

CDB Part IB

Plant Development

Lecture 1:

Plant embryogenesis and establishment of the body plan

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Department of Plant Sciences



Plant Development

Lecture 1: Plant embryogenesis and establishment of the body plan.

Lecture 2: Polarity, auxin traffic and auxin response.

Lecture 3: Regulation of root initiation and growth by auxin.

Lecture 4: Patterning of shoot growth.

Web resources:

An electronic version of the lecture slides, a colour version of these notes and additional teaching materials including review papers and essay topics can be found on the Moodle web site.

Recommended Text books:

For coverage of plant development see:

***Mechanisms in Plant Development*, Ottoline Leyser & Stephen Day, Blackwell Science, UK, 2002.**

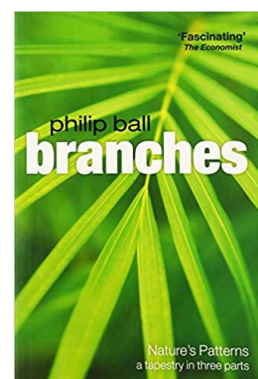
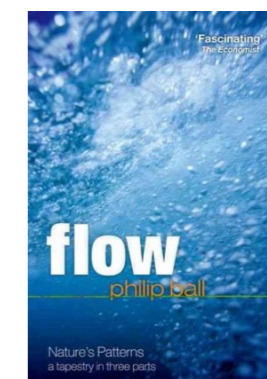
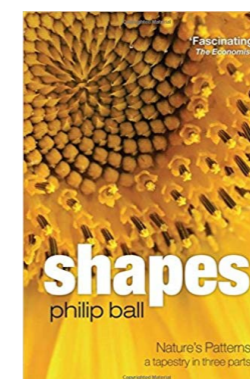
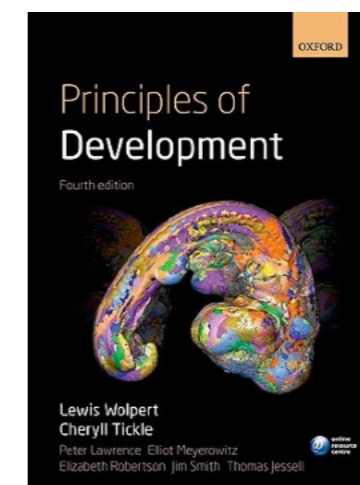
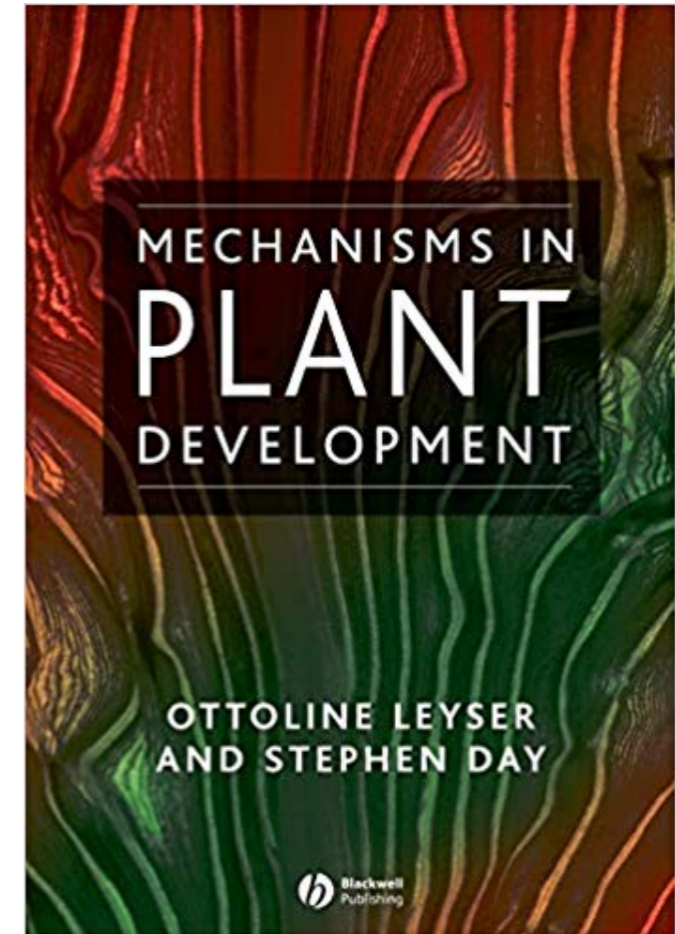
For an integrated overview of animal and plant development see:

***Principles of Development*, Lewis Wolpert and Cheryll Tickle, Oxford University Press, 2011.**

Chapter 7 provides a concise overview of material directly relevant to plants.

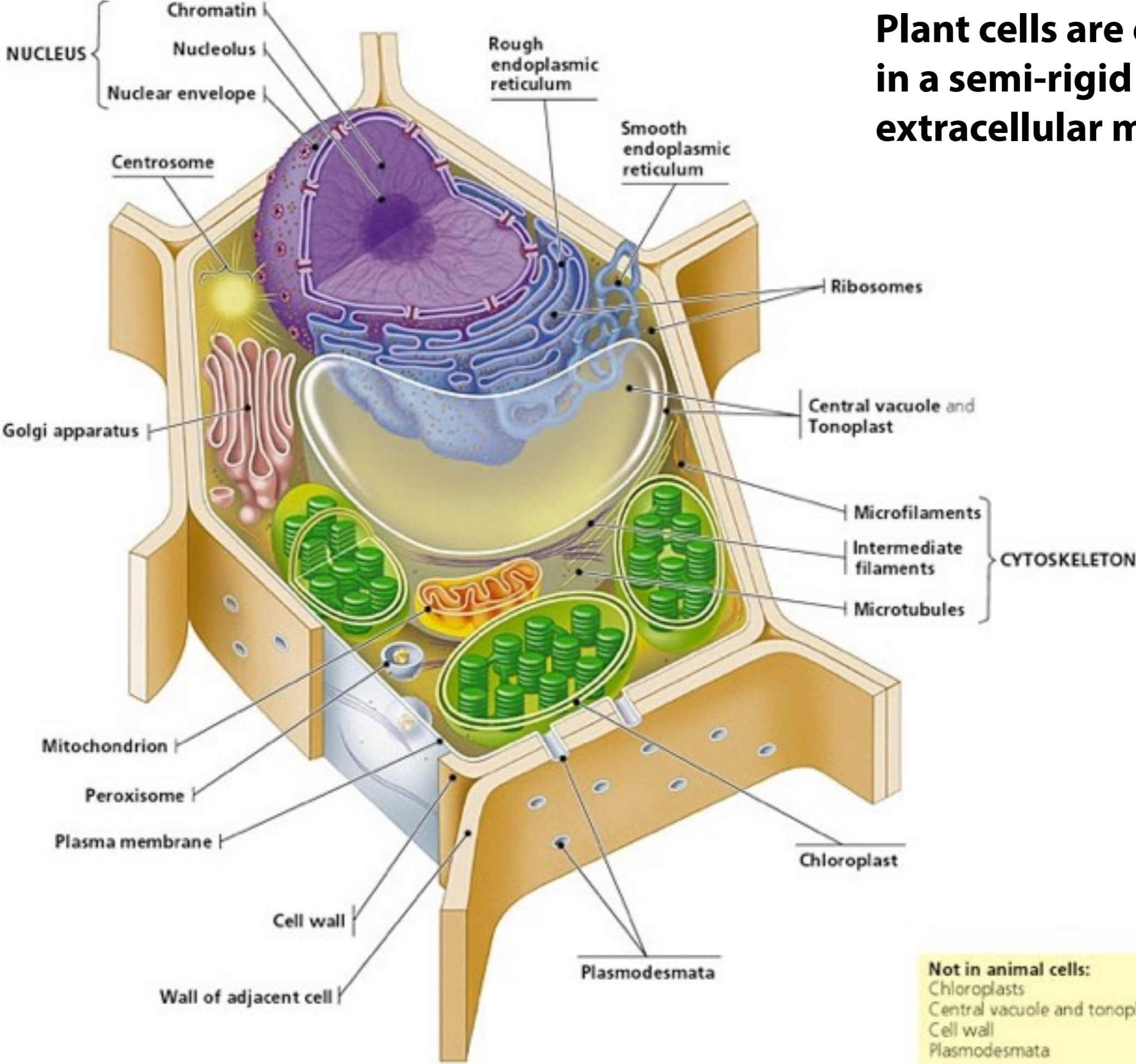
For a general discussion of self-organisation across physical and biological systems see:

***Nature's patterns: a tapestry in three parts, Shapes, Flow and Branches*, Phillip Ball, Oxford University Press, 2009.**

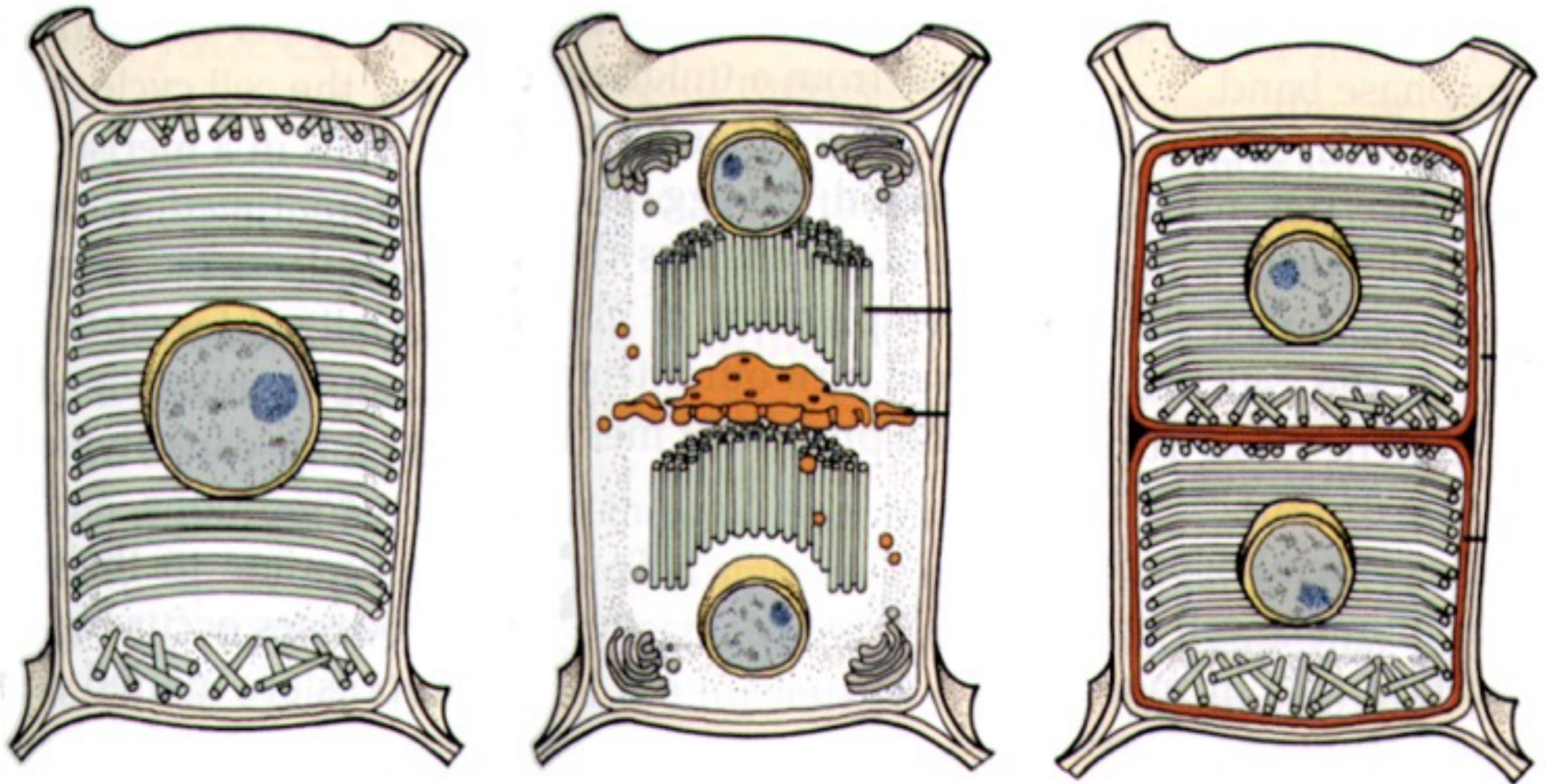




Plant cells are encased in a semi-rigid extracellular matrix

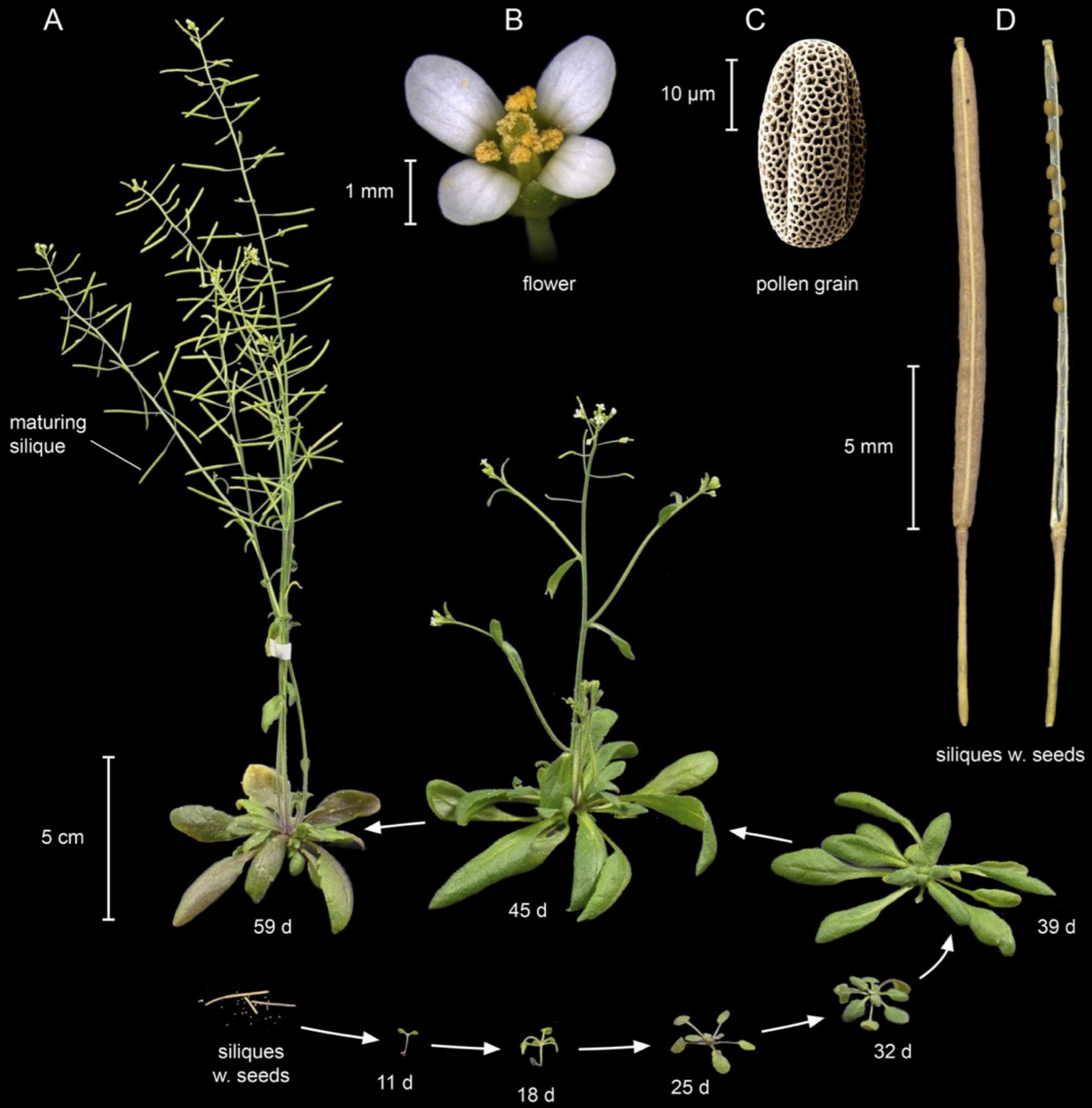


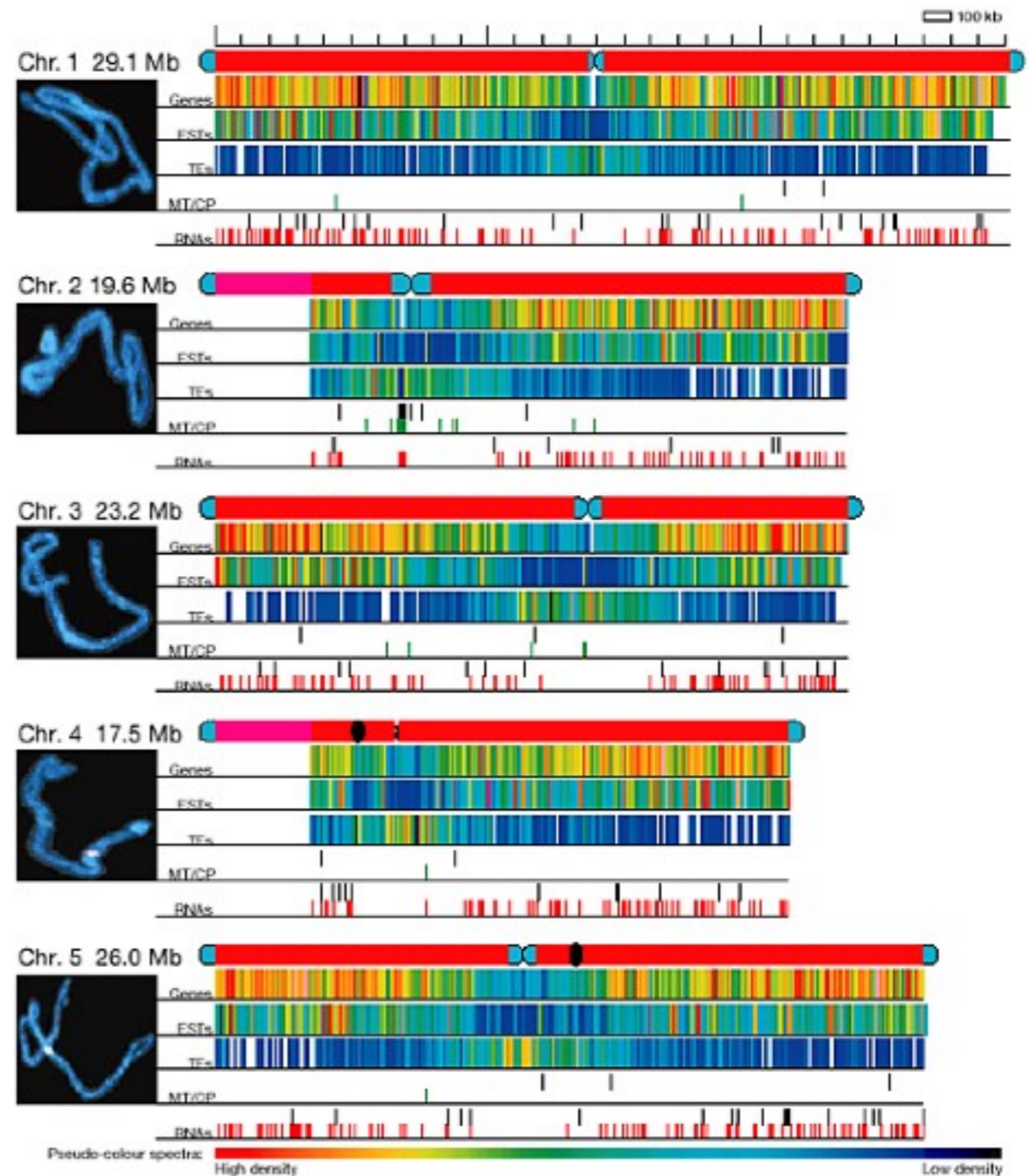
Not in animal cells:
Chloroplasts
Central vacuole and tonoplast
Cell wall
Plasmodesmata



Deposition of new cell walls during plant cell division.

