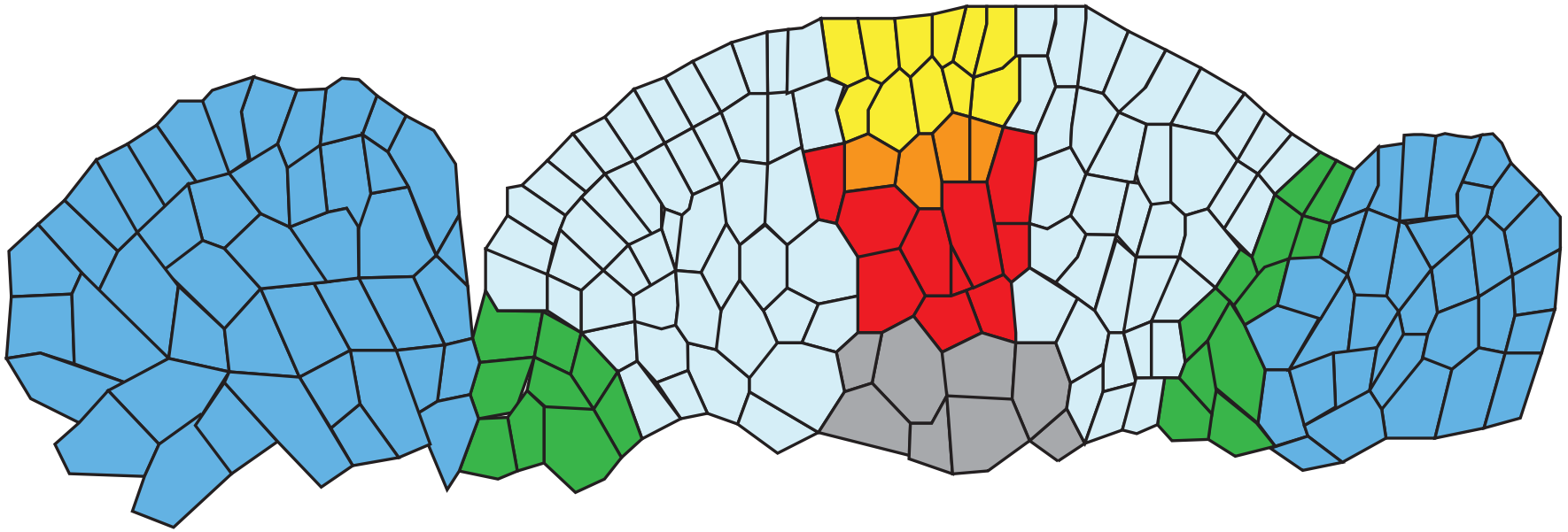
2018 CDB Part IB
Plant Development

Lecture 5.
Formation and specification of lateral organs

Jim Haseloff
Department of Plant Sciences

B

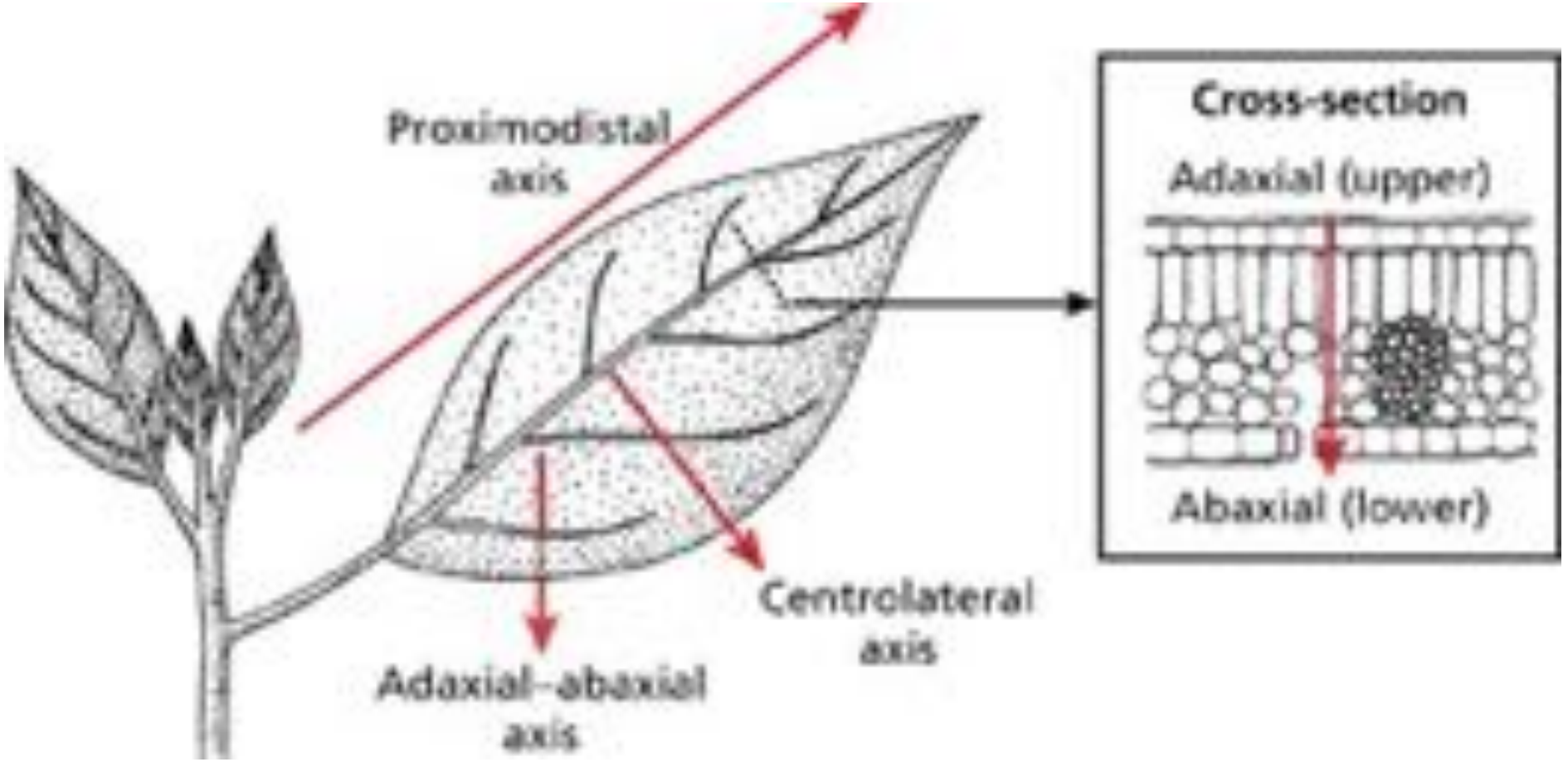
Organ initiation Cell proliferation

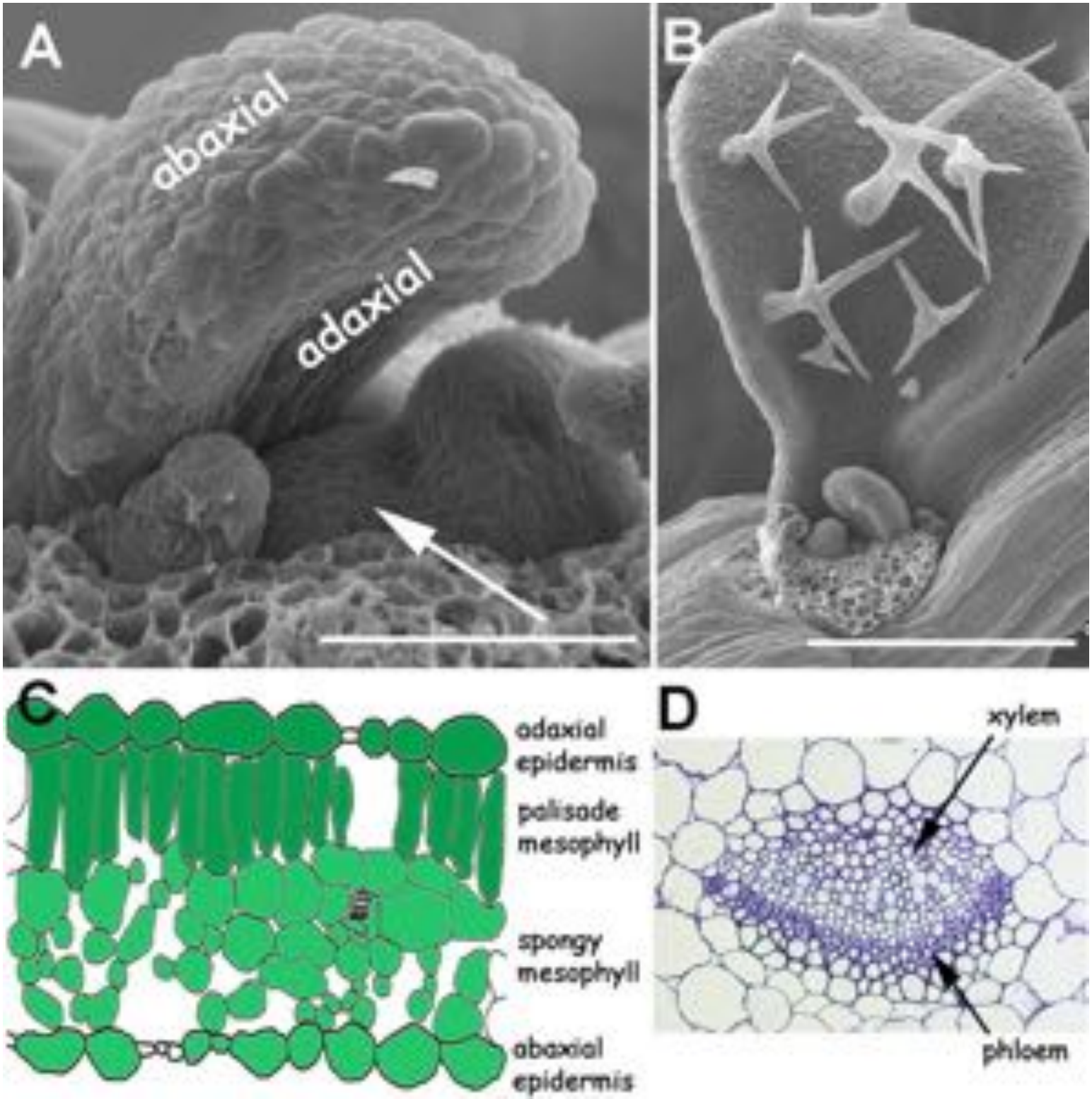


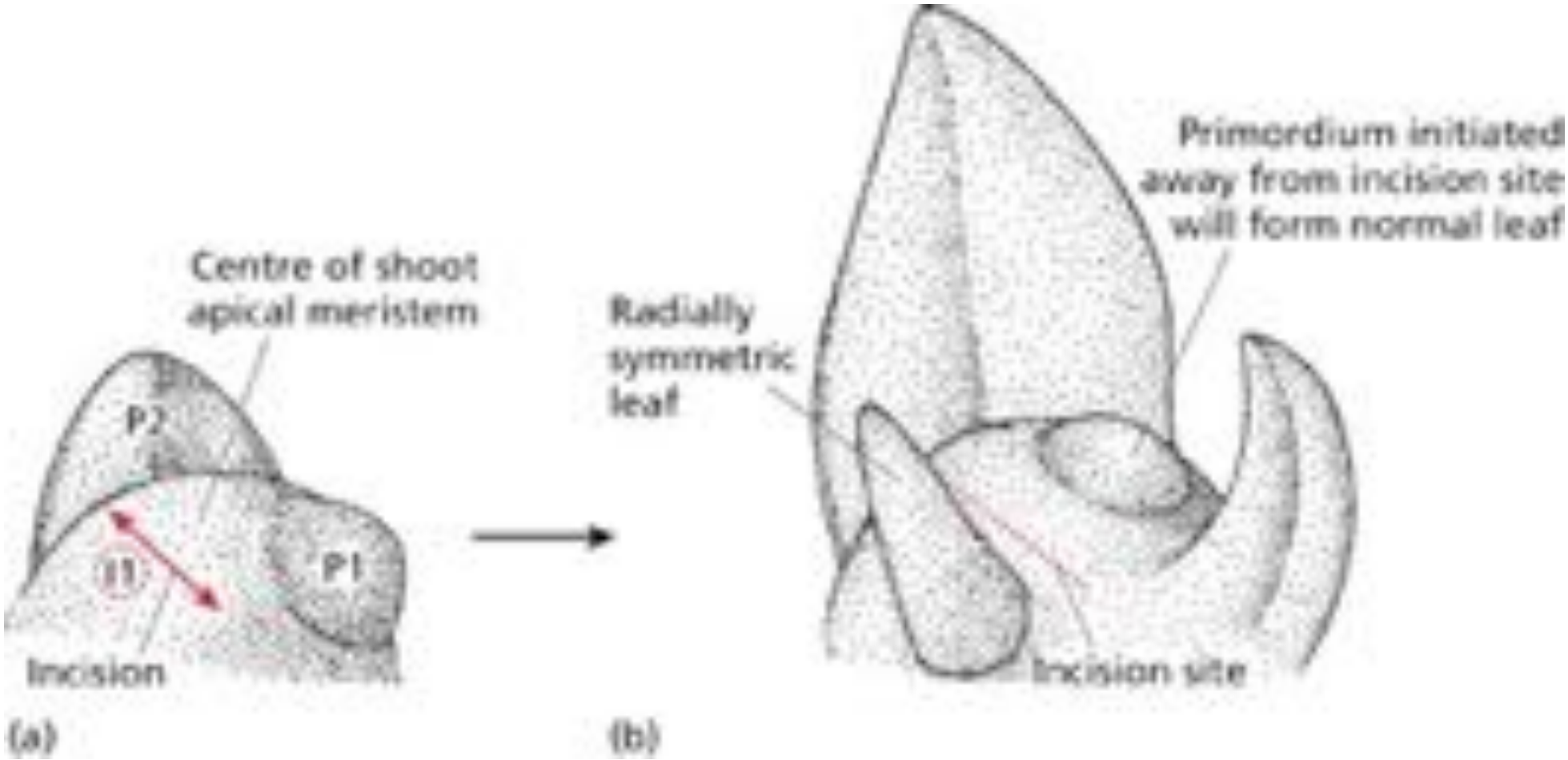
Key

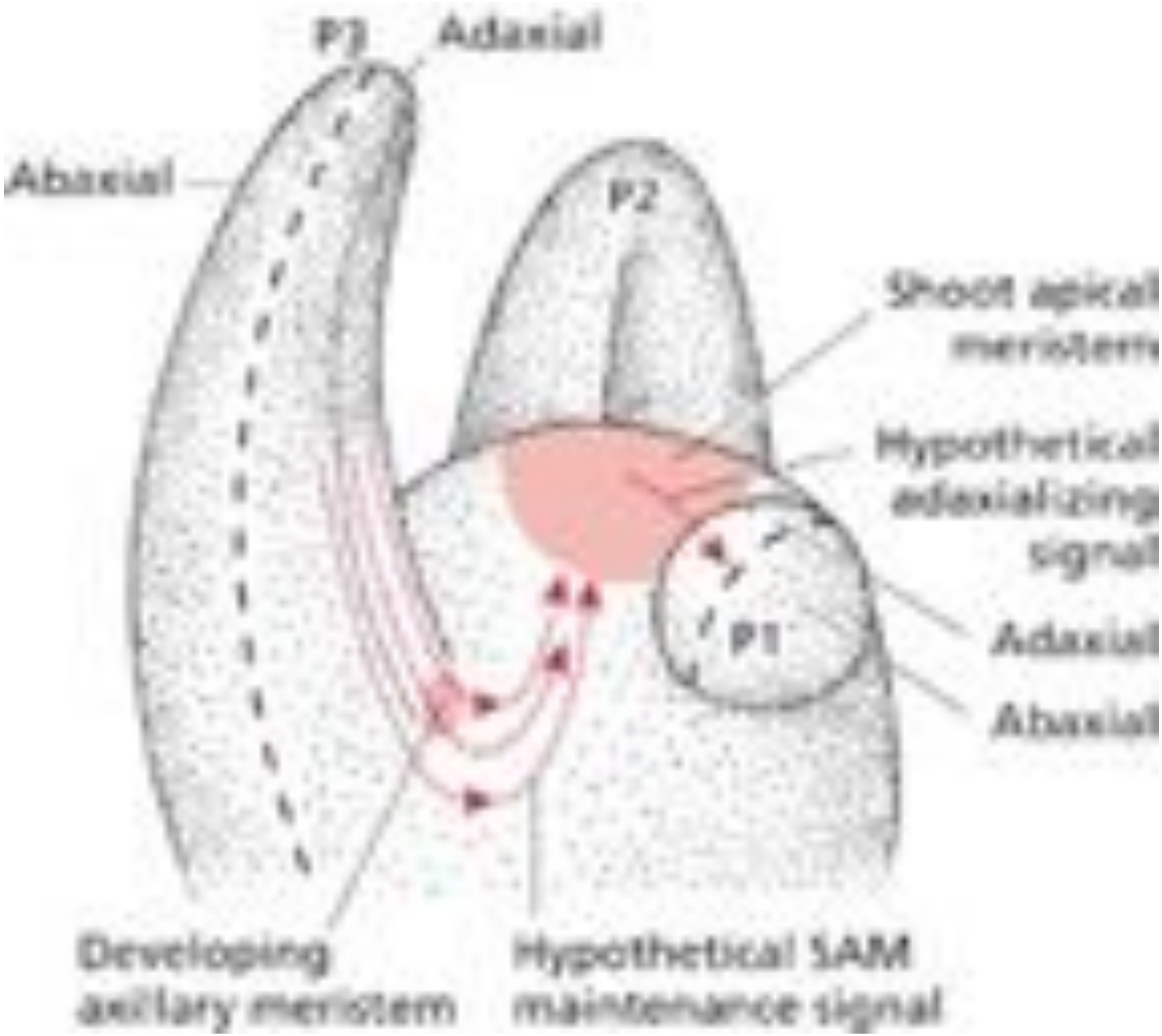
- Central zone (stem cells)
