2018 CDB Part IB
Plant Development

Lecture 4.

Patterning of indeterminate growth

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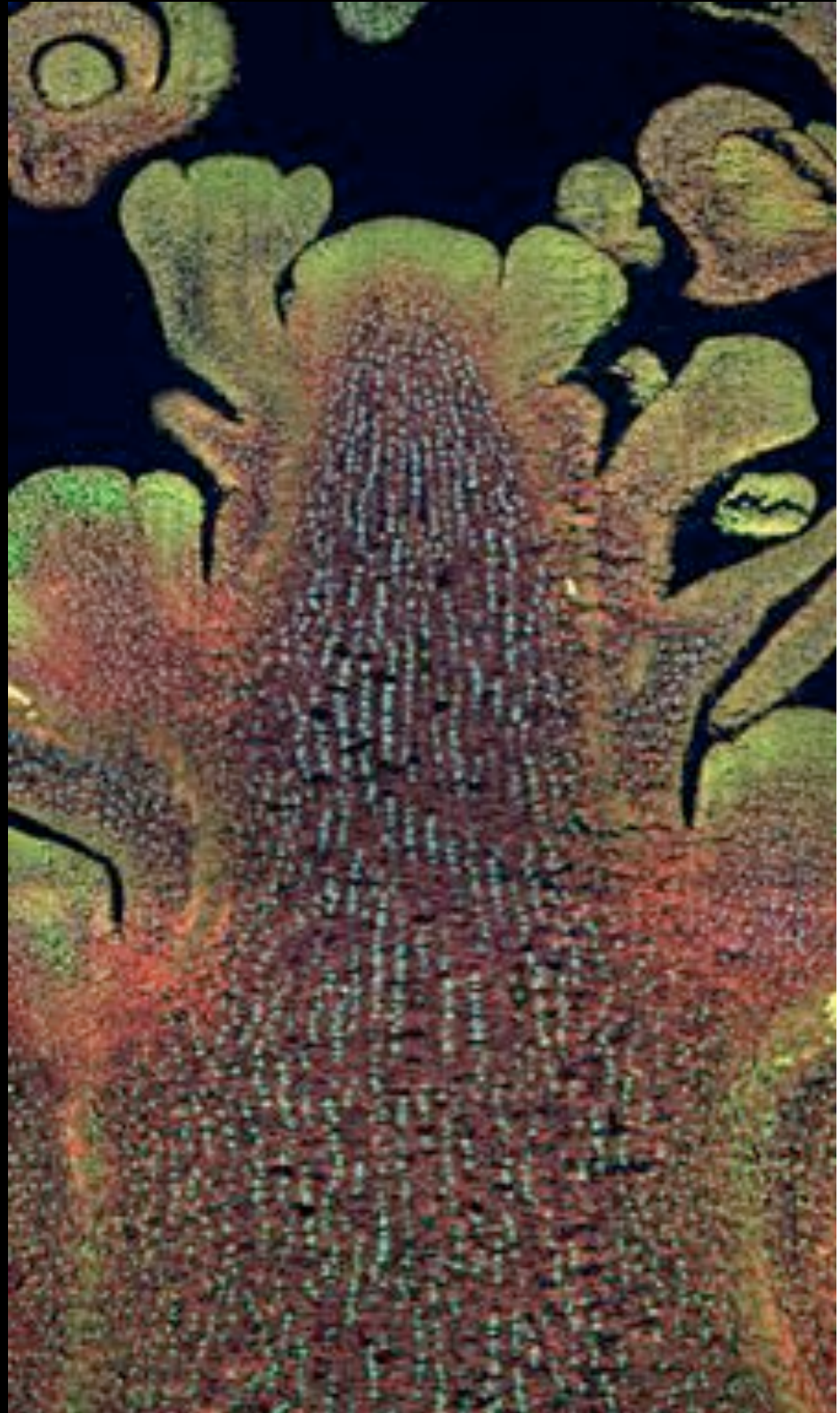
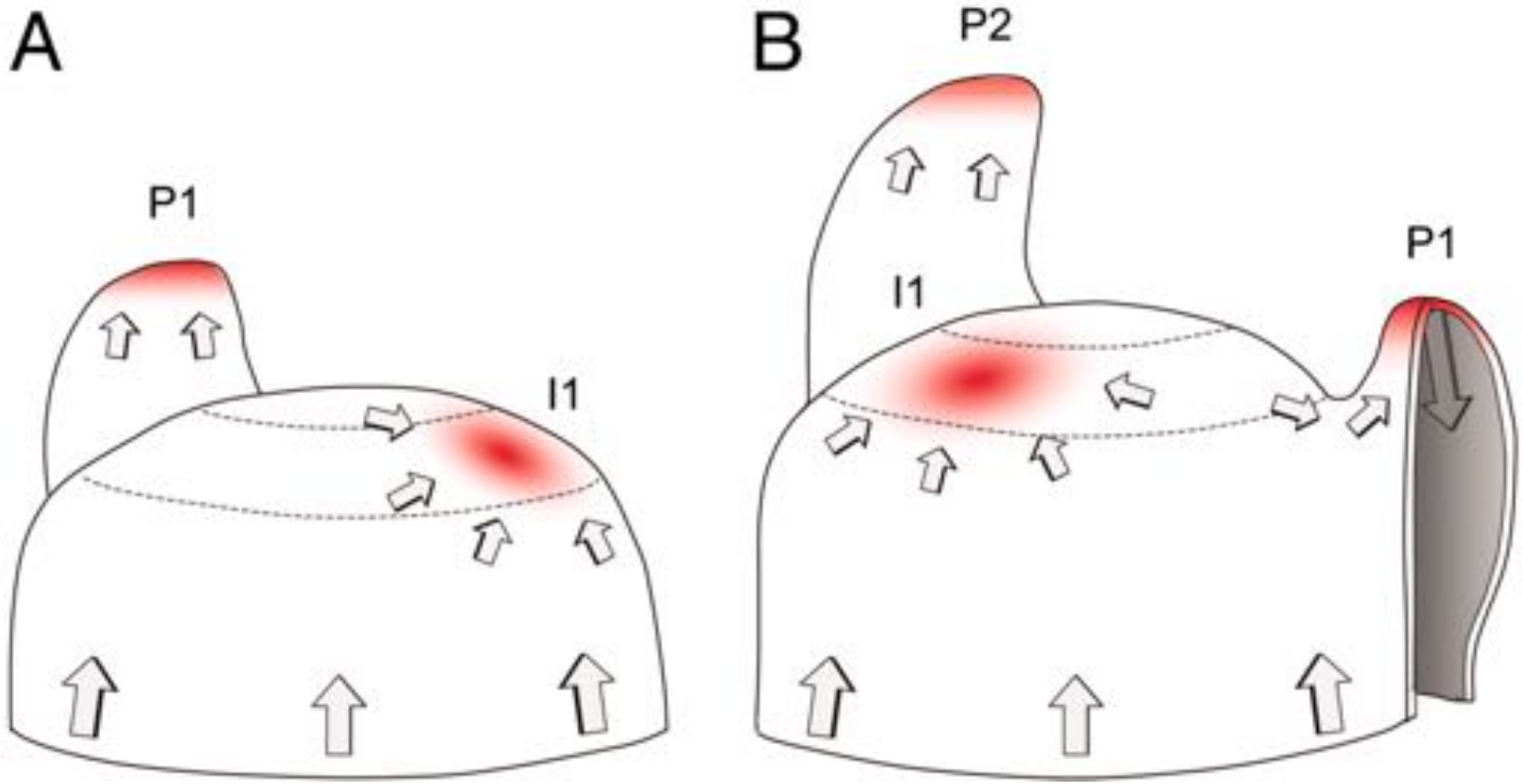
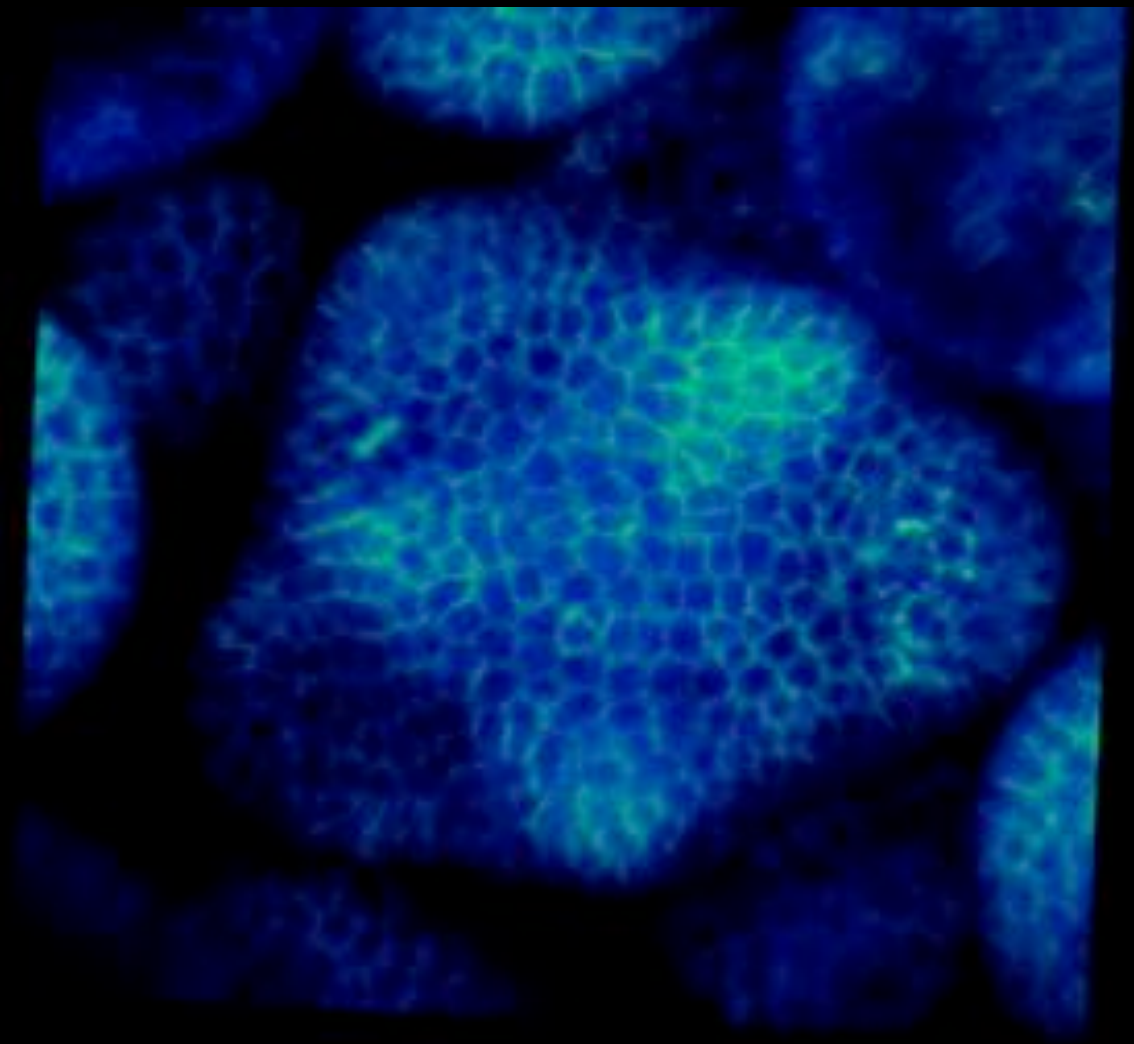
Department of Plant Sciences



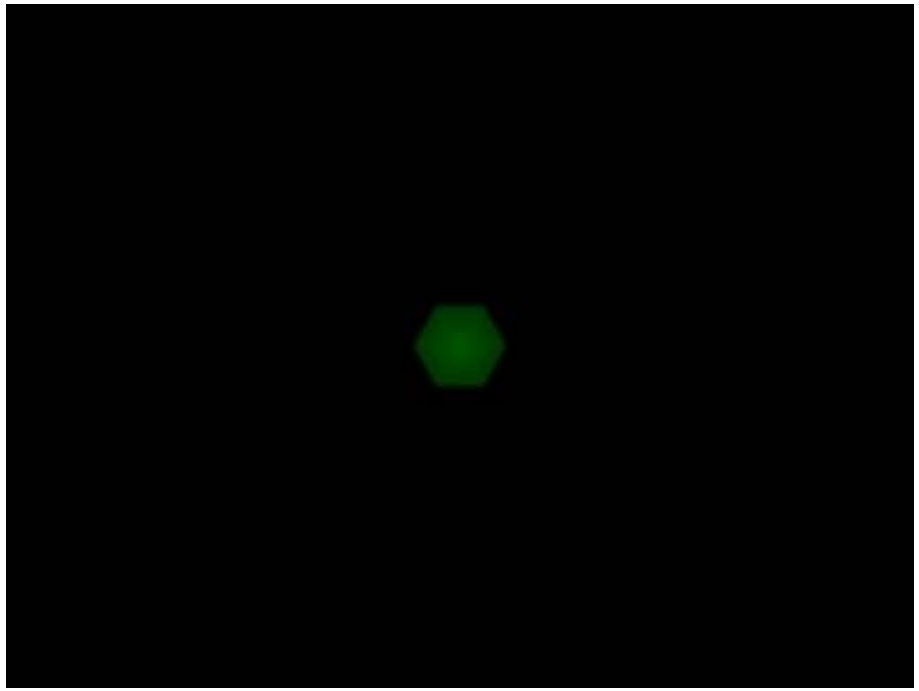


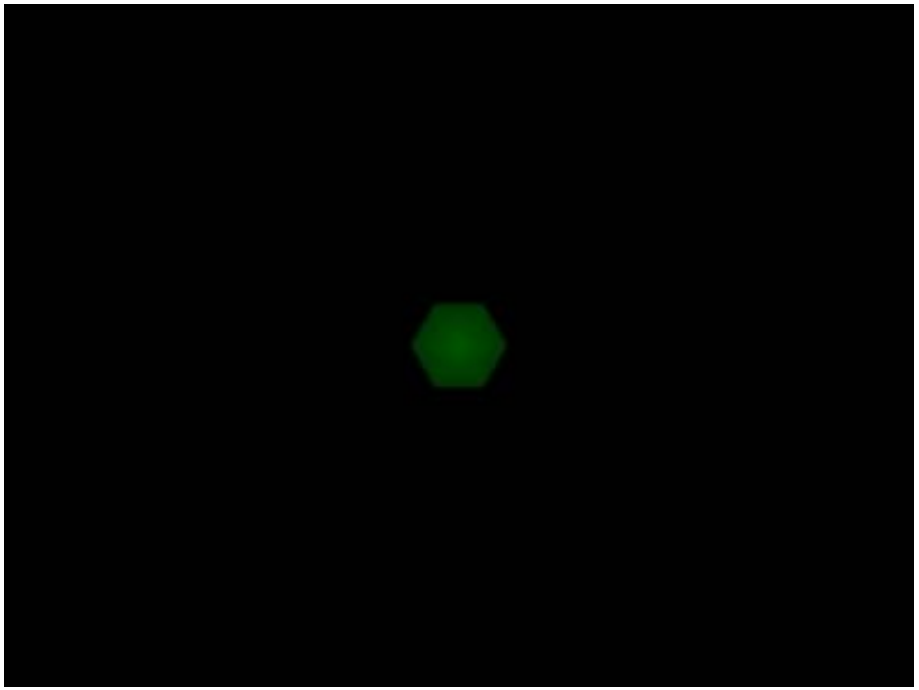
Auxin triggered outgrowth of shoot primordia