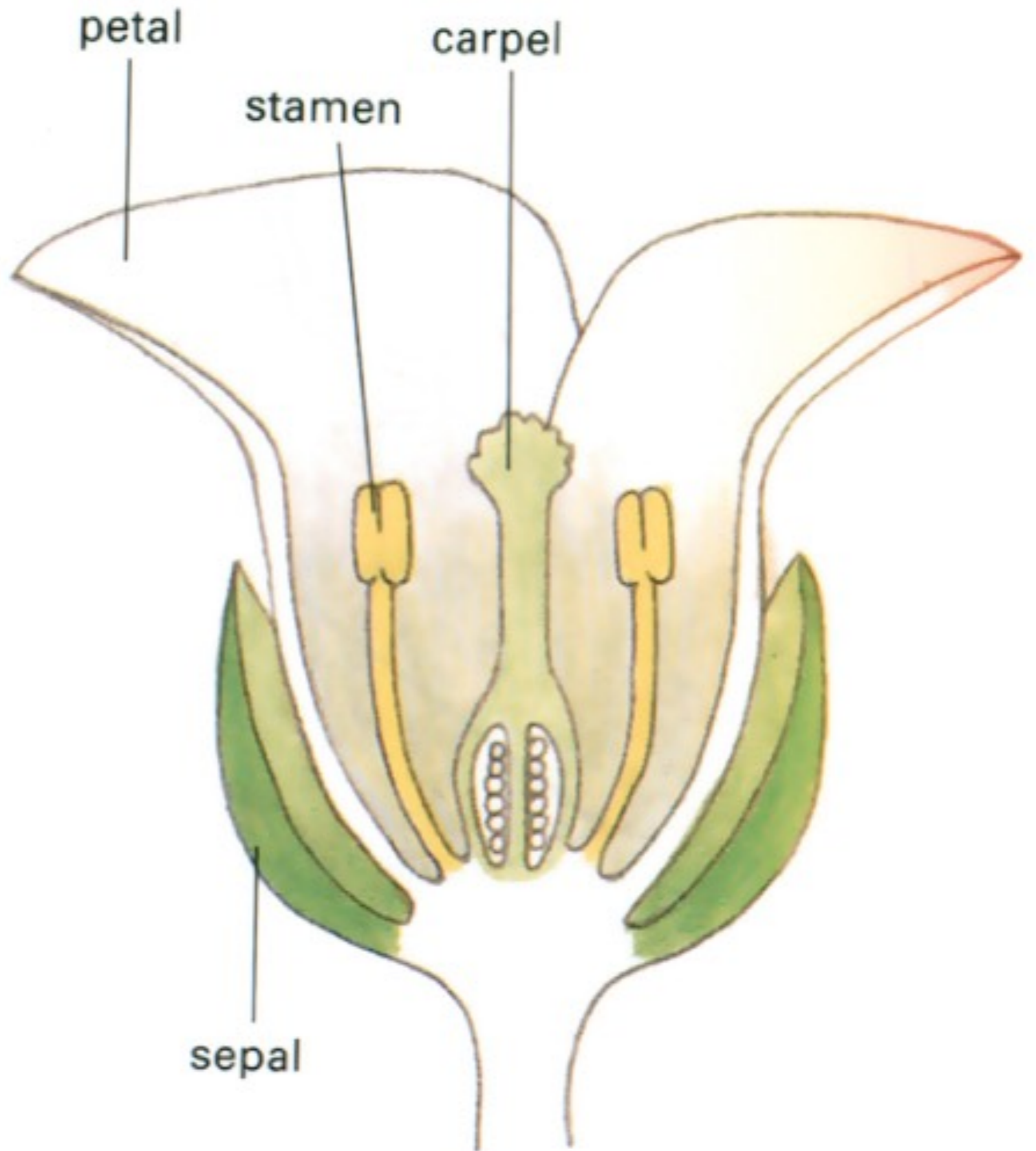
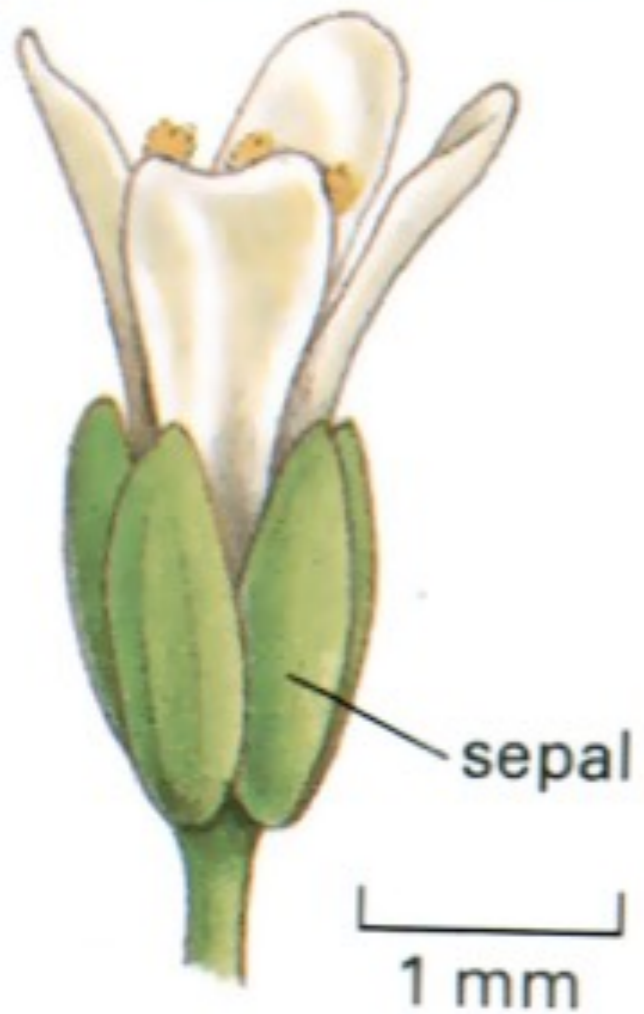
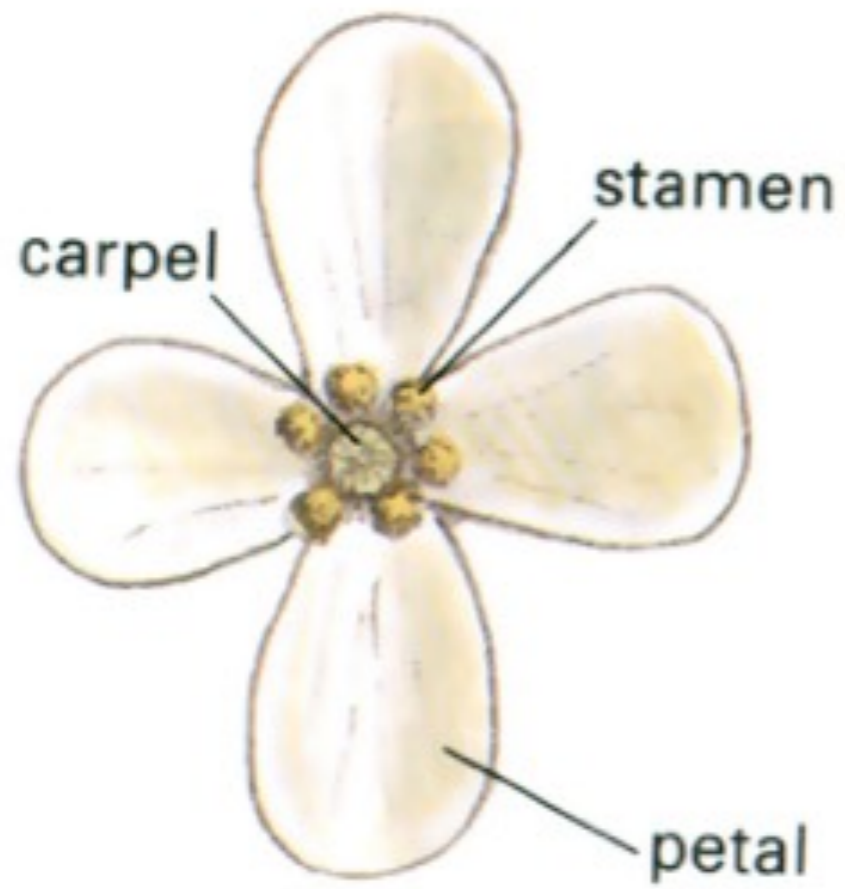
Life cycle of the
model plant
Arabidopsis thaliana

