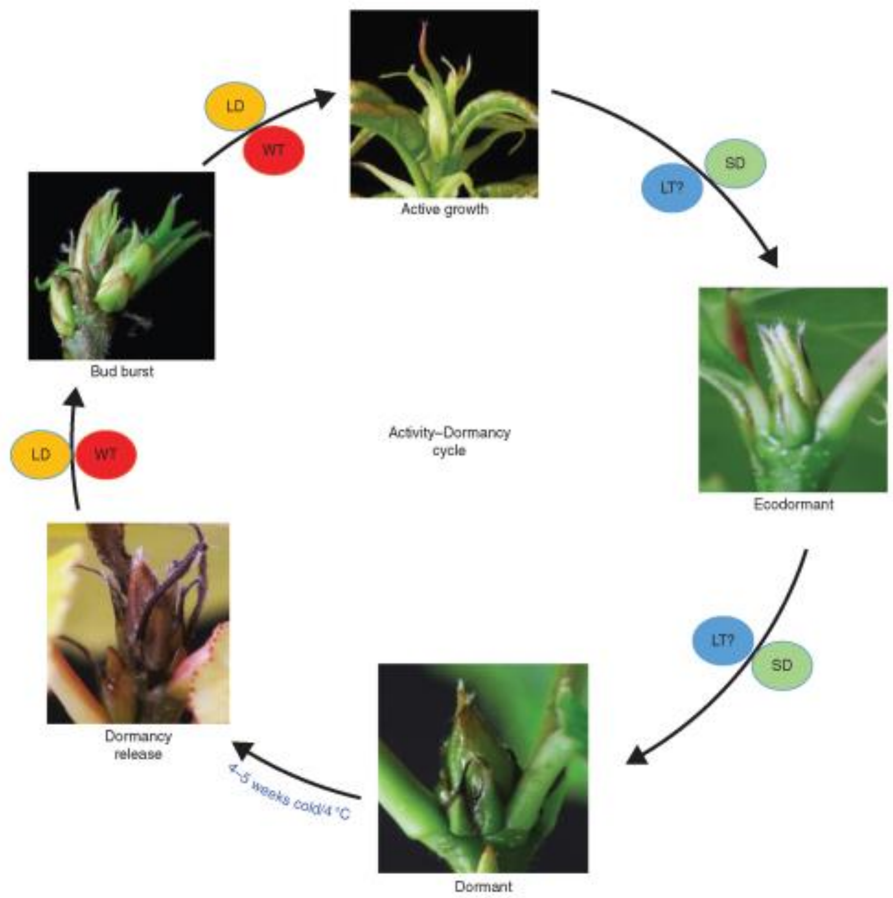
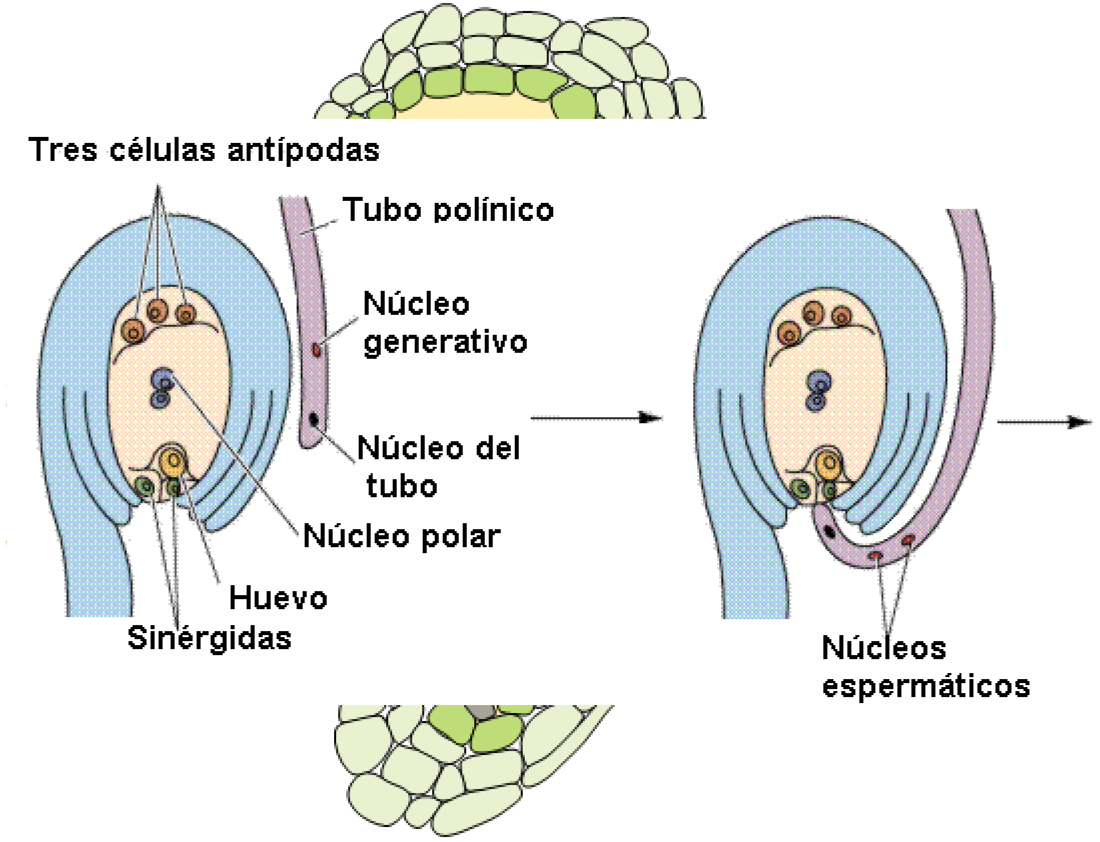
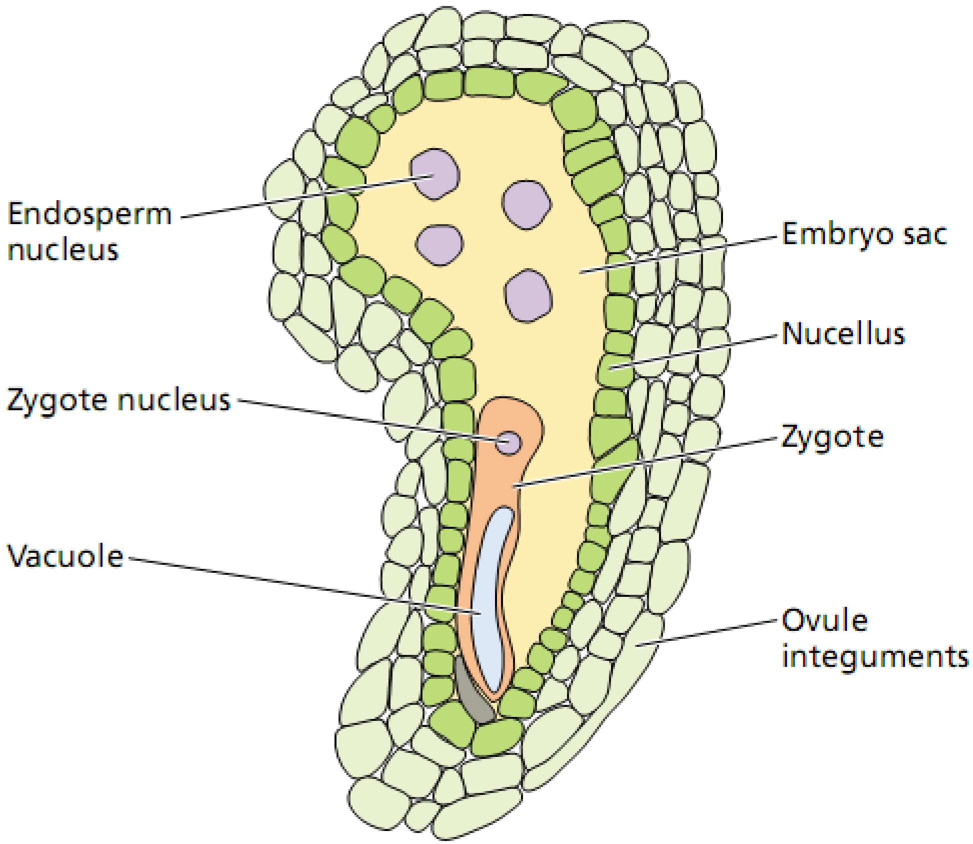
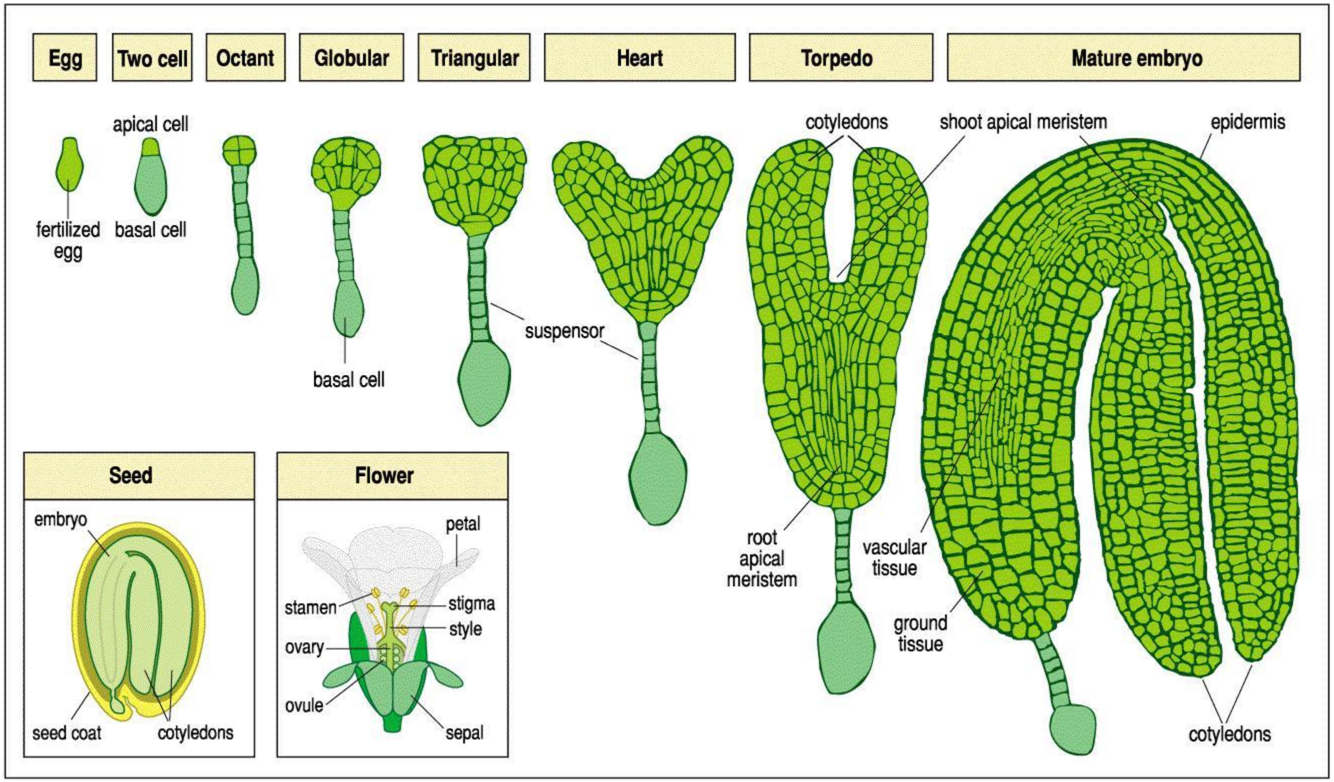


