

FISIOLOGIA DA FLORAÇÃO

Gilberto B. Kerbauy

FASES do DESENVOLVIMENTO

fase adulta reprodutiva



dramática

fase adulta vegetativa



gradual

fase juvenil

DURAÇÃO da FASE JUVENIL

Planta	Tempo
Milho	60 - 70 dias
Café	2 anos
Uva	2 - 4 anos
Maçã	4 - 8 anos
Laranja	5 - 8 anos
Sequóia	5 - 15 anos
Carvalho	25 - 30 anos

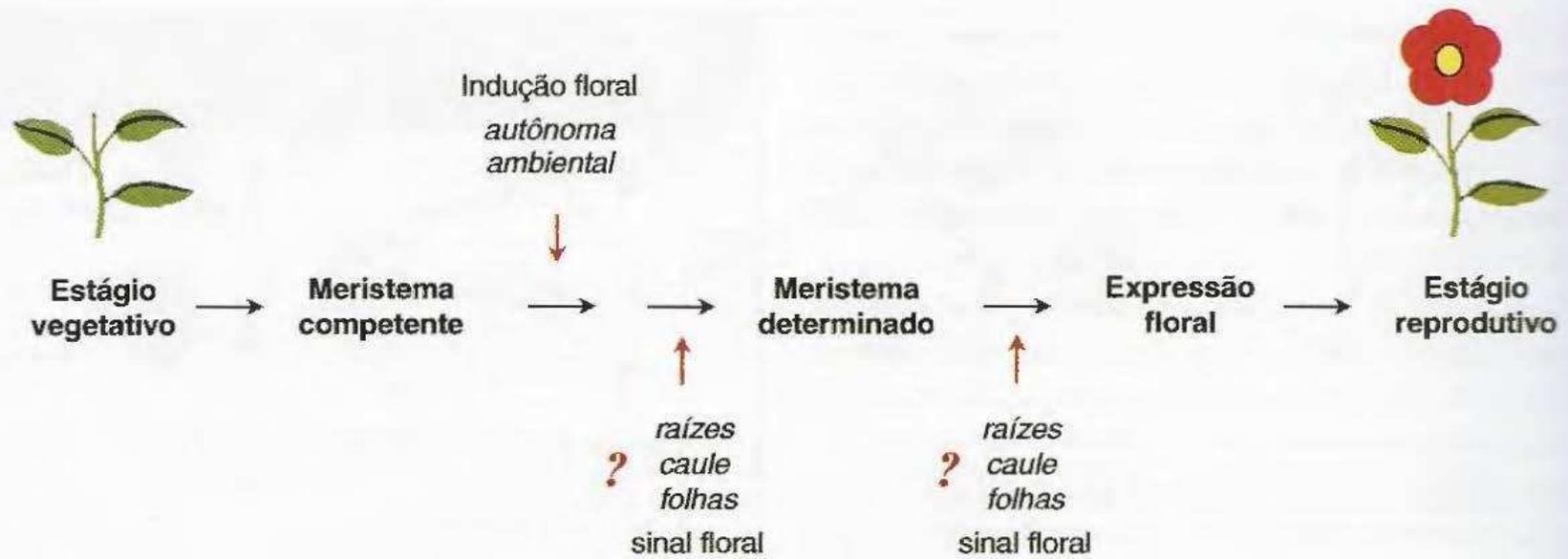
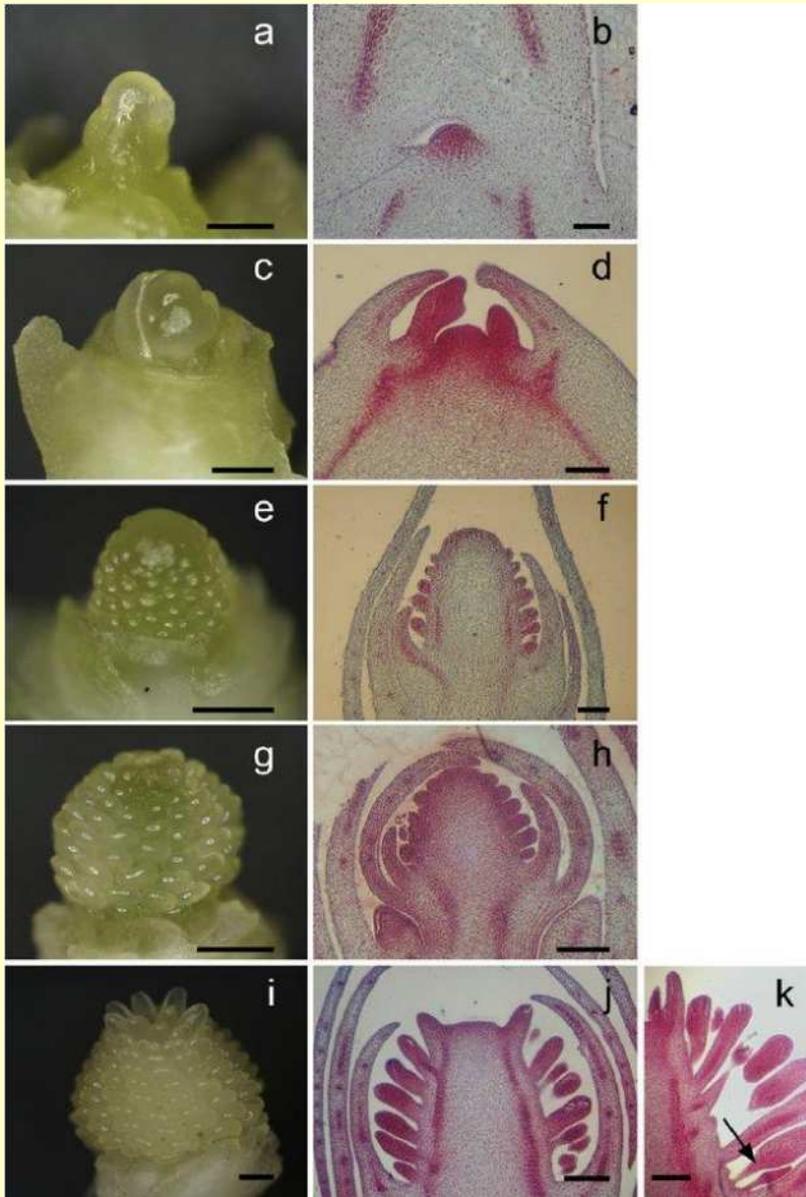


FIGURA 18.11

Eventos associados à transição do meristema caulinar vegetativo em meristema floral.



Helleborus niger

LUZ

- **Plantas de Dia Curto (PDC)**
- **Plantas de Dia Longo (PDL)**
- **Plantas Neutras / Indiferentes / Autônomas**

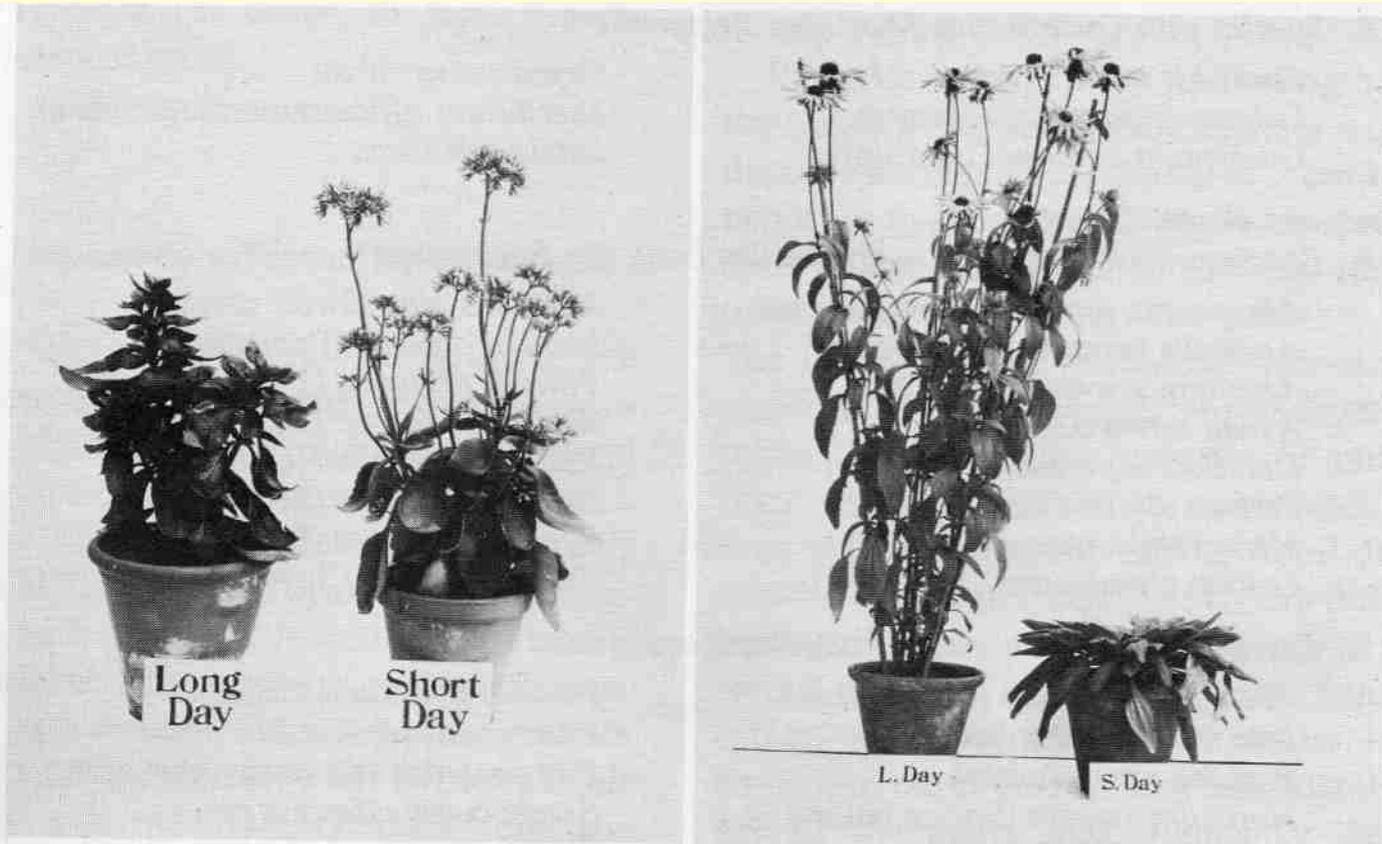


Fig. 9.2. Plants of *Kalanchoë blossfeldiana* (left) and of *Rudbeckia bicolor* (right), flowering in response to short days and long days, respectively.

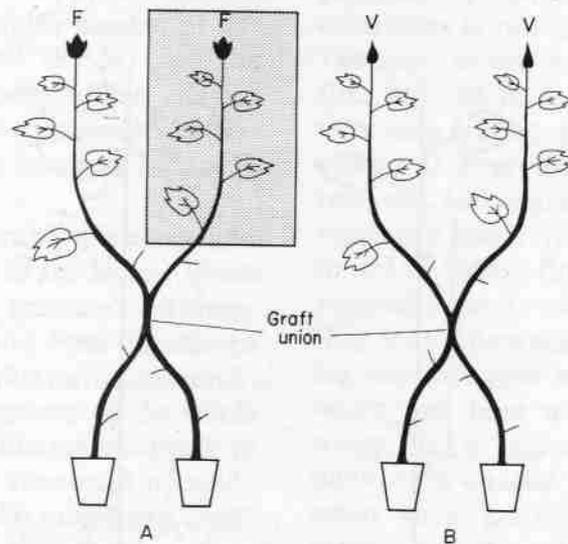
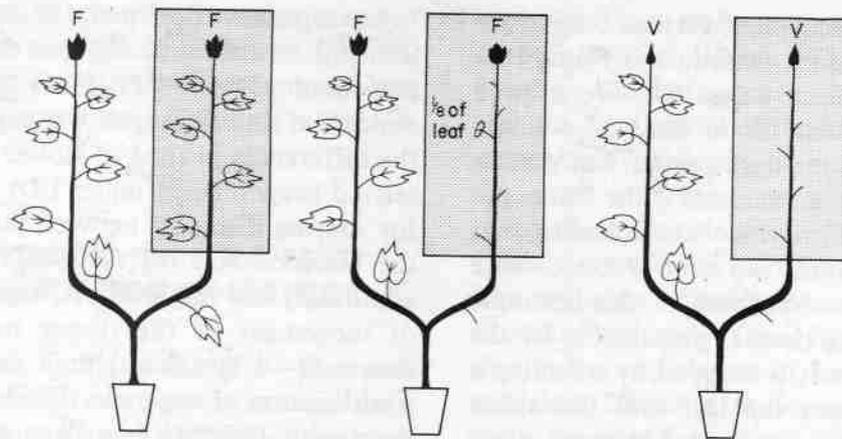
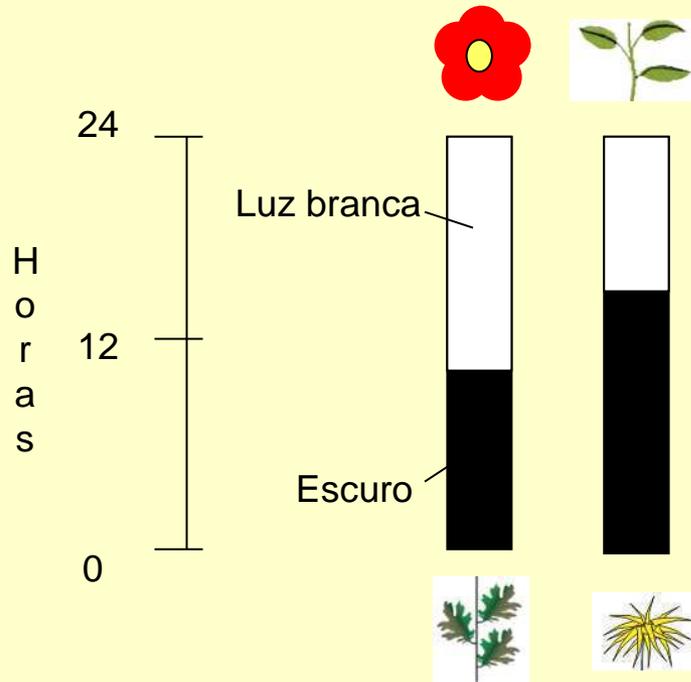


Fig. 9.12. *Above*: Two-branched plants of *Xanthium*, one branch of which was exposed to short days, the rest of the plant being exposed to long days. Both branches have flowered, provided that the "short-day" shoot has at least one-eighth of a leaf, but not if it is completely defoliated (*right*).