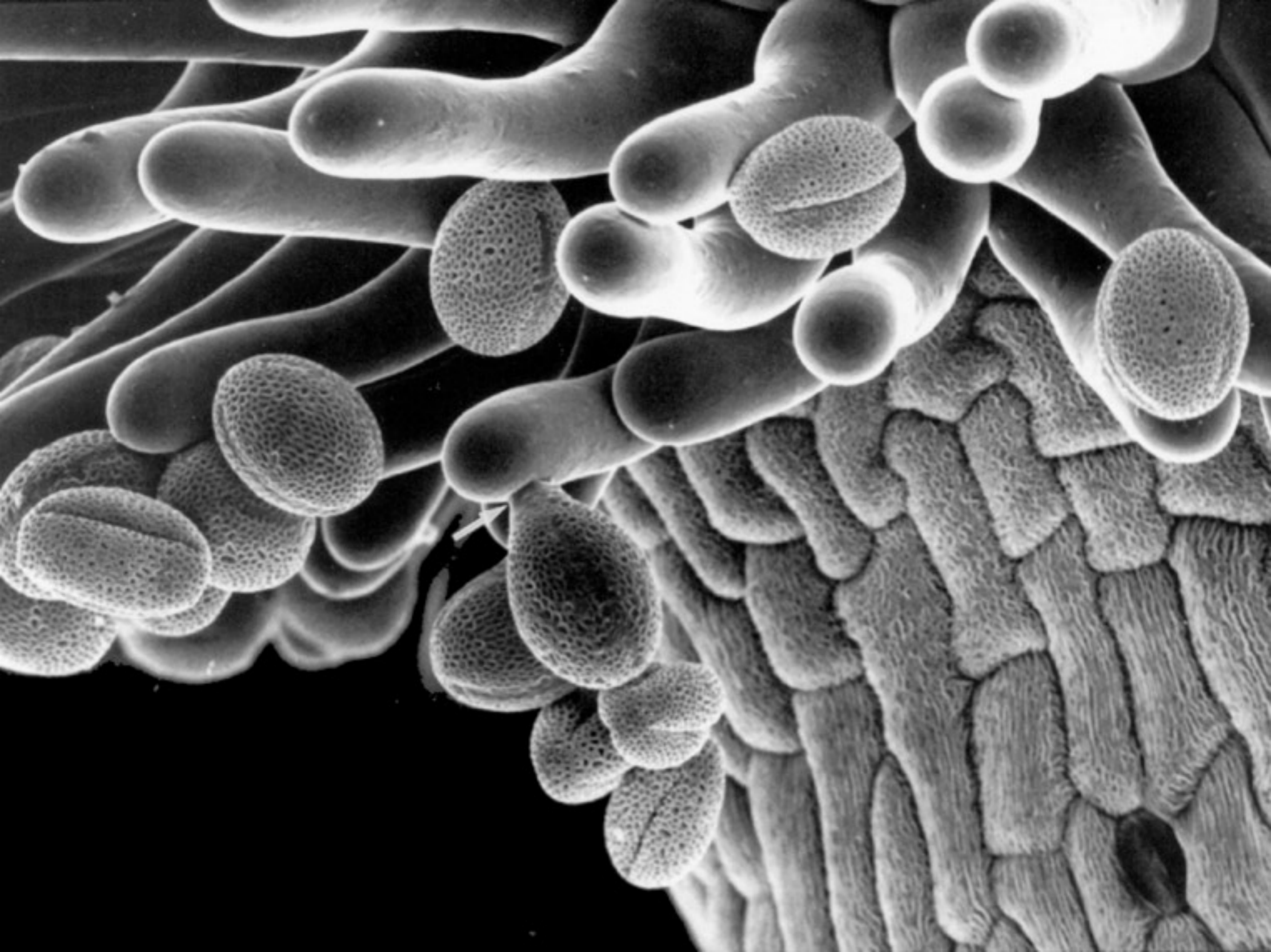


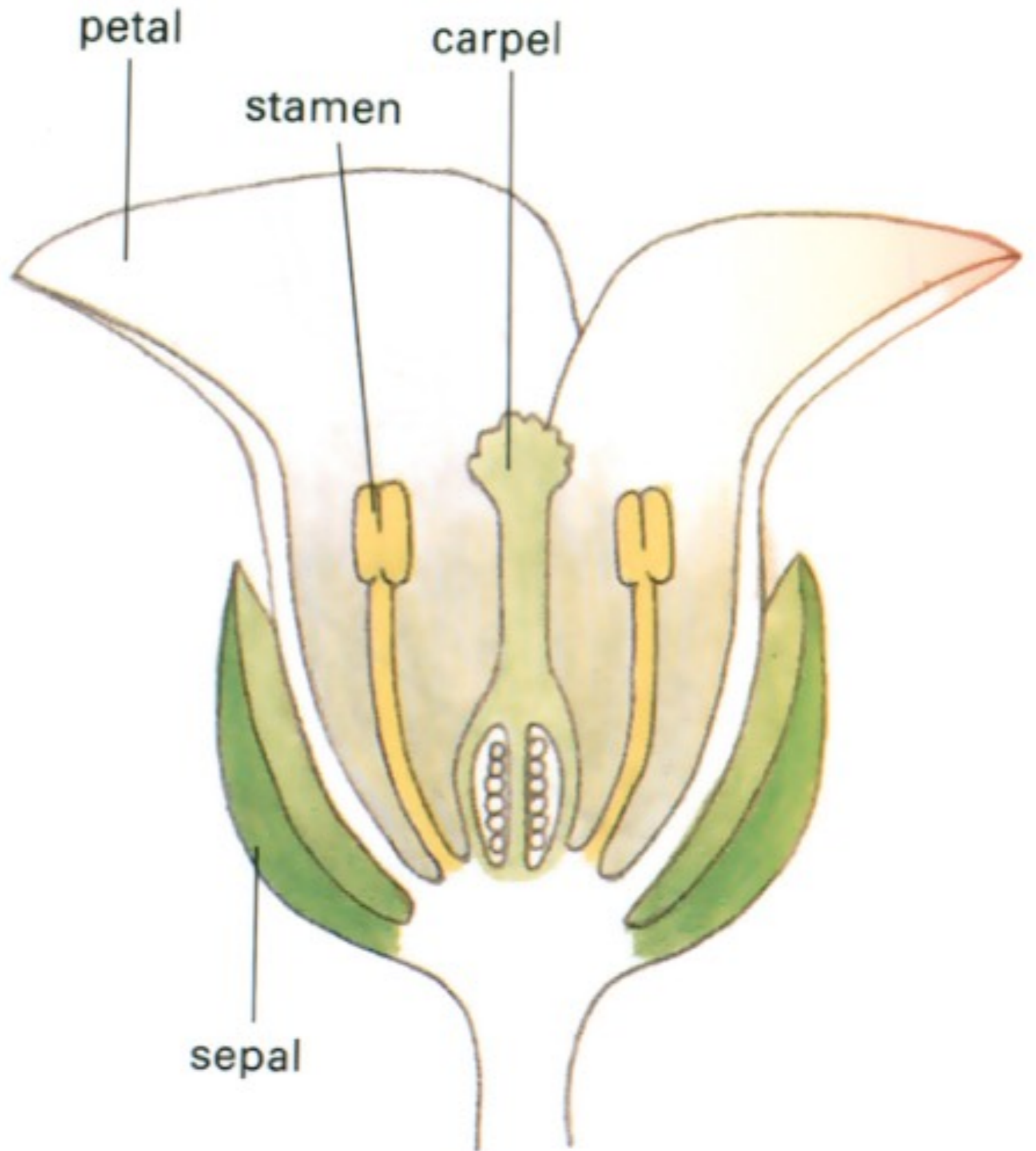