FIG. 1. Seasonal changes that occur in the apex of hybrid aspen during the activity–dormancy cycle. Under long-day (LD) and warm temperature (WT) conditions, such as those experienced during the summer, trees grow actively. They stop their growth upon sensing short days (SDs) during early autumn. Initially, growth cessation is reversible by exposure to the growth-promoting LDs, as the buds are in an ecodormant state. SDs induce dormancy in the buds during late autumn. Once dormancy is established, growth becomes insensitive to any growth-promotive signals and the buds are endodormant. Chilling temperatures during the winter periods promote the release of dormancy and buds become ecodormant again. Relatively warmer temperatures in the spring promote bud burst, which is followed by active growth in the summer.


Tres células antípodas
Tubo polínico
Núcleo generativo
Núcleo del tubo
Núcleo polar
Huevo
Sinérgidas
Núcleos espermáticos



Endosperm nucleus
Embryo sac
Nucellus
Zygote nucleus
Zygote
Vacuole
Ovule integuments


Egg
Two cell
Octant
Globular
Triangular
Heart
Torpedo
Mature embryo
apical cell
fertilized egg
basal cell
basal cell
suspensor
cotyledons
shoot apical meristem
epidermis
root apical meristem
vascular tissue
ground tissue
cotyledons
Seed
embryo
seed coat
cotyledons
Flower
petal
stamen
stigma
style
ovary
ovule
sepal

Polaridad

FIGURE 16.5 The apical-
plant tissues and organs
early in embryogenesis.
how the organs of the ea
originate from specific re
(From Willemsen et al. 1

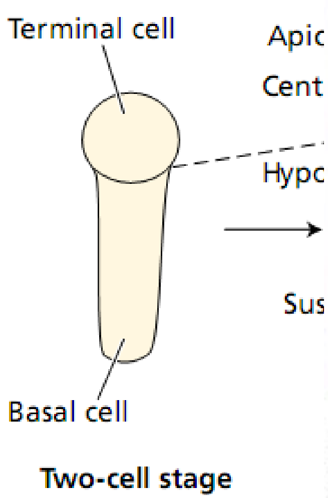
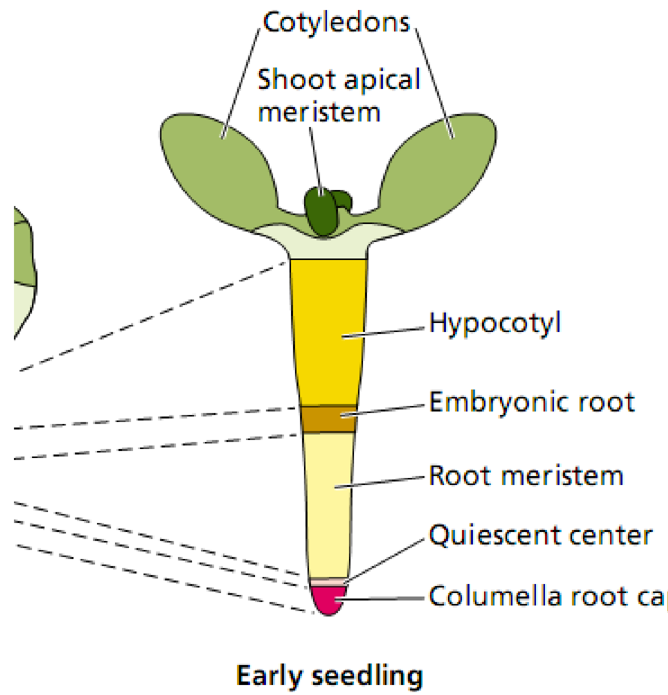


FIGURE 19.12 Roots grow from the basal ends of these bamboo sections, even when they are inverted. The roots form at the basal end because polar auxin transport in the shoot is independent of gravity. (Photo ©M. B. Wilkins.)