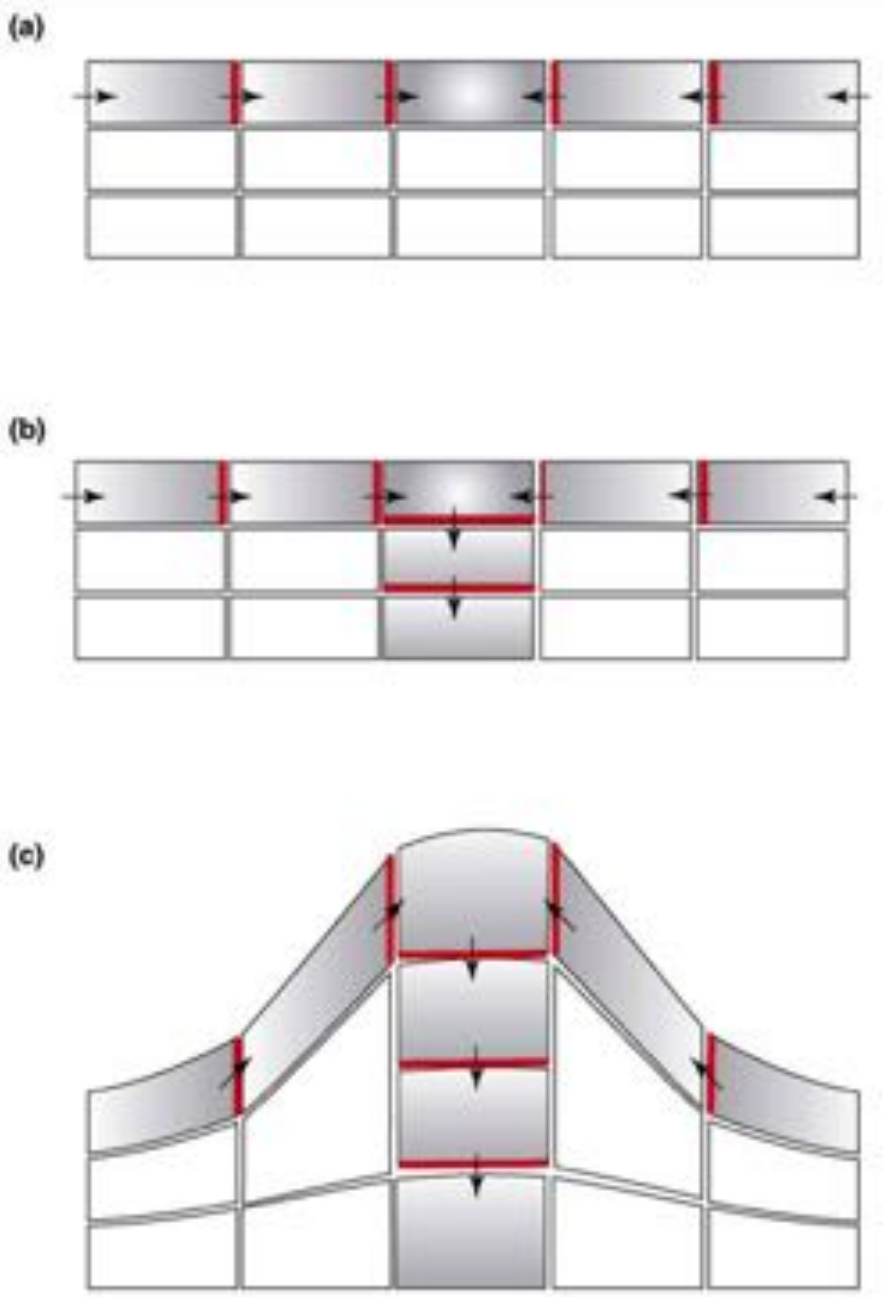
PIN1:GFP distribution in the Arabidopsis shoot apical meristem

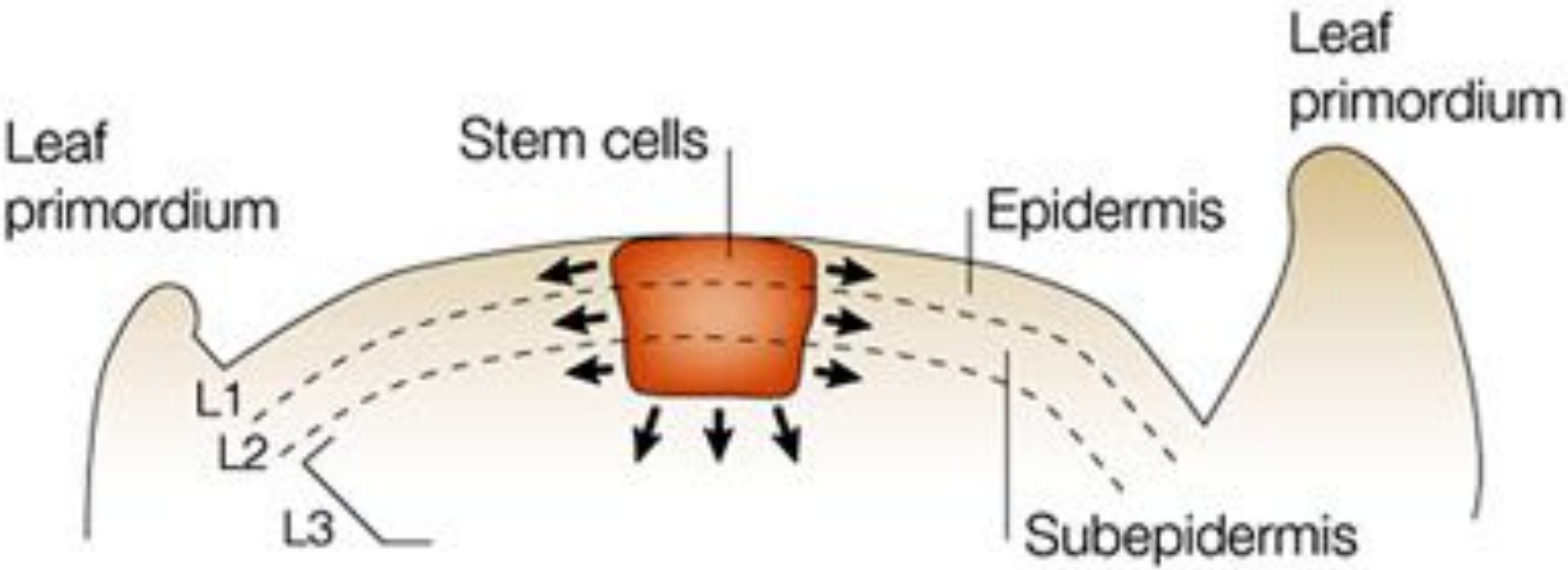


Primordial outgrowths in the meristem are triggered by local influxes of auxin

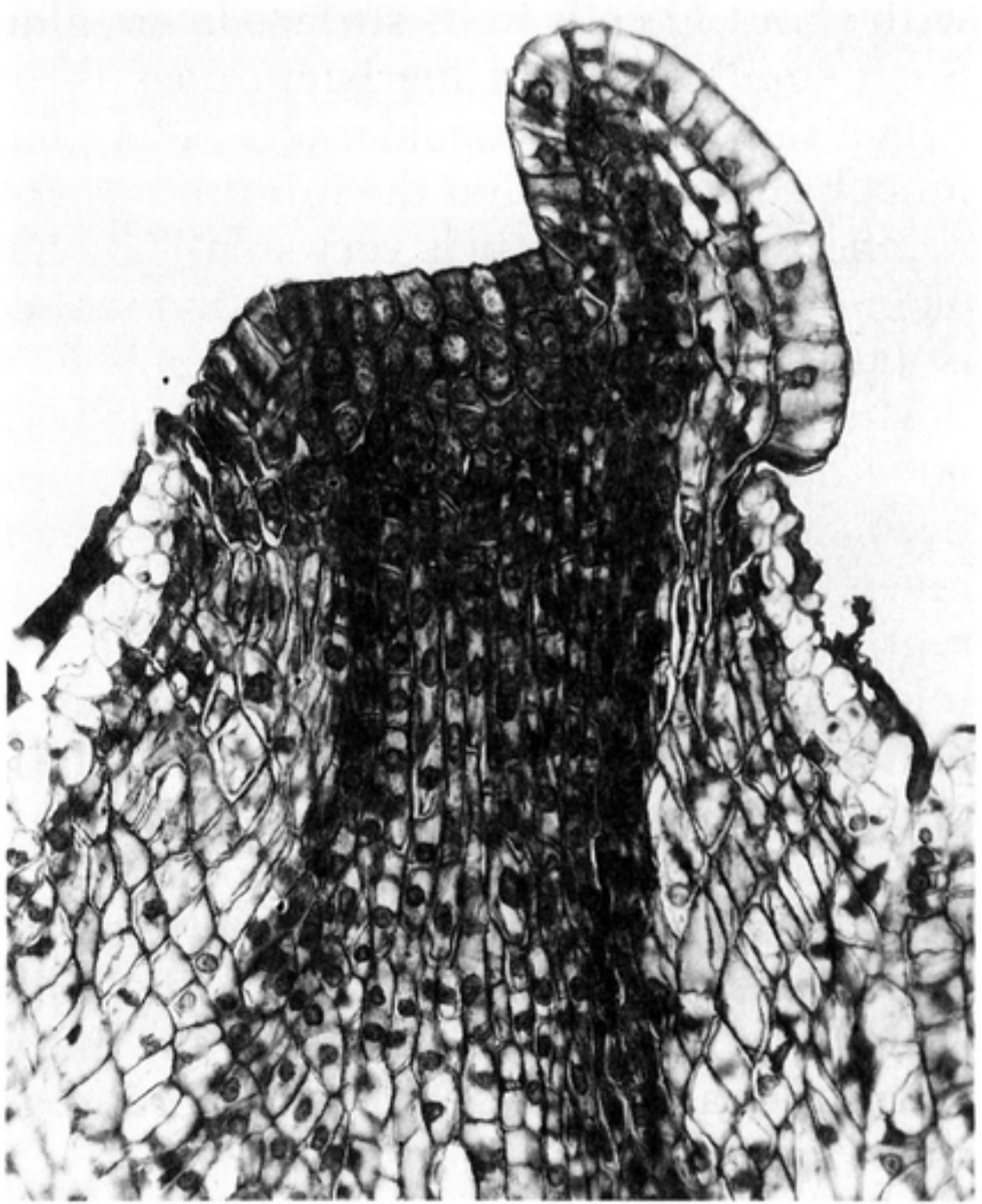






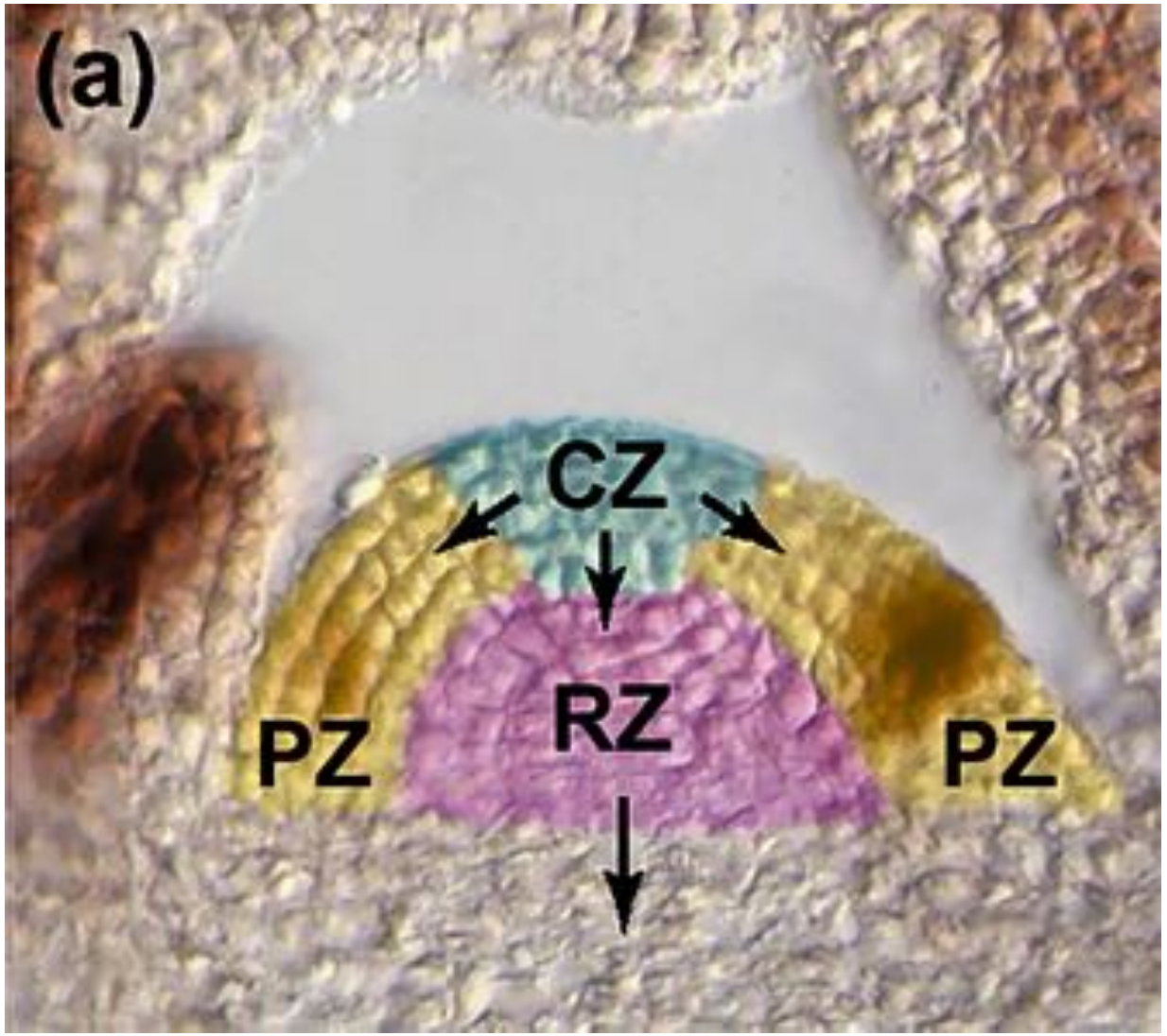


The meristem is self-organising and renews itself.



Sussex, Brookhaven Symp. Biol. 16:1-12 (1964)

The shoot meristem is divided into central, peripheral and rib zones.