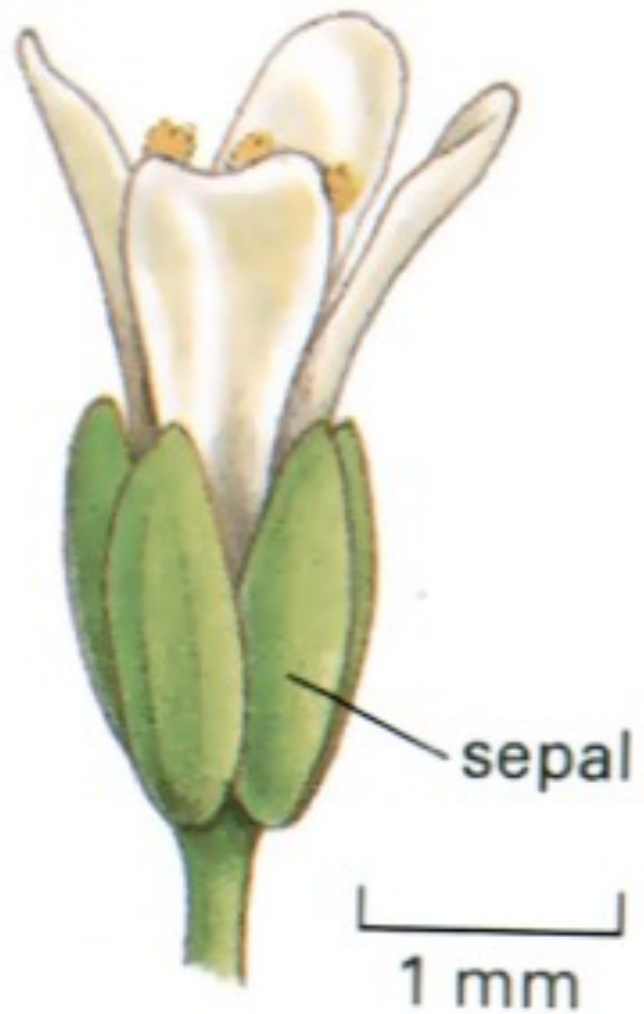
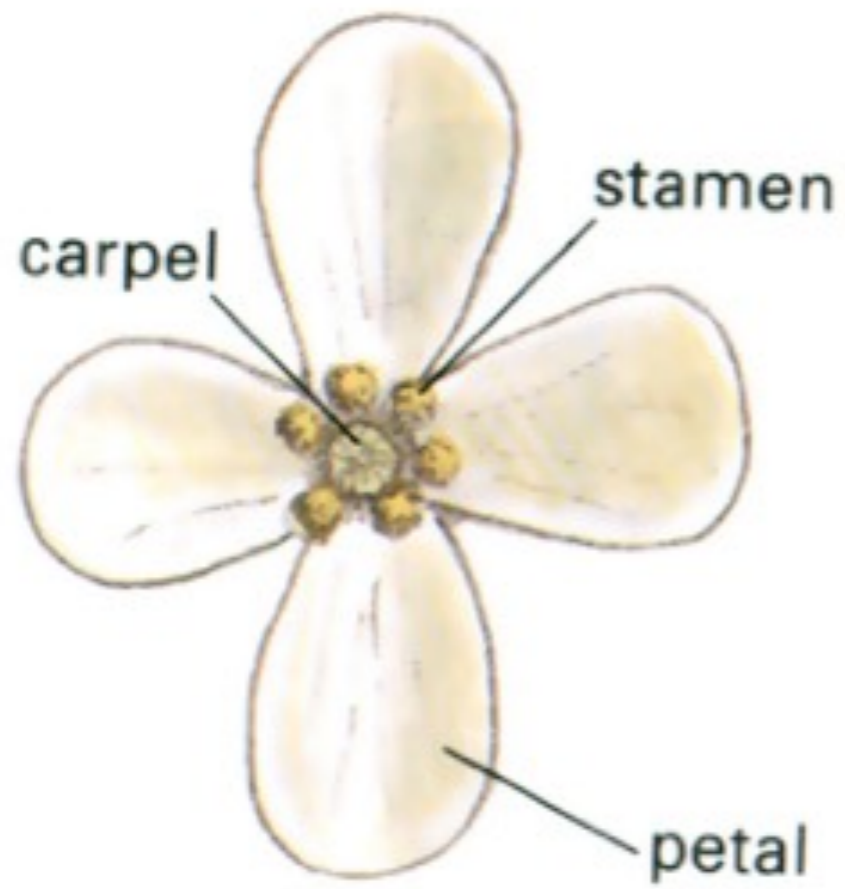