Patrones radiales

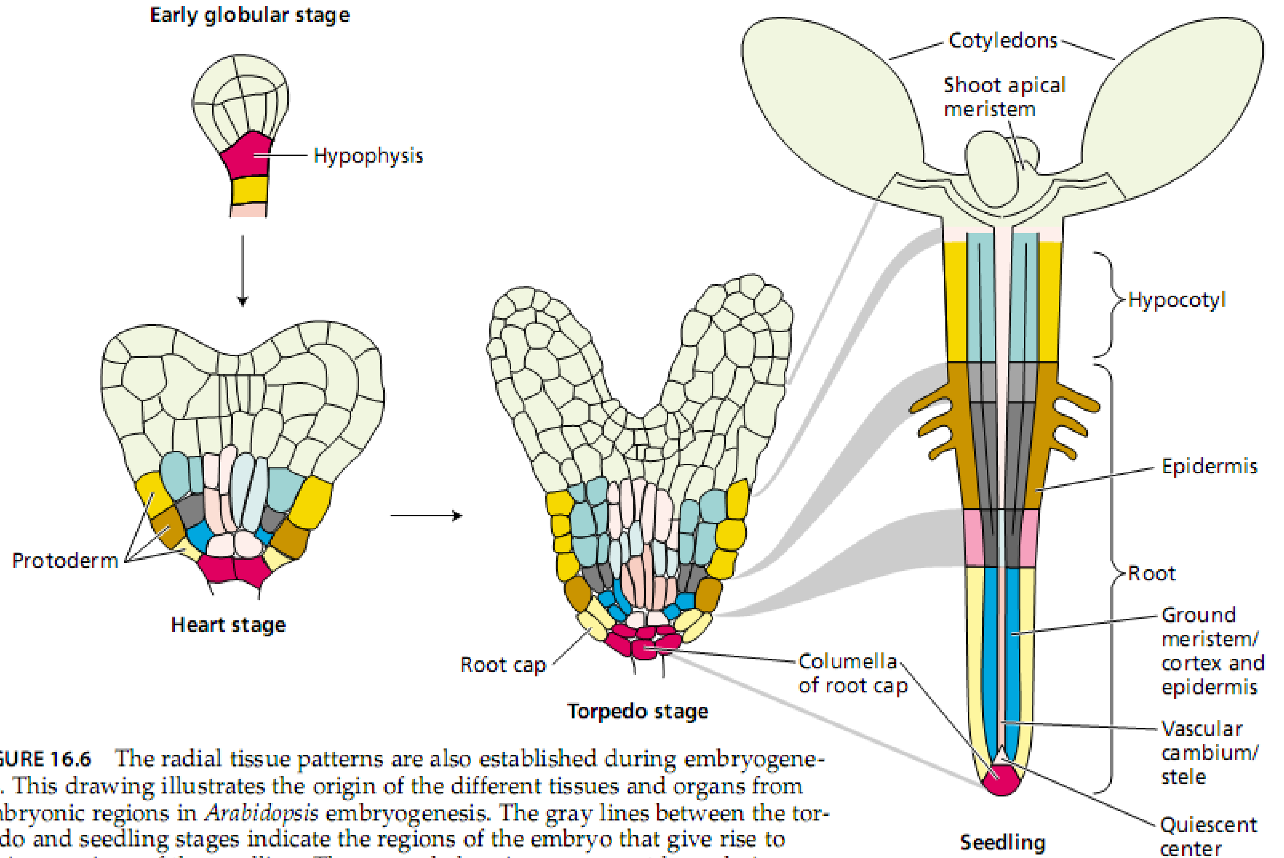
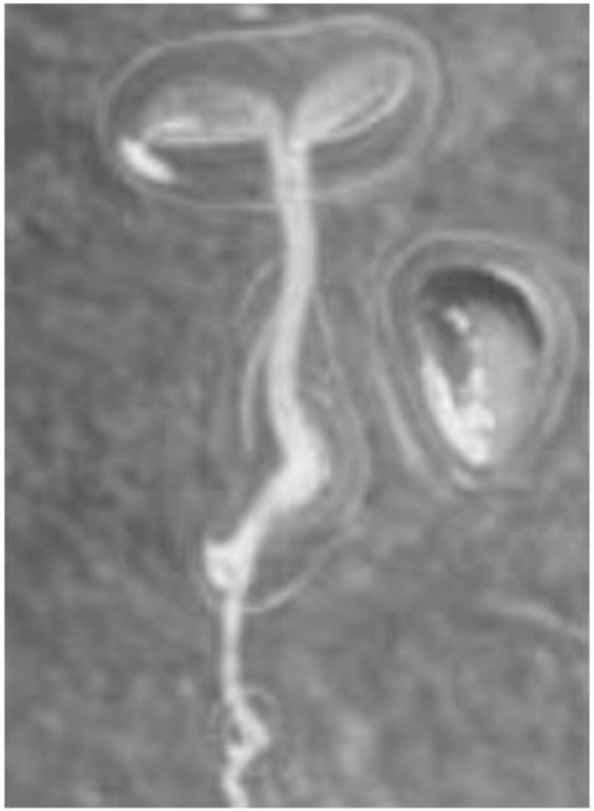


FIGURE 16.6 The radial tissue patterns are also established during embryogenesis. This drawing illustrates the origin of the different tissues and organs from embryonic regions in *Arabidopsis* embryogenesis. The gray lines between the torpedo and seedling stages indicate the regions of the embryo that give rise to various regions of the seedling. The expanded regions represent boundaries where developmental fate is somewhat flexible. (After Van Den Berg et al. 1995.)