- Overlap central zone/ organizing centre
- Organizing centre
- Rib meristem
- Peripheral zone
- Boundary domain
- Lateral organ primordia

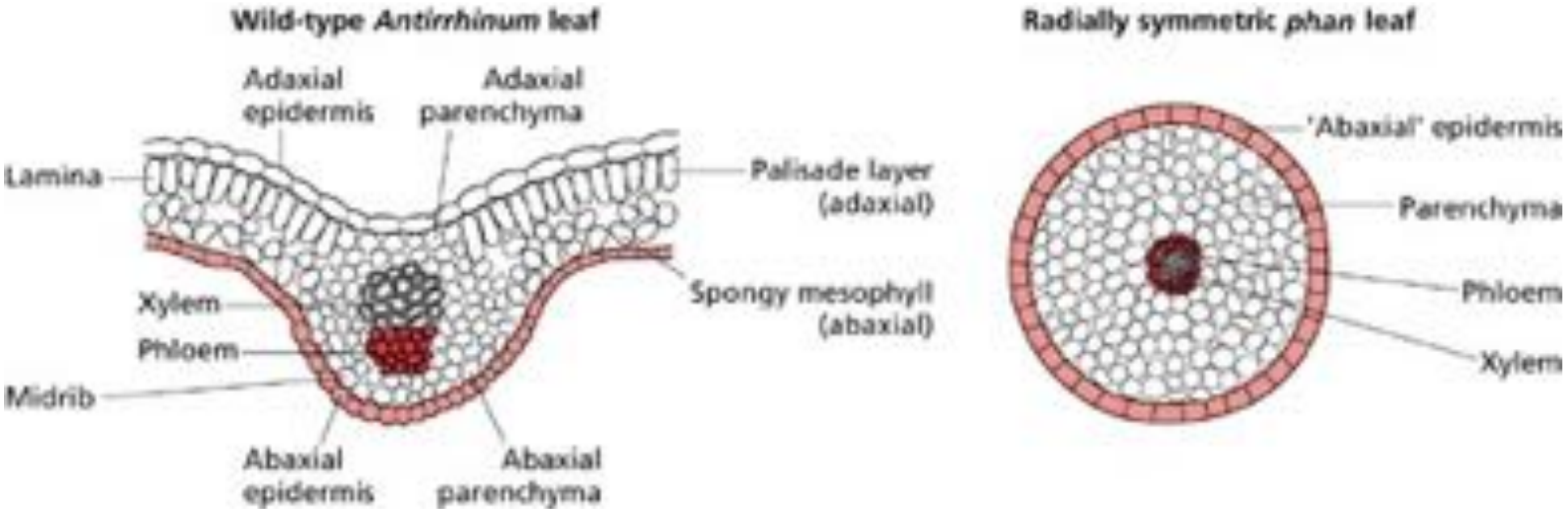
Formation of adaxial and abaxial polarity

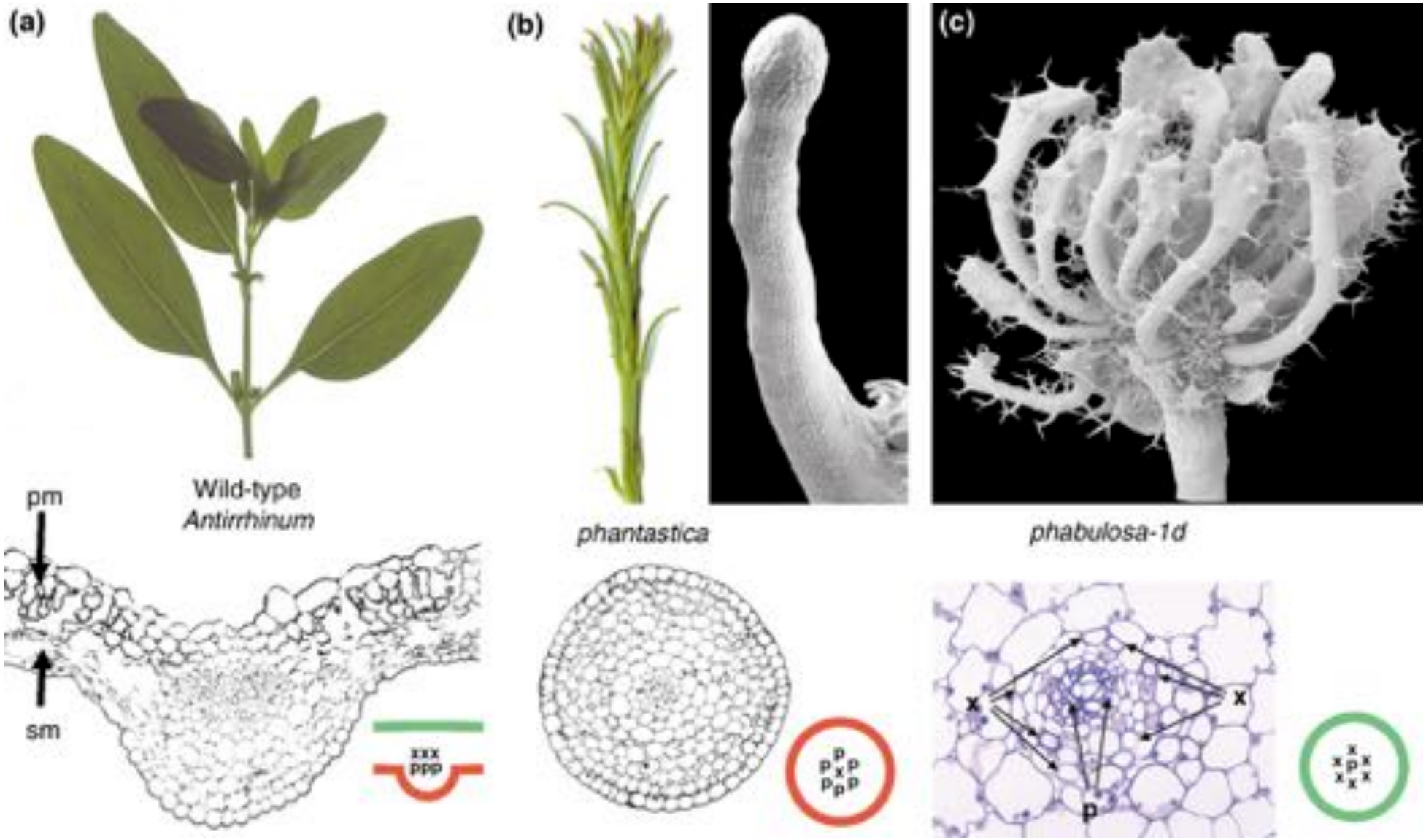


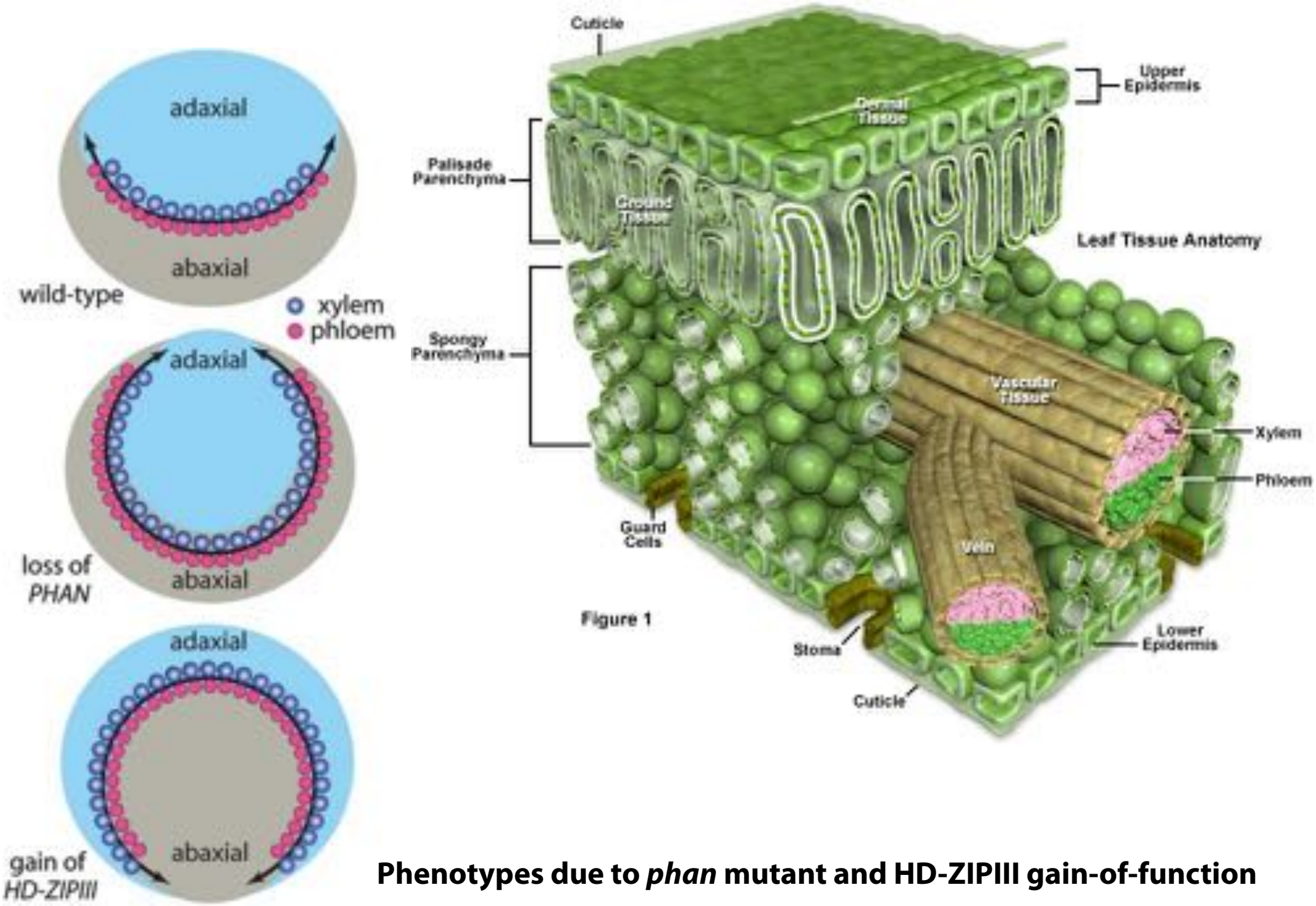

A
abaxial
adaxial
B
C
adaxial epidermis
palisade mesophyll
spongy mesophyll
abaxial epidermis
D
xylem
phloem