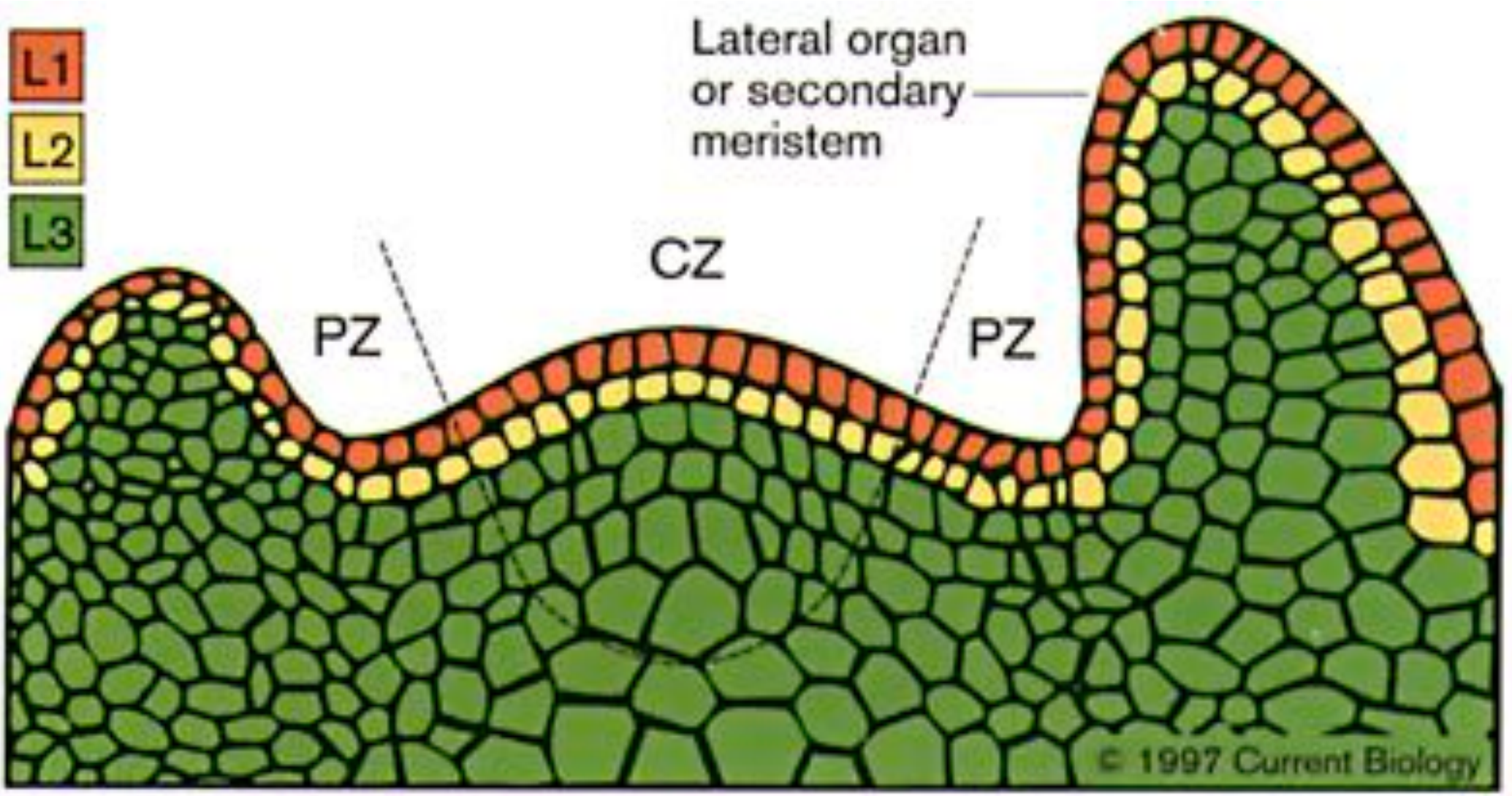
Central zone = undifferentiated cells

Peripheral zone = formation of new lateral organs

Rib zone = formation of new stem

The meristem contains three different layers of cells, L1, L2 & L3.

These generally maintain distinct lineages



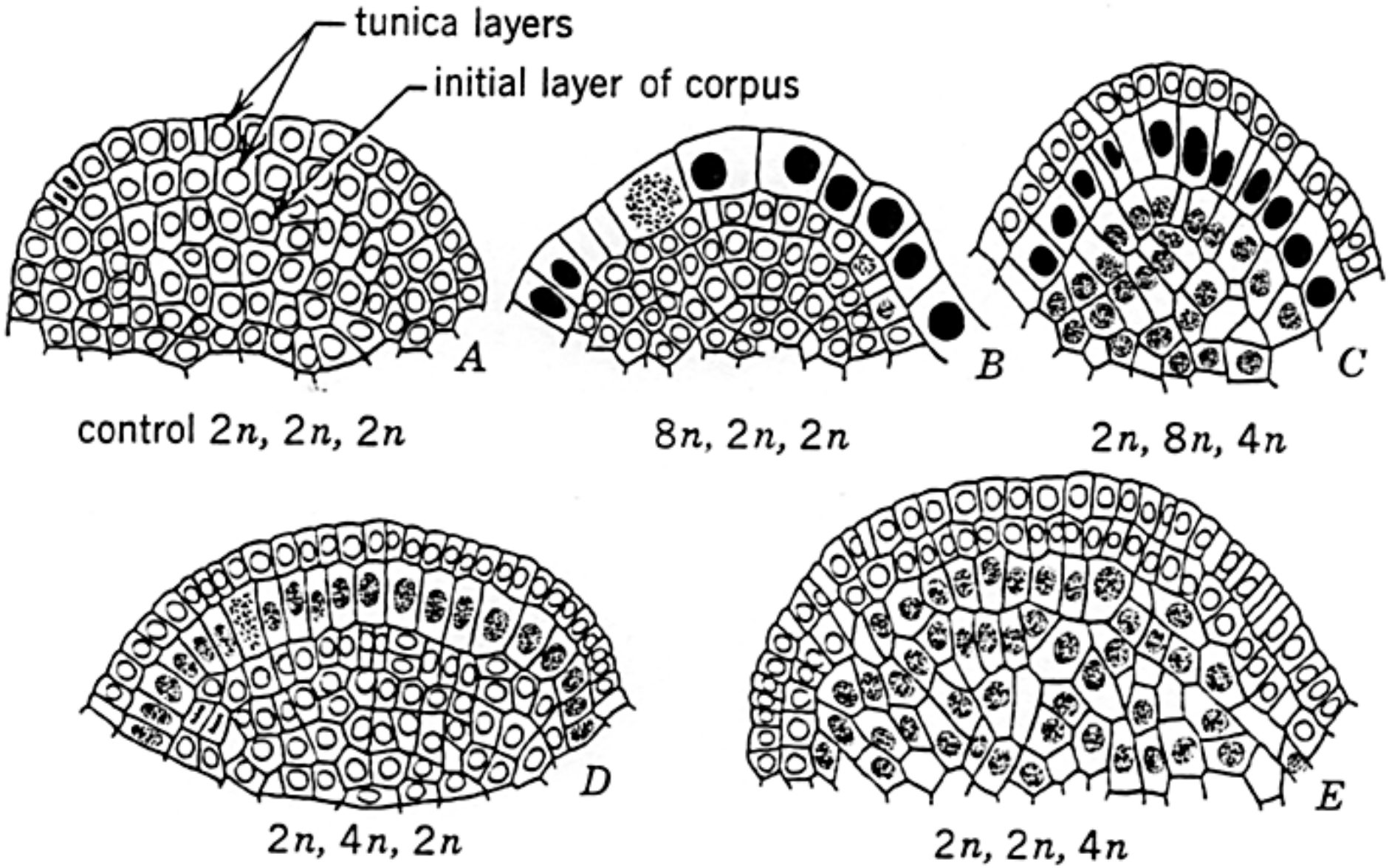


FIG. 5.2. Shoot apices of *Datura* from a diploid plant (*A*) and from several periclinal cytochimeras. Chromosomal combinations are indicated by values given below each drawing.

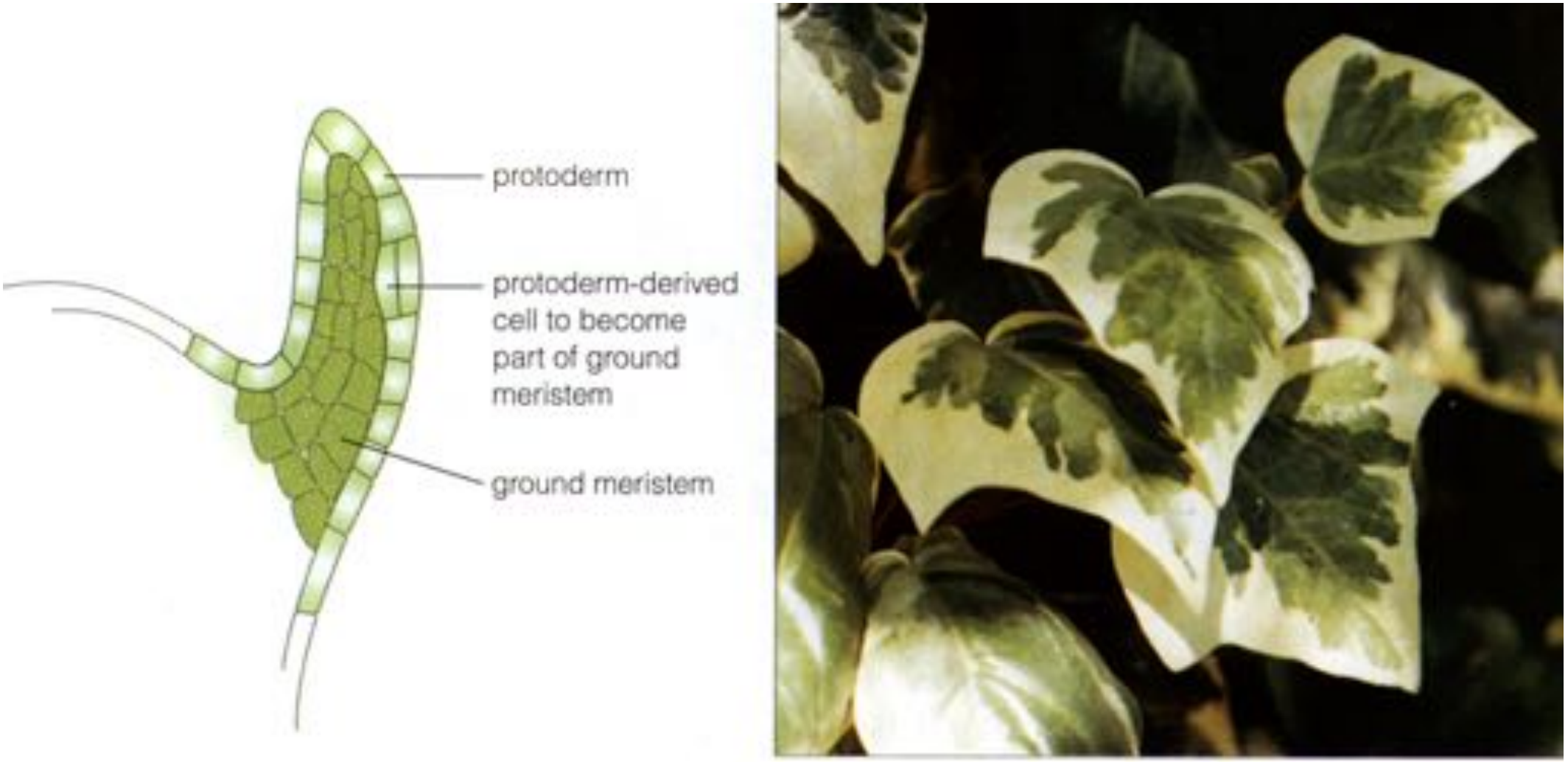
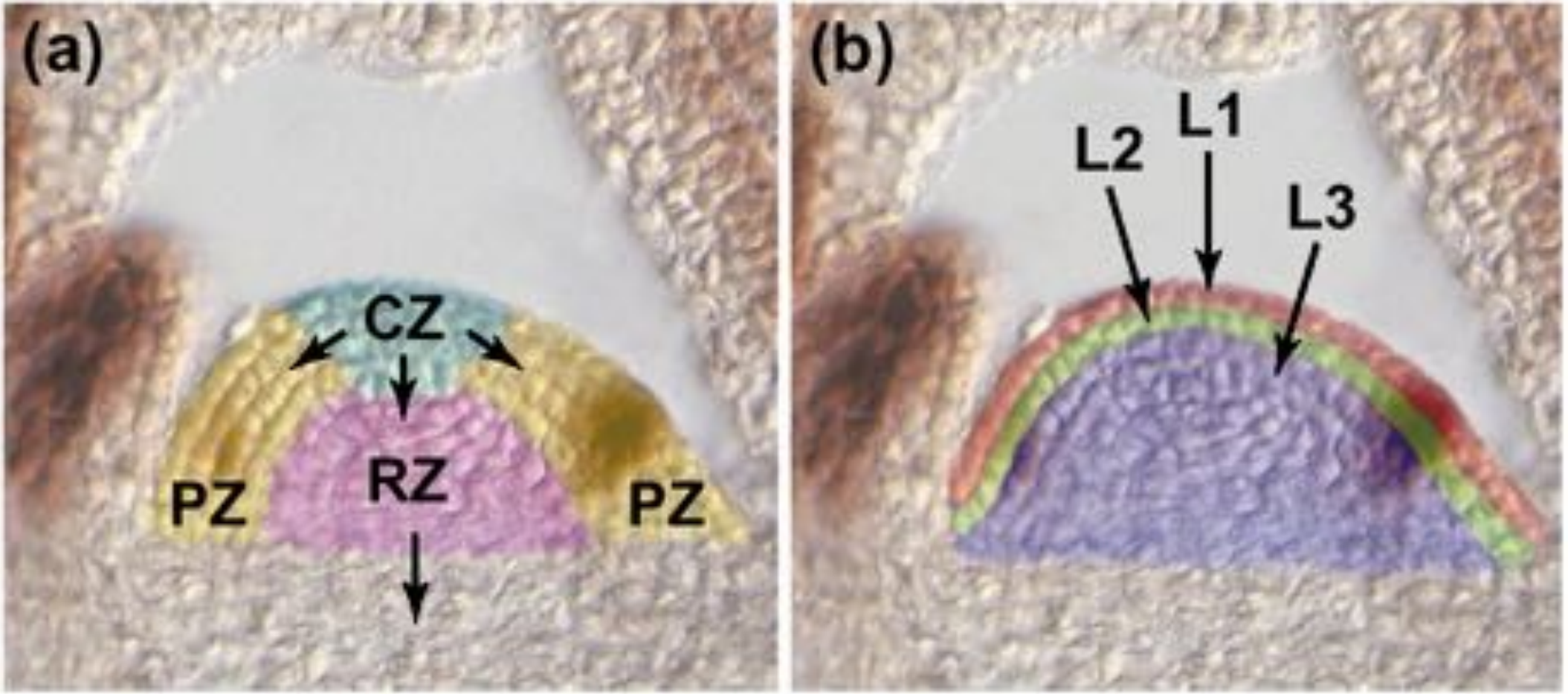


Figure 15.2 An example of reversible determination in plant cells. The protoderm and epidermal cells of English ivy (*Hedera helix*) lack the ability to make chlorophyll, but the ground meristem and its derivatives in a leaf produce chlorophyll normally. When a protoderm cell divides so that one of its resulting cells becomes part of the ground meristem (**a**), mesophyll in the section of leaf produced from that cell will lack chlorophyll and be light green or white (**b**). The cell that became part of the ground meristem lost its determination as protoderm.