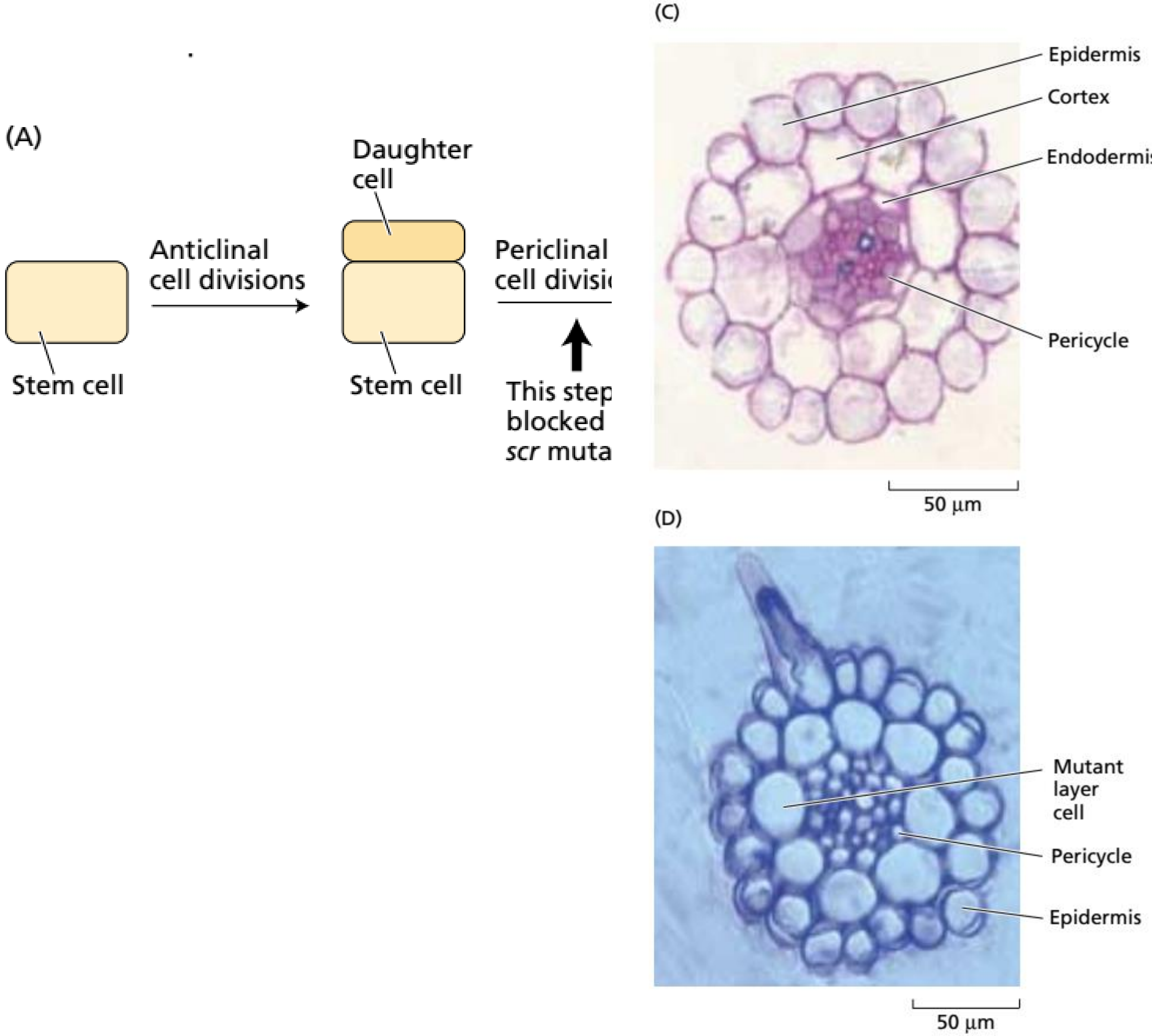
(A) Wild type *gnom mutant*



GNOM genes control apical–basal polarity

(B) Wild type *monopteros* mutant

MONOPTEROS genes control formation of the primary root



(A)
Daughter cell
Anticlinal cell divisions
Periclinal cell divisi
Stem cell
Stem cell
This step blocked *scr* muta
(C)
Epidermis
Cortex
Endodermis
Pericycle
50 µm
(D)
Mutant layer cell
Pericycle
Epidermis
50 µm

Conceptos de desarrollo

Juvenilidad
Fotoperiodismo
Medición del fotoperíodo
Aspectos ecológicos
Vernalización
Control de la floración: integración

FLORÍGENO

✓ **ORGANOGÉNESIS FLORAL**

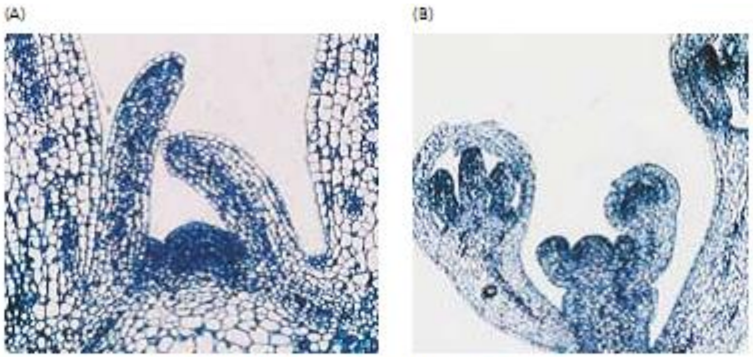
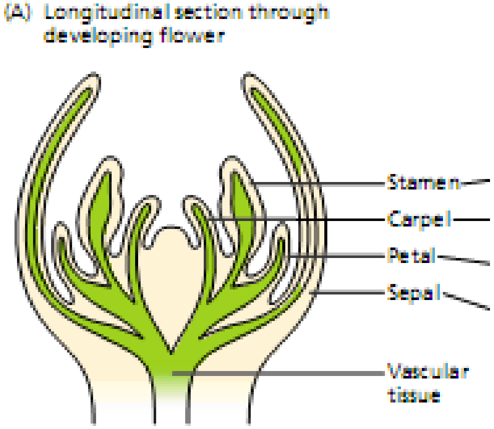
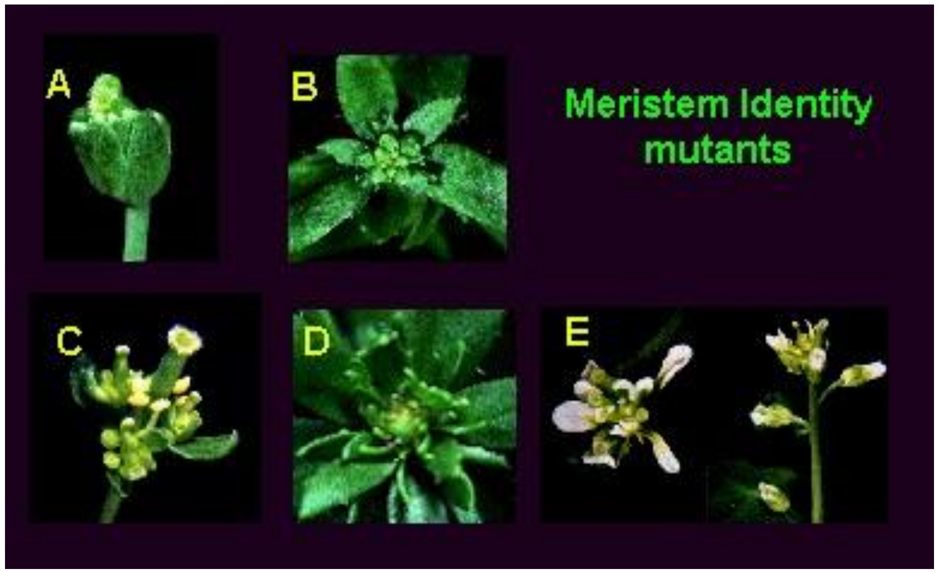


FIGURE 24.2 Longitudinal sections through a vegetative (A) and a reproductive (B) shoot apical region of *Arabidopsis*. (Photos courtesy of V. Grbic' and M. Nelson, and assembled and labeled by E. Himelblau.)