Centre of shoot apical meristem
P2
I1
P1
Incision
(a)
Radially symmetric leaf
Primordium initiated away from incision site will form normal leaf
Incision site
(b)


P3
Adaxial
Abaxial
P2
Shoot apical
meristem
Hypothetical
adaxializing
signal
P1
Adaxial
Abaxial
Developing
axillary meristem
Hypothetical SAM
maintenance signal


Wild-type *Antirrhinum* leaf
Adaxial epidermis
Adaxial parenchyma
Lamina
Palisade layer (adaxial)
Spongy mesophyll (abaxial)
Xylem
Phloem
Midrib
Abaxial epidermis
Abaxial parenchyma
Radially symmetric *phan* leaf
'Abaxial' epidermis
Parenchyma
Phloem
Xylem


(a)
(b)
(c)
Wild-type
Antirrhinum
phantastica
phabulosa-1d
pm
sm
xxx
ppp
p
p x p
p p
x
x
x
p
x
x p x
x

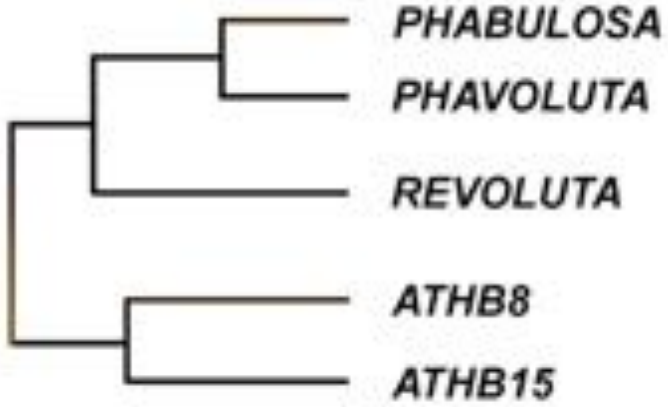


Phenotypes due to *phan* mutant and HD-ZIPIII gain-of-function

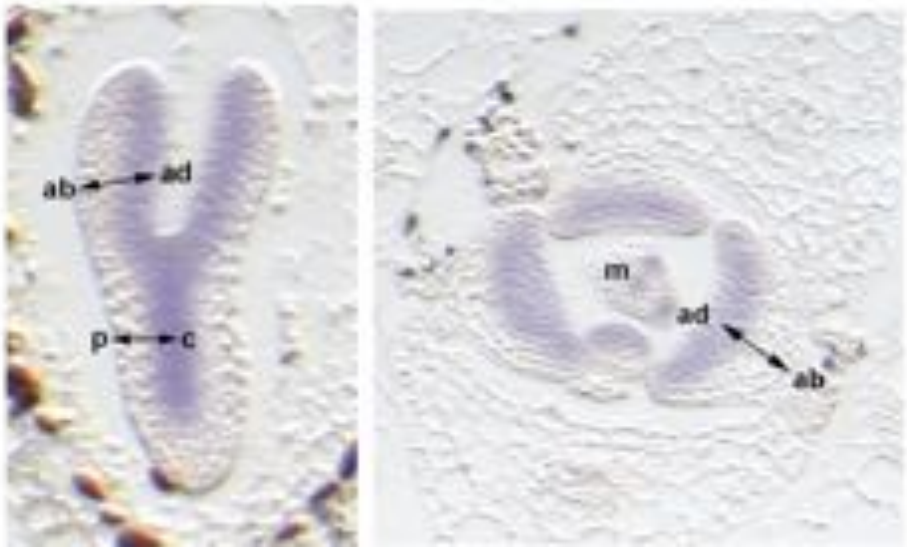
A


HD ZIP
START

B

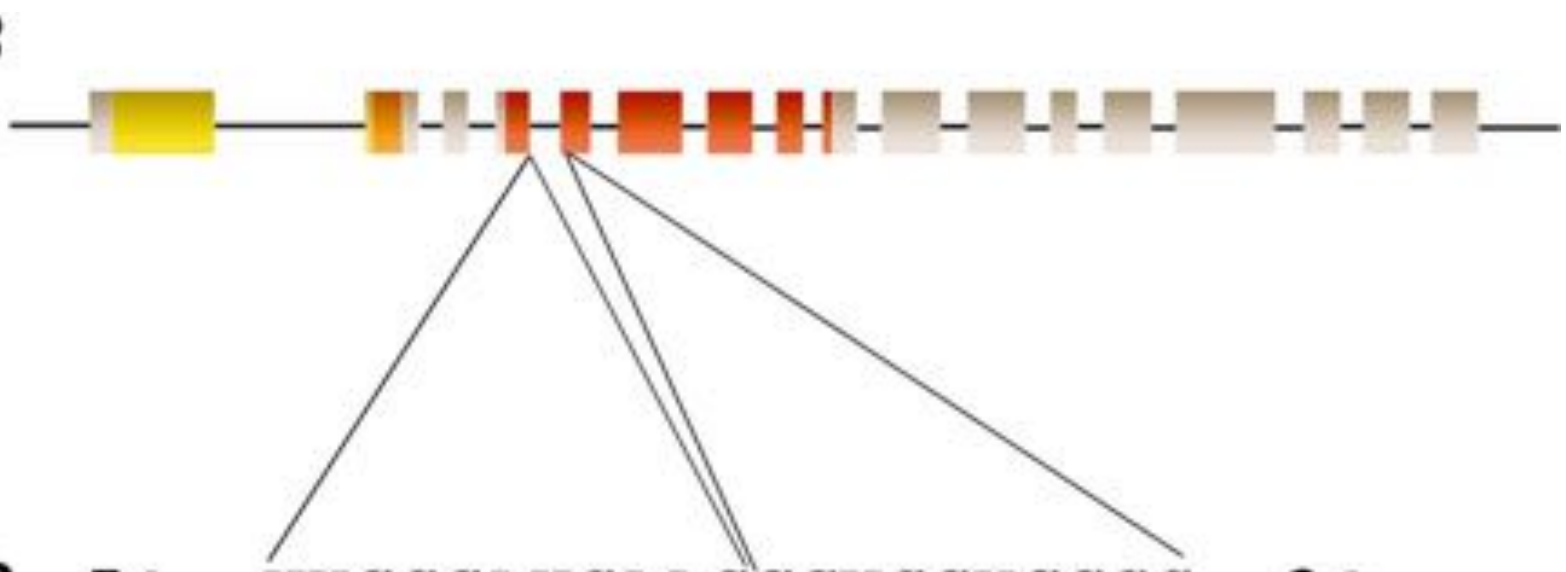

PHABULOSA
PHAVOLUTA
REVOLUTA
ATHB8
ATHB15

C

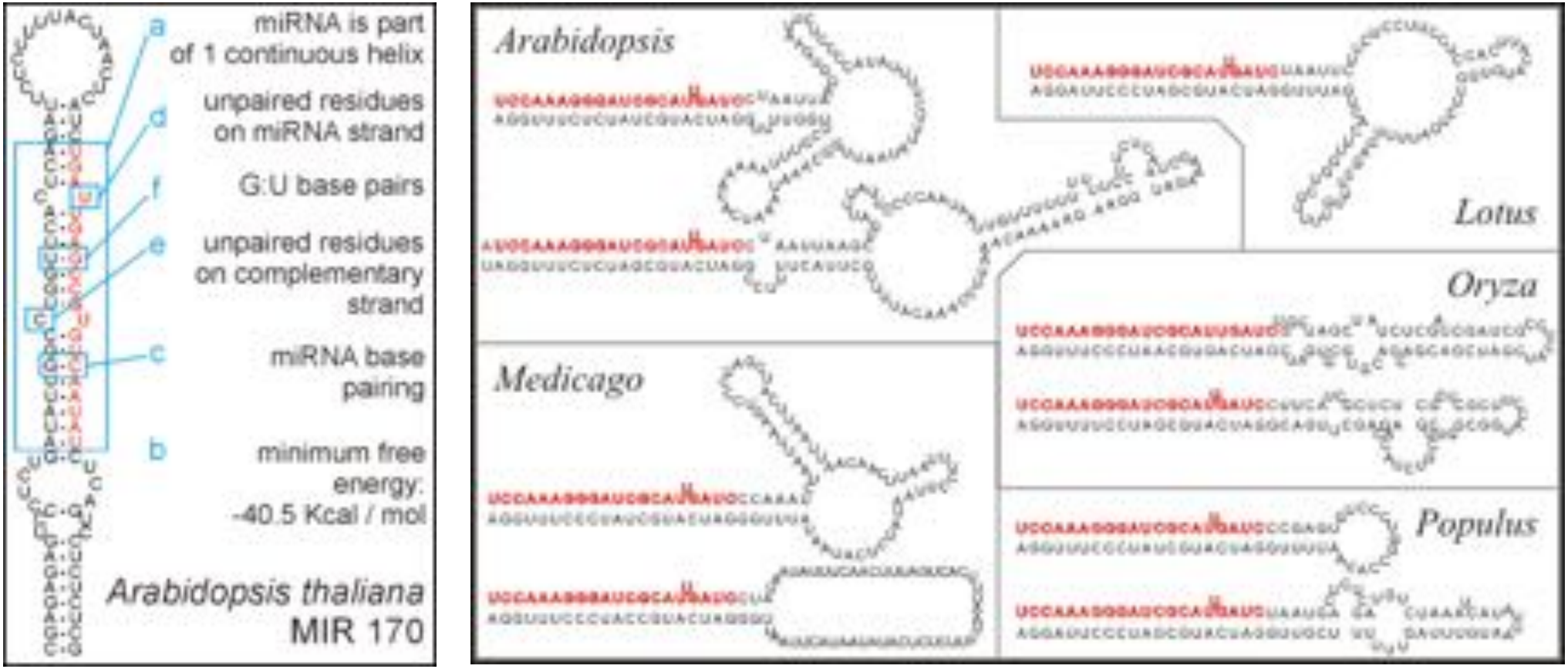

ab
ad
p
c
m
ad
ab

D


wt
rev



PHB	5′	UUGGGAUGAAGCCUGGUCCGG	3′
PHV		UUGGGAUGAAGCCUGGUCCGG	
REV		CUGGGAUGAAGCCUGGUCCGG	
ATHB8		CUGGGAUGAAGCCUGGUCCGG	
ATHB15		CUGGAAUGAAGCCUGGUCCGG	
mir165	3′	CCCCCUACUUCGGACCAGGCU	5′
mir166		CCCCUUACUUCGGACCAGGCU	


a
miRNA is part of 1 continuous helix
d
unpaired residues on miRNA strand
f
G:U base pairs
e
unpaired residues on complementary strand
c
miRNA base pairing
b
minimum free energy: -40.5 Kcal / mol
Arabidopsis thaliana
MIR 170
Arabidopsis
Lotus
Oryza
Medicago
Populus