(a)
CZ
PZ
RZ
PZ
(b)
L2
L1
L3

SHOOT MERISTEMLESS (STM) and WUSCHEL (WUS) are homeodomain genes that are required for formation and maintenance of the shoot apical meristem in Arabidopsis.

wt

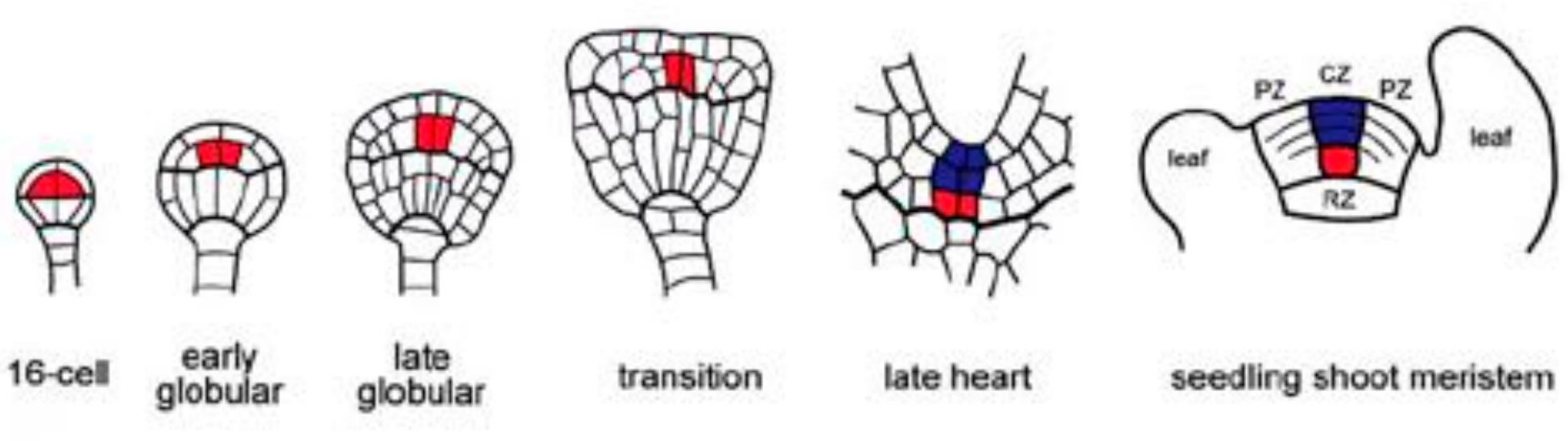
shootmeristemless (stm)

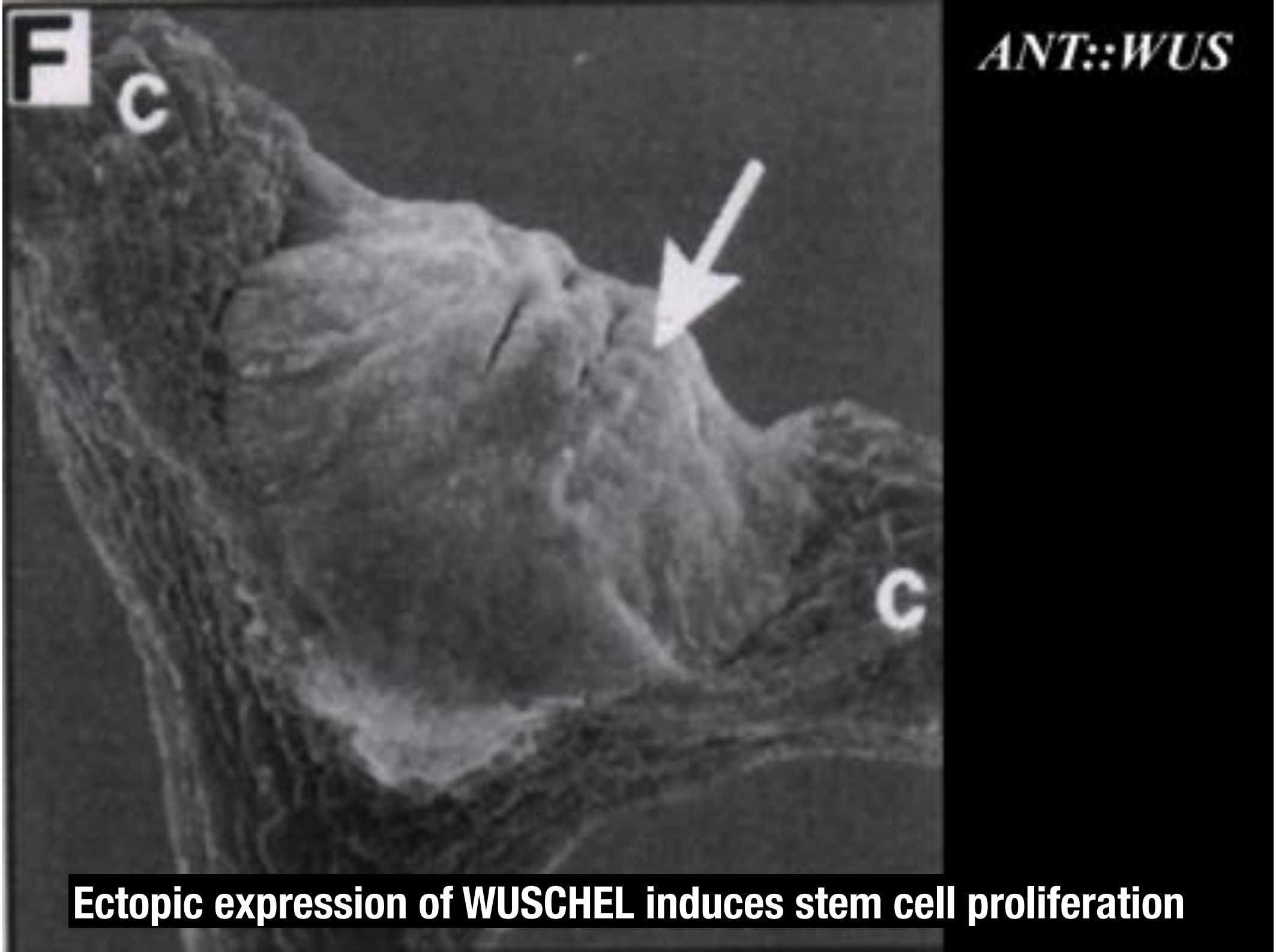
wuschel (wus)

wt

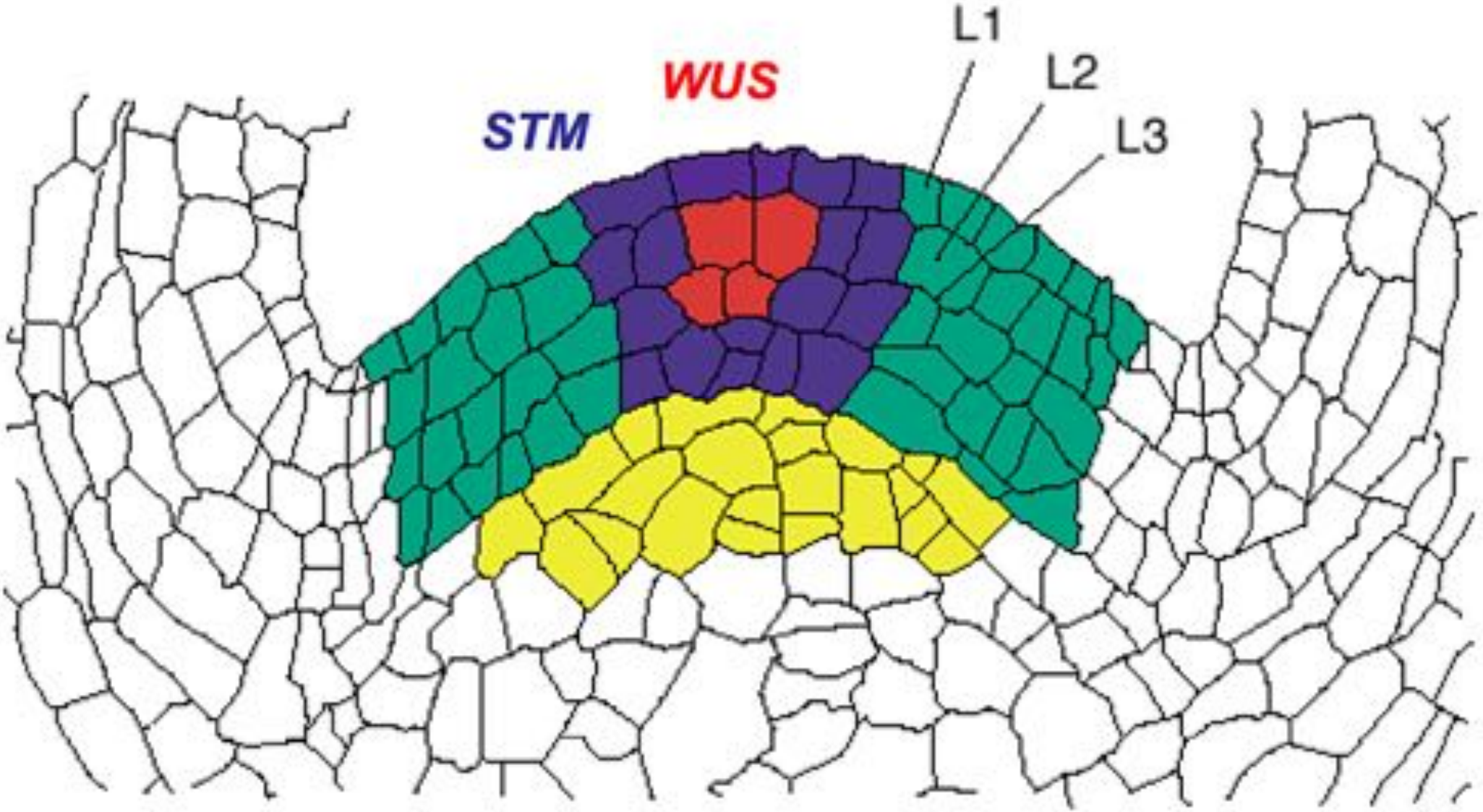
wus

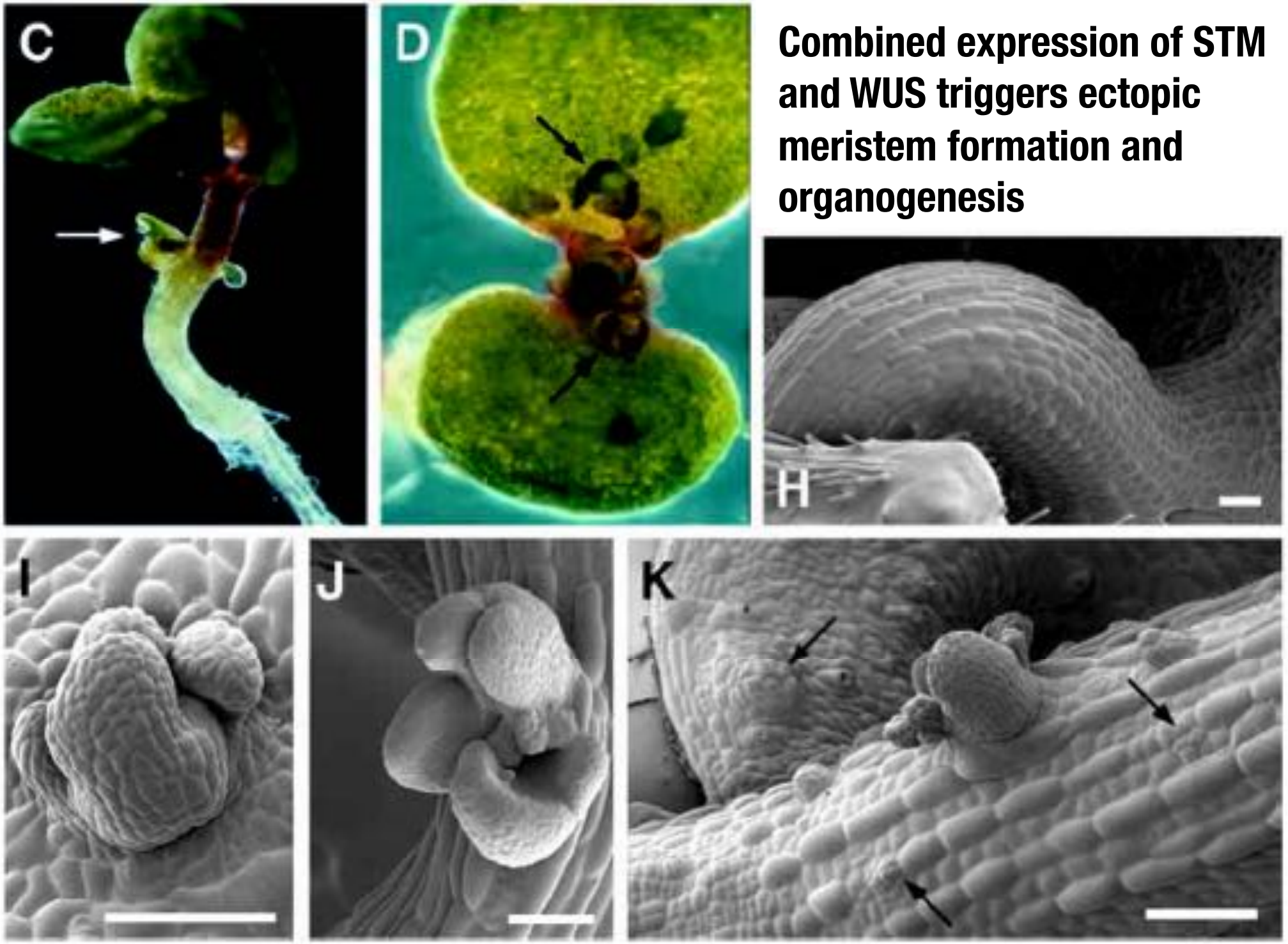
WUSCHEL expression





Ectopic expression of WUSCHEL induces stem cell proliferation


L1
L2
L3
WUS
STM



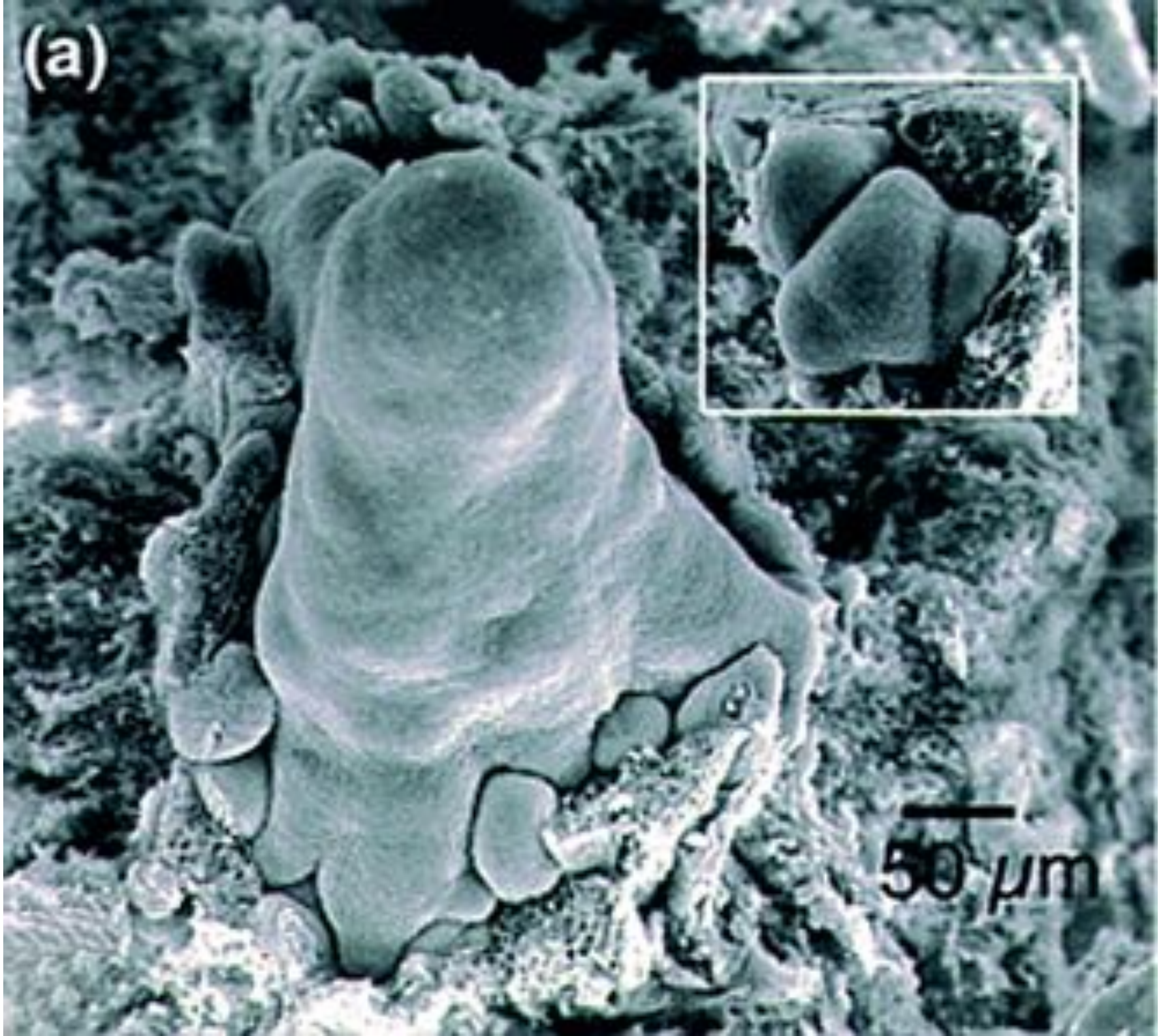
Combined expression of STM and WUS triggers ectopic meristem formation and organogenesis