Below: A. Two *Xanthium* plants were approach grafted, and the top of one plant was exposed to short days while the other plant was maintained under long days. Both plants have flowered. B. Both plants exposed to long days; neither have flowered. (From K. C. Hamner, *Cold Spring Harbor Symp.* 10, 49, 1942.)

LUZ

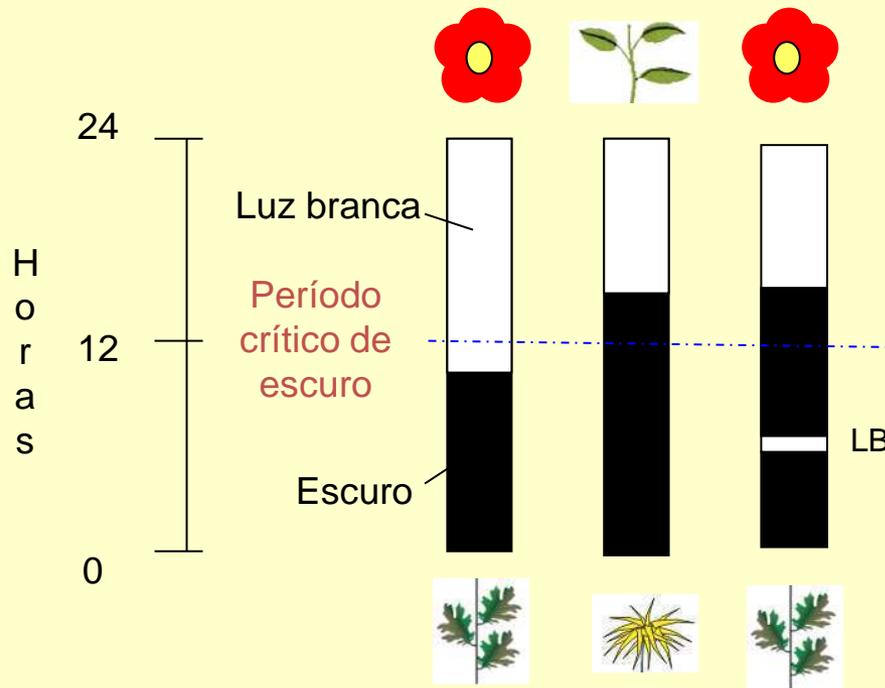
PDL
(noites curtas)



PDC
(noites longas)

LUZ

PDL
(noites curtas)



PDC
(noites longas)

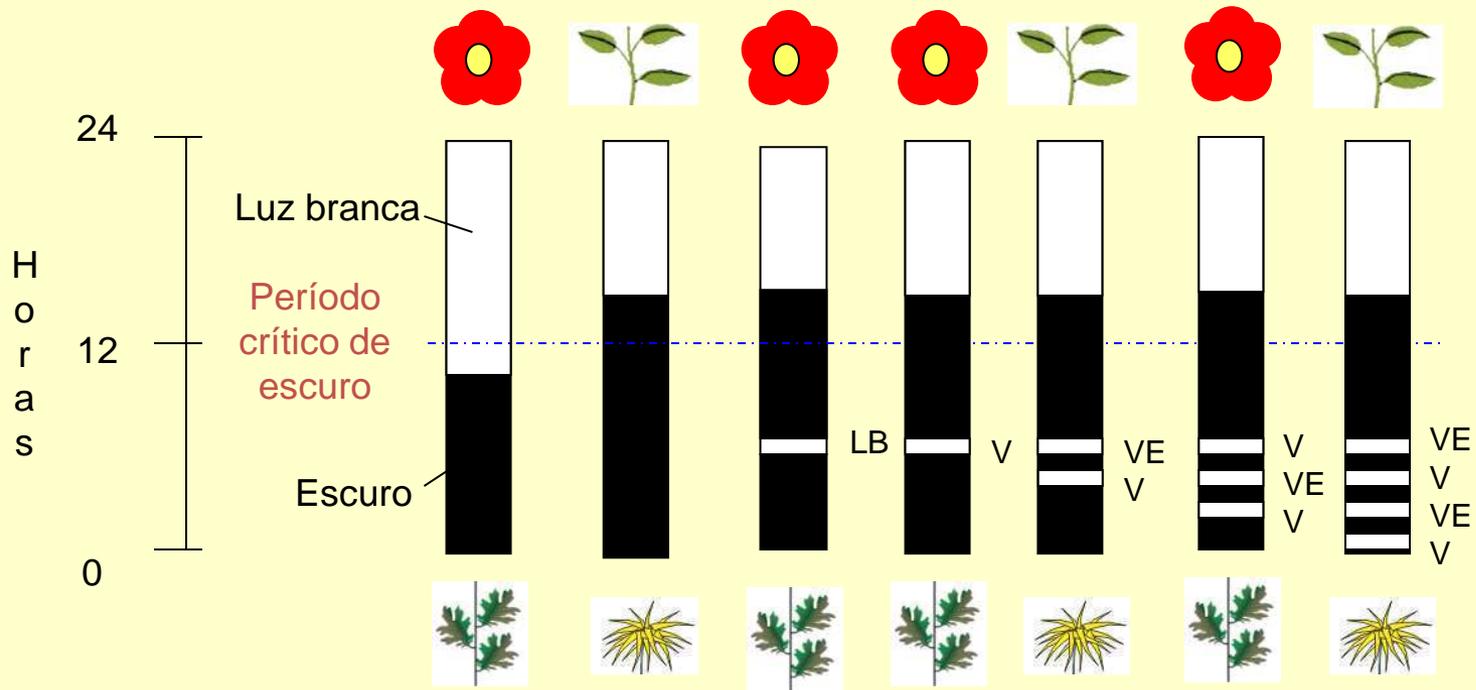
ESCURO:
início dos processos
bioquímicos de indução

variável entre as spp.

Xanthium strumarium : 15 min

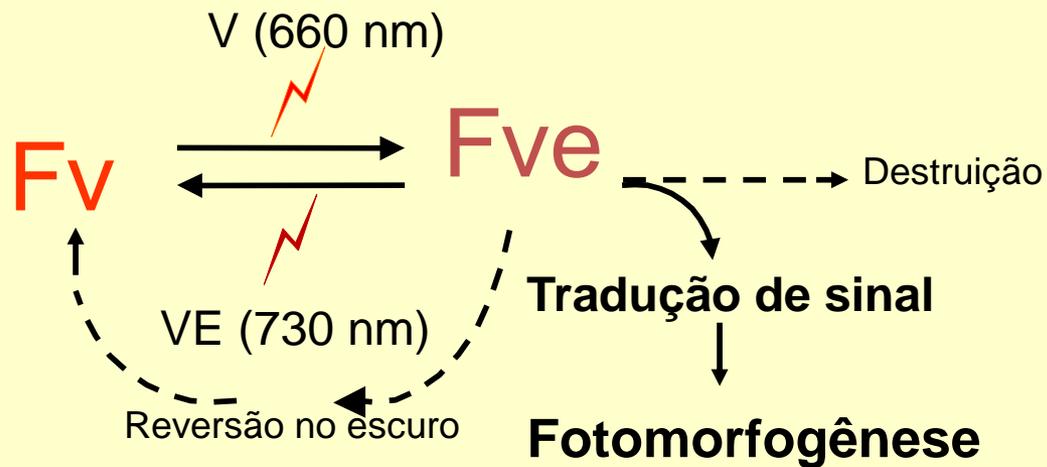
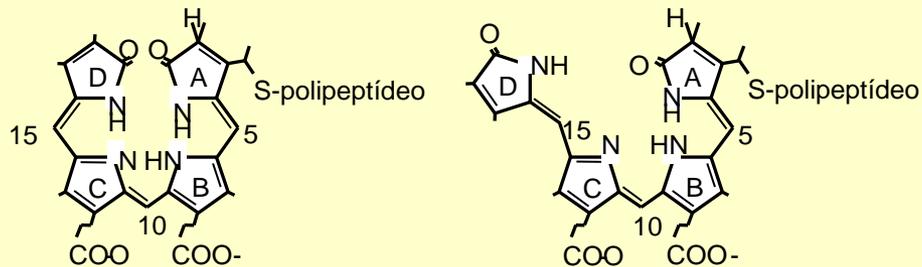
LUZ

PDL
(noites curtas)

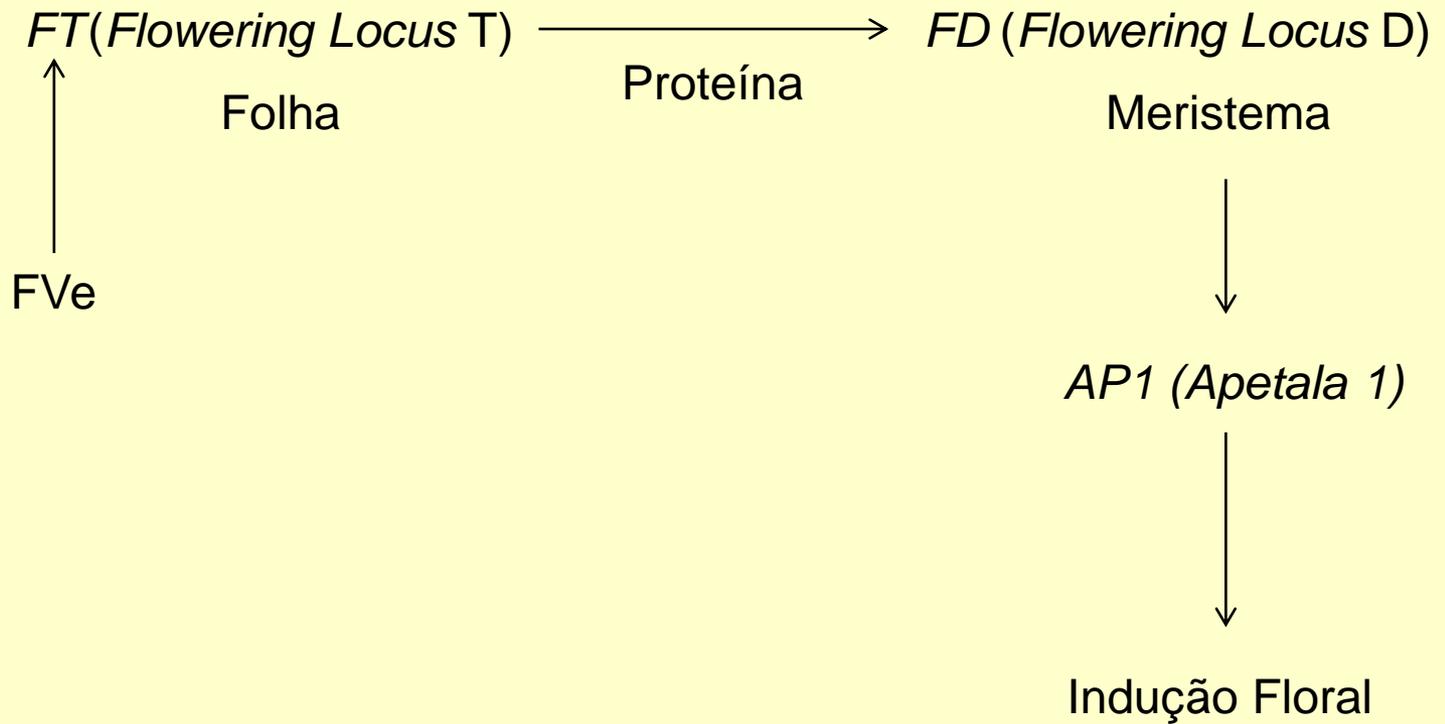


PDC
(noites longas)