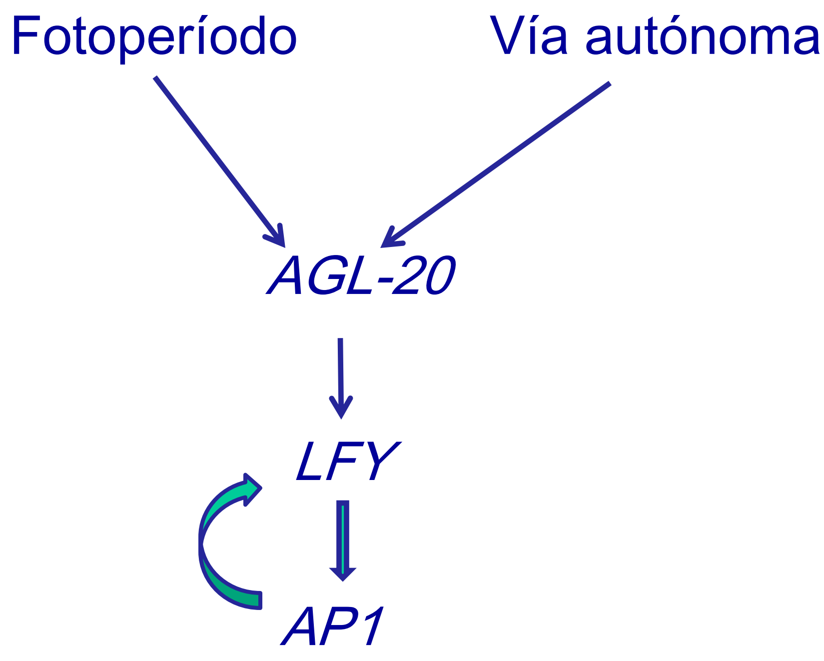


1- Identidad del meristema AGL20 ; LFY; AP1

"*leafy*"

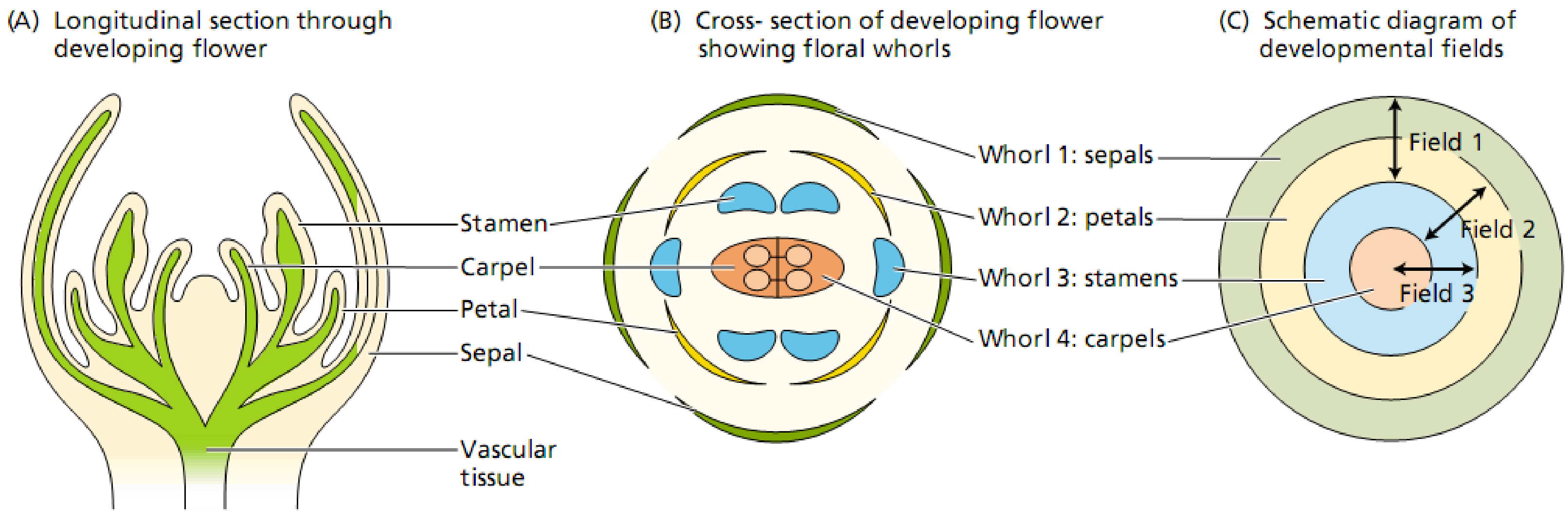


"*terminal flower*"



Fotoperíodo
Vía autónoma
AGL-20
LFY
AP1

2- Identidad de los órganos florales (genes homeóticos)



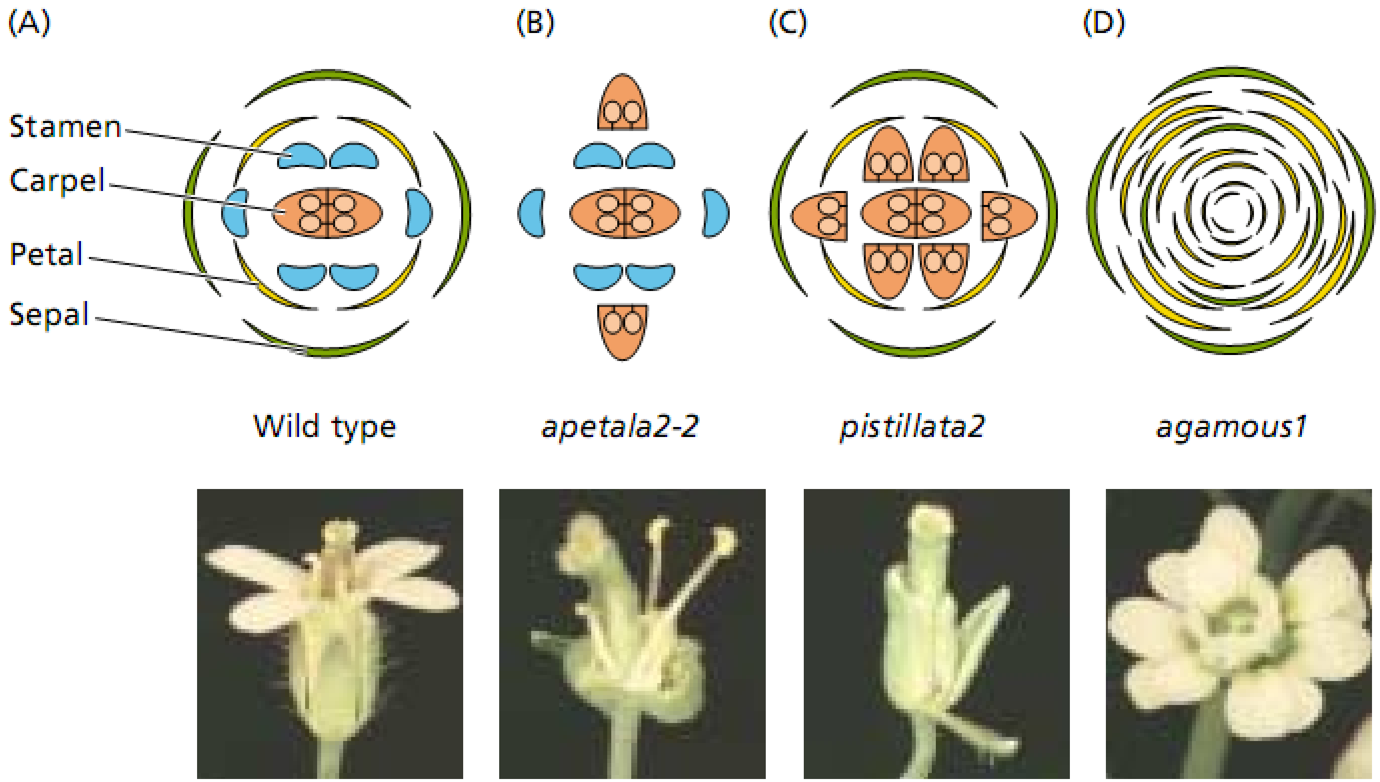


FIGURE 24.5 Mutations in the floral organ identity genes dramatically alter the structure of the flower. (A) Wild type; (B) *apetala2-2* mutants lack sepals and petals; (C) *pistillata2* mutants lack petals and stamens; (D) *agamous1* mutants lack both stamens and carpels. (From Bewley et al. 2000.)