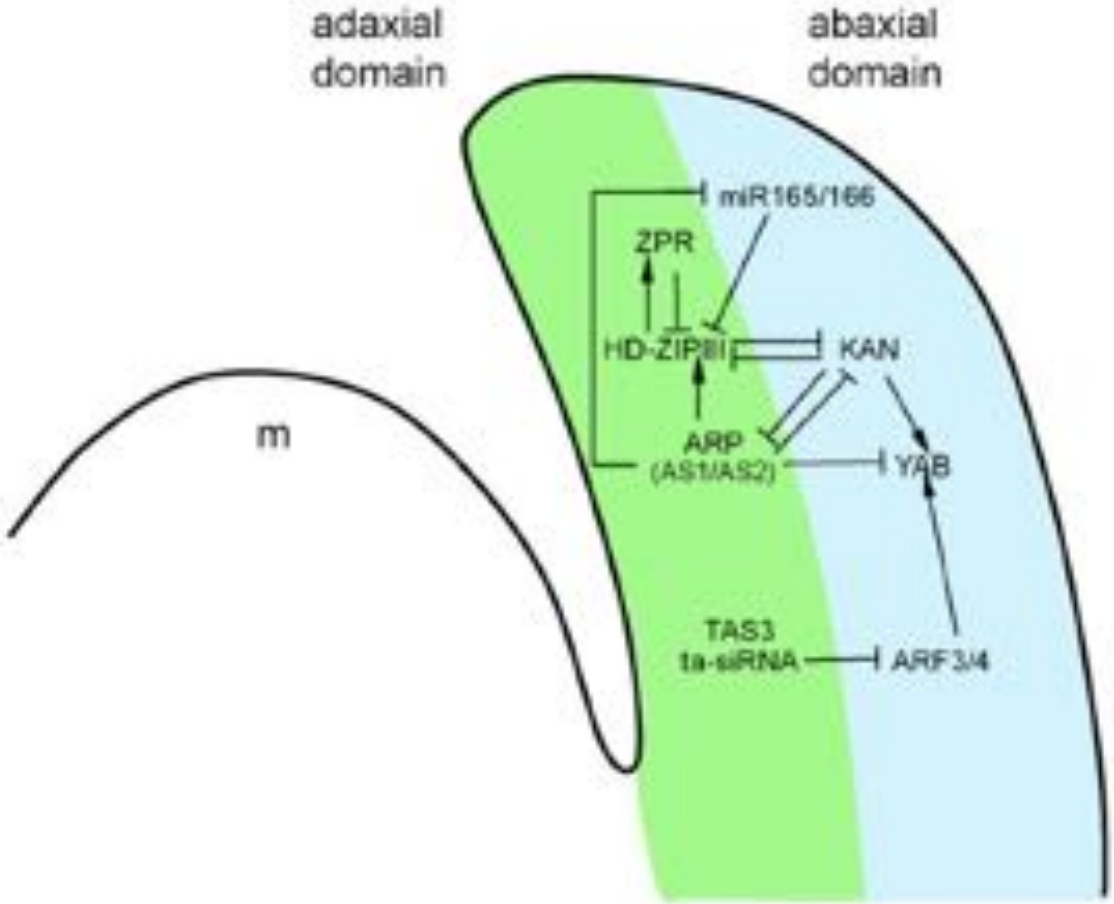
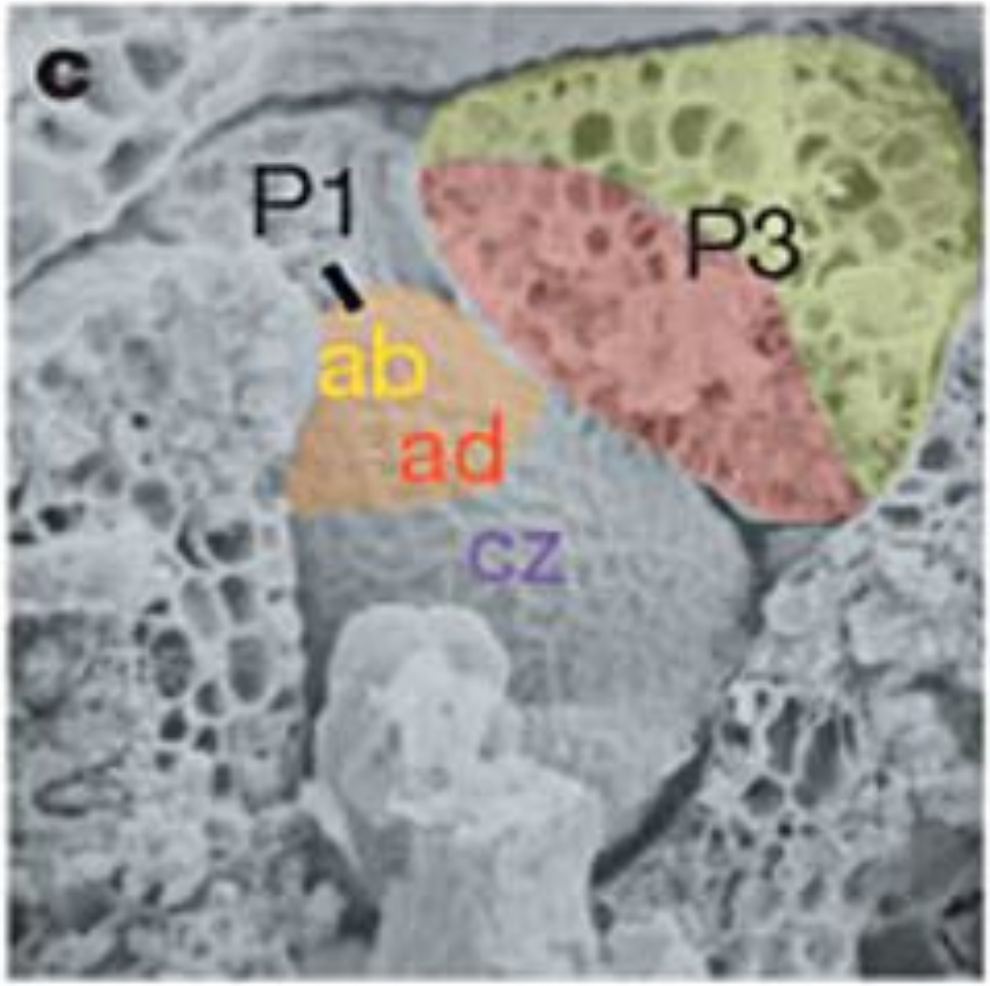
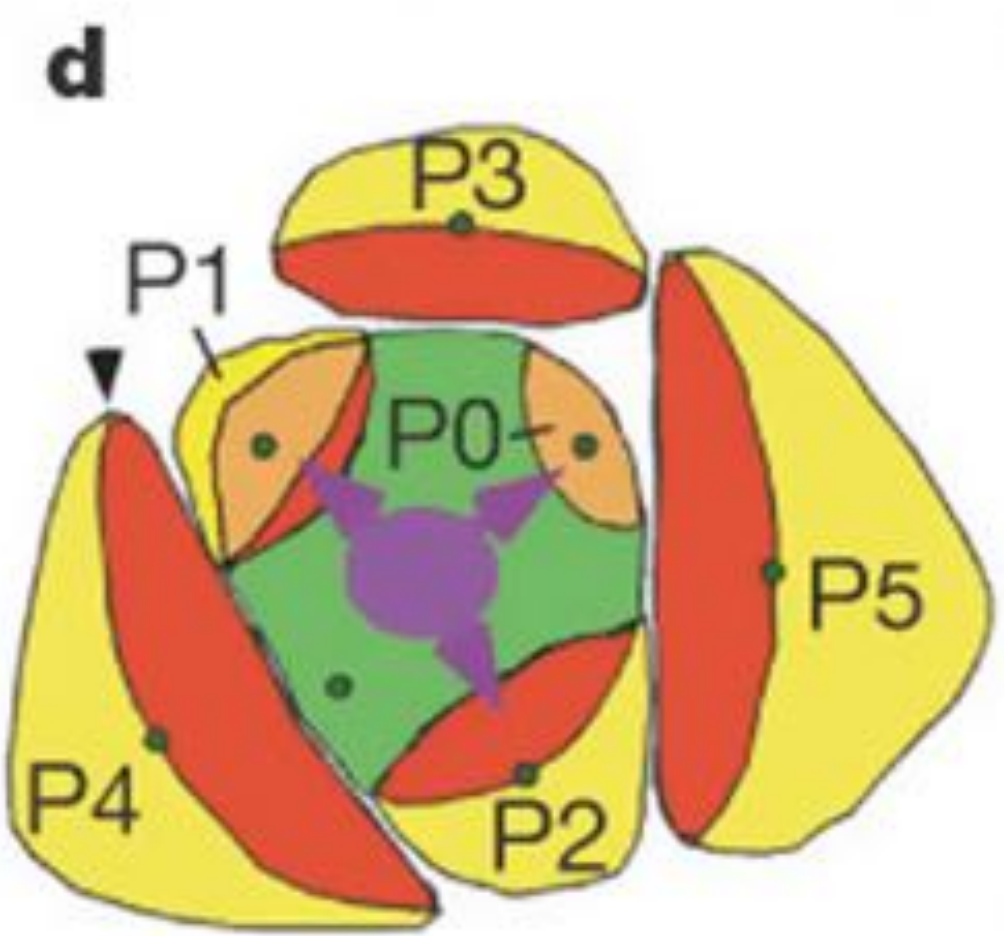
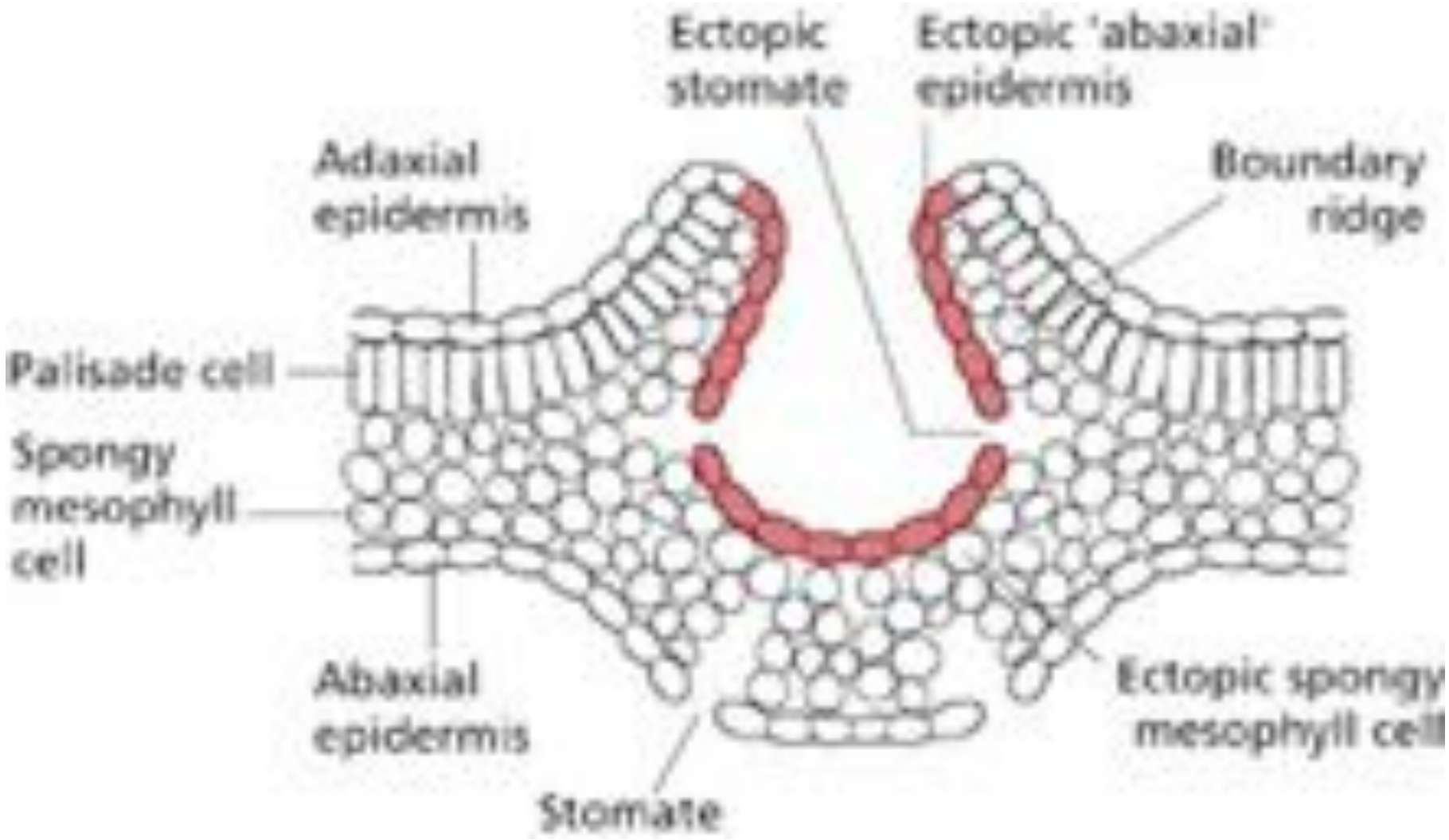
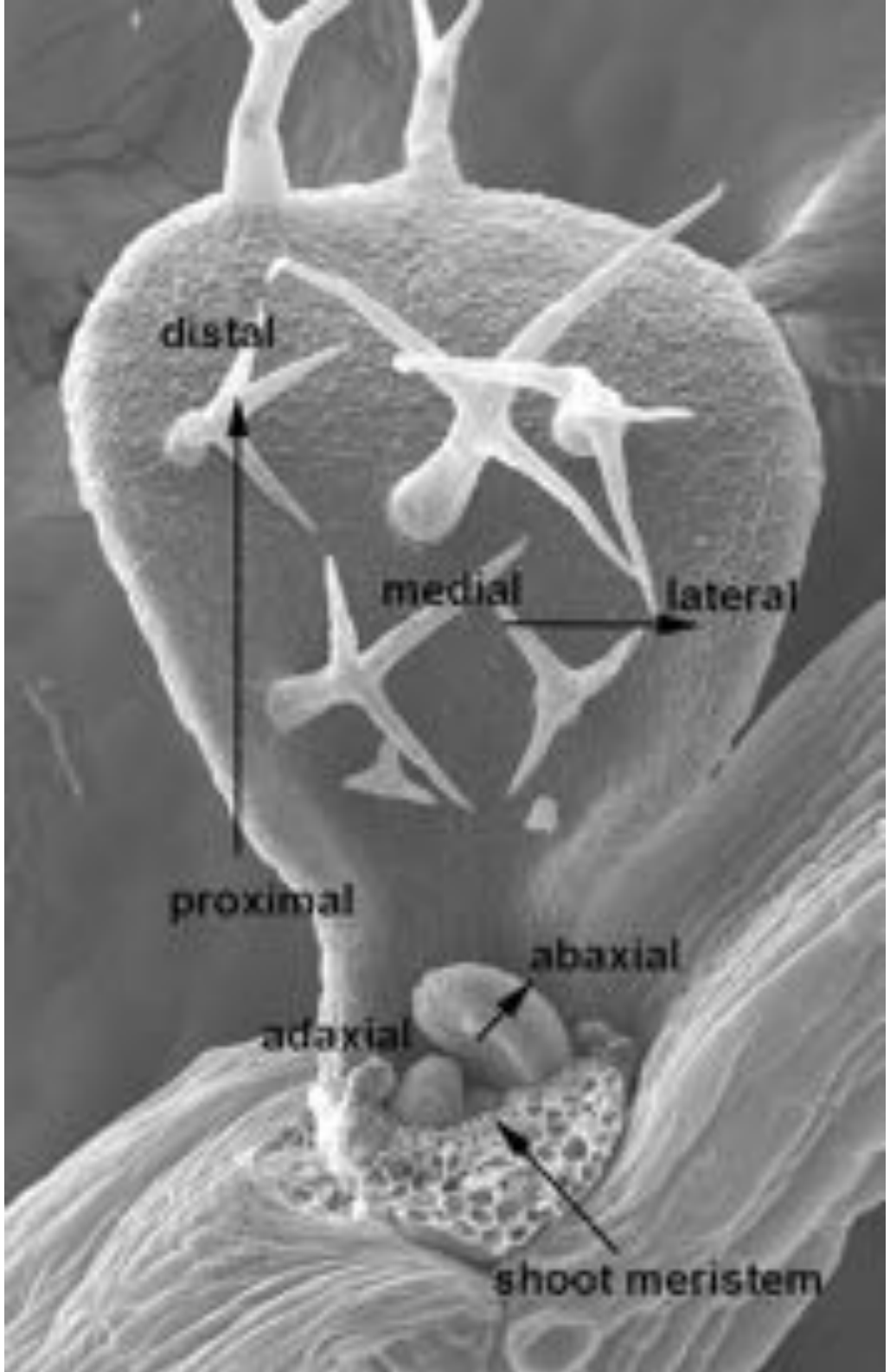