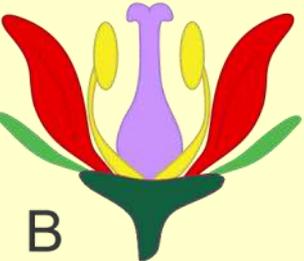
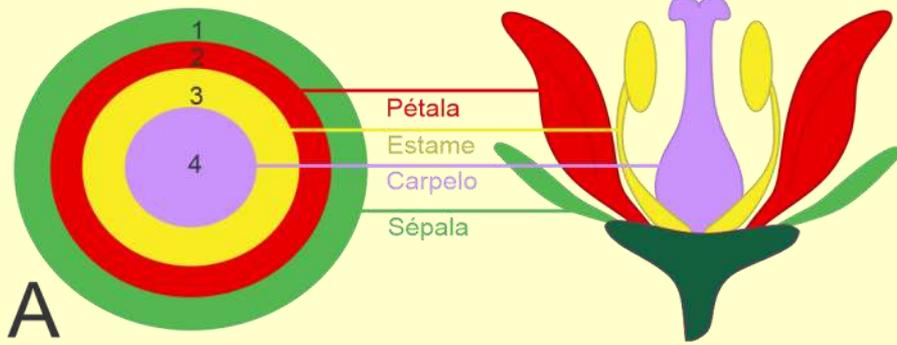
Conversão do fitocromo pela luz



Indução Floral



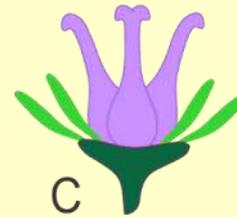
Indução Floral



Selvagem

	Sépala	Pétala	Estame	Carpelo
A	Green	Red	Yellow	Purple
B		Red	Yellow	Purple
C			Yellow	Purple
D				Purple
E	Pink	Pink	Pink	Pink

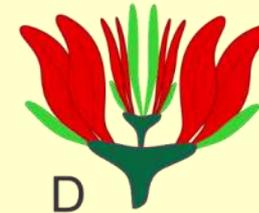
Verticilo: 1 2 3 4



Mutante Apetala 3 e Pistillata sem atividade dos genes do tipo B

	Sépala	Sépala	Carpelo	Carpelo
A	Green	Green	Purple	Purple
B				
C			Purple	Purple

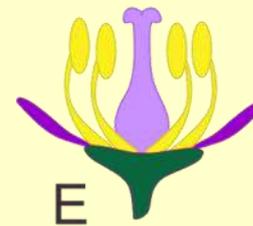
Verticilo: 1 2 3 4



Mutante Agamous sem atividade dos genes do tipo C

	Sépala	Pétala	Pétala	Sépala
A	Green	Red	Red	Green
B		Red	Red	
C				

Verticilo: 1 2 3 4



Mutante Apetala 1 sem atividade dos genes do tipo A

	Carpelo	Estame	Estame	Carpelo
A	Purple	Yellow	Yellow	Purple
B		Yellow	Yellow	
C	Purple	Yellow	Yellow	Purple

Verticilo: 1 2 3 4

TEMPERATURA

vernalização



percepção nos **meristemas**

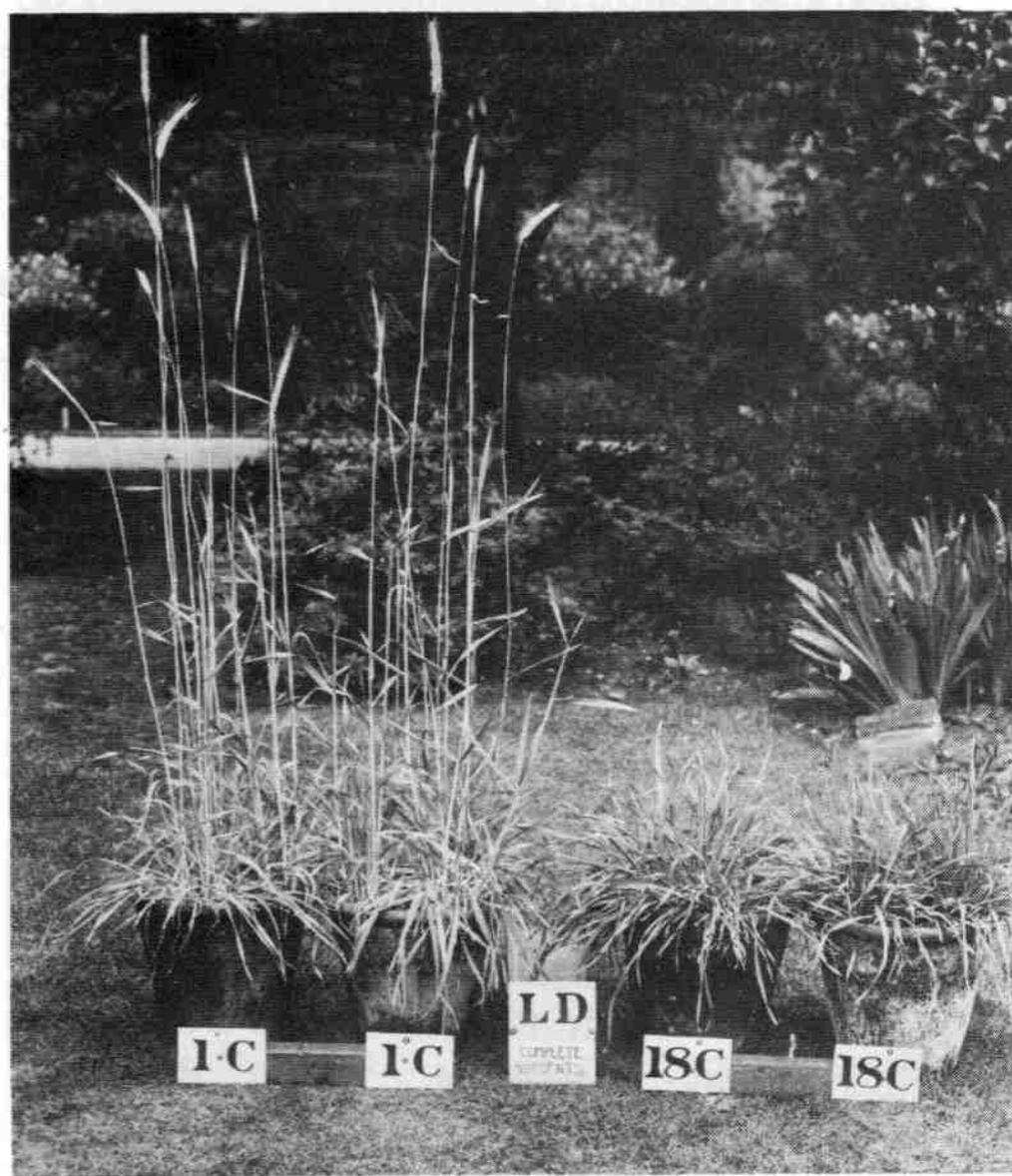


Fig. 10.1. Effect of vernalization of flowering in "Petkus" winter rye (*Secale cereale*). *Left*: maintained for several weeks at 1°C after germination; *right*: seed unvernallized. (From O. N. Purvis, *Ann. Bot.* 48, 919, 1934.)

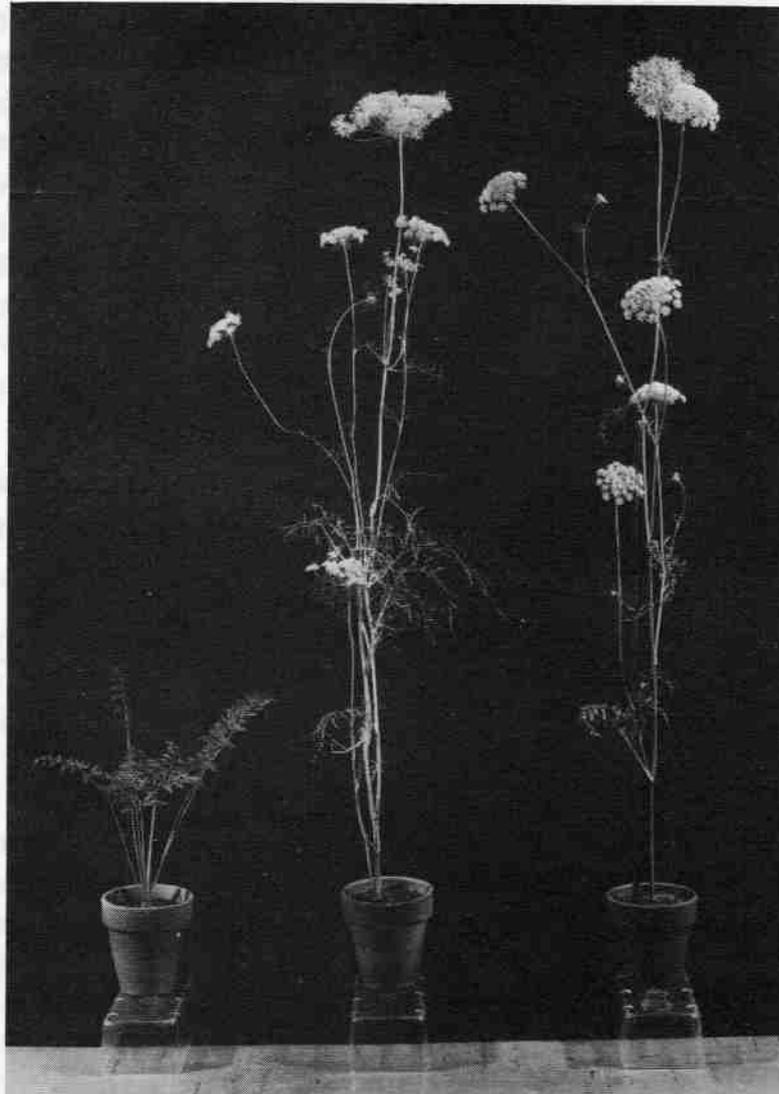
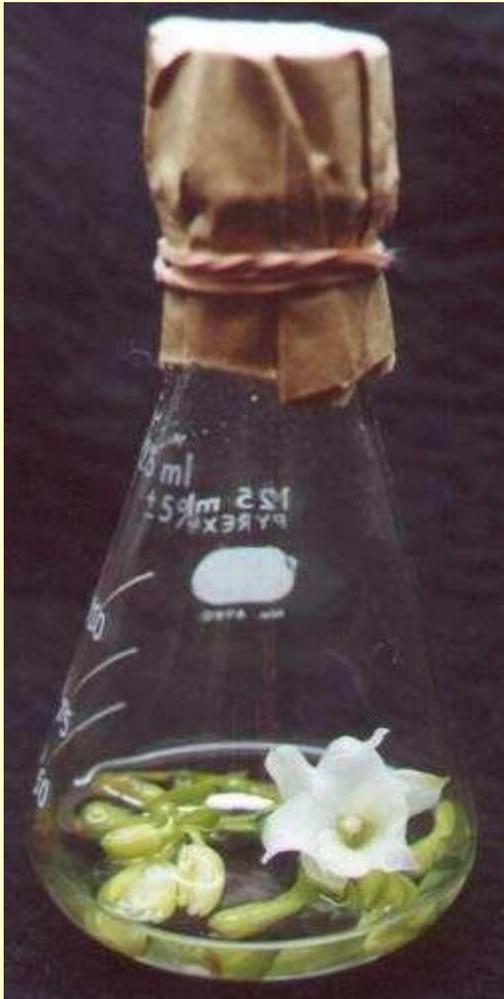


Fig. 10.5. Effect of vernalization and gibberellic acid on flowering of carrot. *Left*: untreated control plant; *right*: plant chilled for 8 weeks; *centre*: plant unchilled but treated with 10g GA₃ per day. (From A. Lang, *Proc. Nat. Acad. Sci., U.S.A.* **43**, 709, 1957.)

FLORAÇÃO In Vitro



Dendrobium nobile Second Love



Doutorado Wagner de Melo Ferreira,
Laboratório de Fisiologia Vegetal, IB-USP,
2004