FIGURE 24.6 The ABC model for the acquisition of floral organ identity is based on the interactions of three different types of activities of floral homeotic genes: A, B, and C. In the first whorl, expression of type A (*AP2*) alone results in the formation of sepals. In the second whorl, expression of both type A (*AP2*) and type B (*AP3/PI*) results in the formation of petals. In the third whorl, the expression of B (*AP3/PI*) and C (*AG*) causes the formation of stamens. In the fourth whorl, activity C (*AG*) alone specifies carpels. In addition, activity A (*AP2*) represses activity C (*AG*) in whorls 1 and 2, while C represses A in whorls 3 and 4.

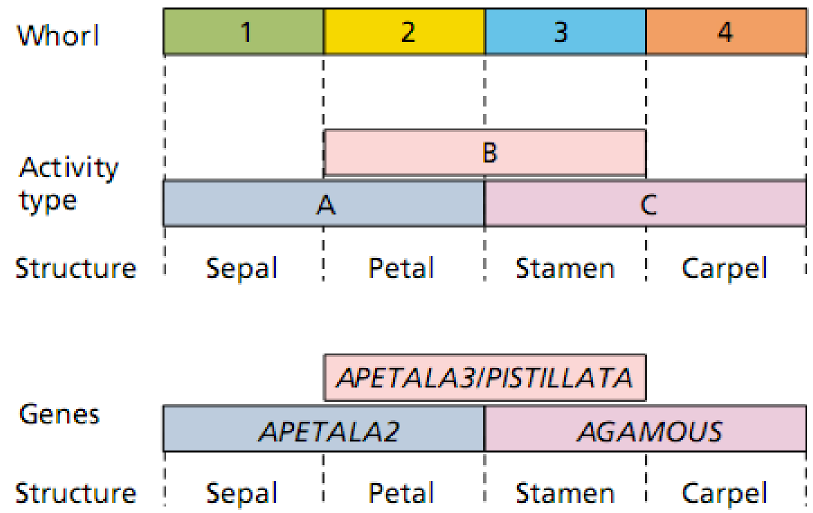
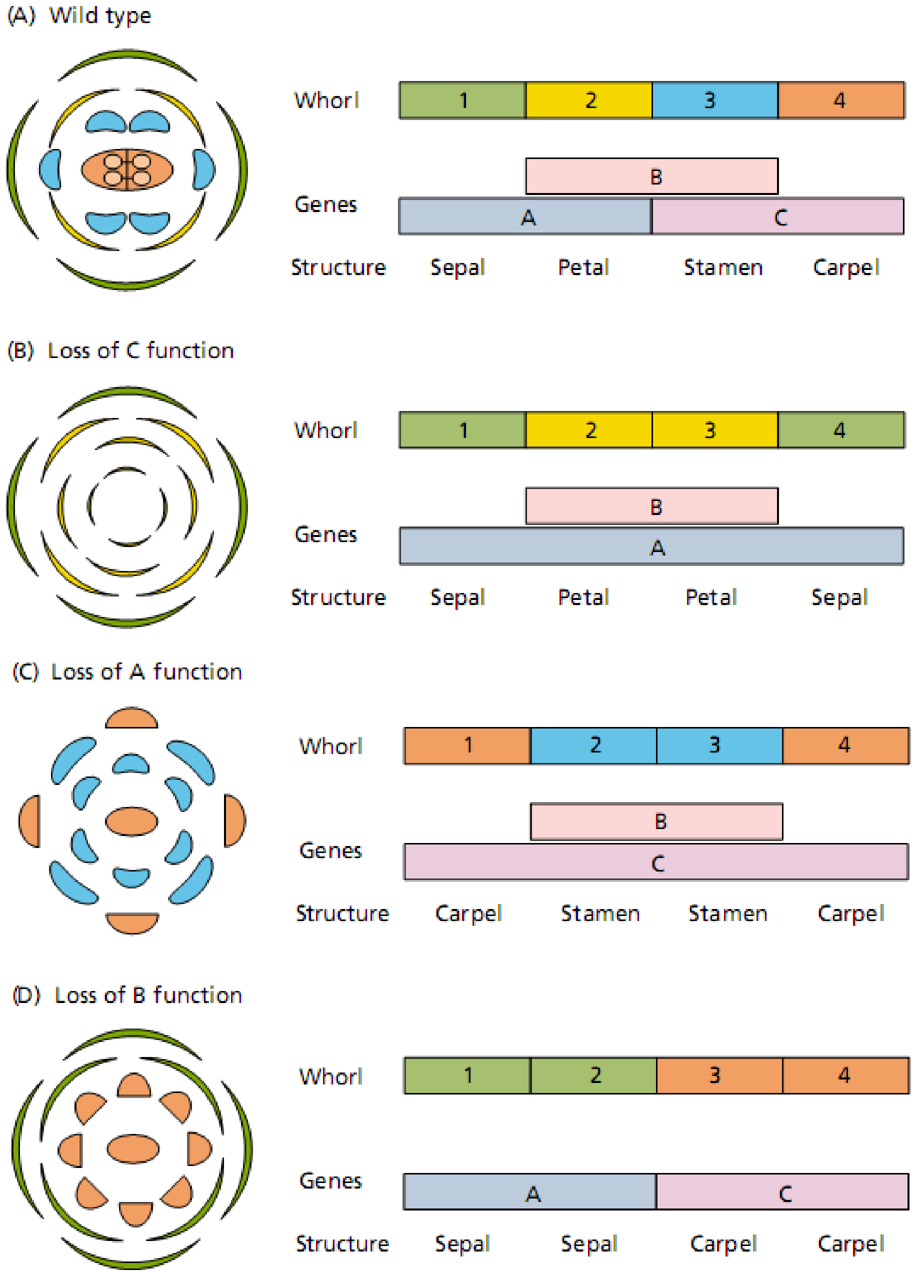
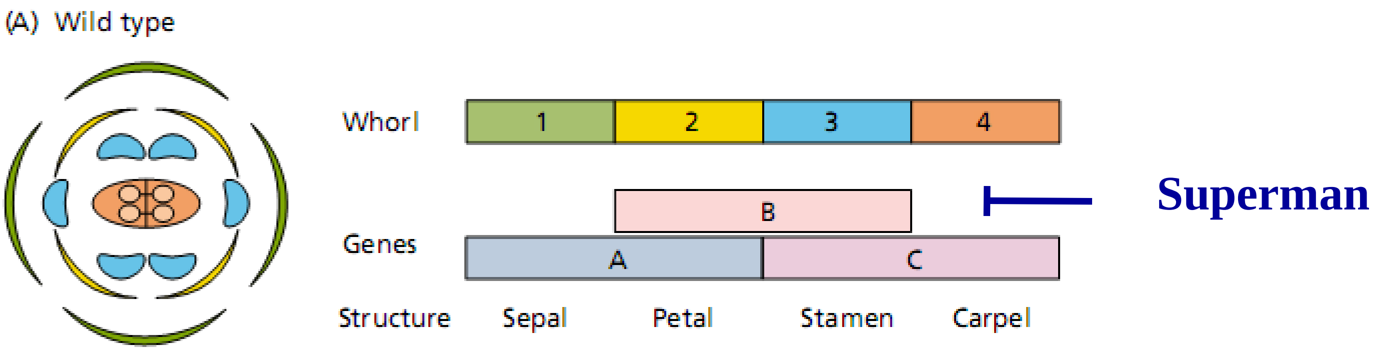