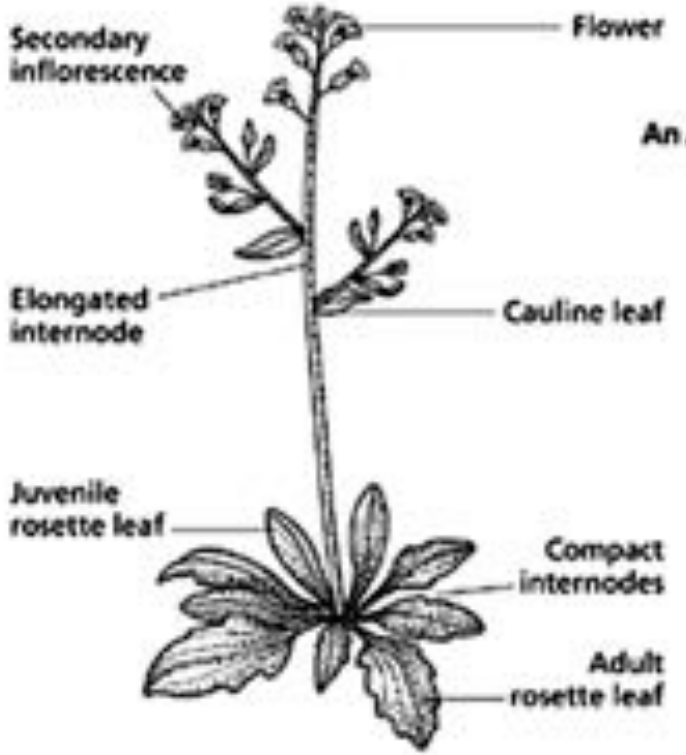
Fig. 4. Genetic and molecular network controlling adaxial-abaxial leaf polarity. Two main genes families are involved in the definition of the identity of the adaxial and abaxial leaf domains: the *KAN* and *HD-ZIPIII* genes are, respectively, expressed in the abaxial and the adaxial domains, and thus define the identity of each territory. The antagonism between these two groups is at the root of their complementary expression domains in the leaf. The contribution of several other molecular actors reinforces these expression patterns: miR165/166 negatively regulates *HD-ZIPIII* genes, while ARP proteins promote *HD-ZIPIII* expression. In parallel, ARP proteins negatively control *KAN* and *miR165/166* expressions. KAN factors activate the expression of the *YAB* genes that contribute to define the abaxial identity, while *YAB* genes are subjected to negative regulation by the ARP and TAS3 pathways.


c
P1
P3
ab
ad
CZ

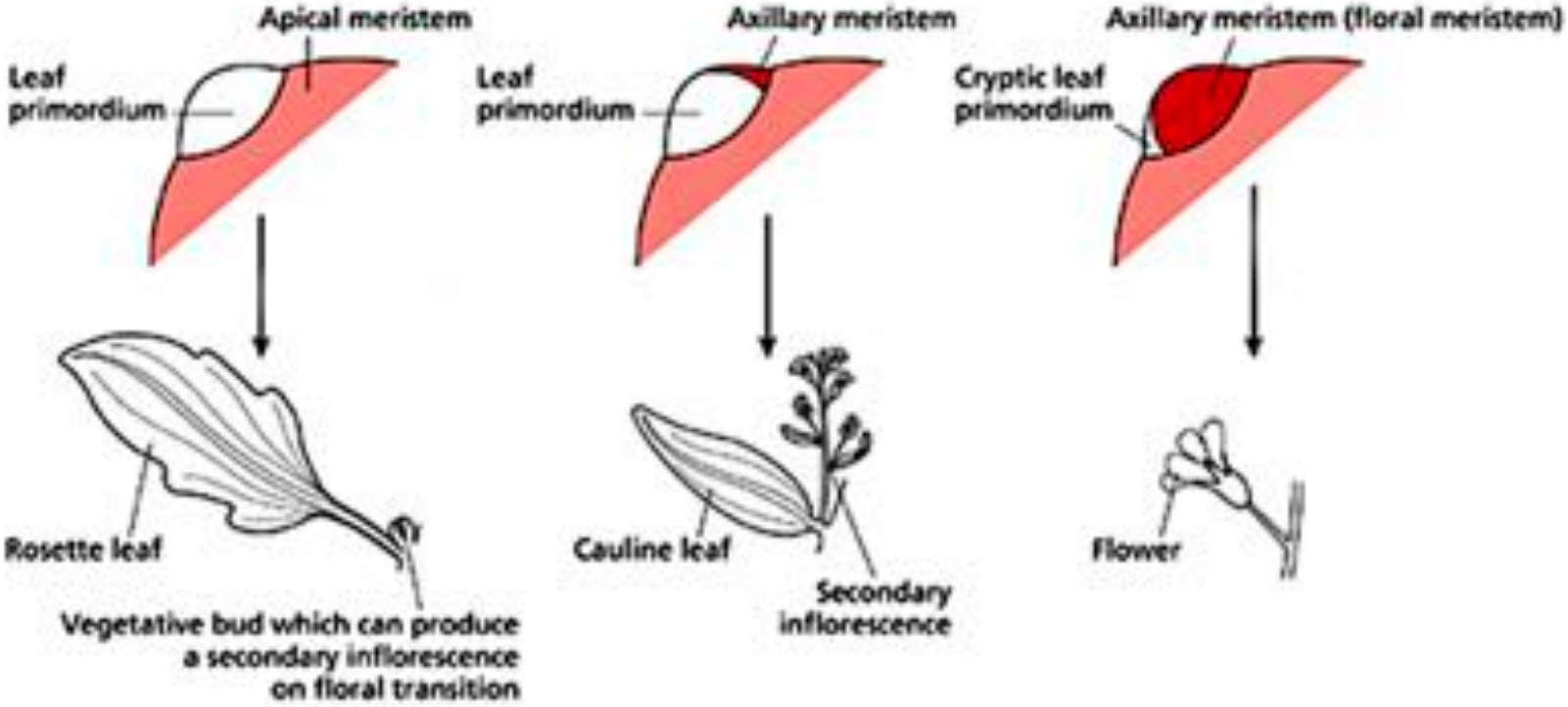

d
P3
P1
P0
P5
P4
P2


Ectopic stomate
Ectopic 'abaxial' epidermis
Adaxial epidermis
Boundary ridge
Palisade cell
Spongy mesophyll cell
Abaxial epidermis
Ectopic spongy mesophyll cell
Stomate