FLORAÇÃO In Vitro



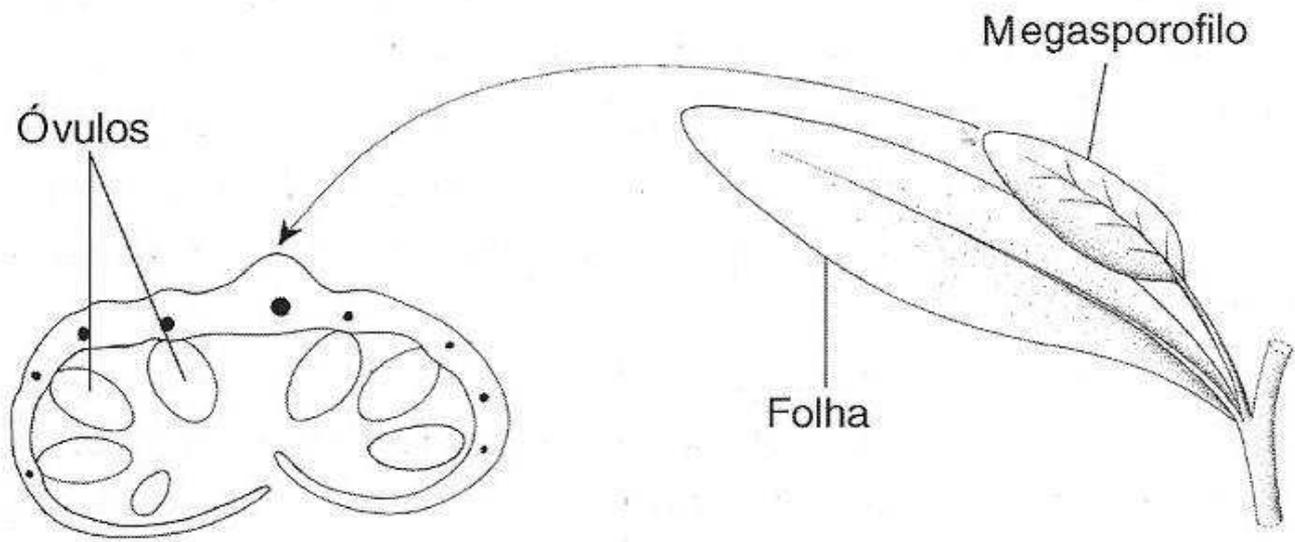
Psycmorchis pusilla

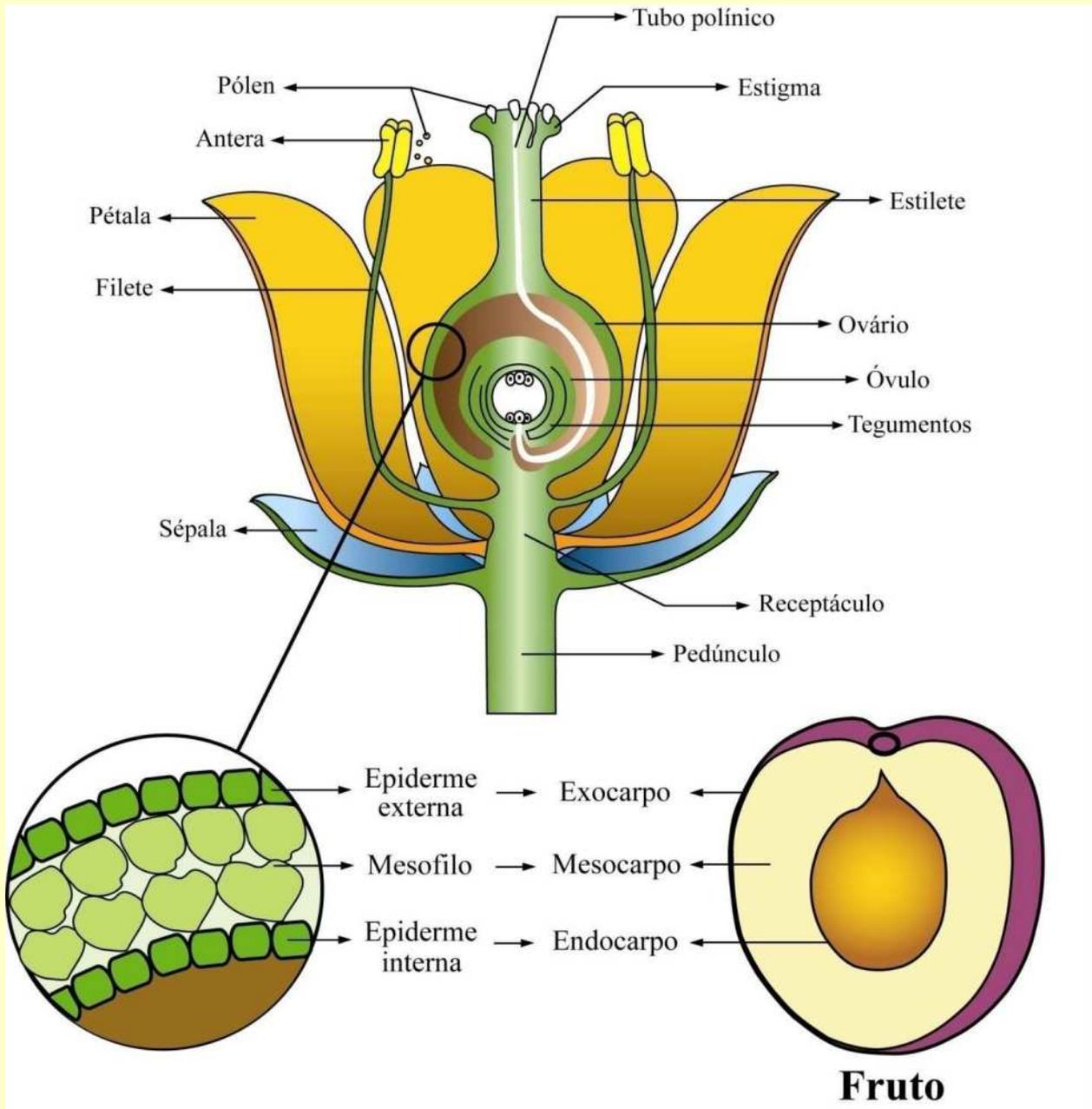
Doutorado Ana Paula Artimonte Vaz,
Laboratório de Fisiologia Vegetal, IB-USP,
2002

FRUTIFICAÇÃO E AMADURECIMENTO

- Prof. Gilberto B. Kerbauy







Frutificação

- Fase I – Envolve a **polinização, fertilização** e o início do desenvolvimento do fruto (“fruit set”).
- Fase II – Marcada pela retomada das **divisões celulares**.
- Fase III – Estágio mais longo, no qual predominam a **expansão celular** e a **maturação do embrião**.

Polinização

Tríplice efeito

- formação do fruto (dreno de utilização);
- formação da semente (dreno de utilização);
- morte celular programada do perianto.



Polinização

Frutos partenocárpicos

- tratamentos hormonais (auxinas e giberelinas);
 - plantas modificadas com o gene *iaa*;
- *Malus domestica* mutante (*mdpi*) para o gene *PISTILLATA*;
 - vantagens comerciais.

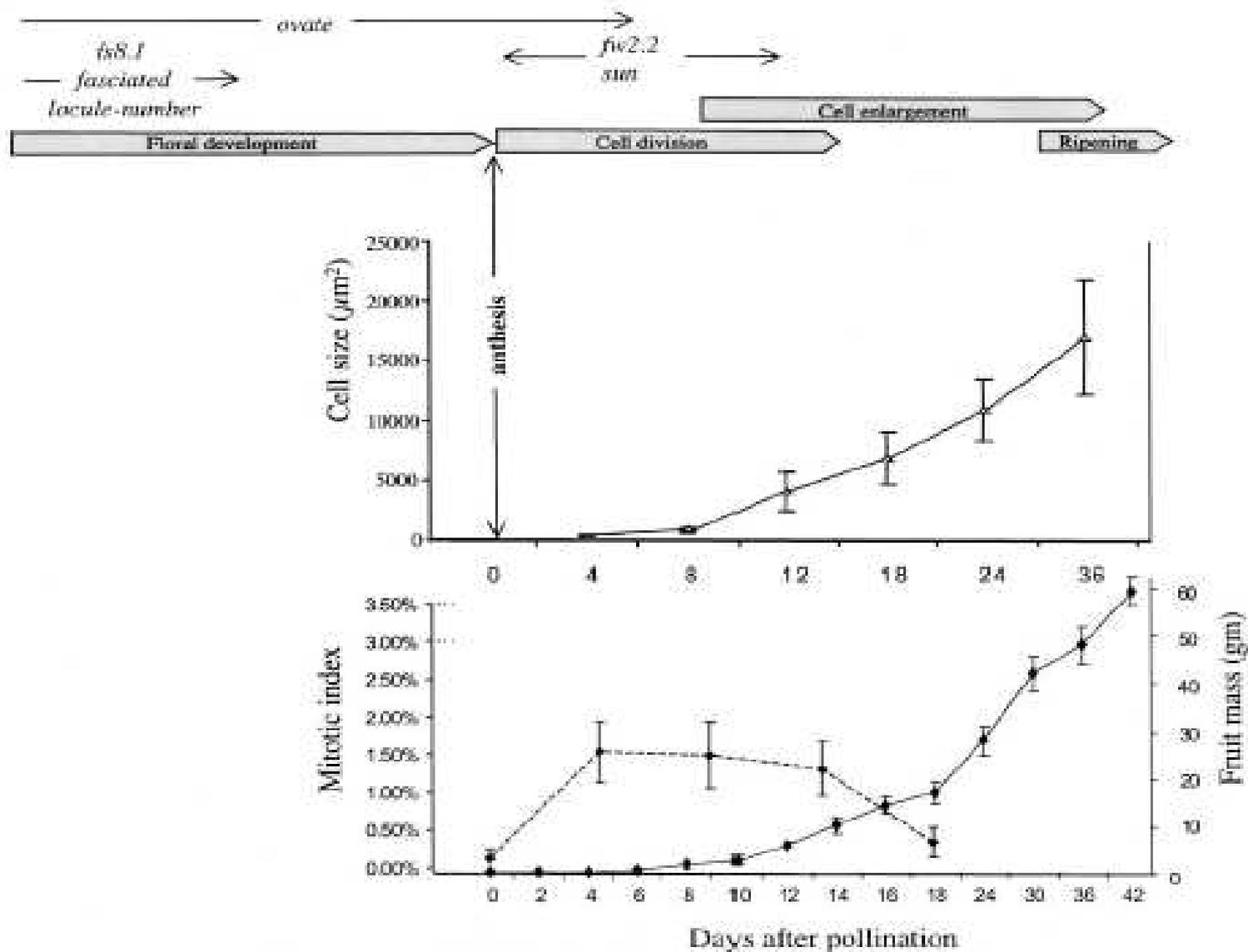


Figure 2. Stages of Tomato Fruit Development

The developmental timing of genes known to affect tomato fruit size and shape is shown at top. Other genes are known to affect fruit size and shape, but the timing of their developmental control is currently unknown (see Table 1).

Expansão celular

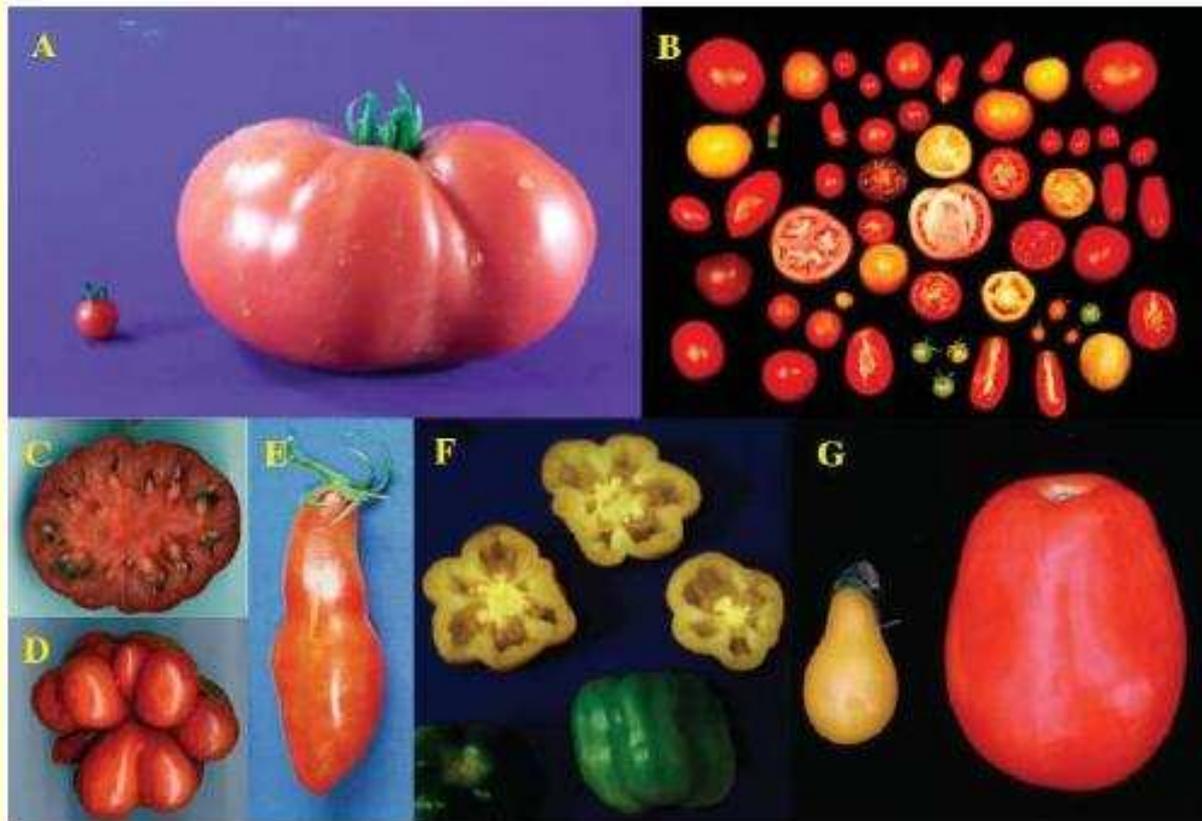
- Hormônios: auxinas e giberelinas.
- Enzimas (xiloglucano endo-transglicosilase – XET).
- Acúmulo de reservas (dreno de armazenamento).