WUS and STM initiate and maintain meristem growth

- but how is the size of the apical meristem constrained?

the growth of the shoot meristem is negatively regulated by….

the CLAVATA genes


(a)
50 μm


A
B
C
wt
clv1-6
clv1-4


clv1-1
WT
A

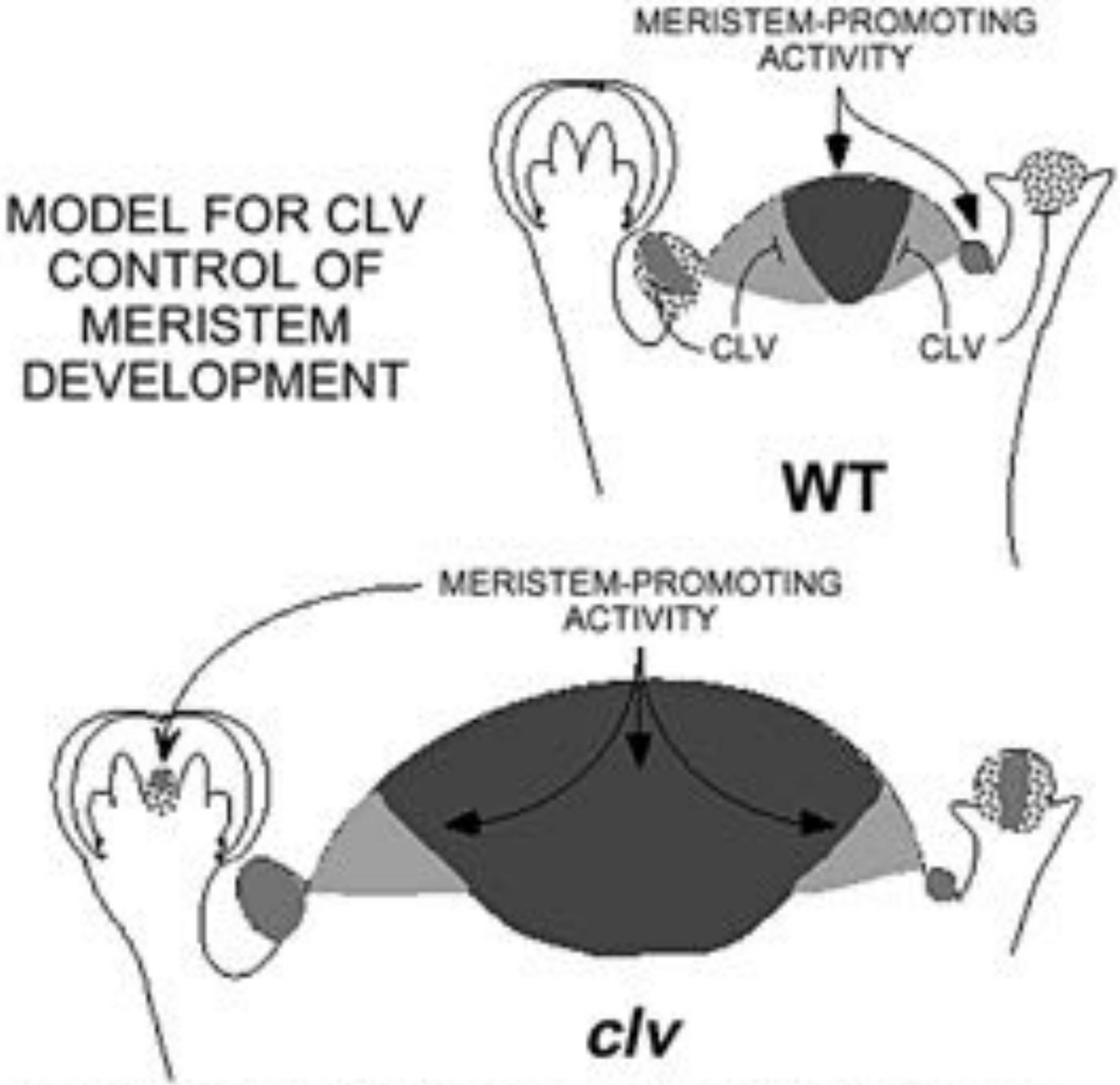
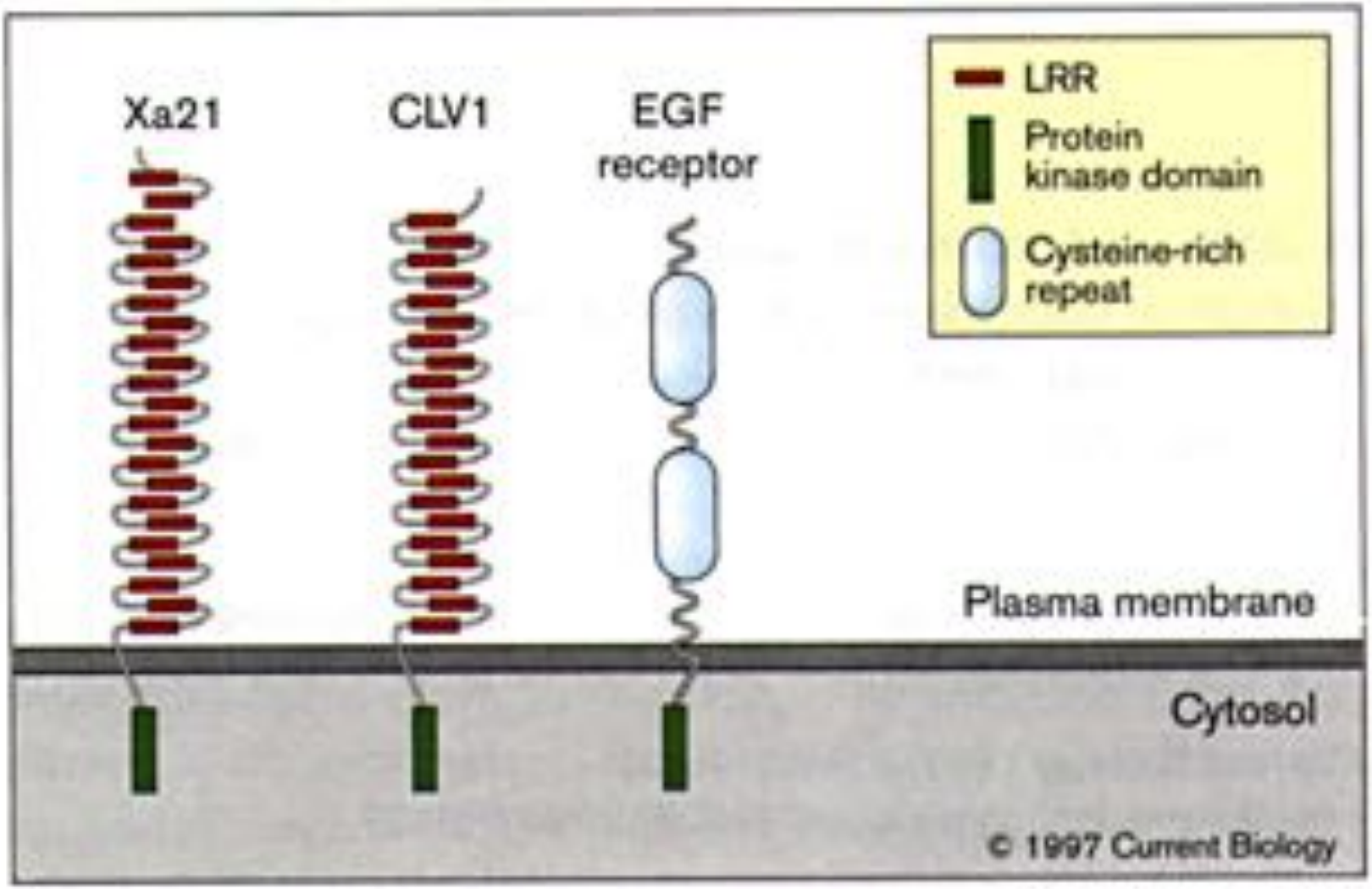
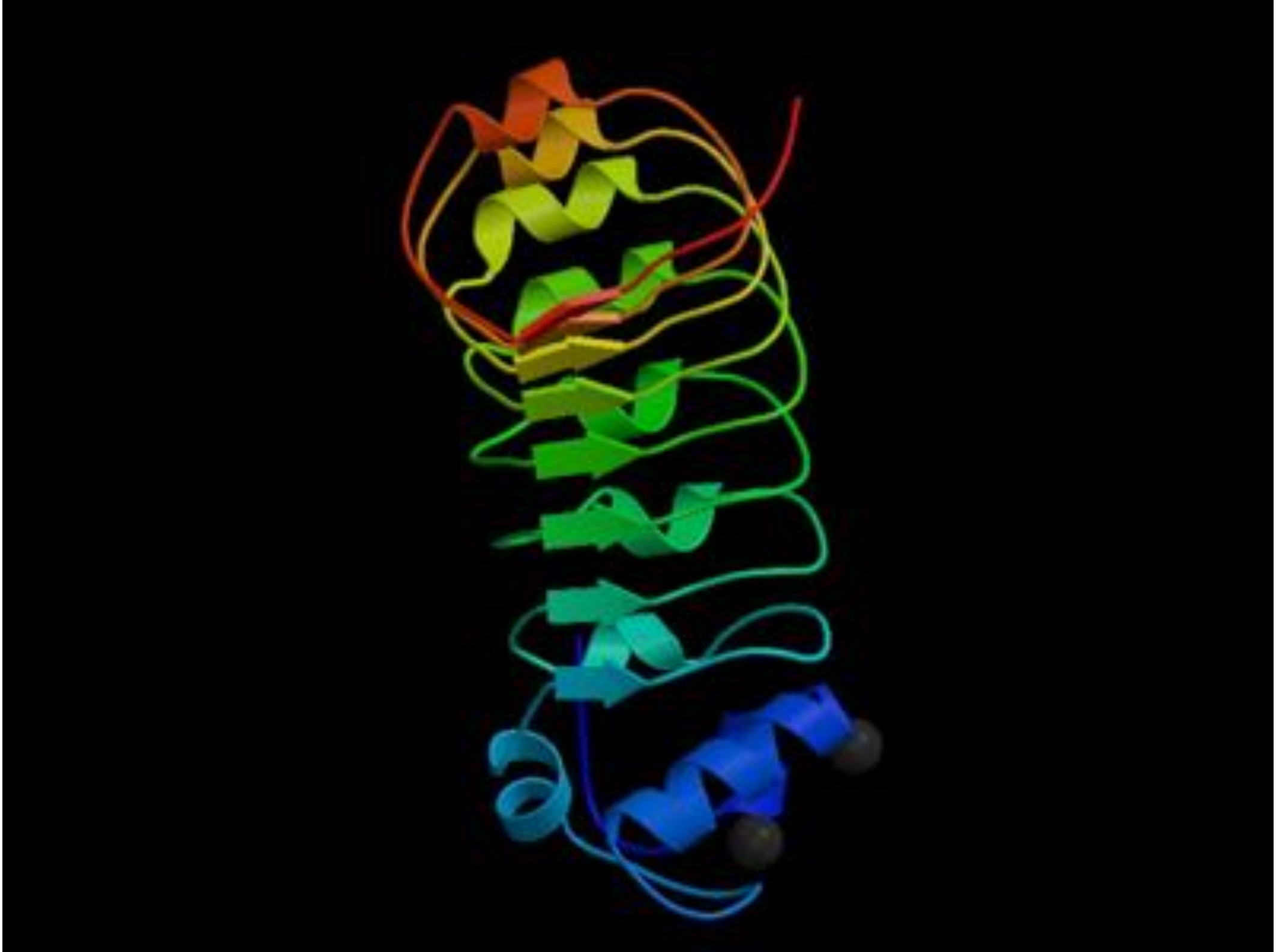
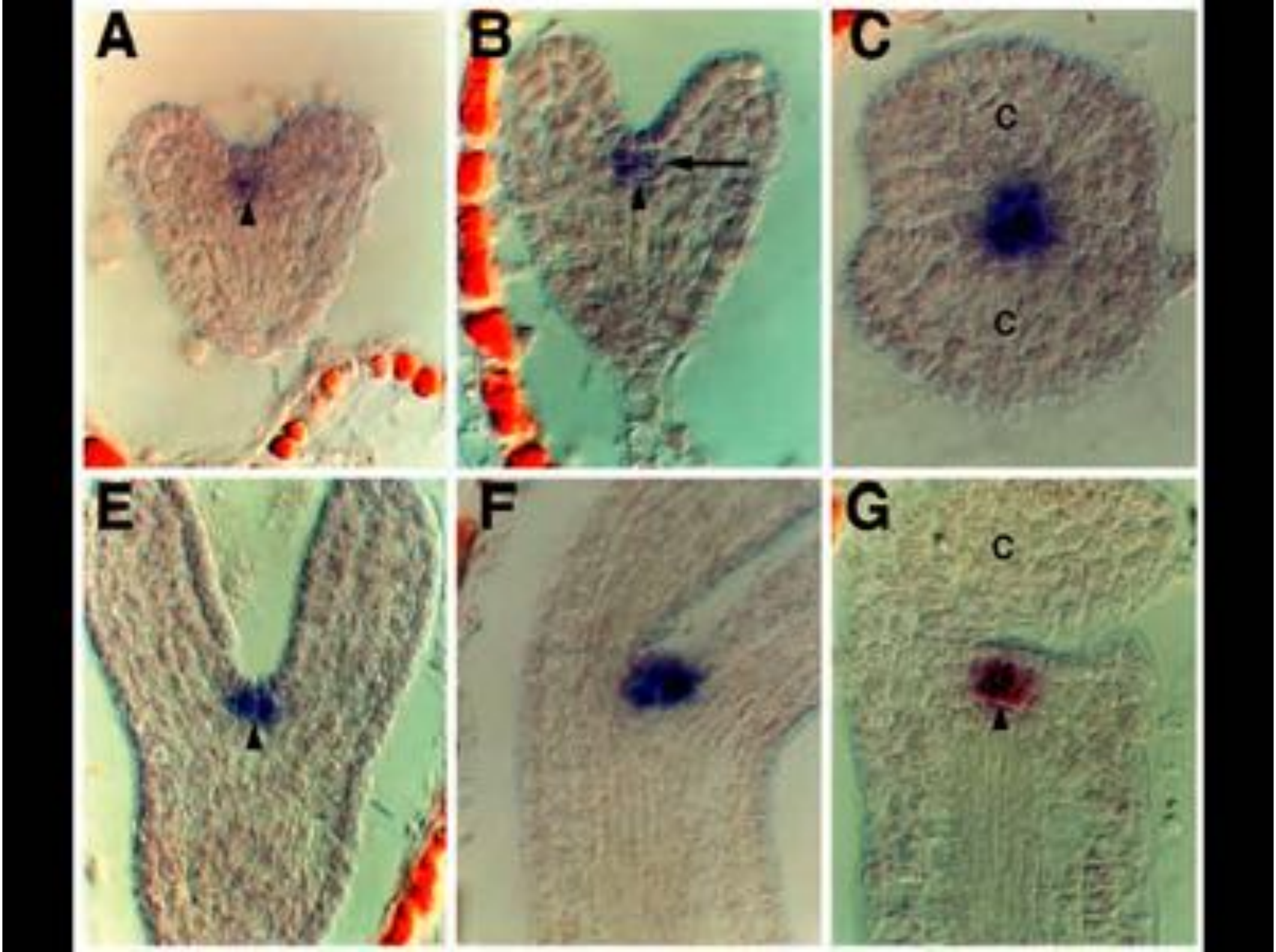


Fig. 9. Model for *CLV* action. The model postulates that there is a meristem-promoting activity (MPA) in shoot meristems and young flowers that maintains cells in a proliferative, undifferentiated state.