***Arabidopsis thaliana* has the best characterised plant genome**

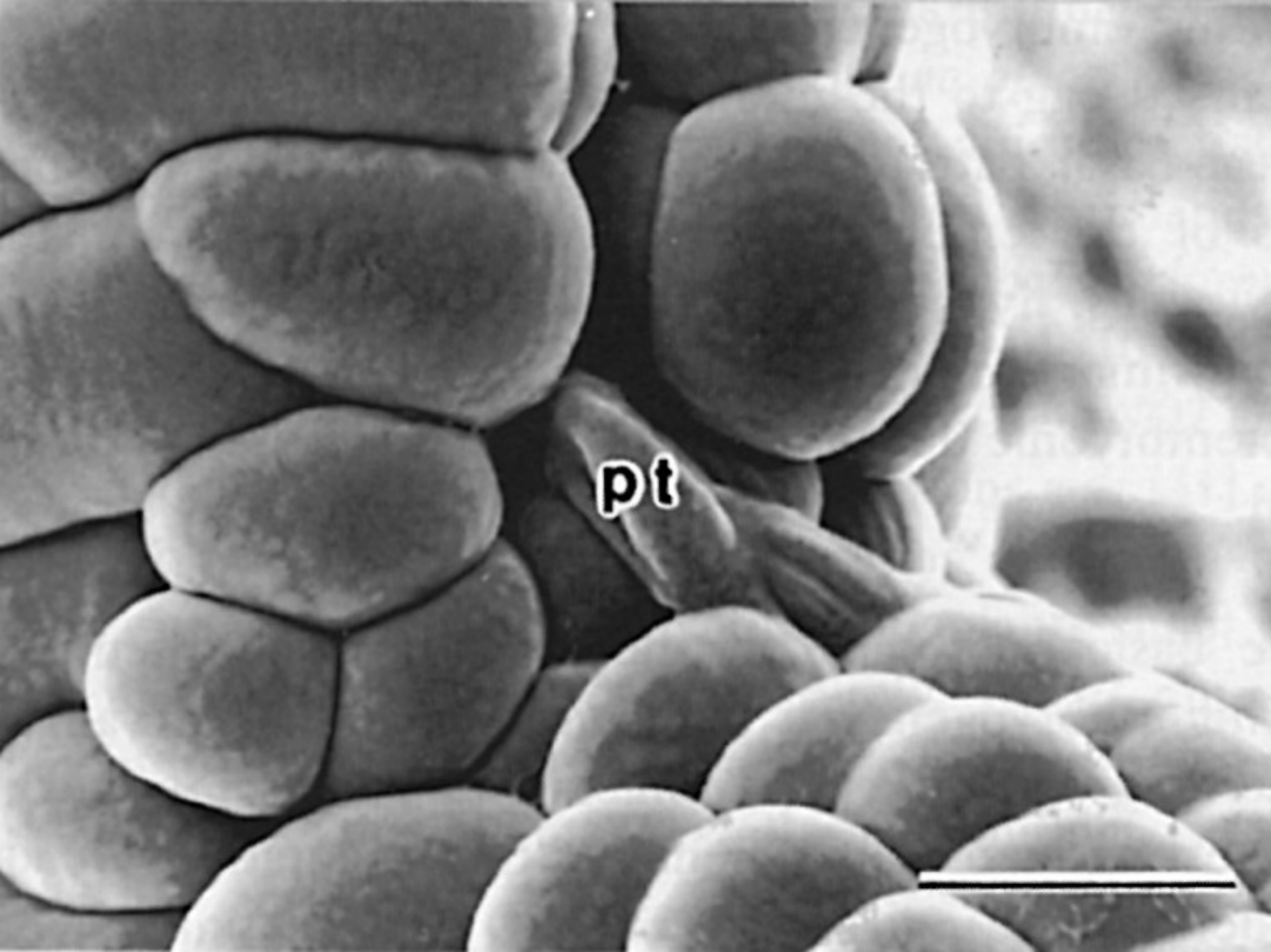






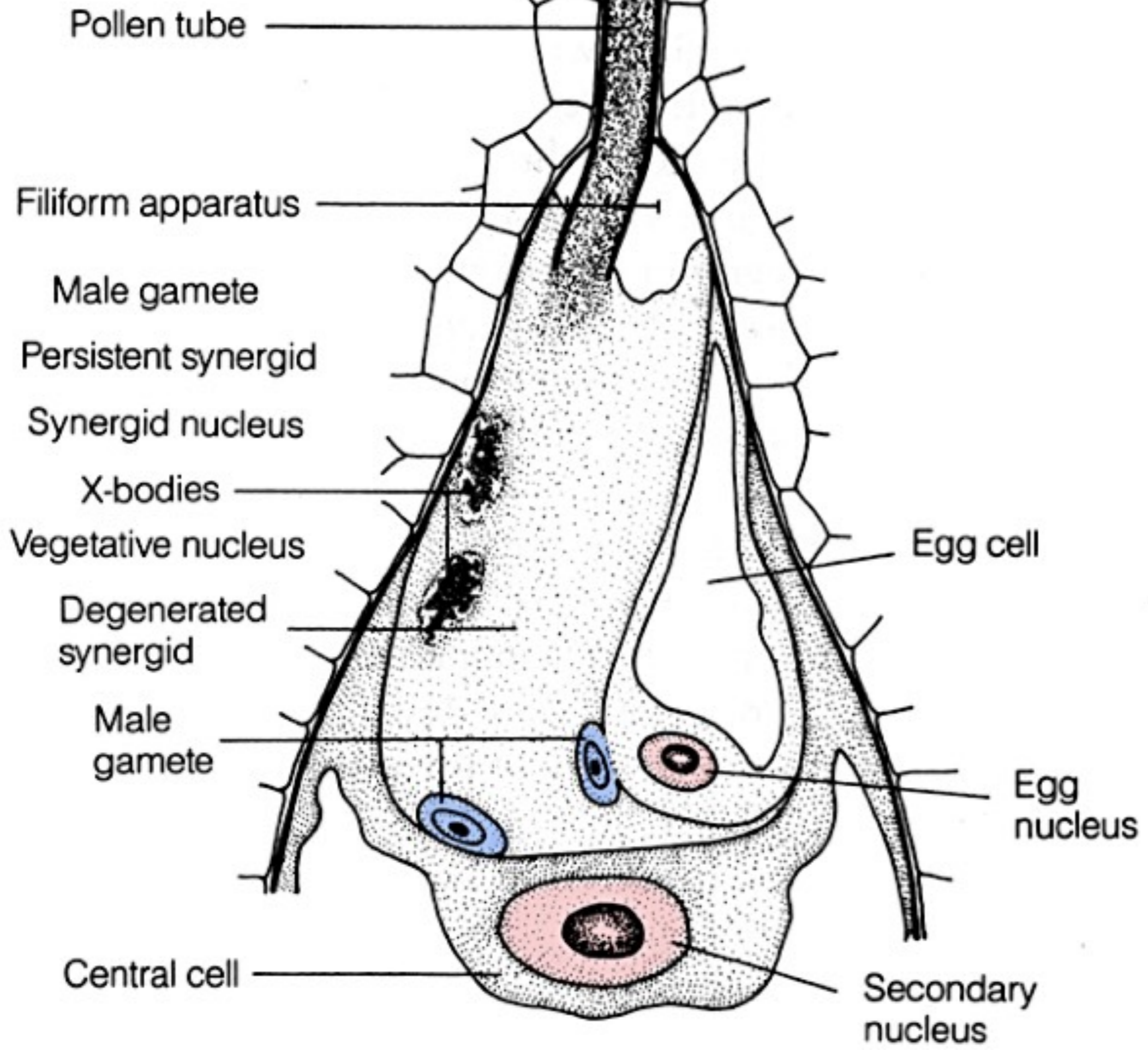






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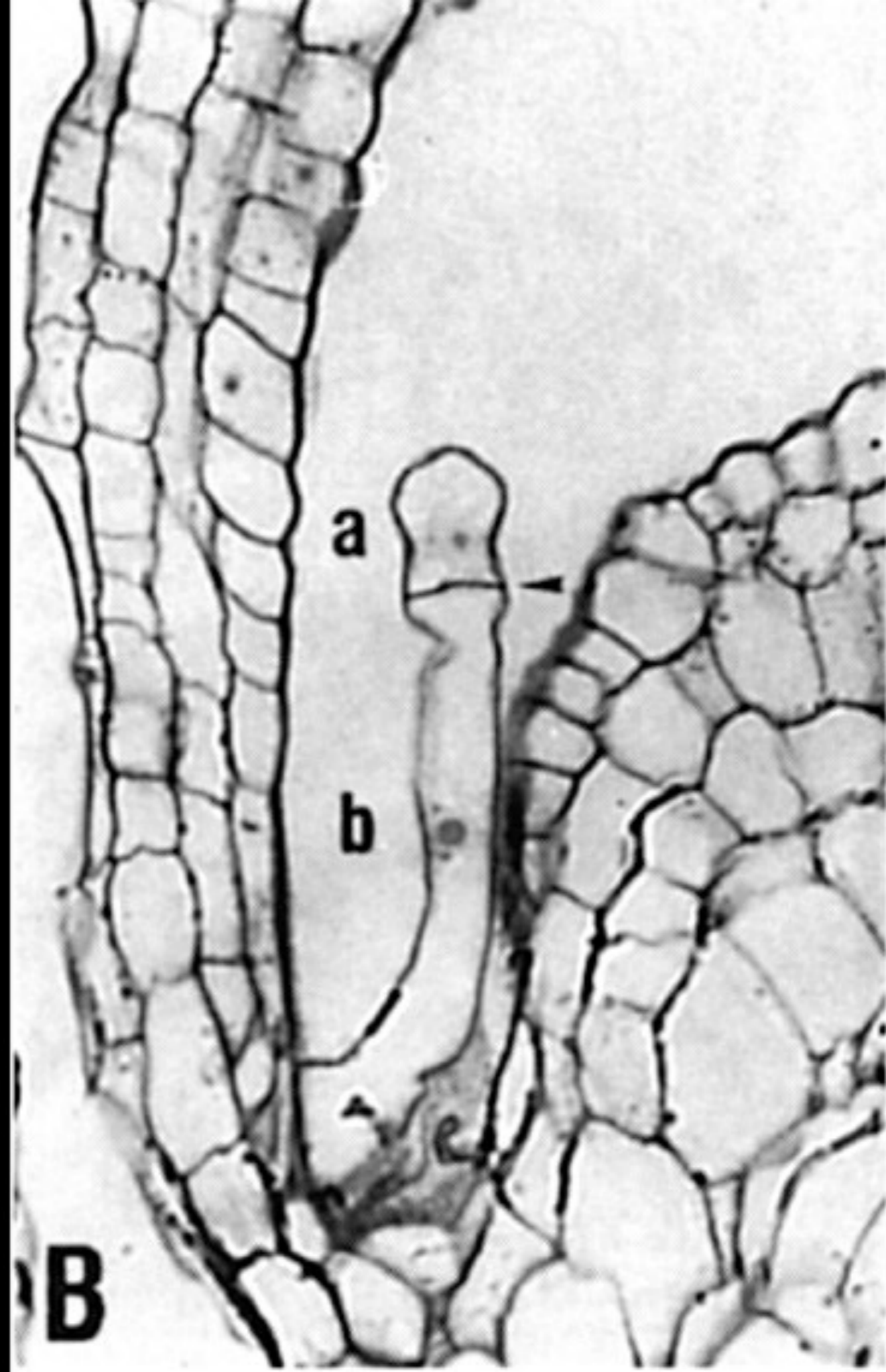