681 Kg

Tamanho e forma do fruto

1. Número final de células do ovário antes da fertilização
2. Número de divisões ocorridas após a fertilização
3. Número de fertilizações bem sucedidas
4. Magnitude da expansão celular
5. Efeito da semente jovem (hormônios)



Interação Fruto X Sementes

Auxinas, giberelinas, citocininas e ácido abscísico



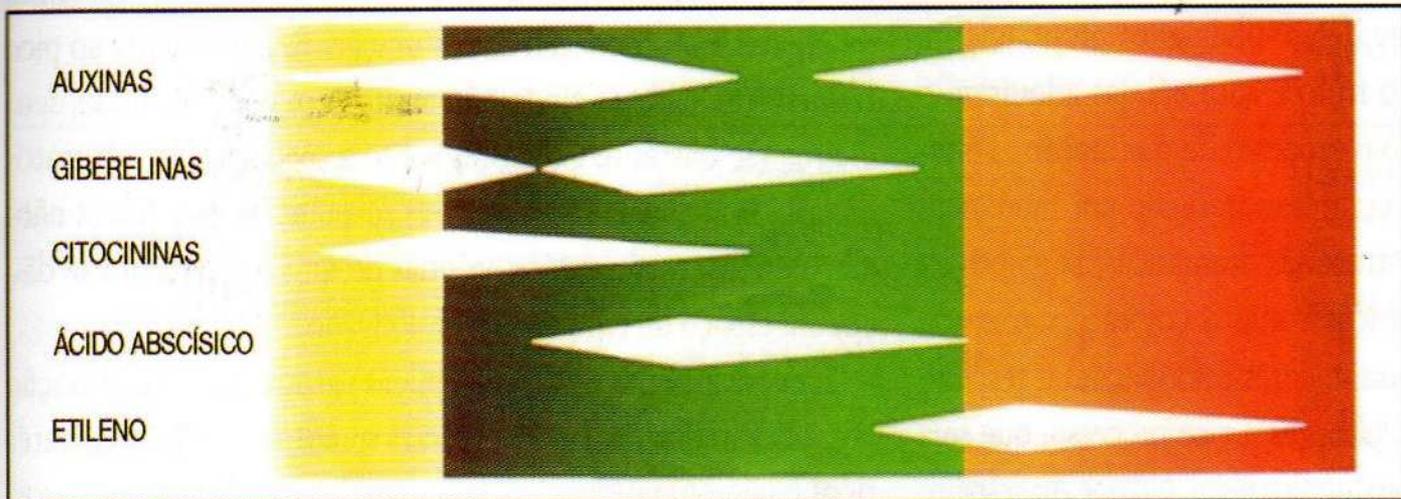
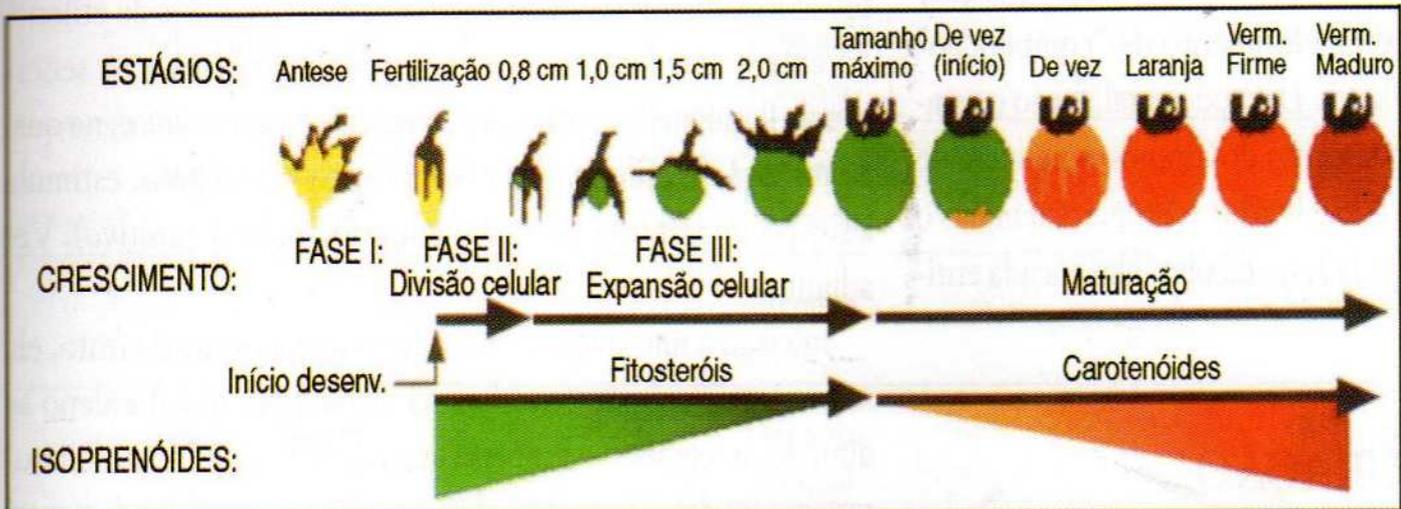
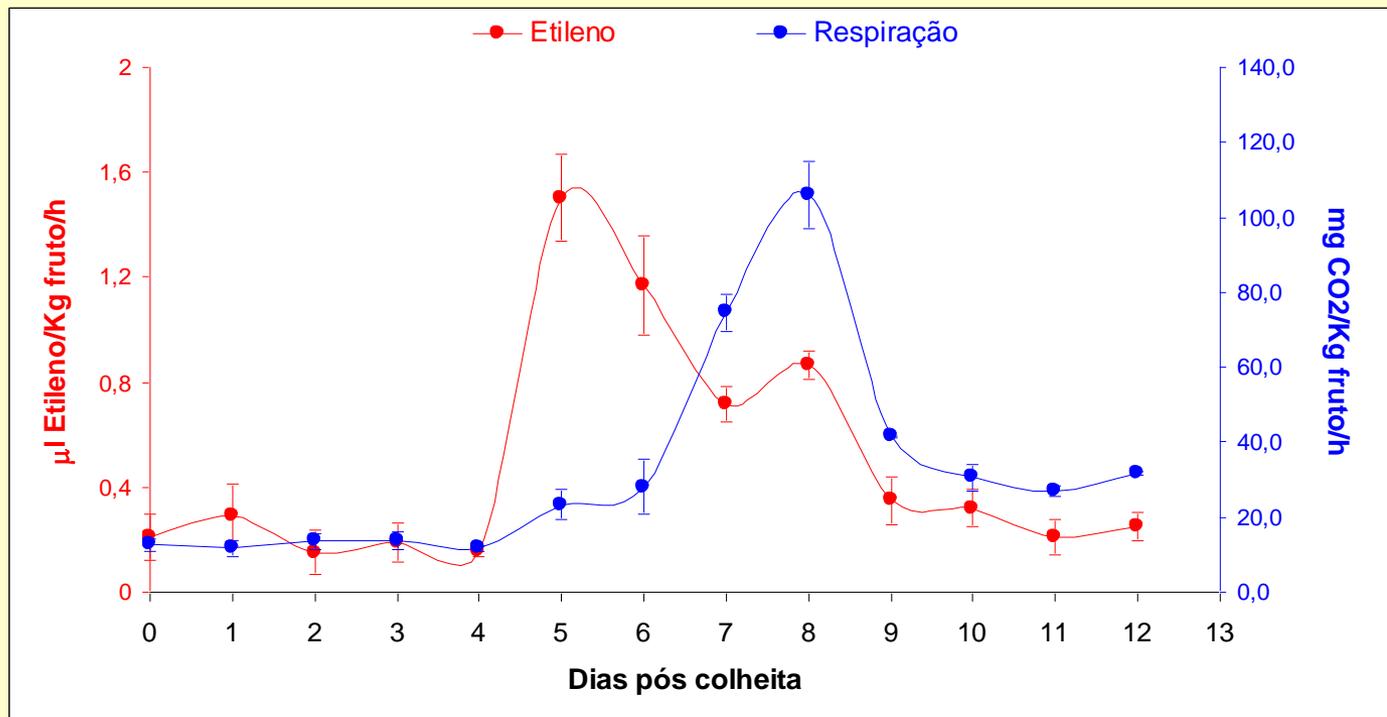


FIGURA 19.10

Variações nos níveis endógenos de auxinas, gibberelinas, citocininas, ácido abscísico e etileno (losangos brancos) durante o desenvolvimento de frutos de tomate. As cores amarela, verde e vermelha indicam os estágios de pré-fertilização, crescimento e amadurecimento, respectivamente. (Reproduzida de Gillaspay G et al. *The Plant Cell*, 2004. American Society of Plant Biologists, Fig. 2, Vol. 5, página 1441.)

Maturação

- Tipos de frutos carnosos.
- Climatéricos - pulsos de etileno e respiratório.
- Não-climatéricos – sem pulsos.



FRUTOS CLIMATÉRICOS E NÃO-CLIMATÉRICOS

<i>Ficus carica</i>	Figo	Morácea	CL
<i>Fragaria</i> (Híbrido)	Moranguinho	Rosácea	NC
<i>Litchi chinensis</i>	Lichia	Sapindácea	NC
<i>Lycopersicon esculentum</i>	Tomate	Solanácea	CL
<i>Malus domestica</i>	Maçã	Rosácea	CL
<i>Mangifera indica</i>	Manga	Anacardiácea	CL
<i>Monstera deliciosa</i>	Banana-de-macaco	Arácea	CL
<i>Musa</i> sp	Banana	Musácea	CL
<i>Passiflora edulis</i> f. <i>flavicarpa</i>	Maracujá-amarelo	Passiflorácea	CL
<i>Persea americana</i>	Abacate	Laurácea	CL
<i>Prunus persica</i>	Pêssego	Rosácea	CL
<i>Prunus armeniaca</i>	Damasco	Rosácea	CL
<i>Prunus domestica</i>	Ameixa	Rosácea	CL
<i>Prunus</i> sp	Cereja	Rosácea	NC
<i>Psidium guajava</i>	Goiaba	Mirtácea	CL
<i>Pyrus communis</i>	Pêra	Rosácea	CL
<i>Rubus rosifolius</i>	Moranguinho silvestre	Rosácea	CL
<i>Syzygium malaccense</i>	Jambo-vermelho	Mirtácea	NC
<i>Vitis vinifera</i>	Uva	Vitácea	NC
<i>Eugenia uniflora</i>	Pitanga	Mirtácea	NC
<i>Feijoa sellowiana</i>	Feijoa	Mirtácea	CL

<i>Actinia deliciosa</i>	Quiuí, quivi	Actiniácea	CL
<i>Anacardium occidentale</i>	Caju	Anacardiácea	NC
<i>Ananas comosus</i>	Abacaxi	Bromeliácea	NC
<i>Annona cherimola</i>	Cherimóia	Anonácea	CL
<i>Annona squamosa</i> L. X <i>A. cherimola</i> Mill.	Atemóia	Anonácea	CL
<i>Annona muricata</i>	Graviola	Anonácea	CL
<i>Annona squamosa</i>	Fruta-do-conde, pinha, ata	Anonácea	CL
<i>Artocarpus heterophyllus</i>	Jaca	Morácea	CL
<i>Averrhoa carambola</i>	Carambola	Oxalidácea	NC
<i>Carica papaya</i>	Mamão	Caricácea	CL
<i>Citrus aurantifolia</i>	Lima, lima-da-ásia, limão-galego	Rutácea	NC
<i>Citrus reticulata</i>	Tangerina	Rutácea	NC?
<i>Citrus sinensis</i>	Laranja	Rutácea	NC
<i>Diospyros digyna</i>	Sapota-preta, graxa	Ebenácea	CL
<i>Diospyros kaki</i>	Caqui	Ebenácea	CL



—
1cm



Frutos climatéricos



Tomate, banana, caqui, mamão etc.

ETILENO

ABA?



Uva, citrus, moranguinho, kiwi etc.

Frutos não climatéricos

Mudanças Durante o Amadurecimento

Coloração

- degradação das clorofilas
- síntese de antocianina (flavonóides)
- síntese de carotenóides (terpenos – 40C)
- (sintase do fitoeno – genes *Psy1* e *Psy2*)