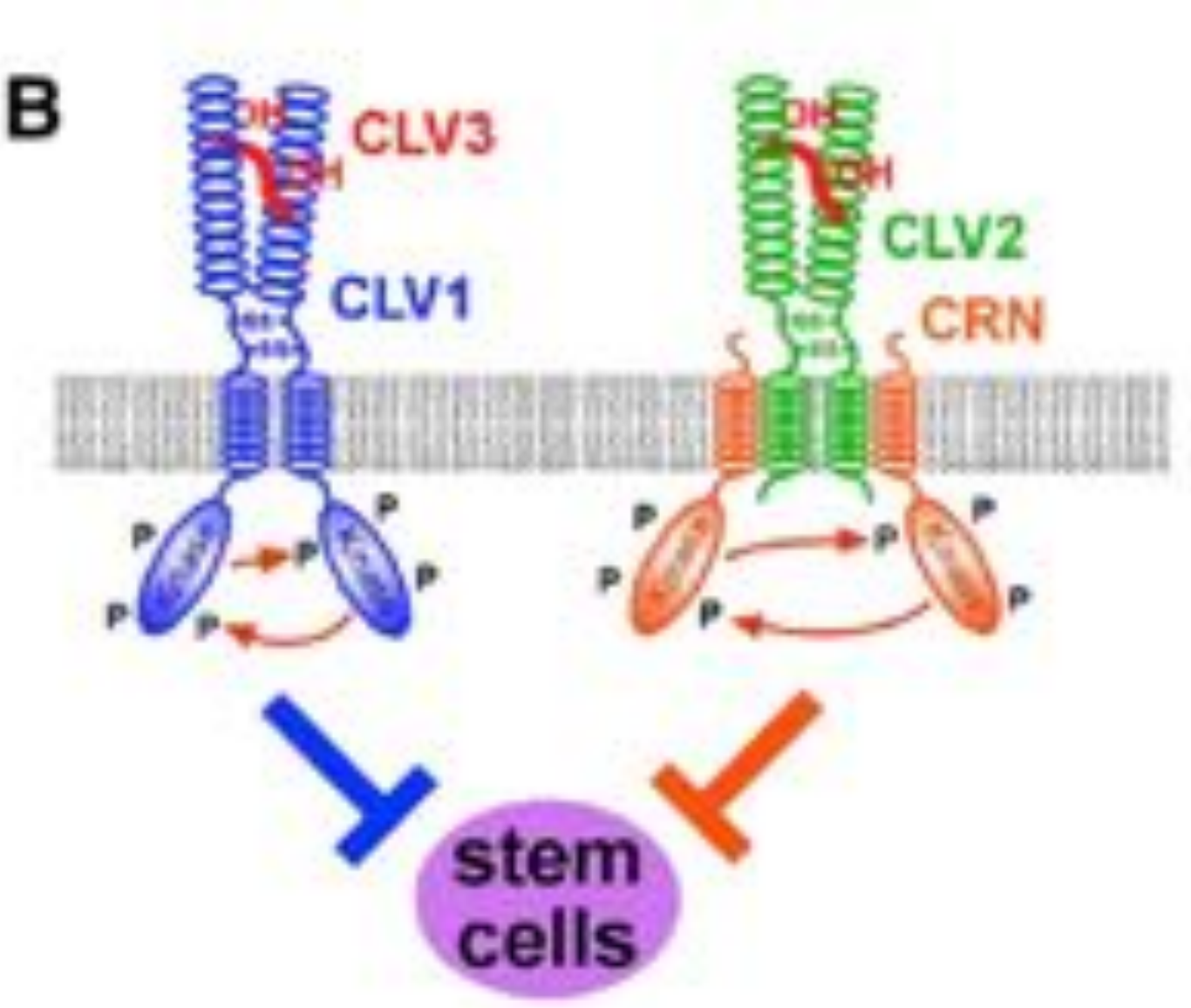


Topology of the CLV1 protein, showing the signal peptide, extracellular leucine-rich repeat (LRR) domain, transmembrane region and cytoplasmic kinase domain. Included for comparison are the rice Xa21 disease resistance protein and the human epidermal growth factor (EGF) receptor. The plant receptors are serine/threonine kinases, whereas the EGF receptor is a tyrosine kinase and has a ligand-binding domain containing cysteine-rich repeats.




A
B
C
C
C
E
F
G
C

Two other membrane proteins Clavata2 and Coryne associate to form a receptor kinase that functions on a parallel path.



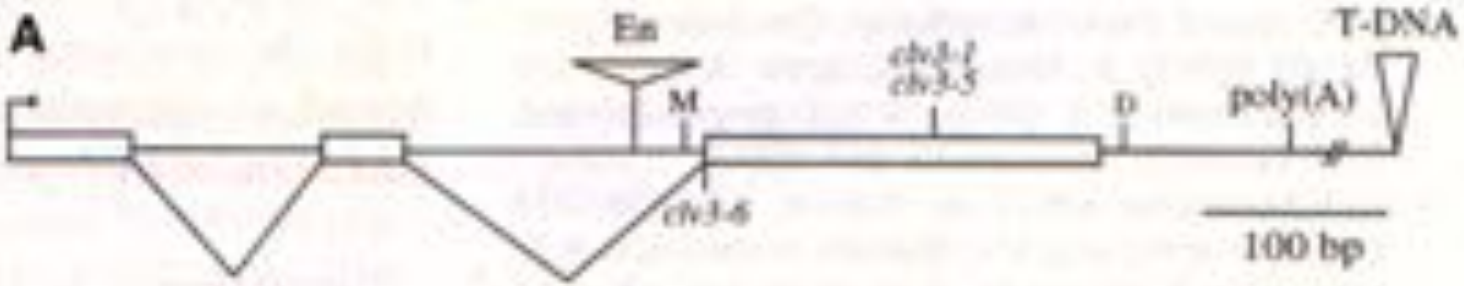
1. Mutations in the genes, clavata1, clavata2, coryne and clavata3, produce similar phenotypes - enlarged meristems.

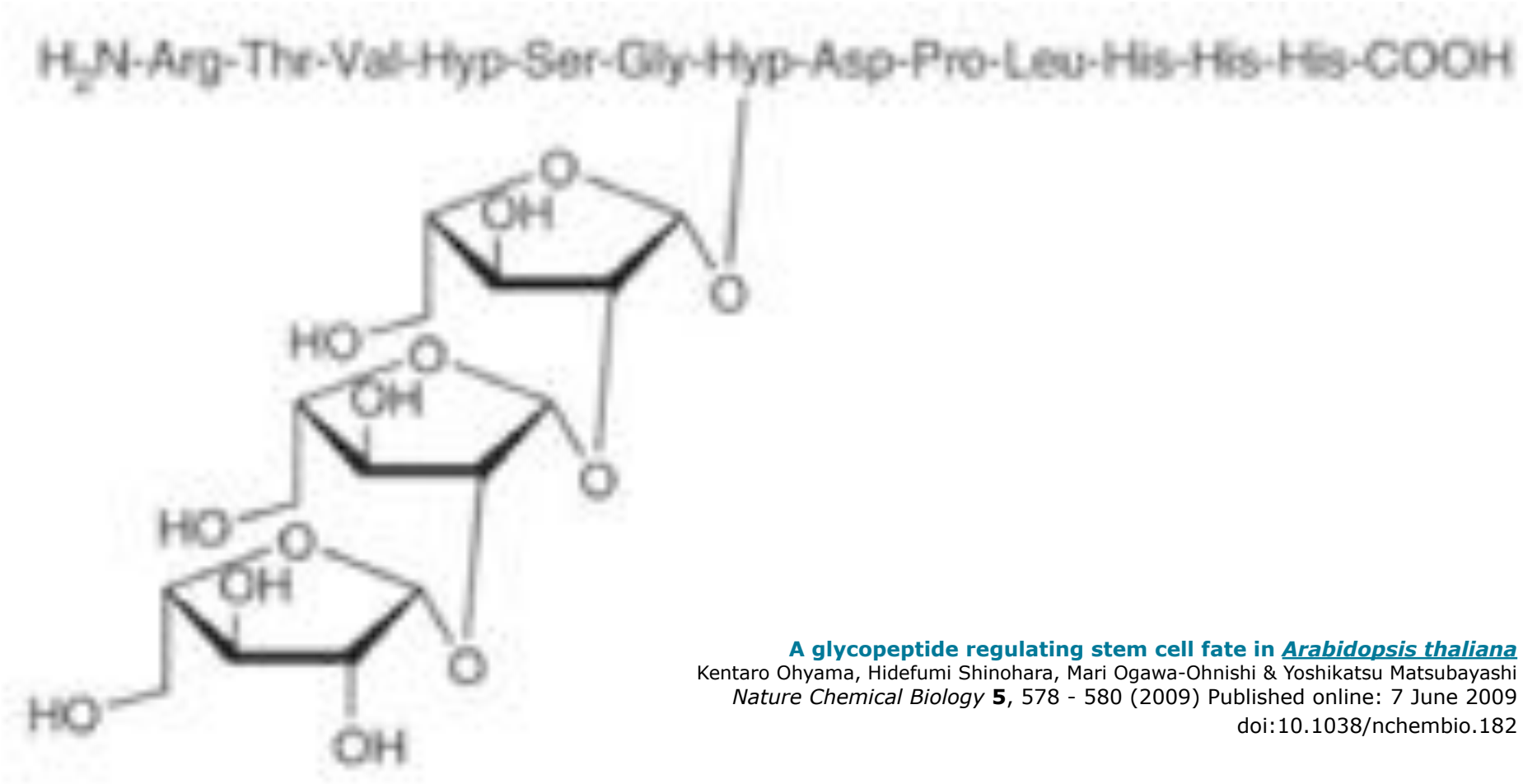
2. These genes function in the same regulatory pathway.

3. CLAVATA3 is a ligand for the CLAVATA1/ CLAVATA2/CORYNE receptors

Fig. 1. *clv3* shoot and flower phenotypes. (**A**) Wild-type inflorescence meristem. (**B**) *clv3-2* inflorescence meristems undergo fasciation, growing as a ring or line rather than a point. (**C**) *clv3-2* mutant flowers contain extra organs of all types, particularly stamens and carpels. Bars, 1 mm.

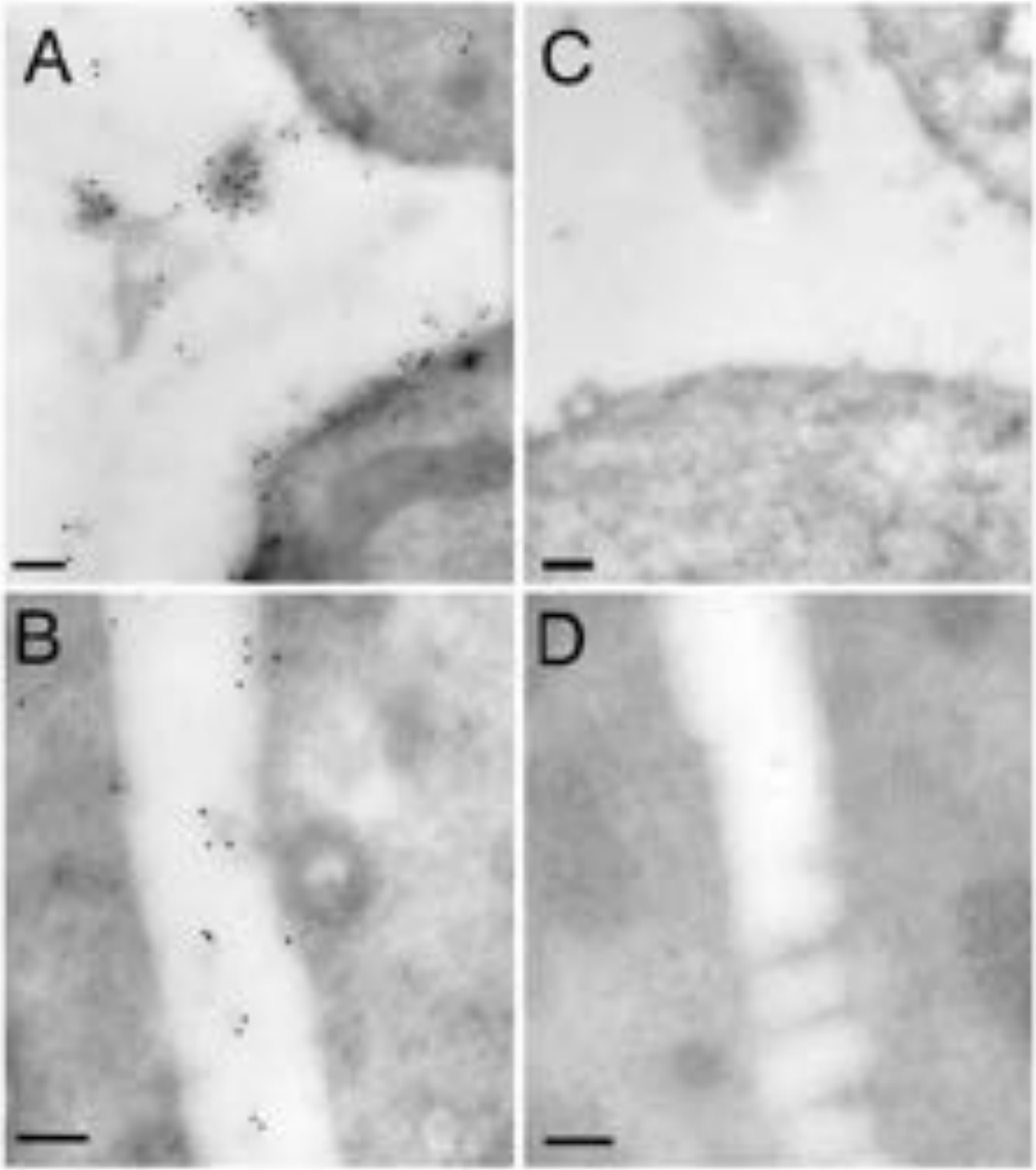
Fig. 2. *CLV3* genomic region and peptide sequence. (**A**) The *CLV3* genomic region. The translation start site is denoted by the arrow and the exons by boxes. The relative positions of the *clv3* mutations are shown. Restriction sites: M, Mfe I; D, Dra I. The genom-