A

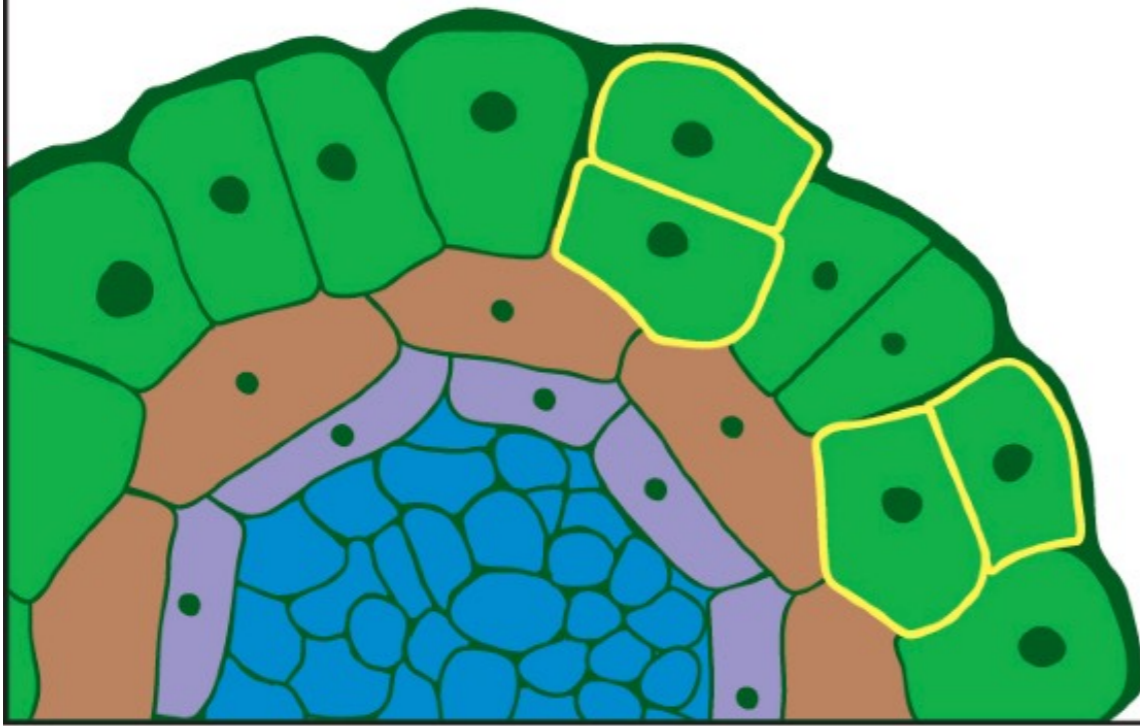




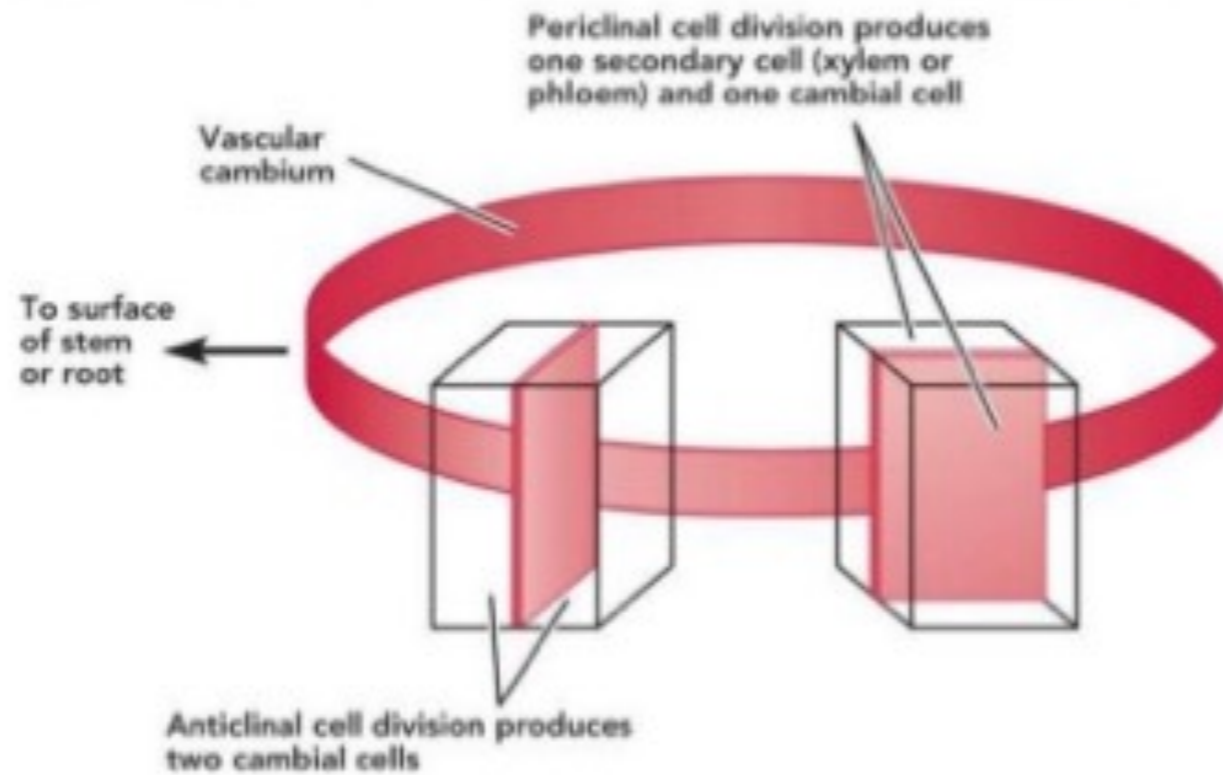