Mudanças Durante o Amadurecimento

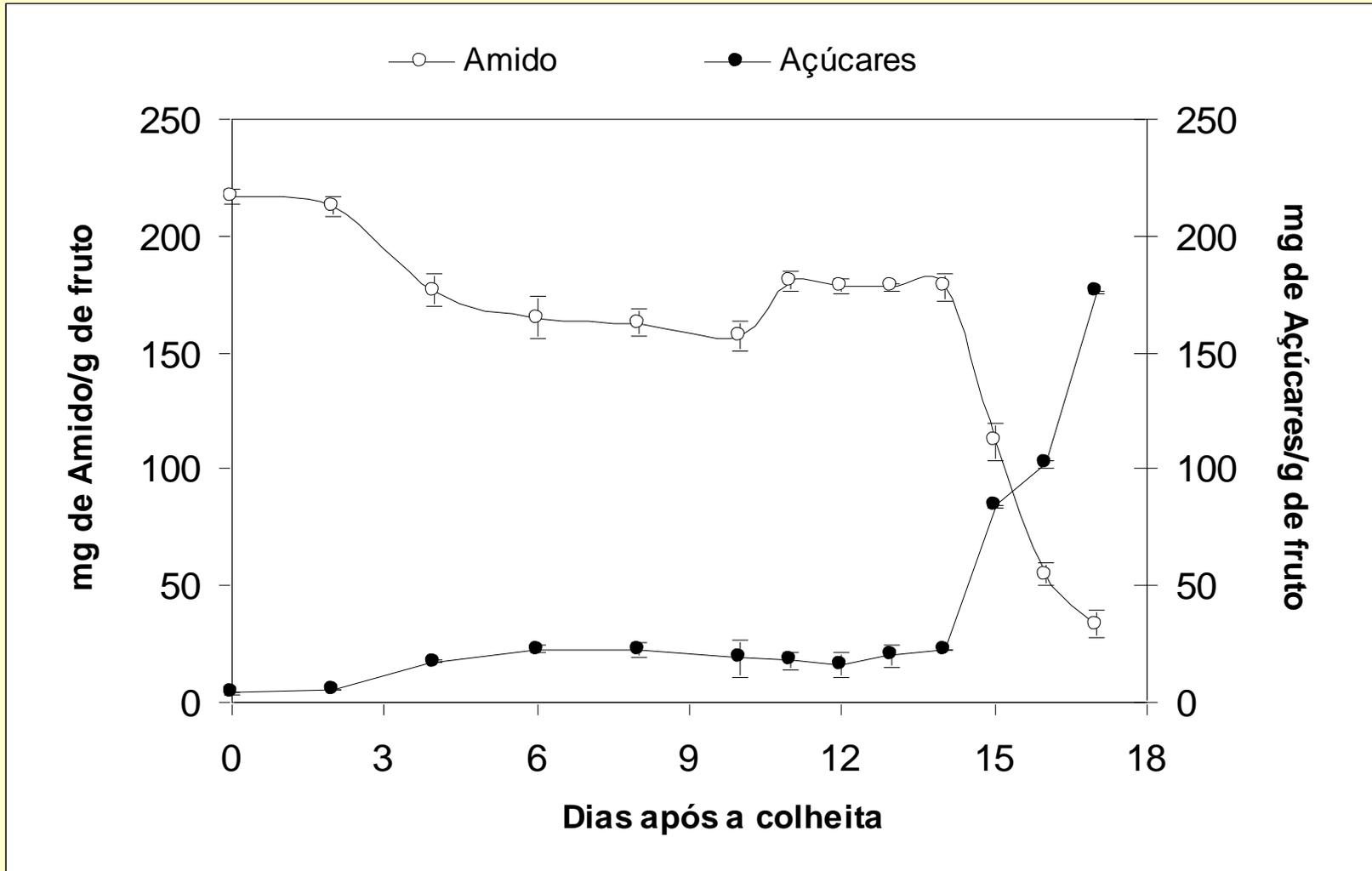
Amolecimento

- pectinas → poligalacturonases
- celulose → celulasas
- hemiceluloses → XET

Mudanças Durante o Amadurecimento

Sabor

- açúcares
- ácidos orgânicos
- taninos



Mudanças Durante o Amadurecimento

Aroma

- tomate → + de 400 substâncias voláteis
- maçã → ± 300 voláteis

Armazenamento de maçãs sob condições de atmosfera controlada (AC) e frio.

Cultivar	Temperatura (°C)		Concentrações (%)		Período (meses)	
	AC	Frio	CO₂	O₂	AC	Frio
Gala	0 a 1	0 a 1	1 a 2	1,5 a 2	5	3
Golden Delicious	0 a 0,5	0	3 a 4	1 a 2	7 a 8	5 a 6
Fuji	1 a 1,5	0 a 1	0 a 1	1,5 a 2	7 a 9	6 a 7
Granny Smith	0 a 0,5	0	1 a 3	1 a 2	7 a 9	5 a 7

Senescência e morte celular programada



Growth and Differentiation in Plants

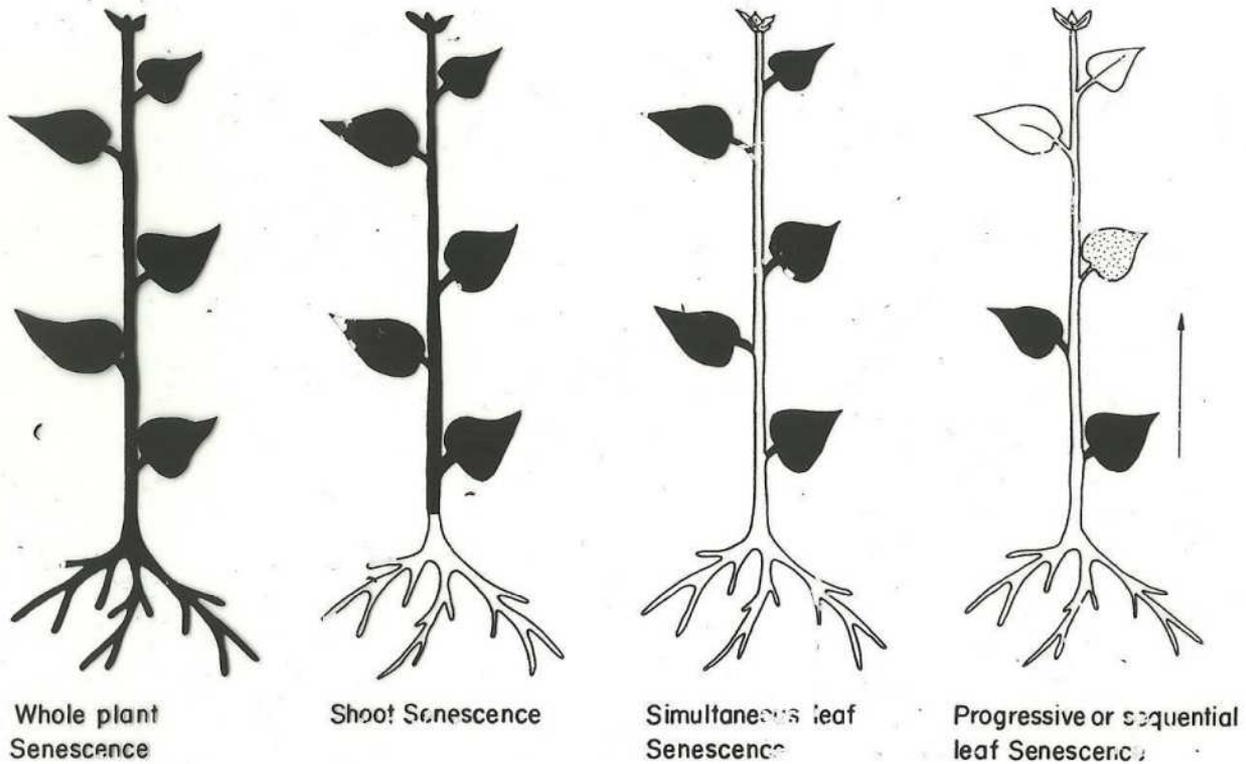
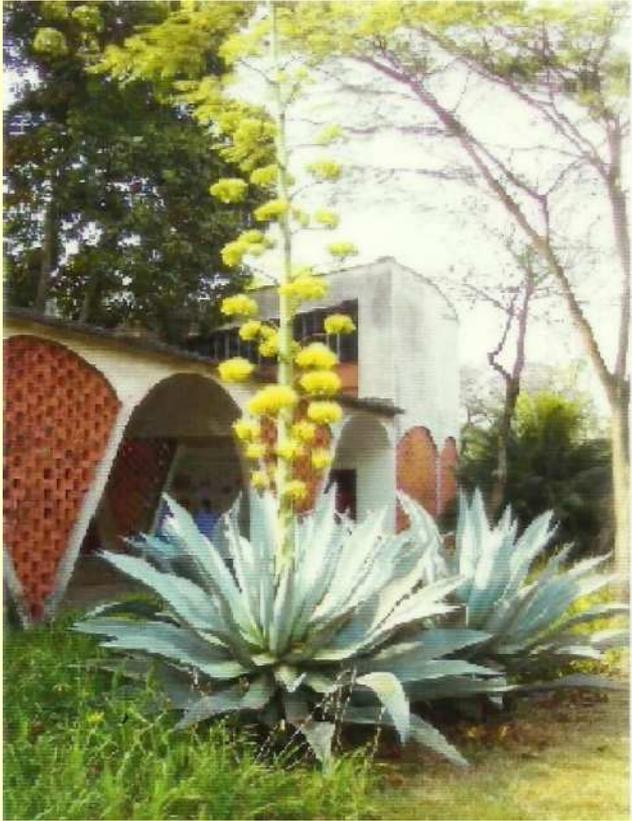


Fig. 12.1. Types of plant- and leaf-senescence.



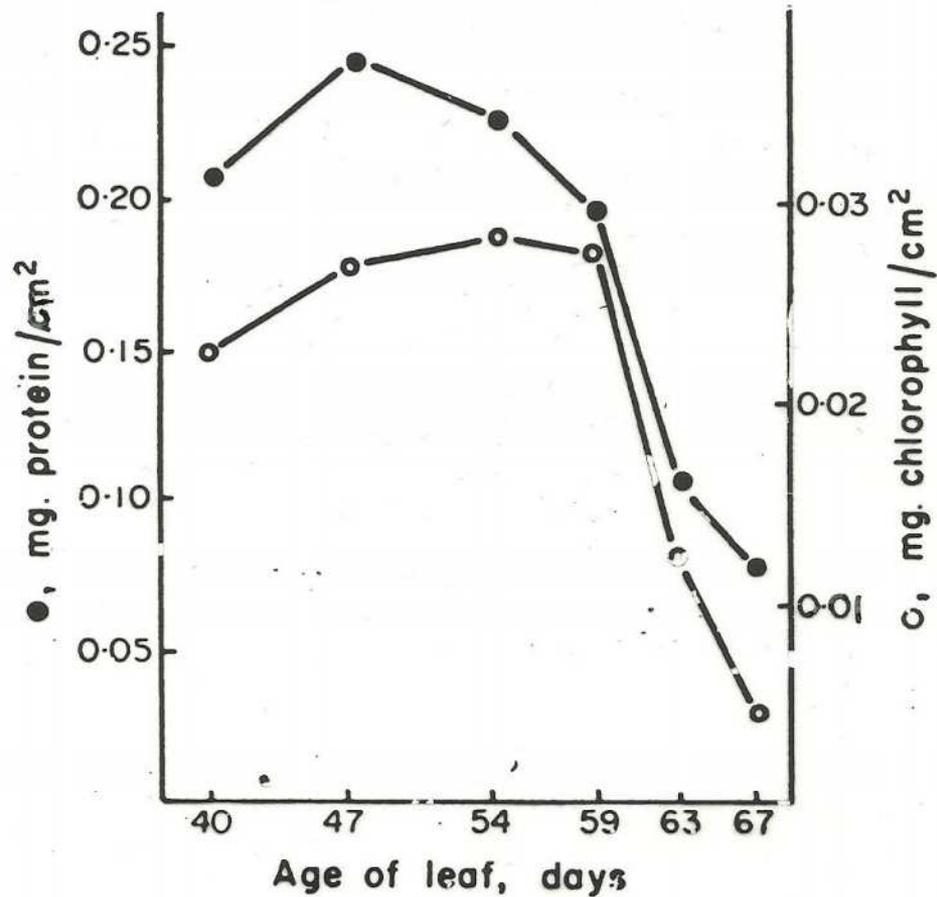


Fig. 12.2. Changes in protein and chlorophyll content of attached leaves of *Perilla frutescens* from expansion to abscission. (From H. W. Woolhouse, *Symp. Soc. Exp. Biol* 21, 179, 1967.)

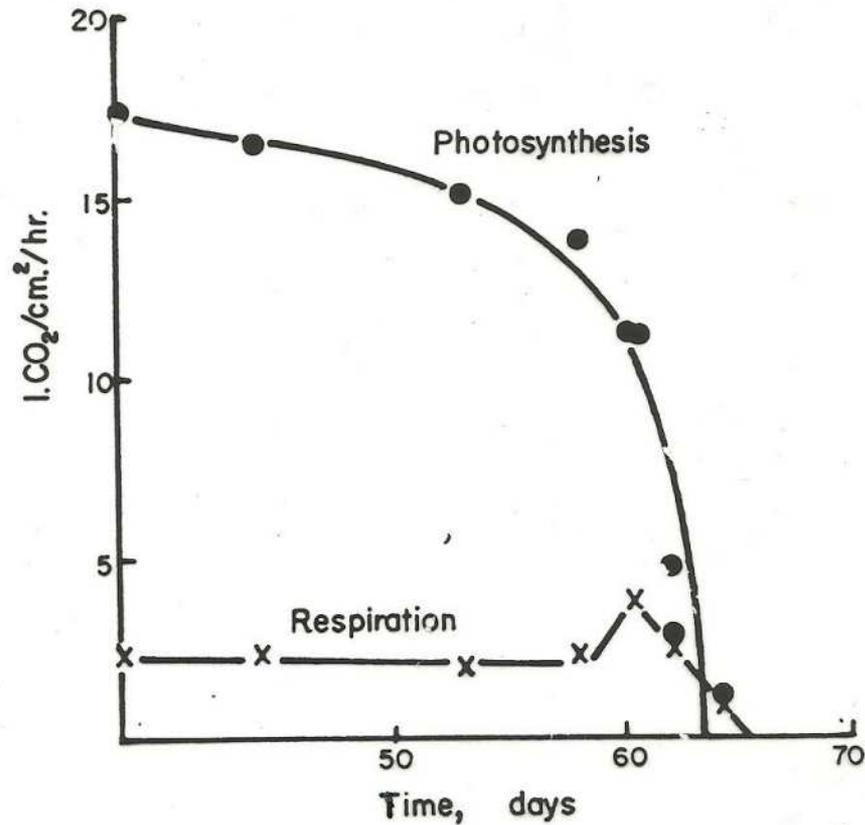


Fig. 12.4. Changes in rates of photosynthesis and respiration of attached leaves of *Perilla frutescens* from completion of expansion to abscission. (From H. W. Woolhouse, as for Fig. 12.2.)