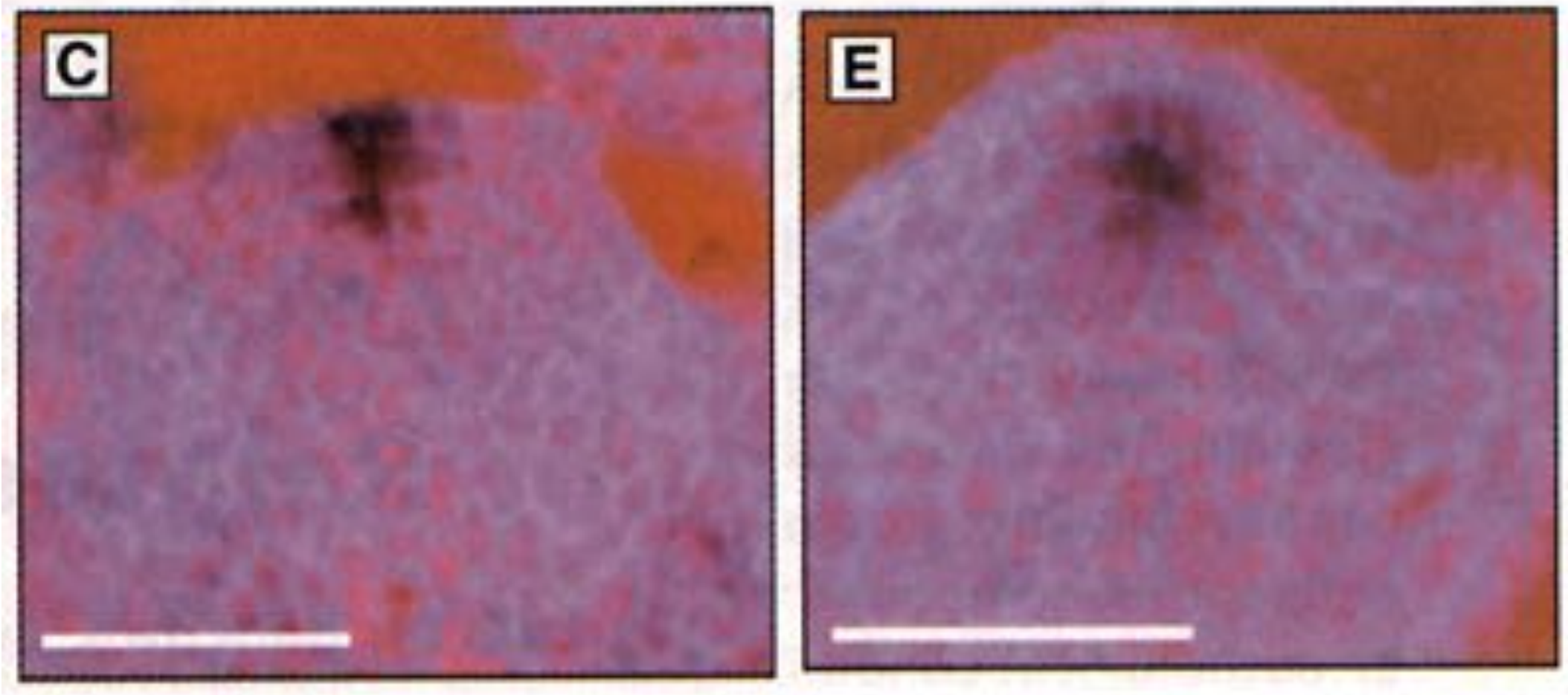


A glycopeptide regulating stem cell fate in *Arabidopsis thaliana*
Kentaro Ohyama, Hidefumi Shinohara, Mari Ogawa-Ohnishi & Yoshikatsu Matsubayashi
Nature Chemical Biology **5**, 578 - 580 (2009) Published online: 7 June 2009
doi:10.1038/nchembio.182

Clavata3 forms a 13 amino acid arabinosylated glycopeptide



CLV3 Is Localized in the Extracellular Space.

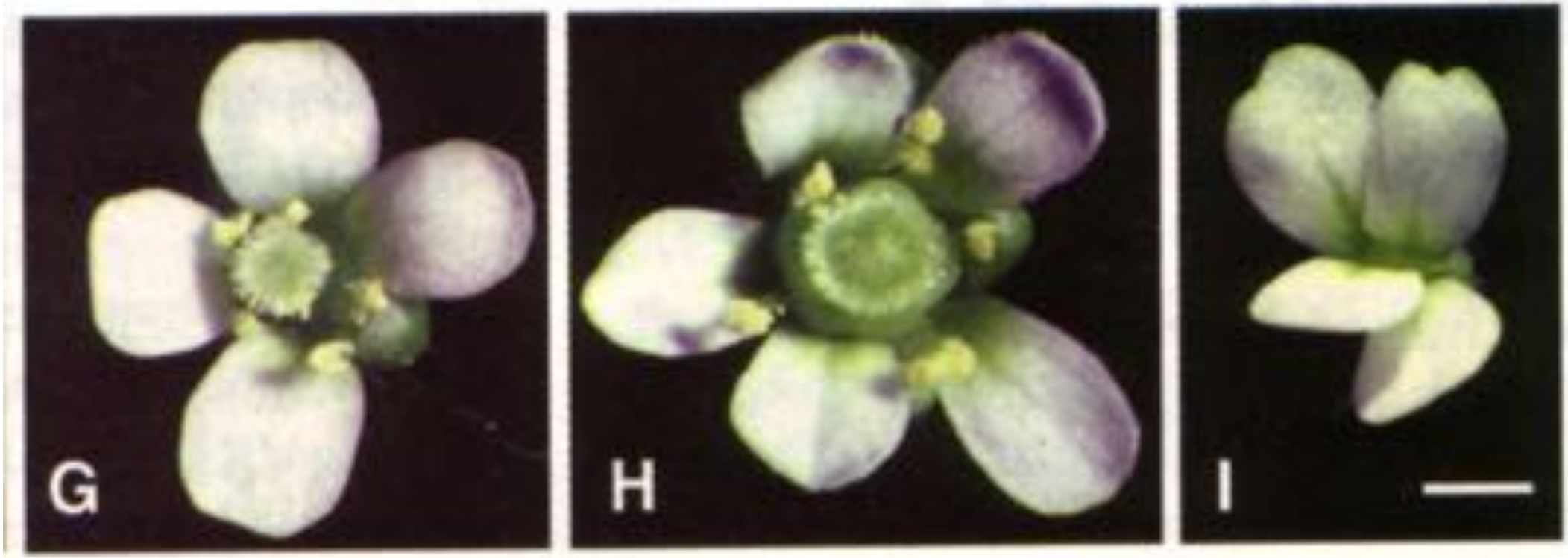


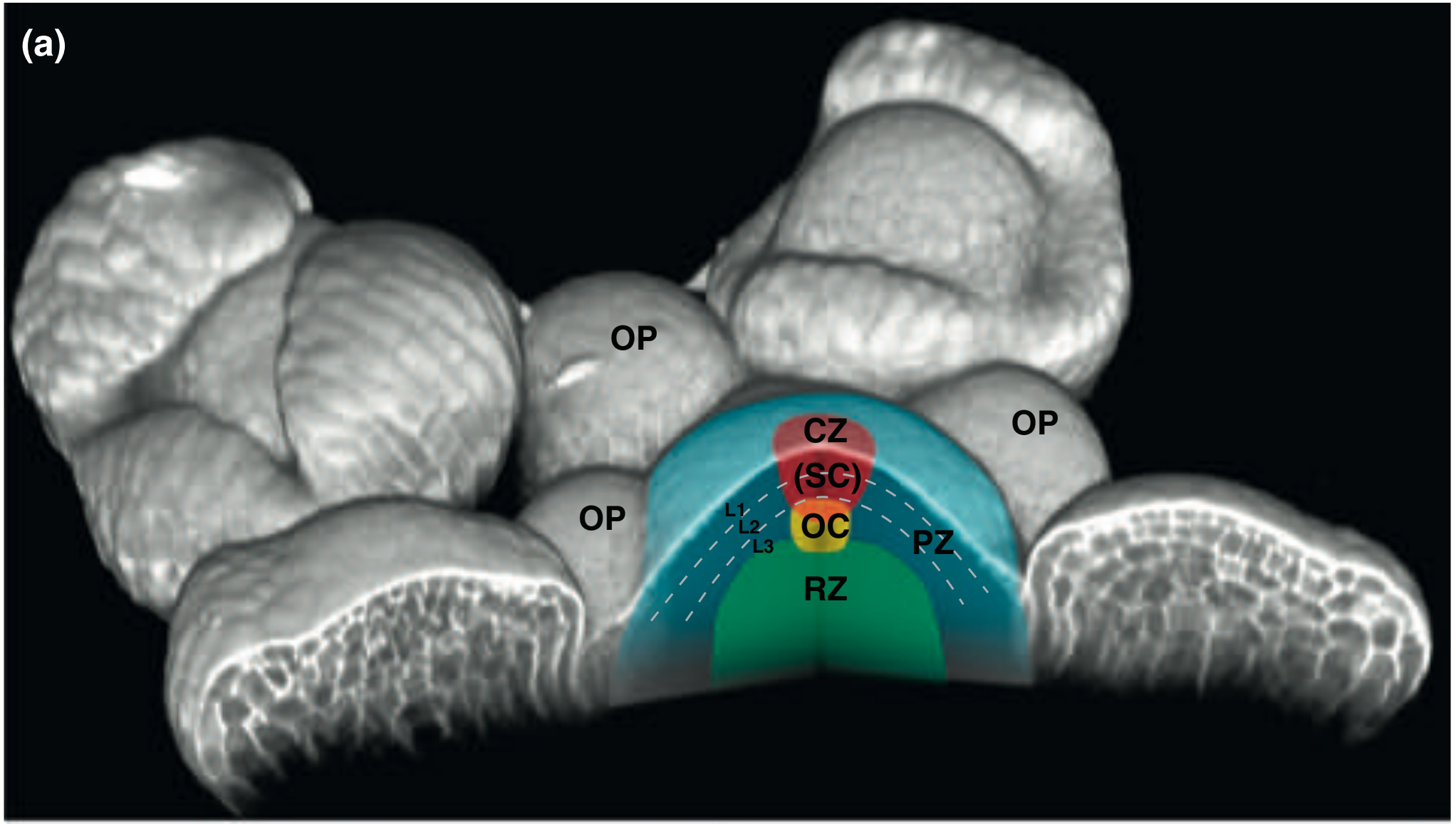
CLV3 mRNA

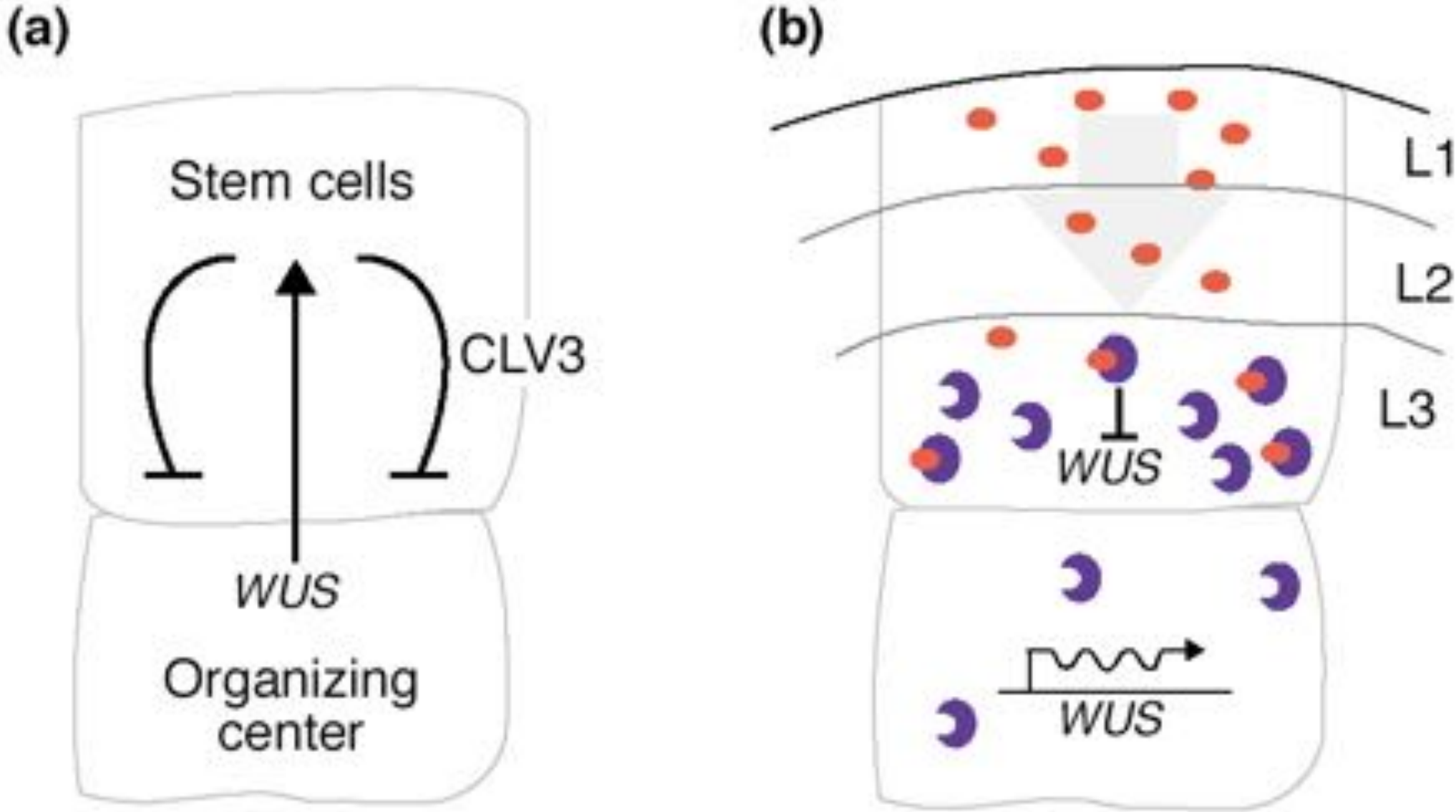
CLV1 mRNA

Over expression of CLAVATA3 causes depletion of the central zone of the meristem.