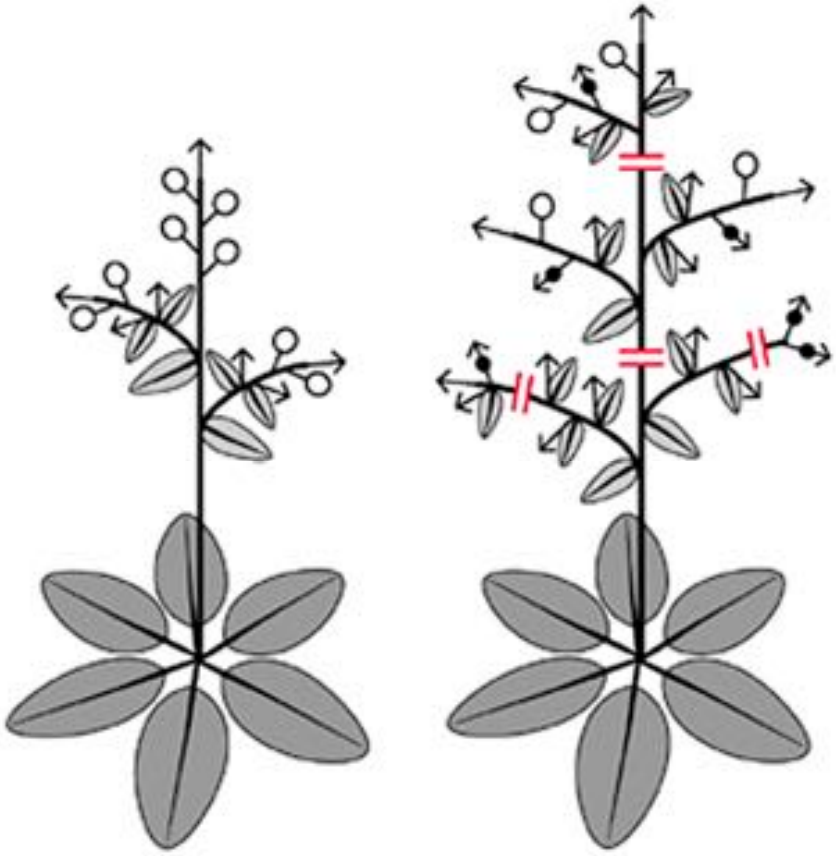

distal
medial
lateral
proximal
abaxial
adaxial
shoot meristem

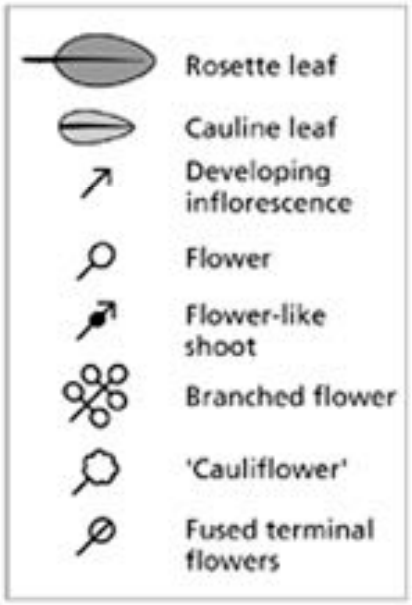


An *Arabidopsis* plant in flower

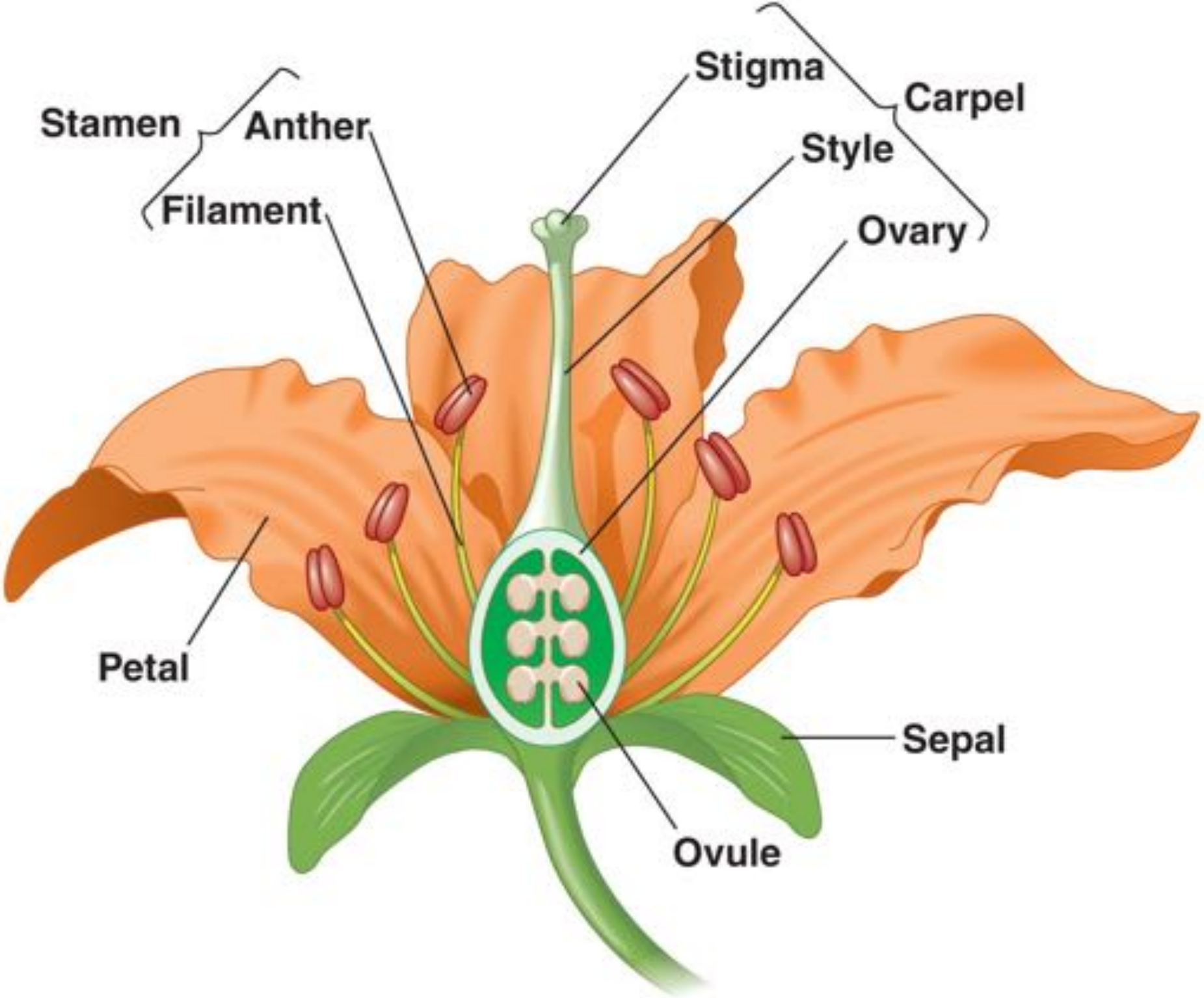


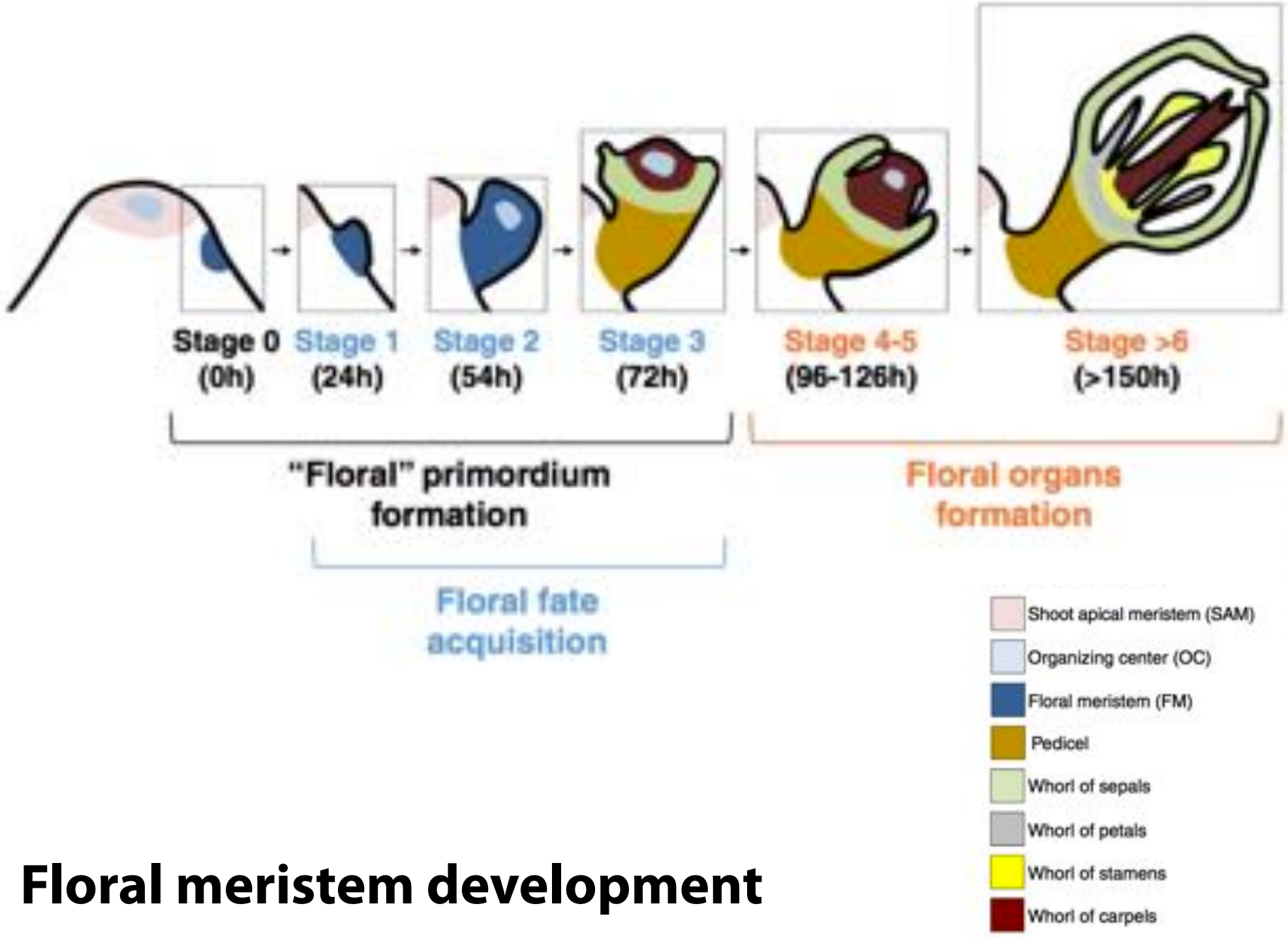
Ectopic *LEAFY* expression results in precocious flowering