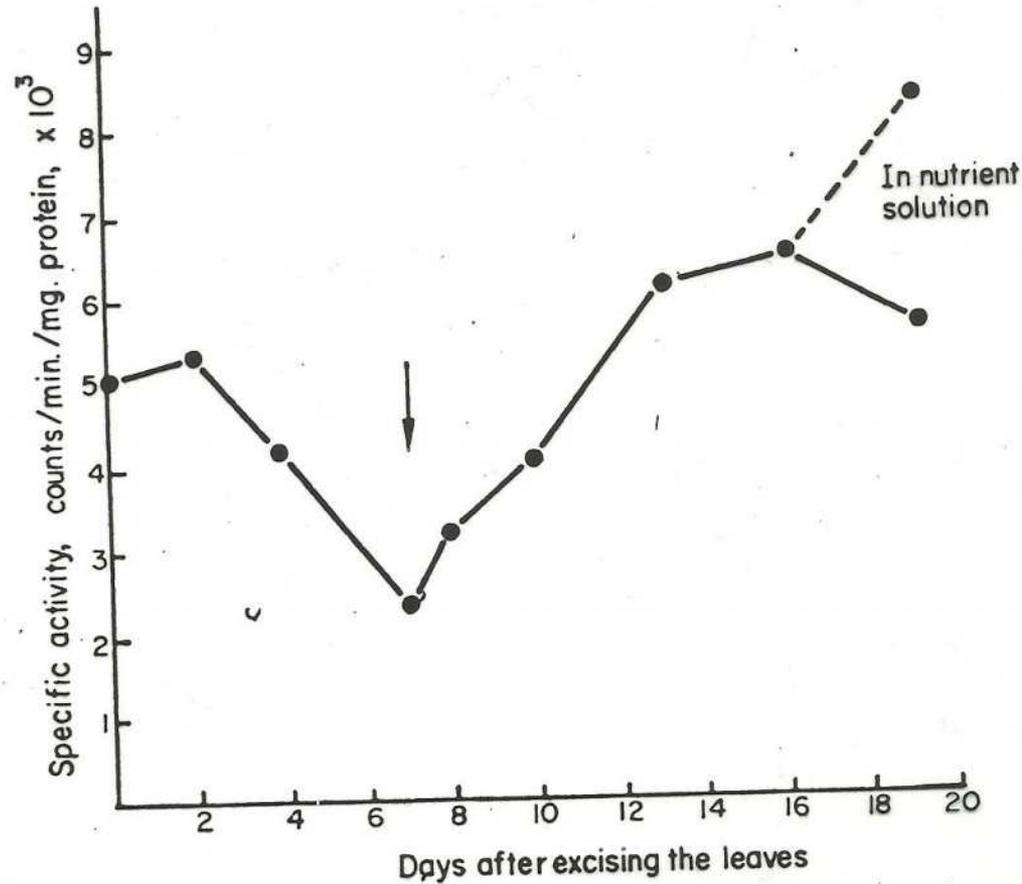


Fig. 12.7. Changes in capacity for protein synthesis (as measured by incorporation of ^{35}S -methionine into protein) in leaves of *Nicotiana rustica*. Note initial decline in capacity for protein synthesis, followed by recovery when roots appeared on petiole (indicated by arrow). (After von. B. Parthier, *Flora, Jena*, 154, 230, 1964.)

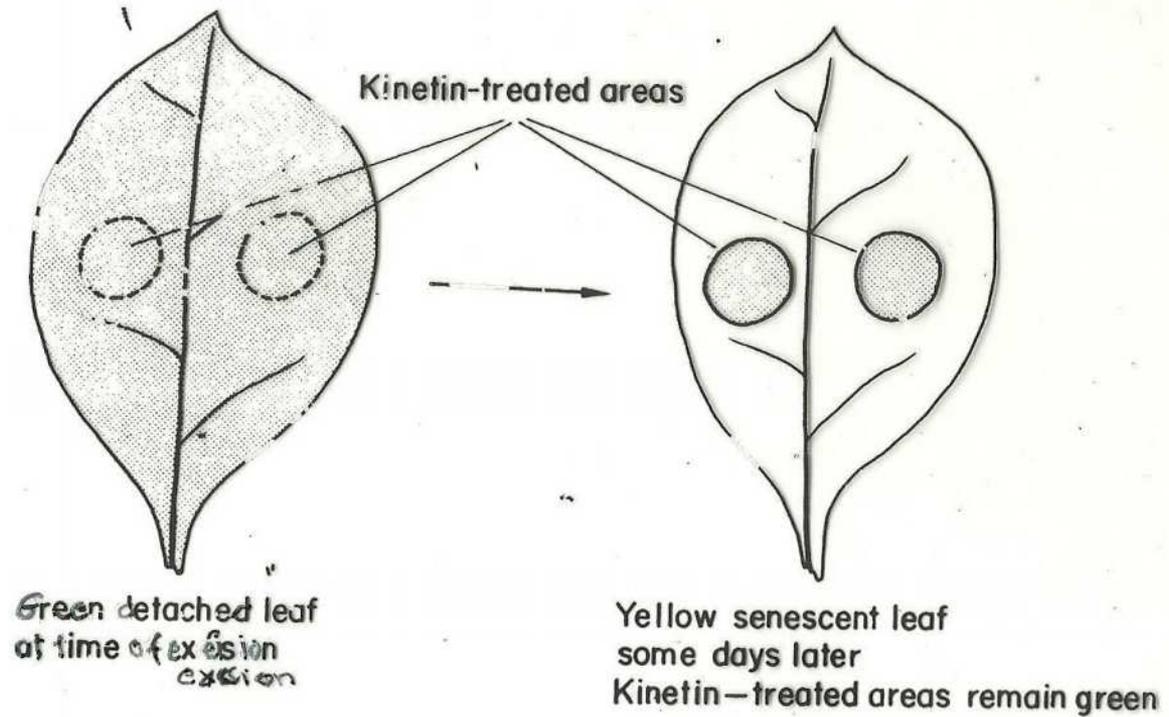
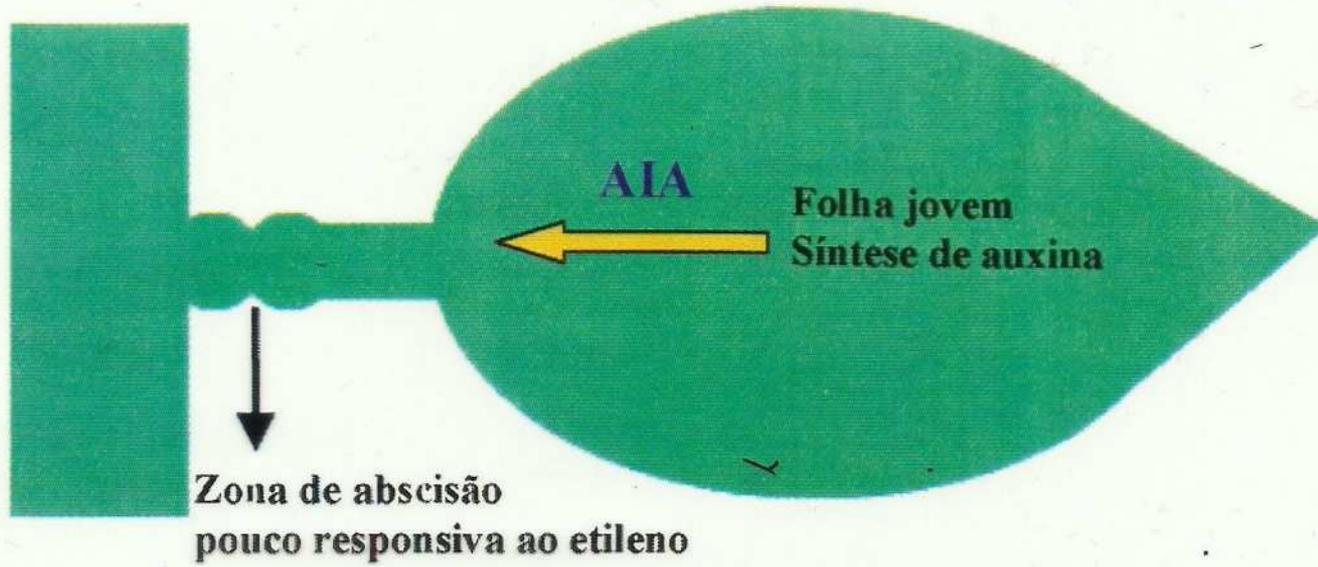


Fig. 12.8. Effects of kinetin on leaf senescence.



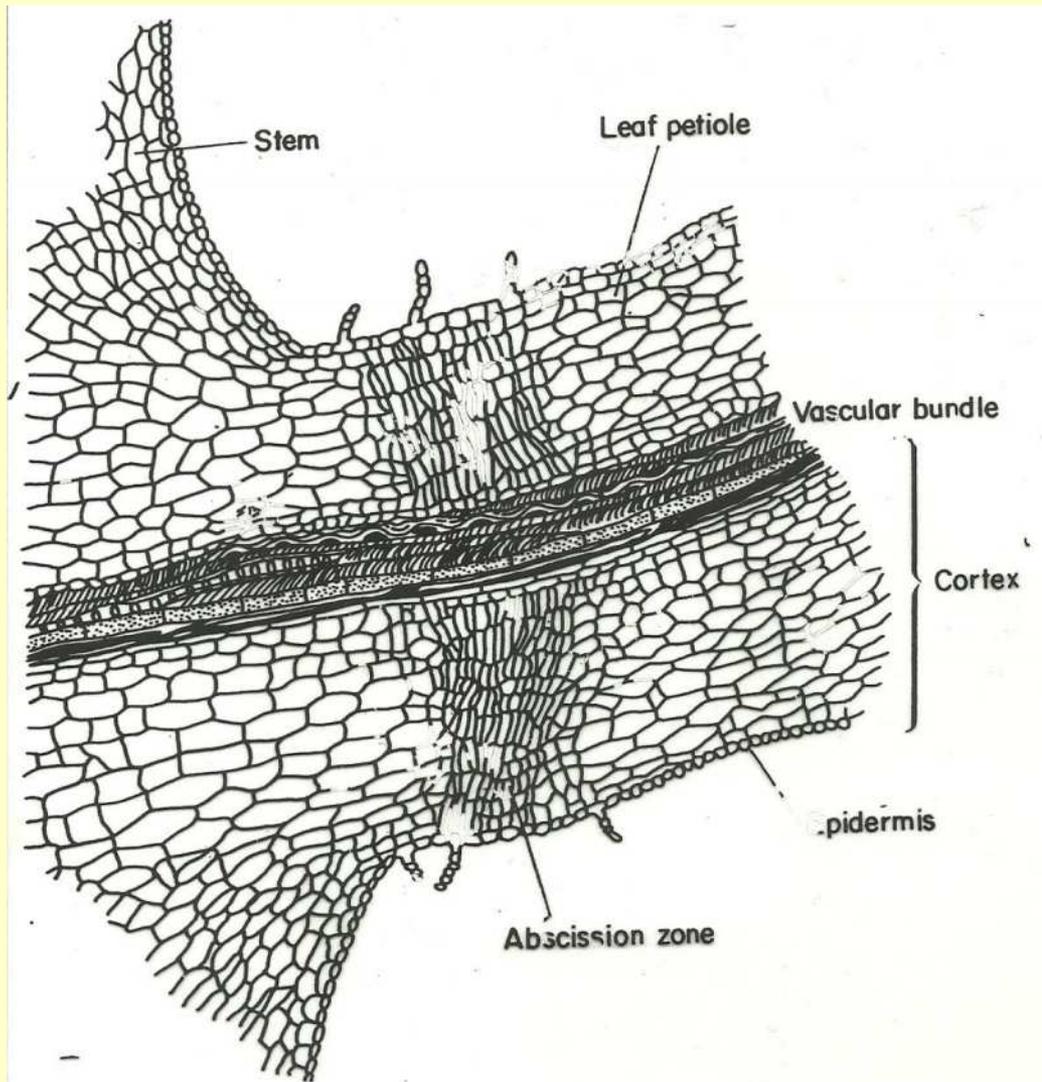


Fig. 12.12. Longitudinal section through the abscission region of the base of the petiole of a leaf of a typical dicotyledonous plant. (From J. Torrey, *Development in Flowering Plants*, Macmillan, New York, 1967.)