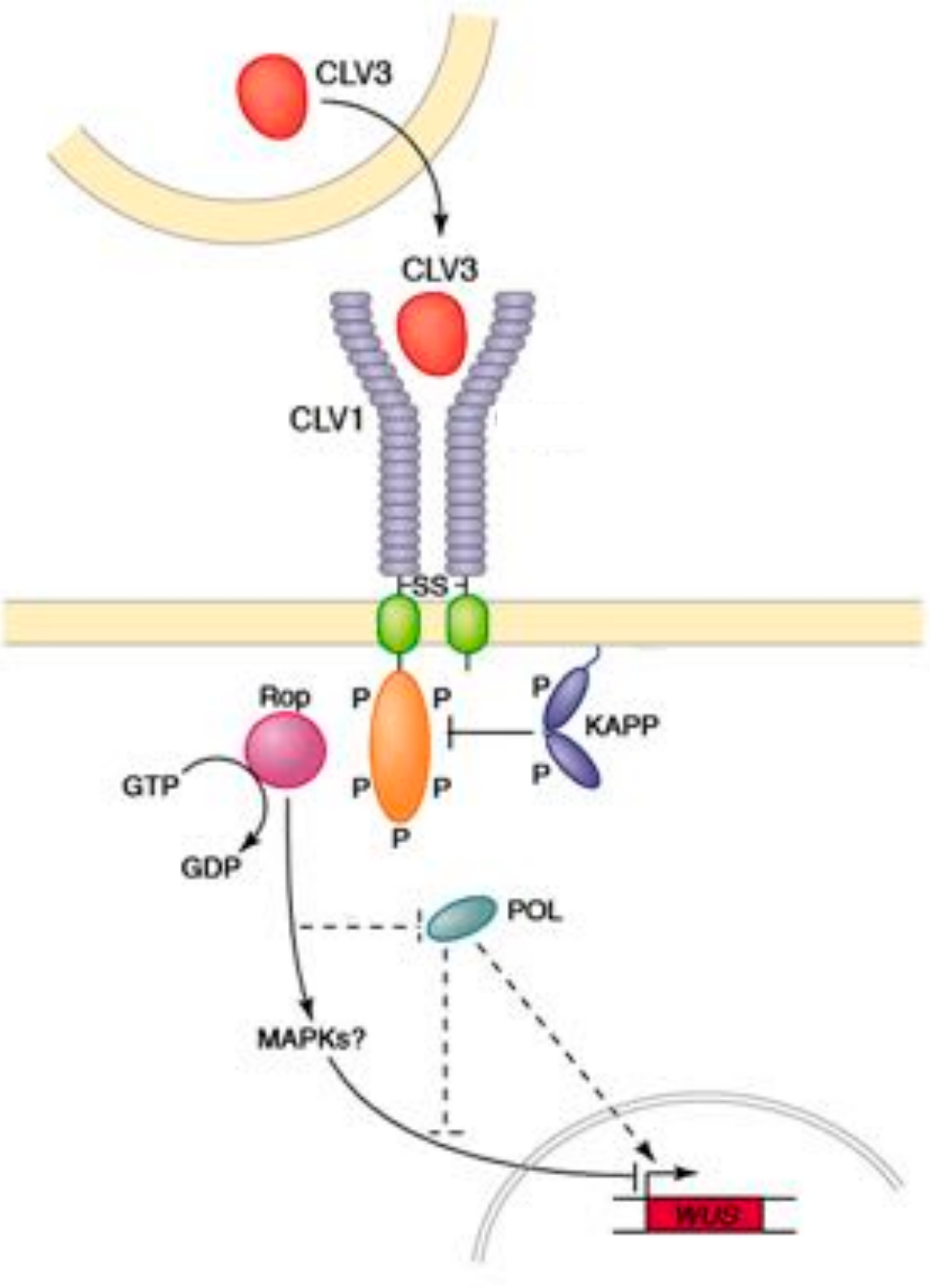
wt *clv3-2* *35S:clv3*




(a)
OP
OP
OP
CZ
(SC)
OC
L1
L2
L3
PZ
RZ


(a)
Stem cells
CLV3
WUS
Organizing
center
(b)
L1
L2
L3
WUS
WUS

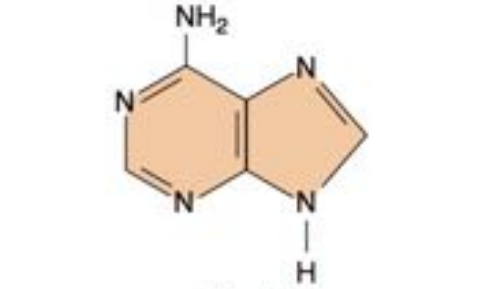
CLAVATA3 acts as a signal across the meristem, repressing WUSCHEL activity in the central zone of the shoot meristem.

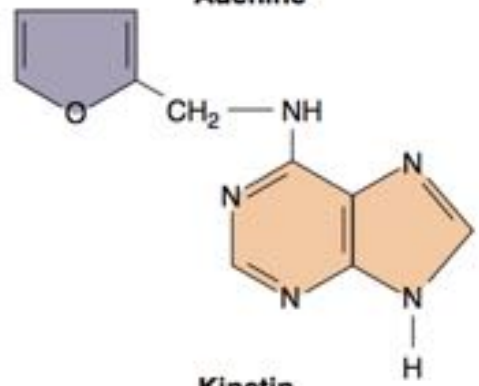


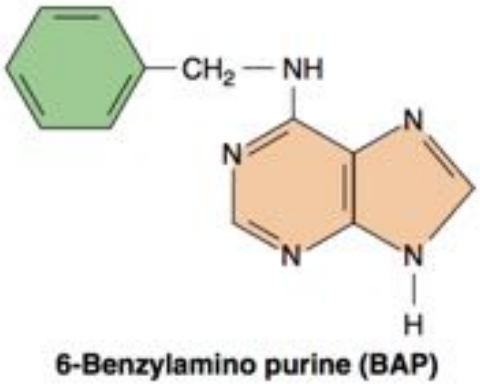
Auxin regulated feedback initiates shoot outgrowth.

The Clavata and Wus genes form part of a feedback regulated circuit, controlling cell proliferation within each meristem

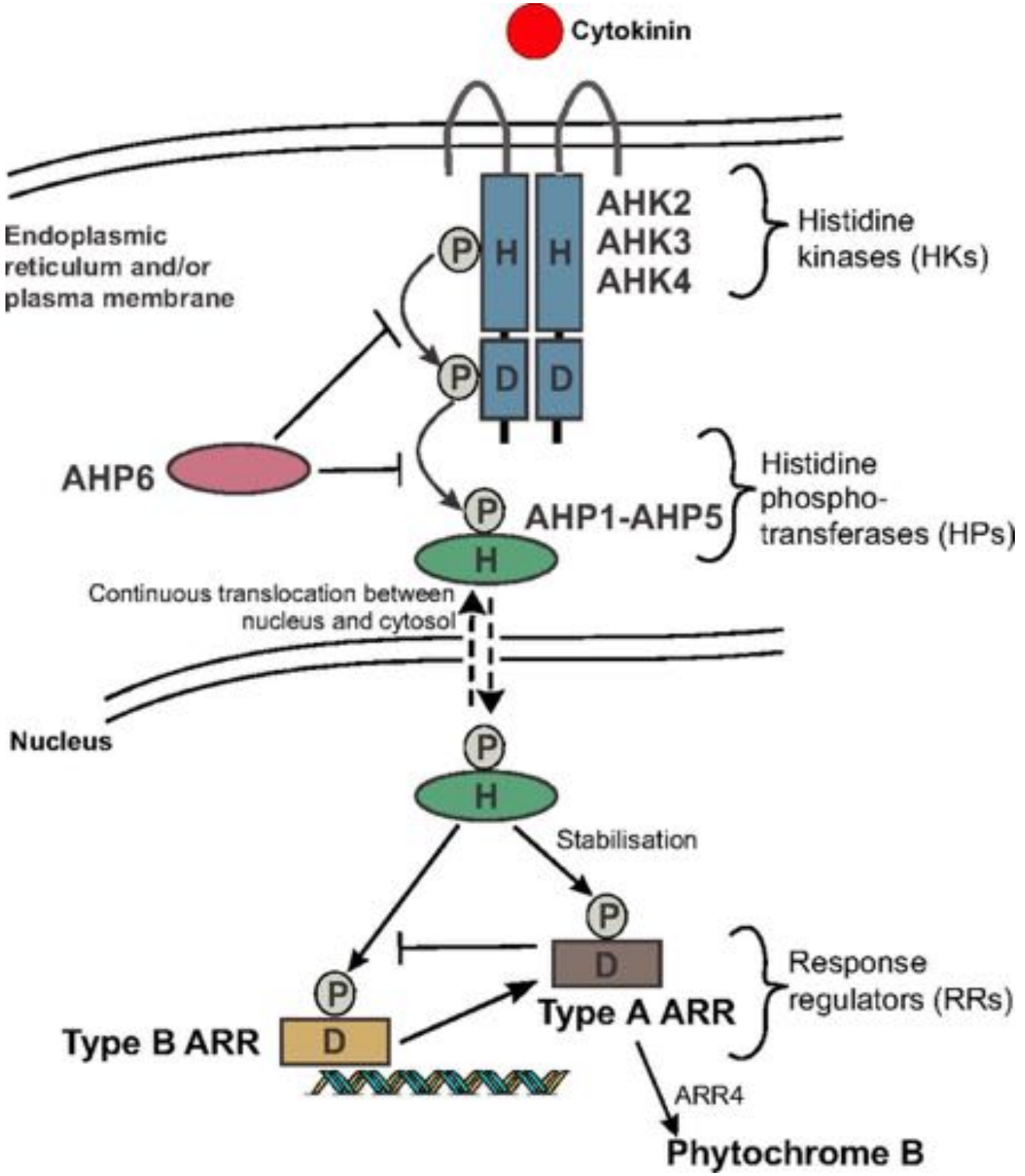
Wus activates a local cytokinin response in the meristem

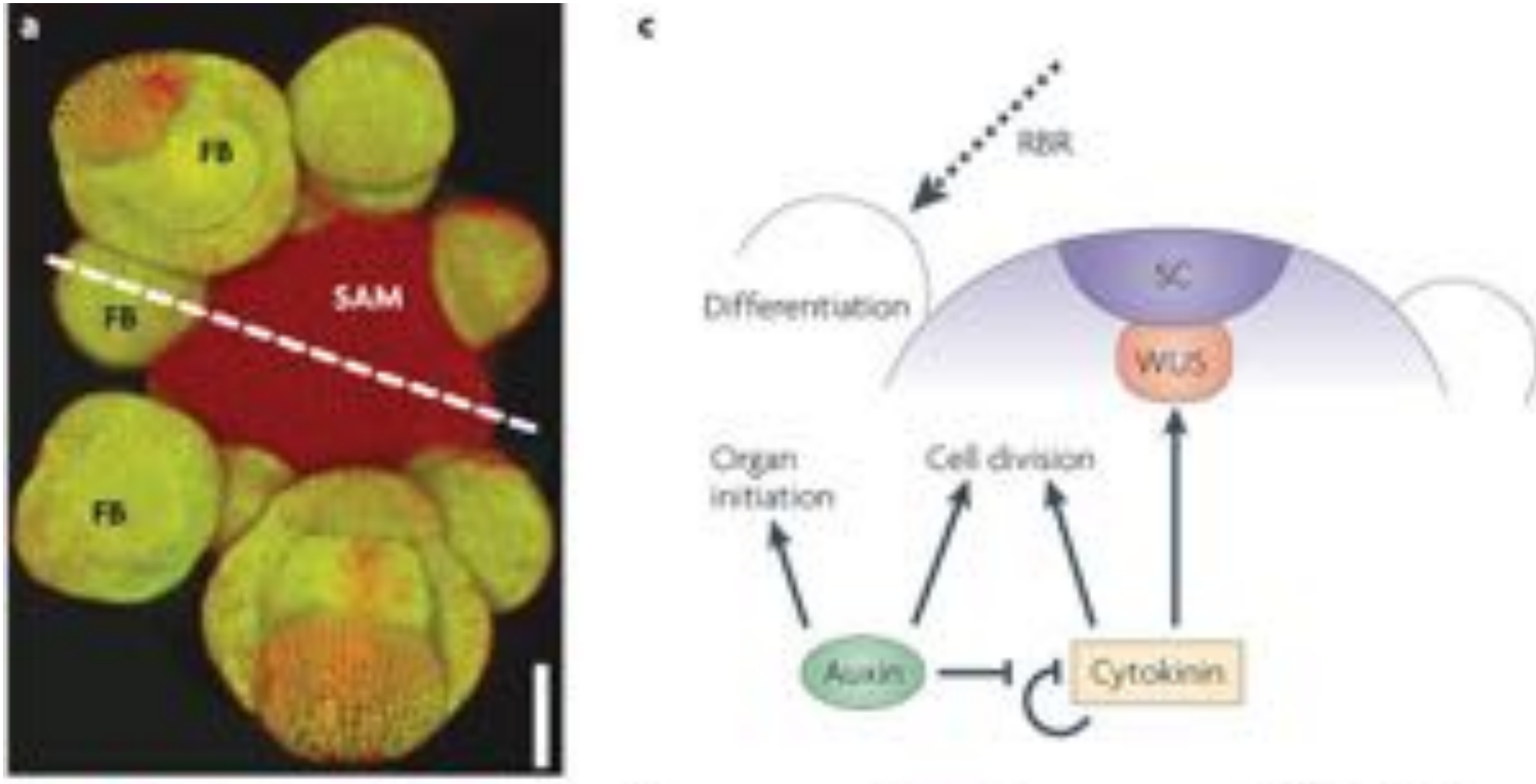




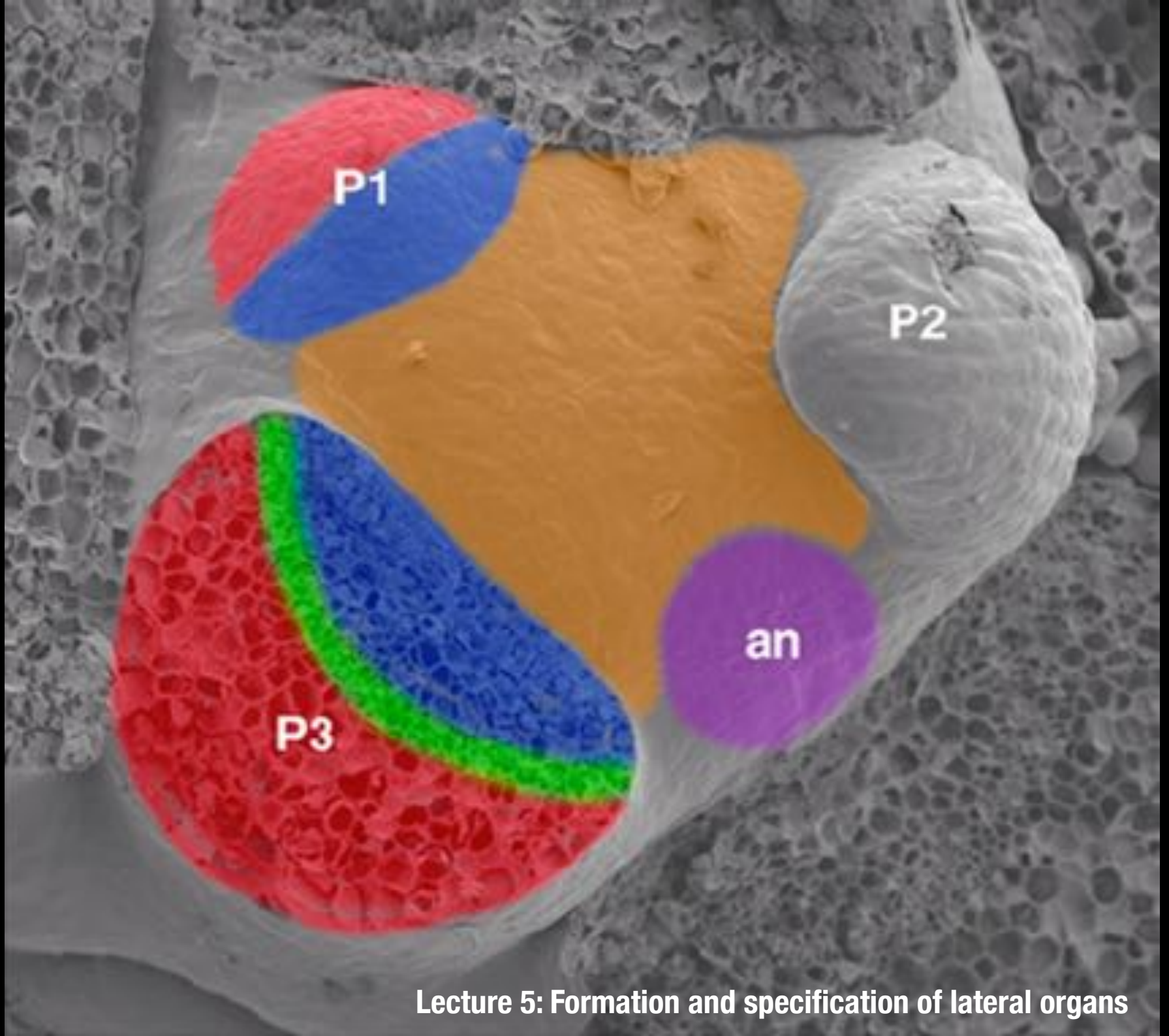


Cytokinin signalling





Walls around tumours — why plants do not develop cancer
John H. Doonan and Robert Sablowski, Nature Reviews Cancer, 10: 794 (2010)


P1
P2
an
P3