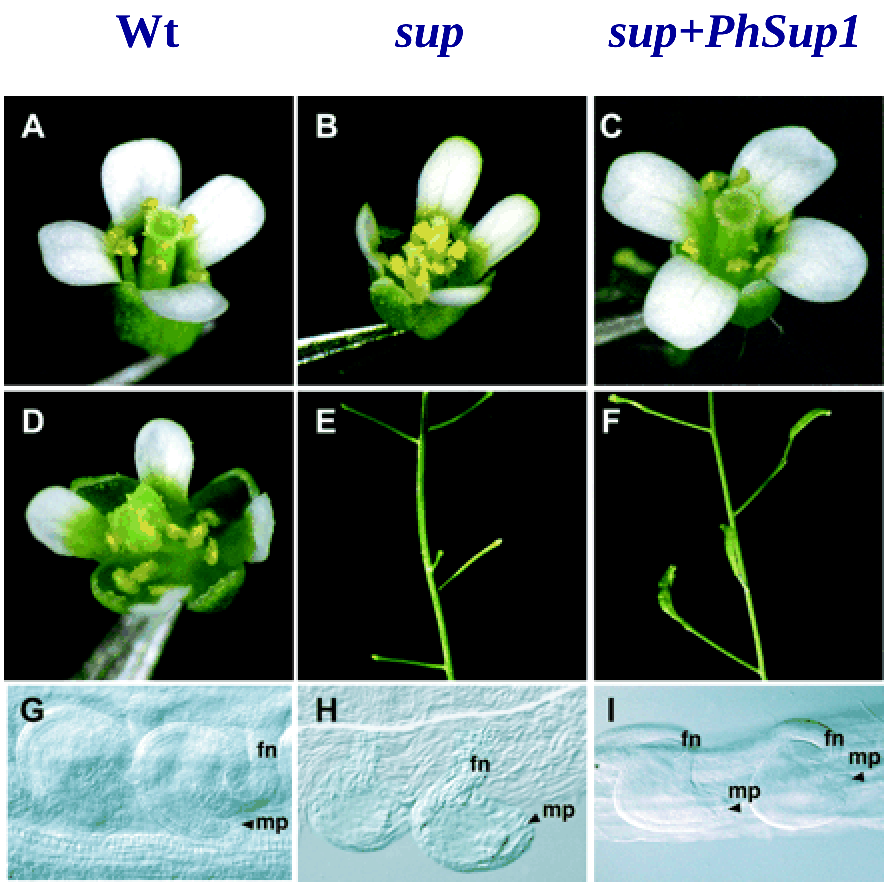
FIGURE 24.7 A quadruple mutant (*api1, ap2, ap3/pi, ag*) results in the production of leaf-like structures in place of floral organs. (Courtesy of John Bowman.)



3- Actividad catastral

3- Actividad catastral

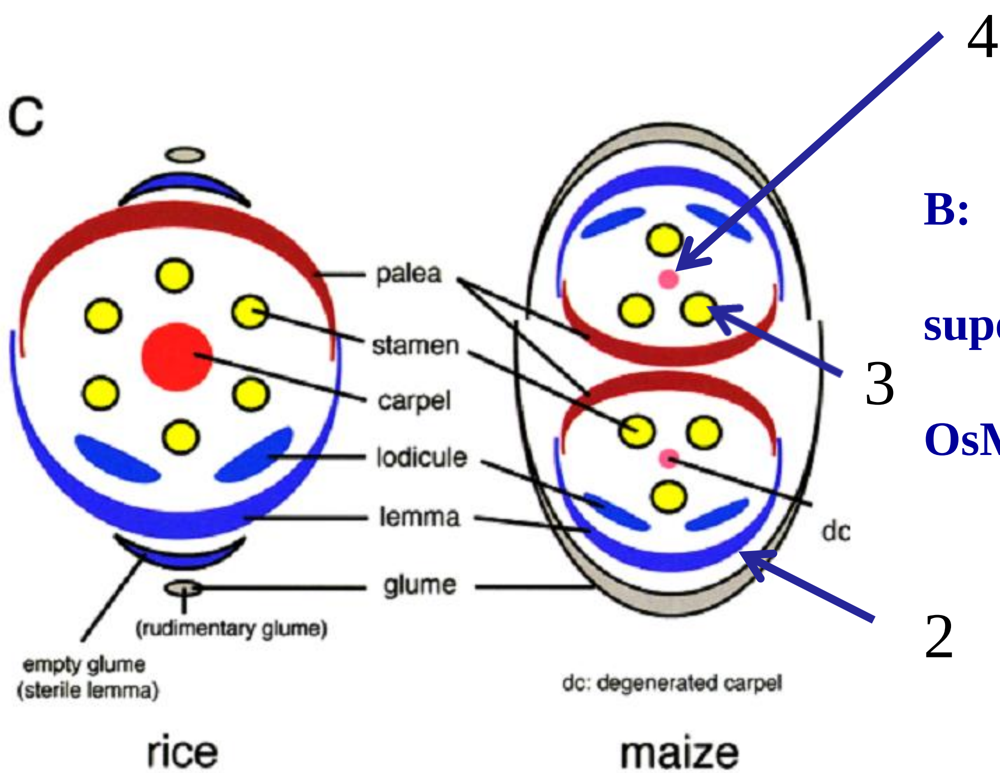



Wt
sup
sup+PhSup1
A
B
C
D
E
F
G
fn
mp
H
fn
mp
I
fn
fn
mp
mp

Interacciones entre genes homeóticos

1- Intra-clase, v.g. PI y AP3 (B)
2- Combinatorias (v.g., B+A, B+C)
3- Competitivas (catastrales, v.g., A vs C)

POACEA



B:

superwoman (Os), ~ AP3

OsMADS4 ~ PI

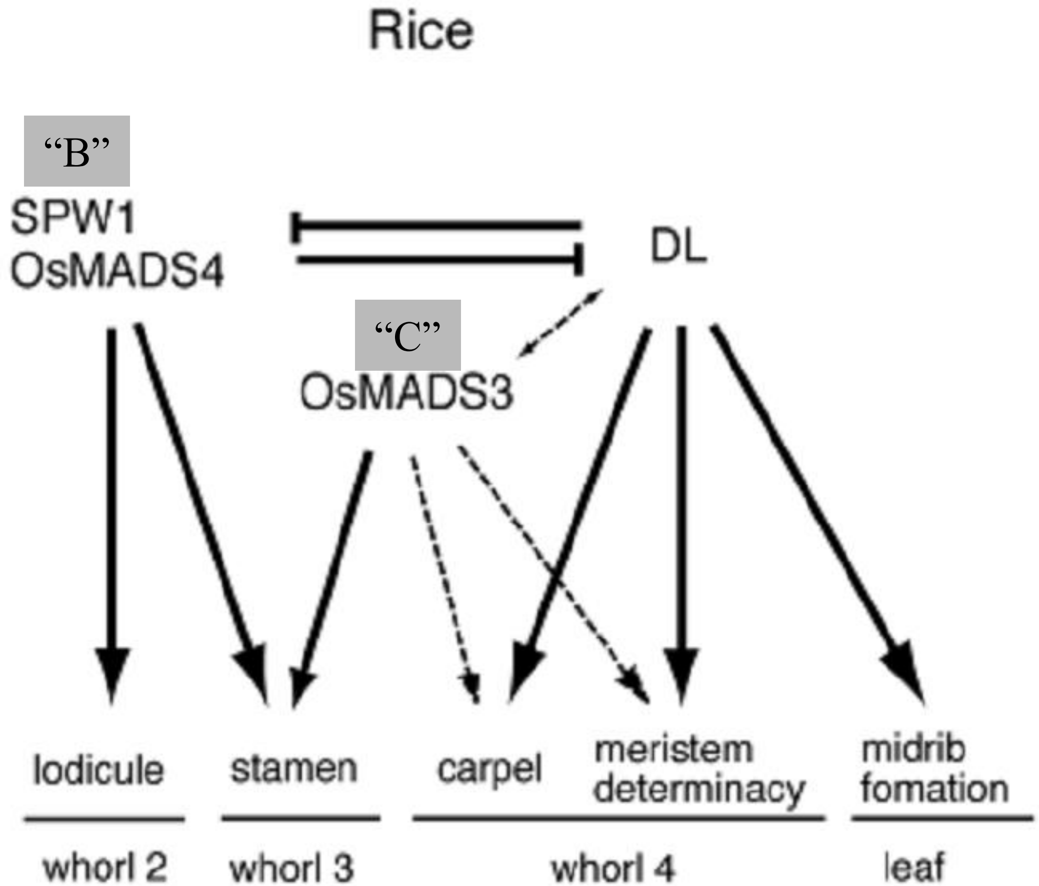
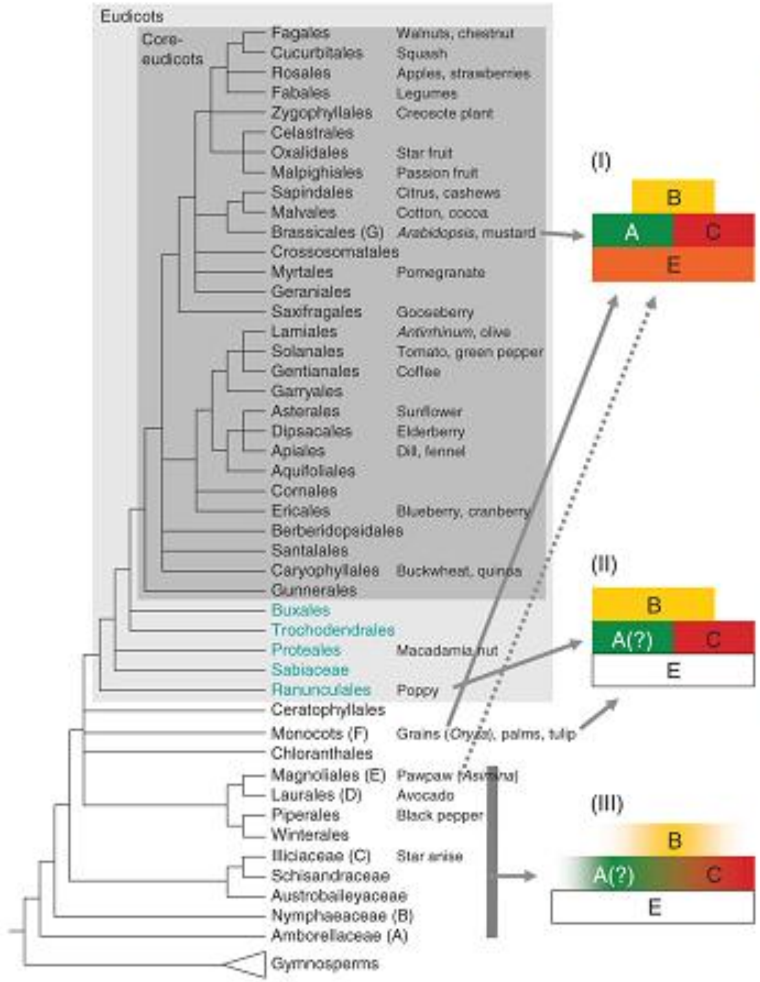

Rice
"B"
SPW1
OsMADS4
DL
"C"
OsMADS3
lodicule
stamen
carpel
meristem
determinacy
midrib
fomation
whorl 2
whorl 3
whorl 4
leaf

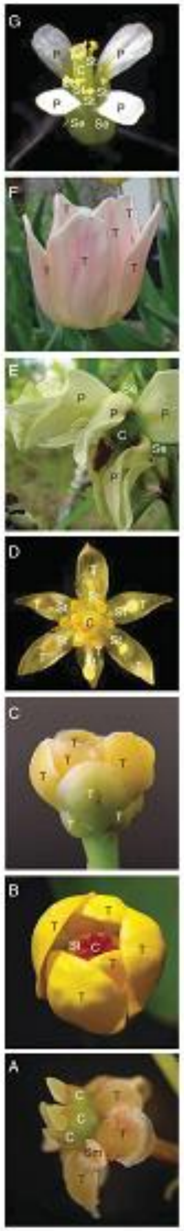
Table 1. MADS-box gene sequences identified in Floral Genome Project expressed sequence tag sets and via screening using degenerate primers[a]

Subfamilies	Unpl	*AG*	*ST11*	*DEF/GLO*	*DEF*	*GLO*	*SEP*	*AGL6*	*SQUA*	*TM3*	*TM8*	*MIKC**
Functional group		C and D		B			E		A			
Gymnosperms												
Welwitschia mirabilis	3	–	1	1	–	–	–	1	–	1	–	–
Zamia fischeri	2	–	–	1	–	–	–	3	–	–	–	–
Basalmost angiosperms												
Amborella trichopoda	1	2	1	–	2	1	2	1	1	–	1	–
Nuphar advena	1	1	–	–	2	1	2	1	1	–	–	–
Magnoliids												
Liriodendron tulipifera	–	–	1	–	1	–	1	2	–	–	–	1
Persea americana	–	2	1	–	2	1	2		1	1	1	–
Saruma henryi	–	1	–	–	1	–	2	1	–	–	–	–
Monocots												
Acorus americanus	–	–	1	–	–	1	2	1	–	1	–	–
Asparagus officinalis	–	1	–	–	–	2	2	2	–	1	–	–
Yucca filamentosa	–	–	1	–	–	2	–	–	–	–	–	–
Eudicots												
Eschscholzia californica	–	2	–	–	2	1	2	1	–	–	–	–
Cucumis sativus	–	–	–	–	–	–	–	1	–	–	–	–

Abbreviations: *AG*, *AGAMOUS*; *AGL*, *AGAMOUS-like*; *DEF*, *DEFICIENS*; *GLO*, *GLOBOSA*; *MIKC**, a type of MIKC gene with unusual I- and K-regions compared with classical MIKC-type genes; *SEP*, *SEPALLATA*; *SQUA*, *SQUAMOSA*; *ST11*, *Solanum tuborosum MADS11*; *TM3*, *TOMATO MADS3*; *TM8*, *TOMATO MADS8*; Unpl, identified as MADS-box gene family member but unplaced in known subfamilies (ambiguous subfamily identification because of short sequence or potential presence of new subfamilies); –, indicates no data.

[a]The numbers of genes identified for each clade and taxon are shown.





Arabidopsis

Tulipa

Asimina

Persea

Illicium

Nuphar

Amborella