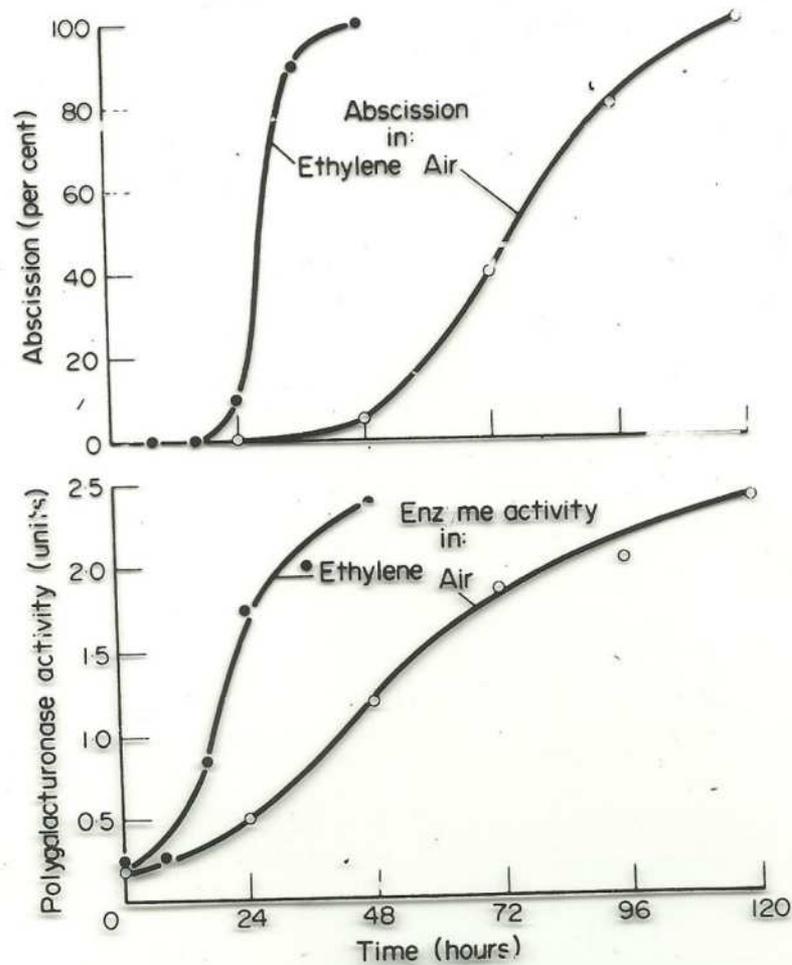


Fig. 12.13. A comparison of the time-courses of development of polygalacturonase activity and occurrence of abscission in *Citrus sinensis* leaf explants incubated in either air or in air containing 10 ppm ethylene. (Adapted from J. Riov, *Plant Physiol.* 53, 312-16, 1974.)

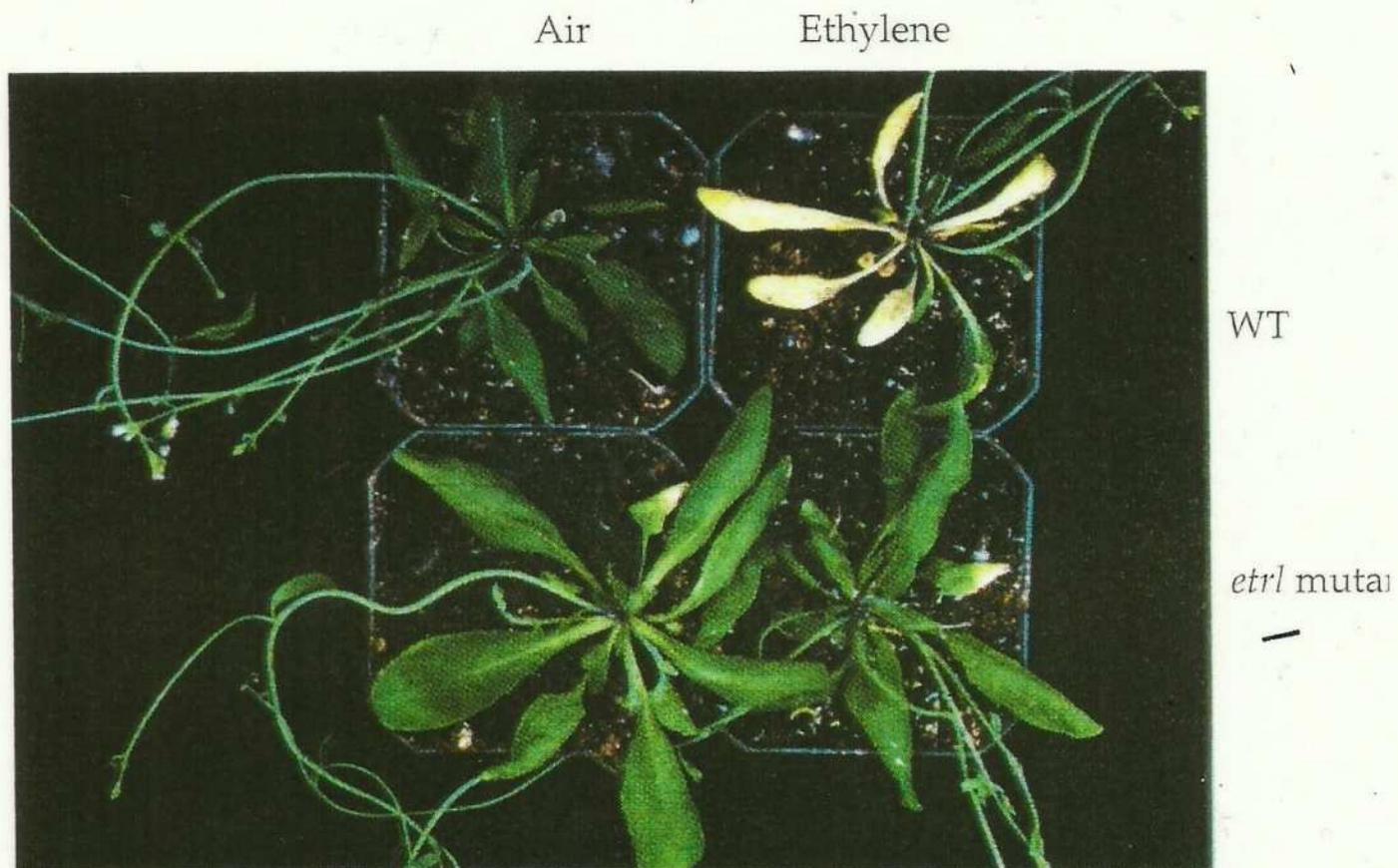


Figure 20.26

Ethylene promotes leaf senescence in wild-type (WT) *Arabidopsis*, but not in the ethylene-insensitive *etr1* mutant.



Gene quimérico auto-regulador da senescência

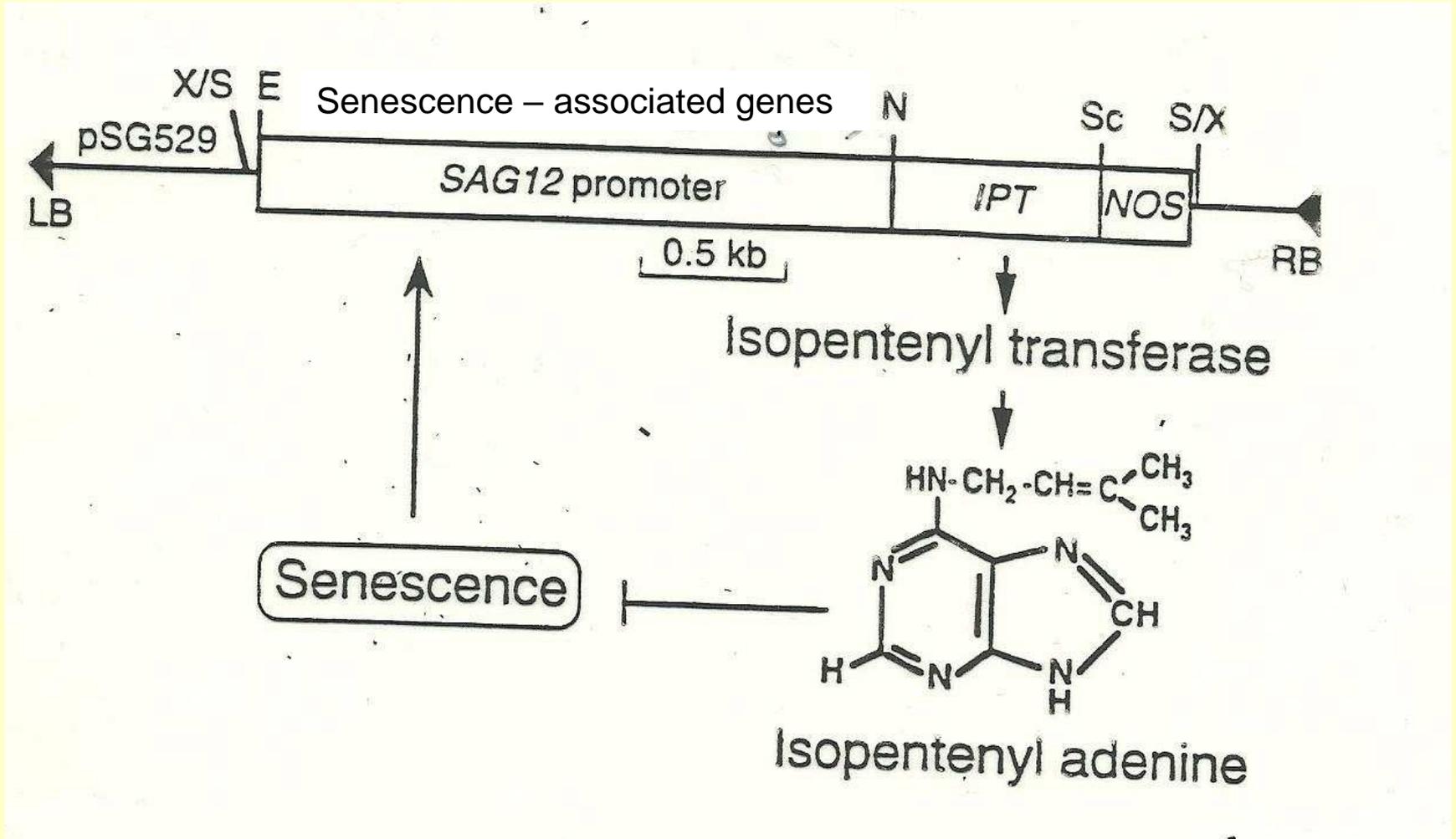




Fig. 6. Retarded leaf senescence in a transgenic tobacco plant containing the autoregulatory system (left) compared with that of an age-matched, wild-type plant (right)⁽⁴³⁾. (Reproduced by permission of *Science*.)

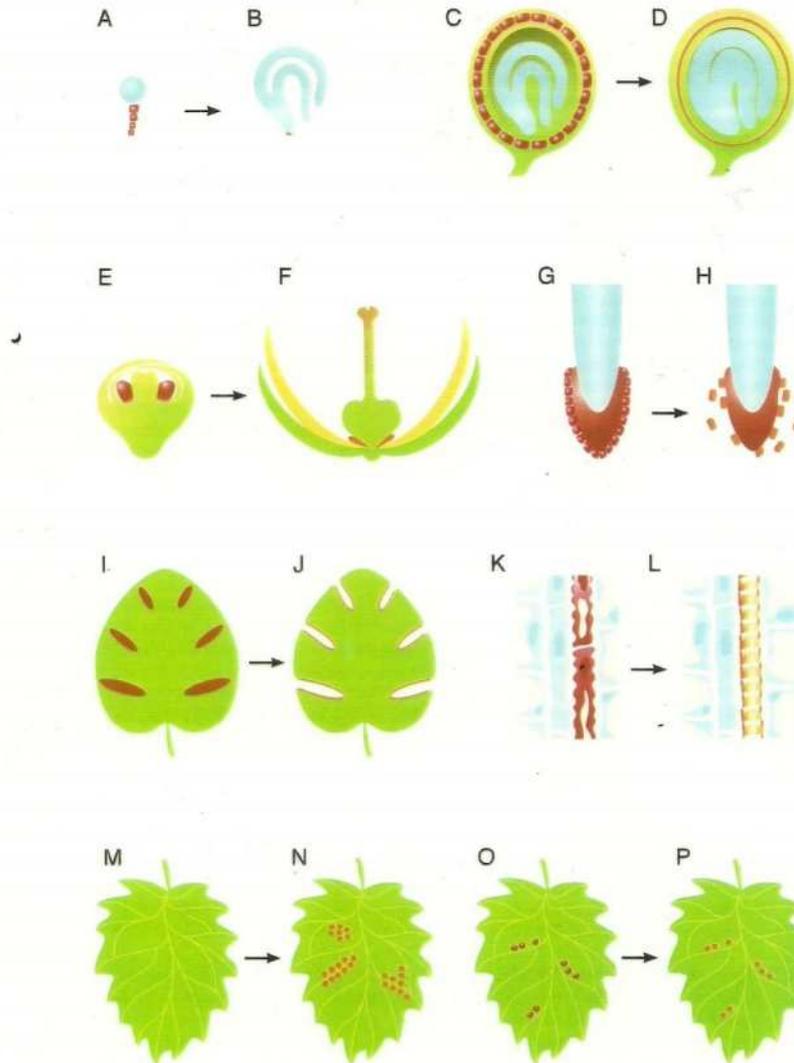


Figure 4. Functions of PCD in Plants.

(A) to (D) Deletion of cells with temporary functions. These include deletion of suspensor cells in embryos ([A] and [B]) and of aleurone cells in seeds ([C] and [D]).

(E) to (H) Deletion of unwanted cells. These include stamen primordia cells in unisexual flowers ([E] and [F]) and root cap cells ([G] and [H]).

(I) and (J) Deletion of cells during sculpting of the plant body (I) and deletion of leaf cells during leaf lobing (J).

(K) and (L) Deletion of cells during cell specialization in TEs. (Elementos Transcritivos)

(M) to (P) Deletion of cells during plant interactions with pathogens. These include cells in an HR ([M] and [N]) and cells in uninfected leaves in response to HR-derived signals ([O] and [P]).

The red regions represent cells that have been targeted for PCD, and the orange regions represent cells that have died by PCD.