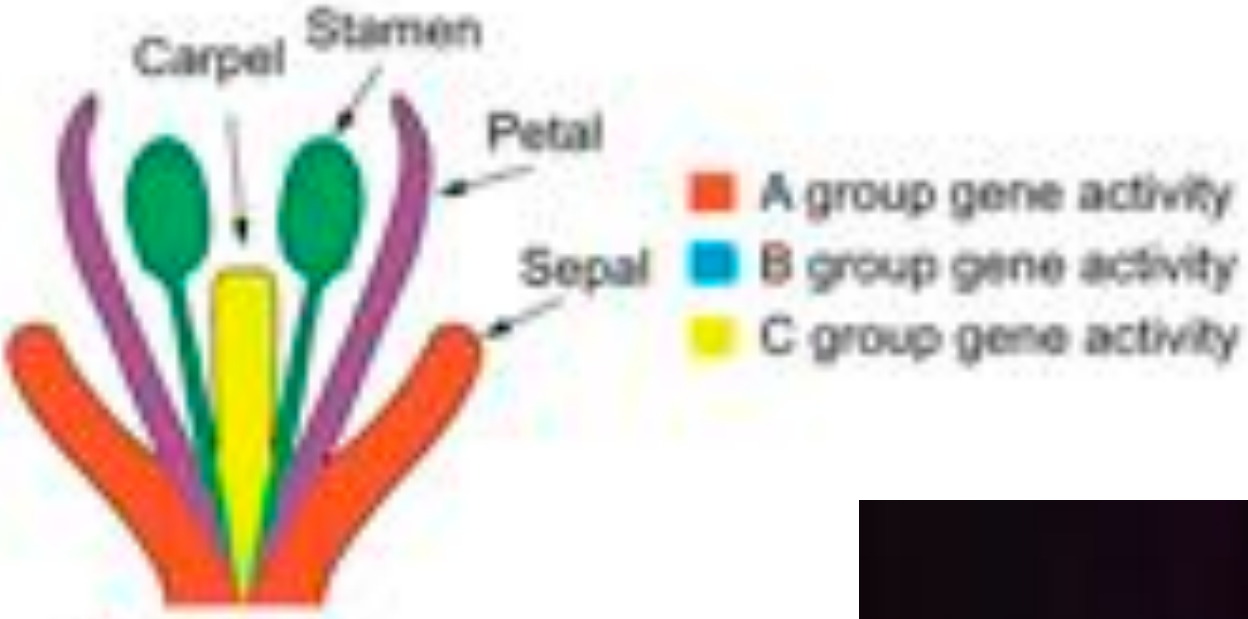
Patterning of the floral meristem





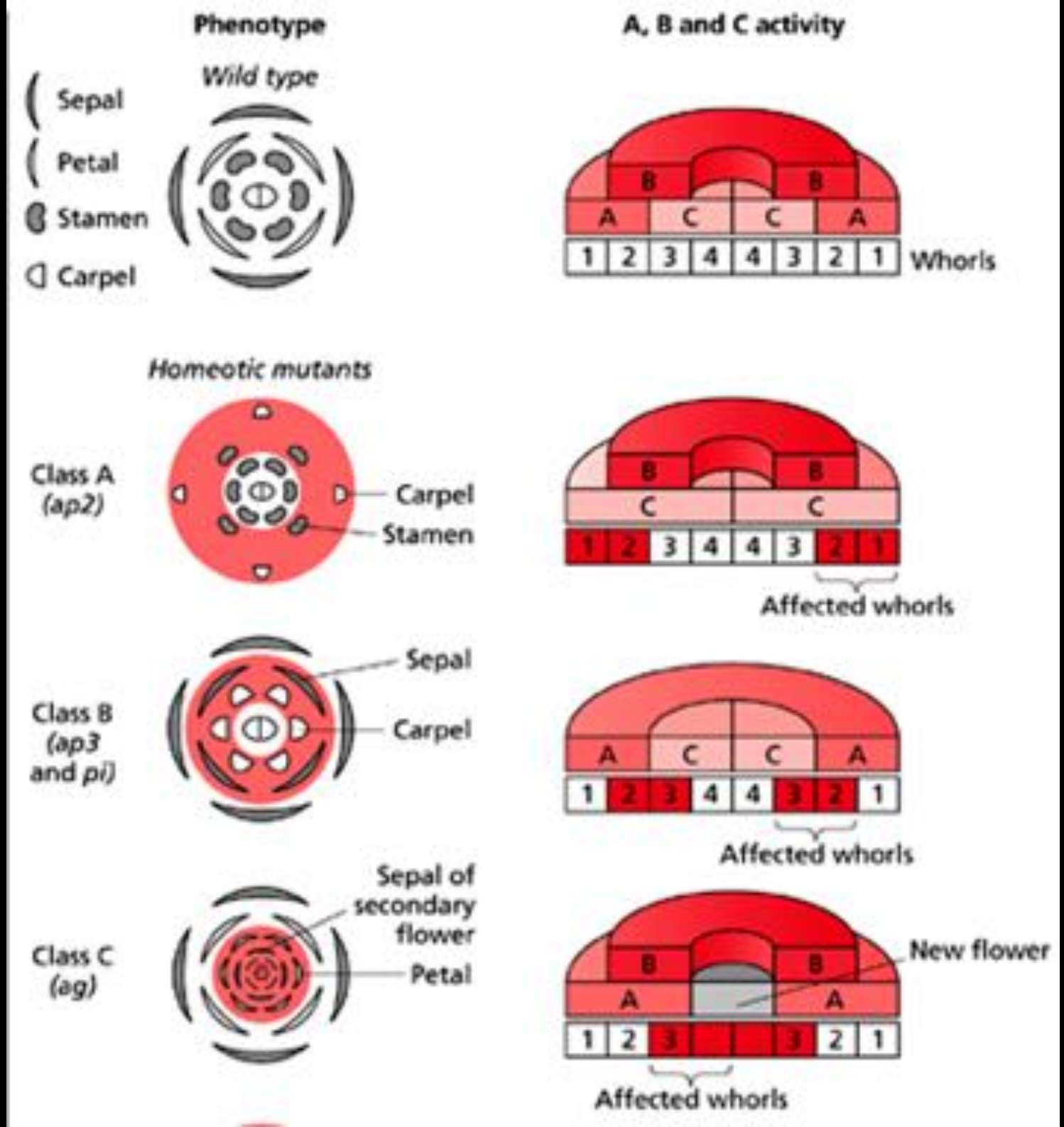
Floral meristem development

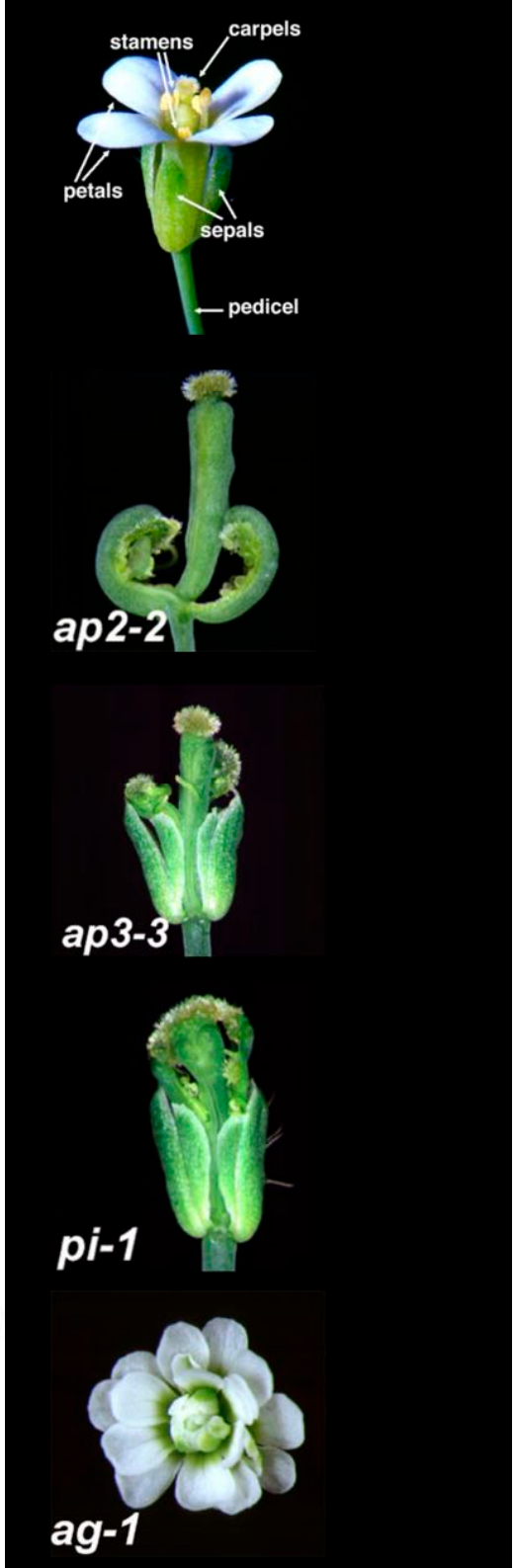

se pe el ca el pe se
B B
A C C A
LEAFY LEAFY

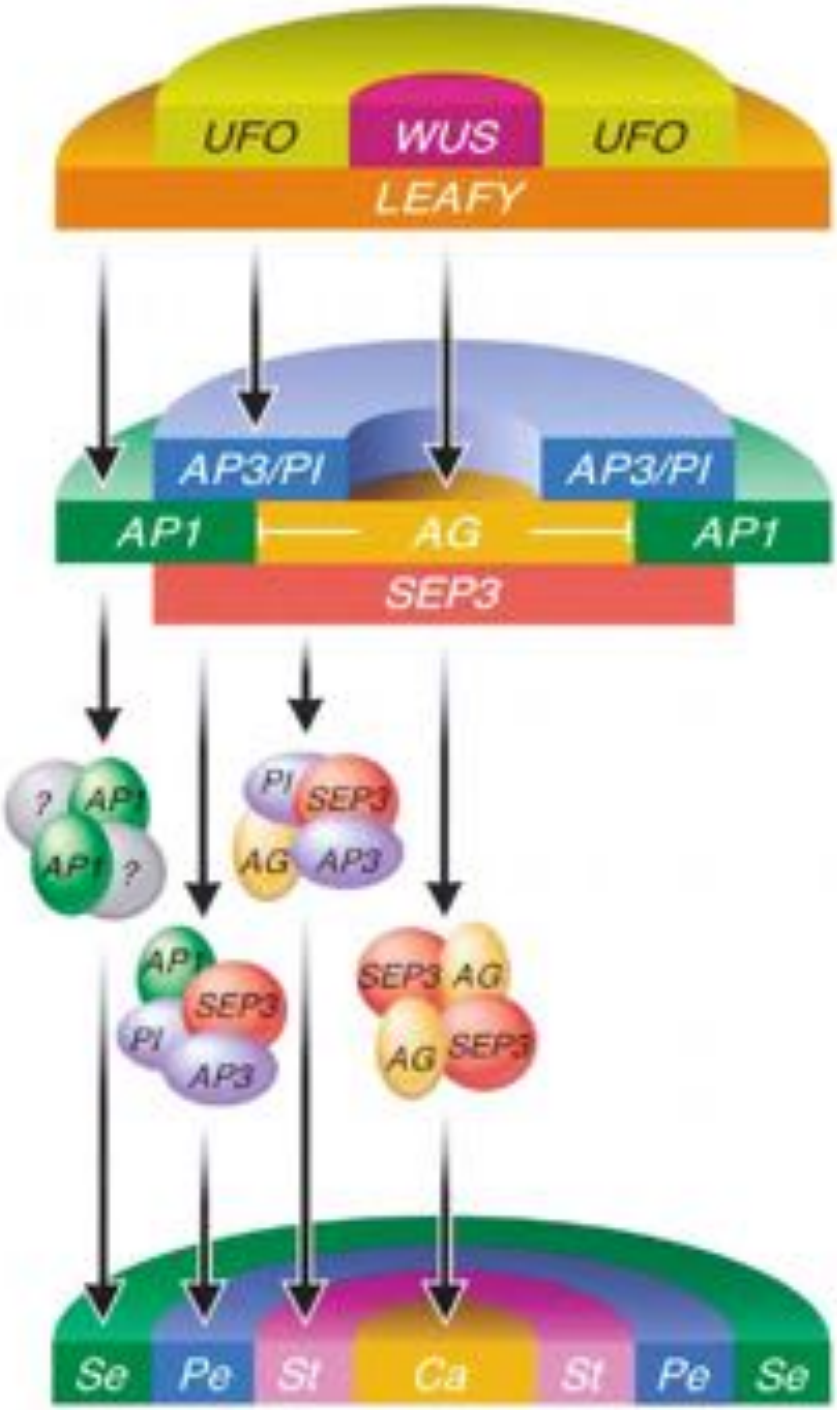


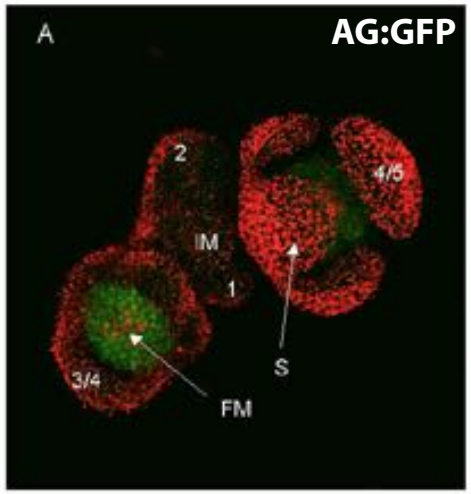
(a) Wild type *Arabidopsis* flower

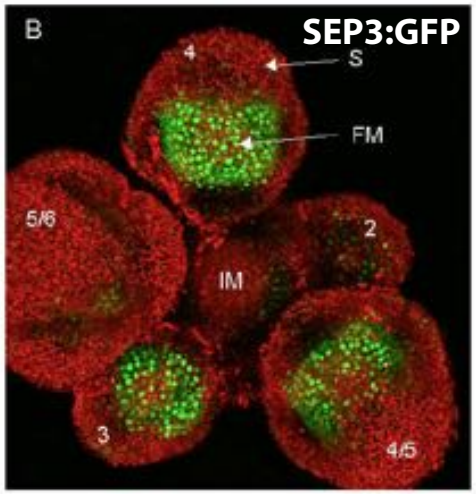
(b) ap3 mutant *Arabidopsis* flower

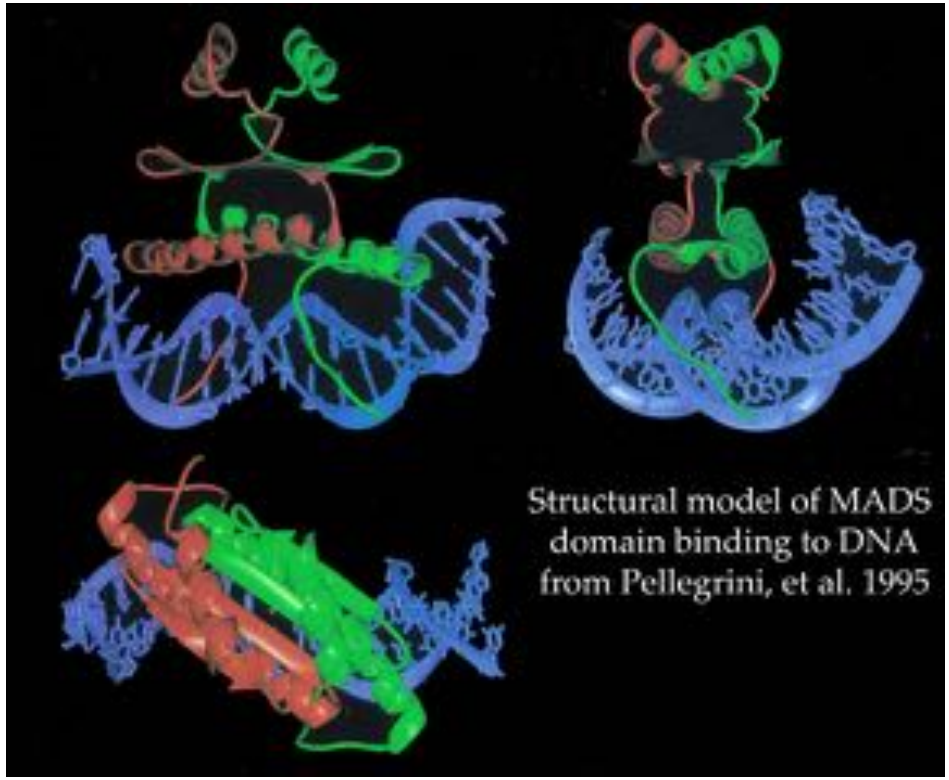

Phenotype
A, B and C activity
Wild type
Sepal
Petal
Stamen
Carpel
B
A
C
1 2 3 4 4 3 2 1
Whorls
Homeotic mutants
Class A
(ap2)
Carpel
Stamen
Affected whorls
Class B
(ap3
and pi)
Sepal
Carpel
Affected whorls
Class C
(ag)
Sepal of
secondary
flower
Petal
New flower
Affected whorls

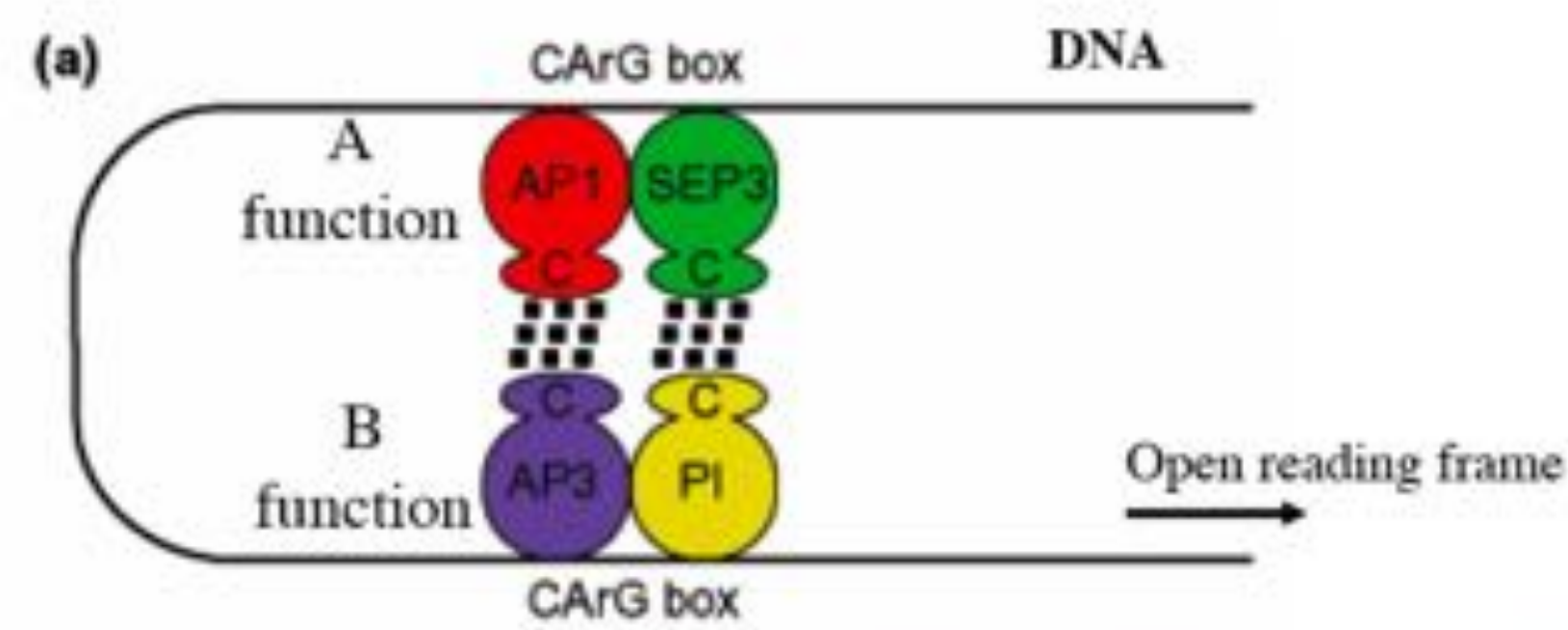

stamens
carpels
petals
sepals
pedicel
ap2-2
ap3-3
pi-1
ag-1


UFO
WUS
UFO
LEAFY
AP3/PI
AP3/PI
AP1
AG
AP1
SEP3
?
AP1
AP1
?
PI
SEP3
AG
AP3
AP1
SEP3
PI
AP3
SEP3
AG
AG
SEP3
Se
Pe
St
Ca
St
Pe
Se

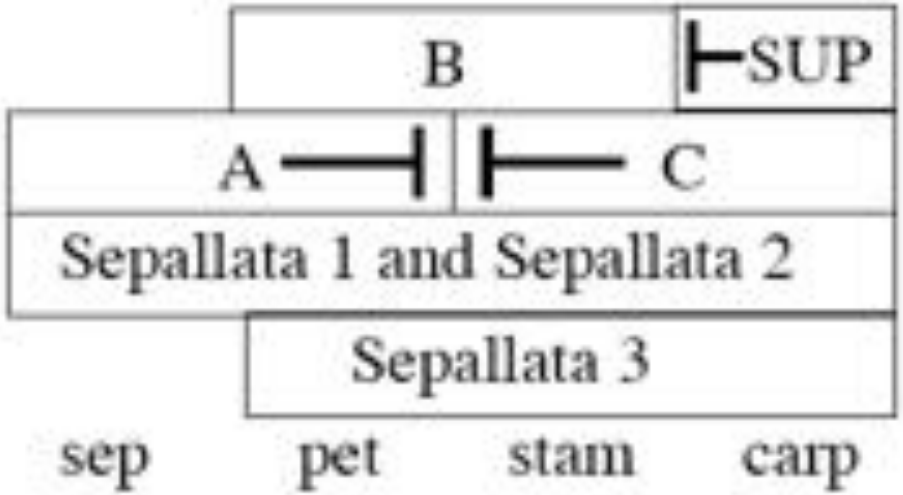

A
AG:GFP
2
4/5
IM
1
3/4
S
FM

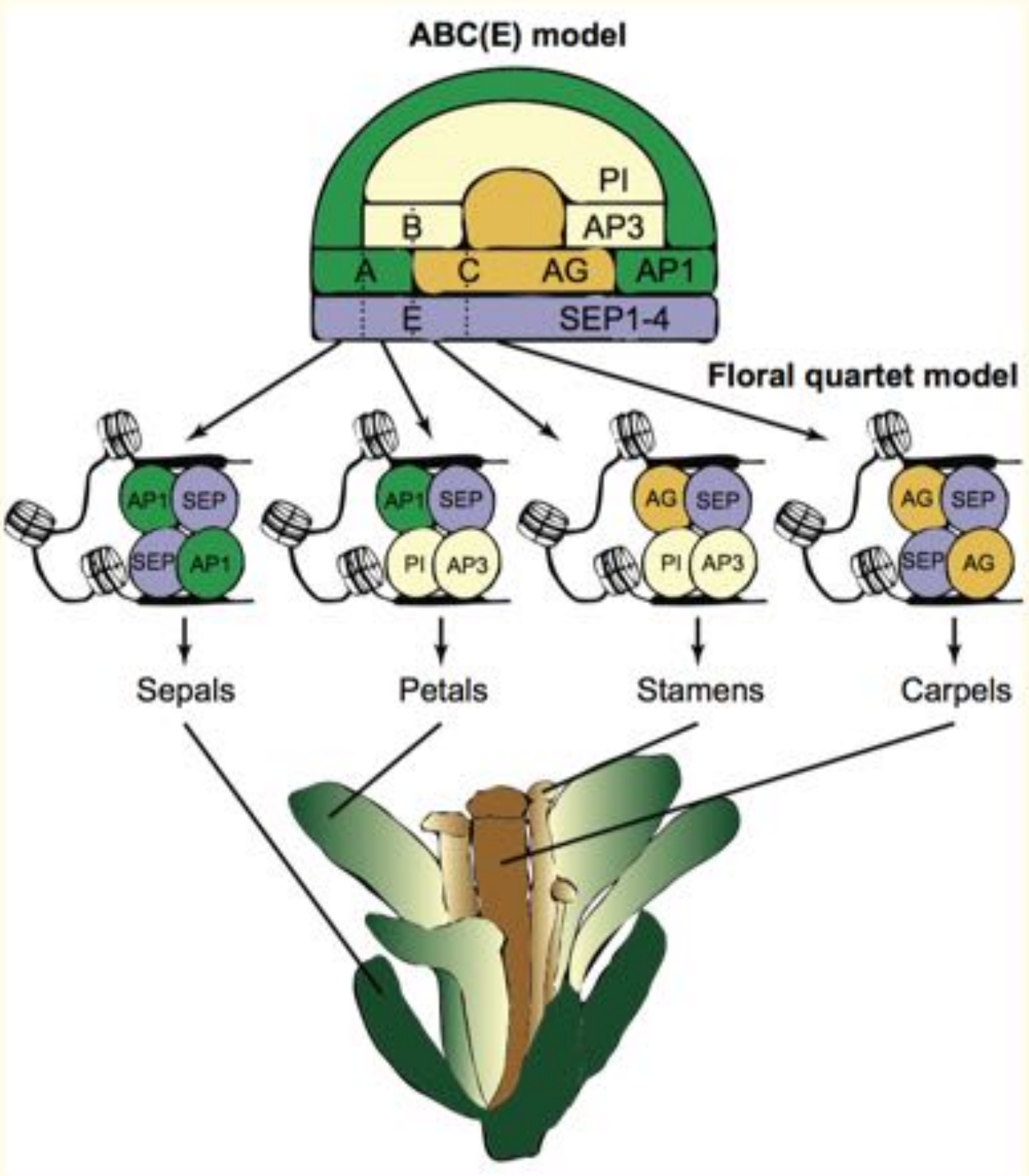

B
SEP3:GFP
4
S
FM
5/6
2
IM
3
4/5


Structural model of MADS domain binding to DNA from Pellegrini, et al. 1995



Model explains how A function (AP1) and B function (AP3/PI) Combine to specify the second whorl – petals.




ABC(E) model
PI
B
AP3
A
C
AG
AP1
E
SEP1-4
Floral quartet model
AP1
SEP
SEP
AP1
AP1
SEP
PI
AP3
AG
SEP
PI
AP3
AG
SEP
SEP
AG
Sepals
Petals
Stamens
Carpels

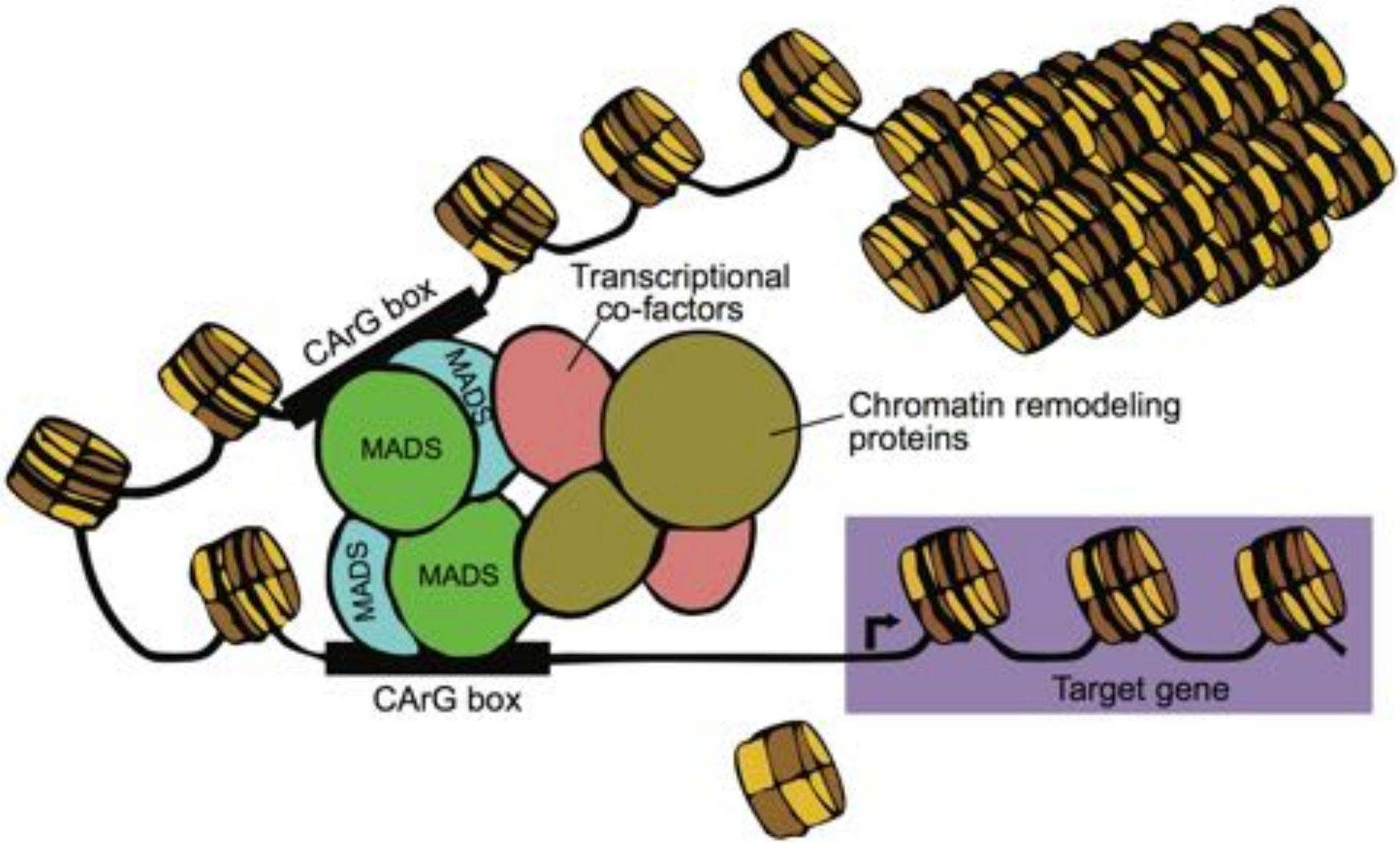
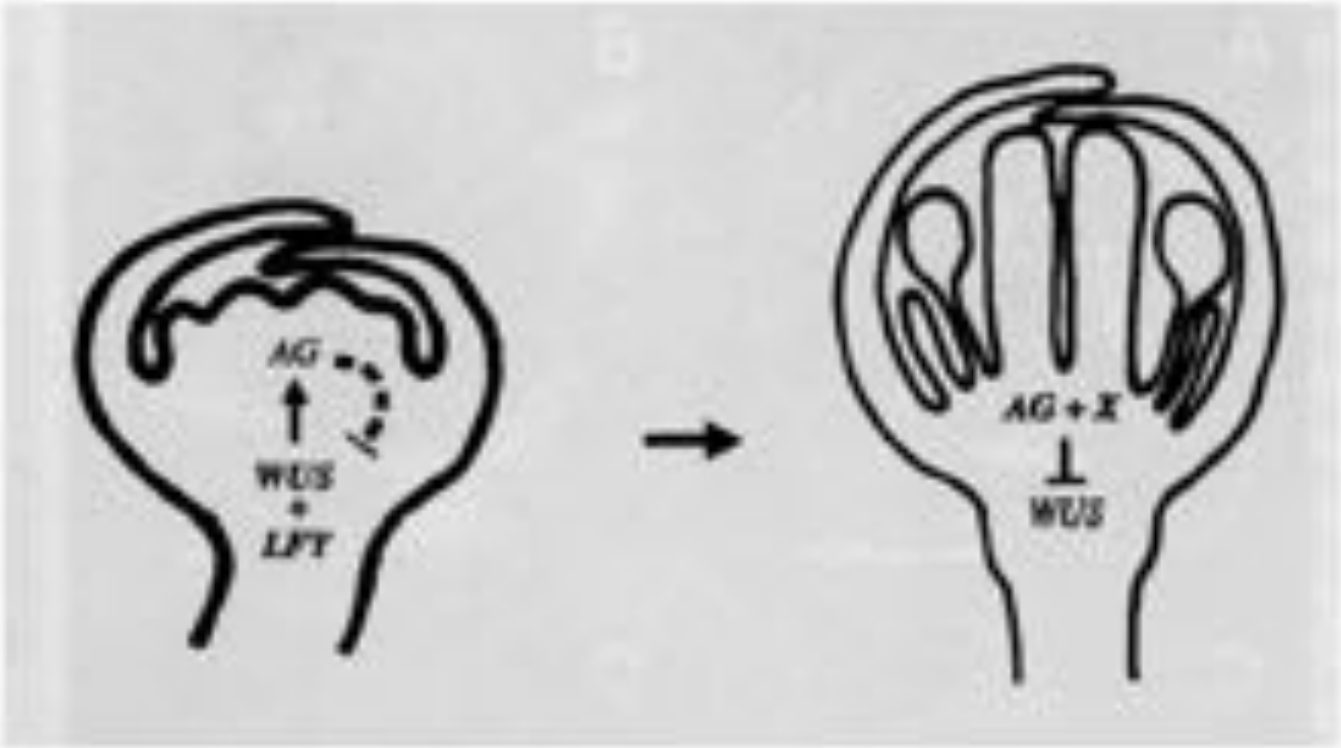


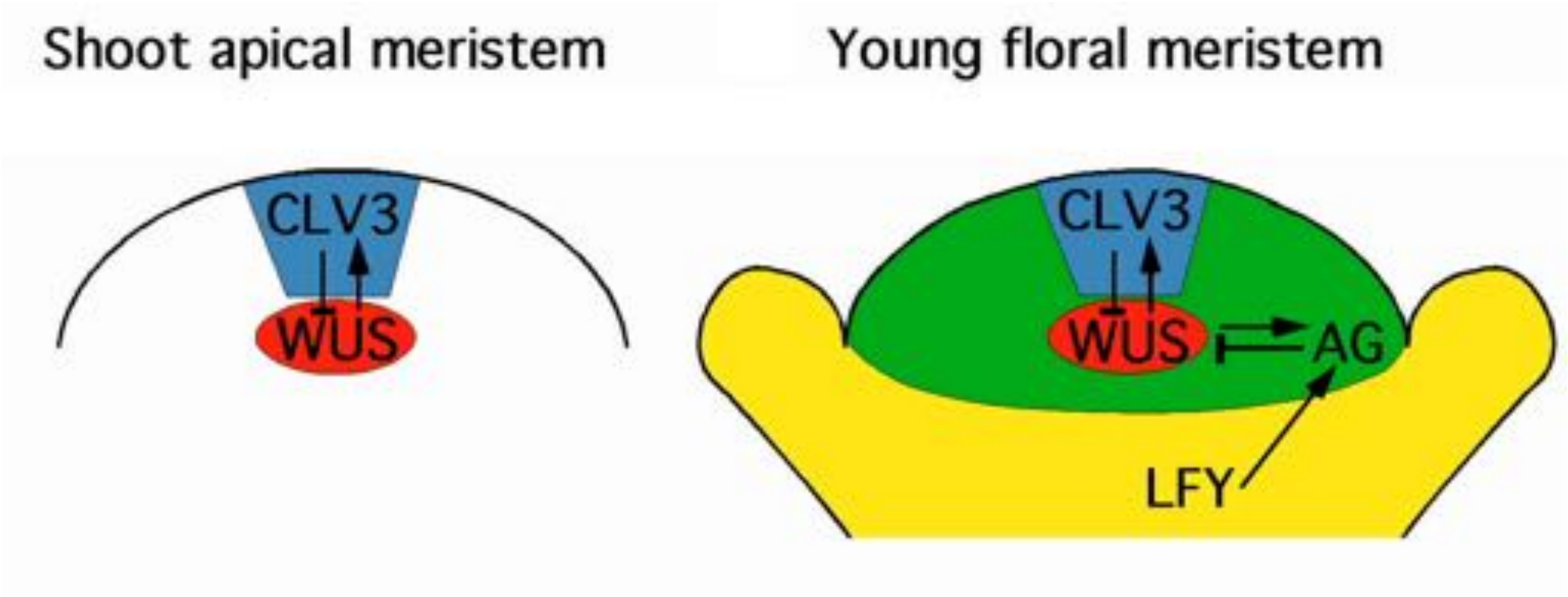
Fig. 3. Model for the action of MADS-domain protein complexes.

agamous mutant flowers are indeterminate

Activation of AG (C function) requires WUSCHEL and LEAFY

A negative feed-back loop regulates WUSCHEL expression in the flower meristem





Feedback regulated control of meristem growth