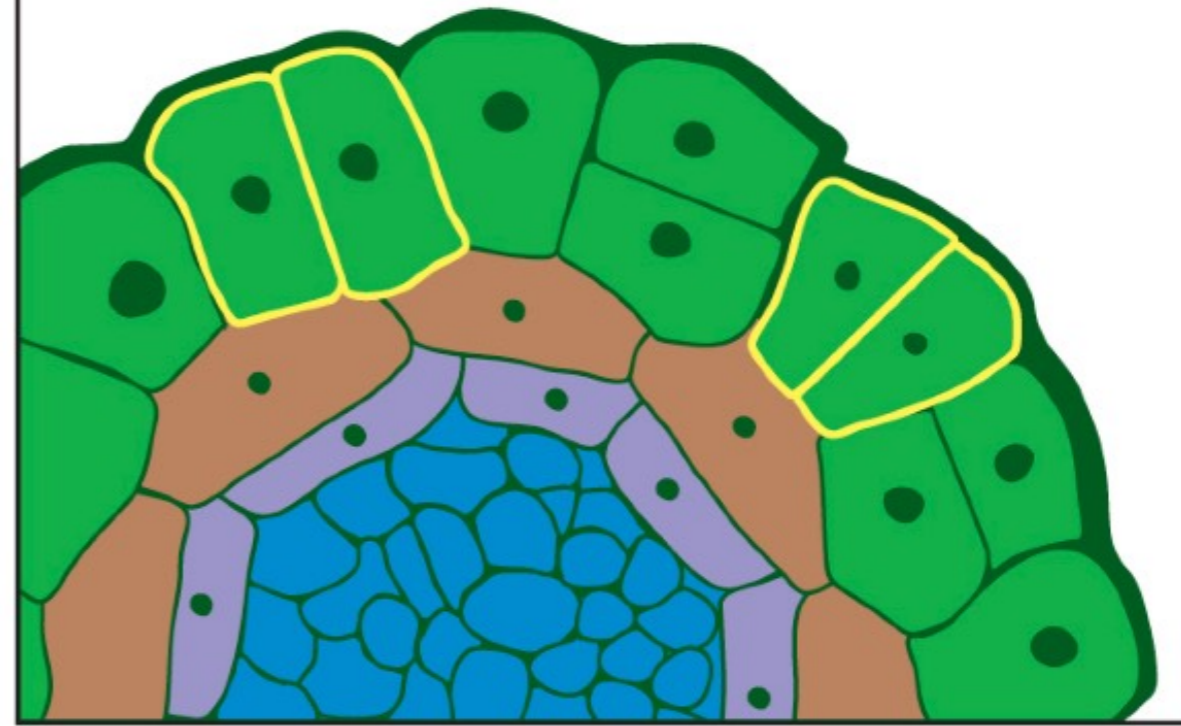
Octant stage embryo

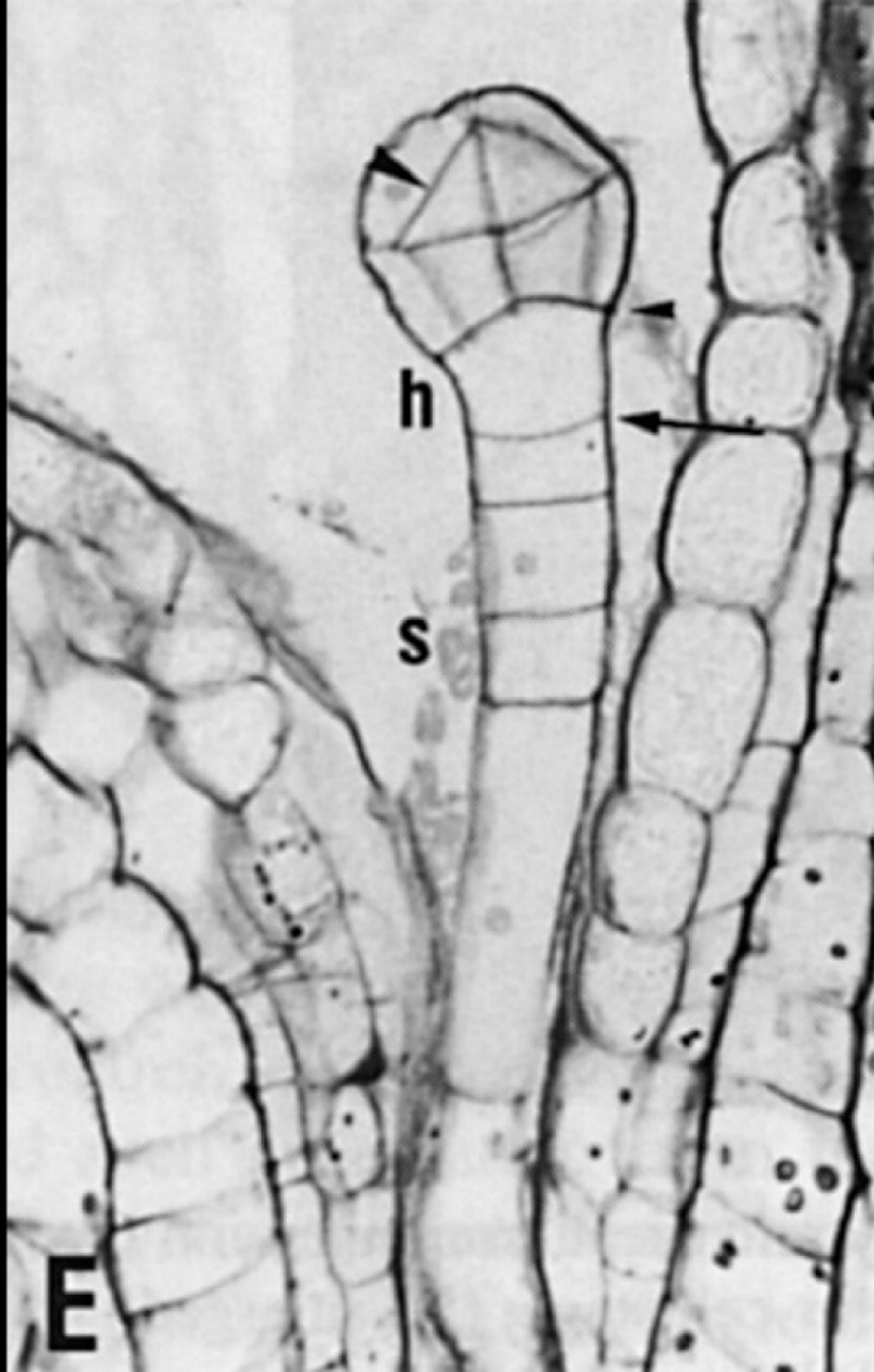


Periclinal divisions



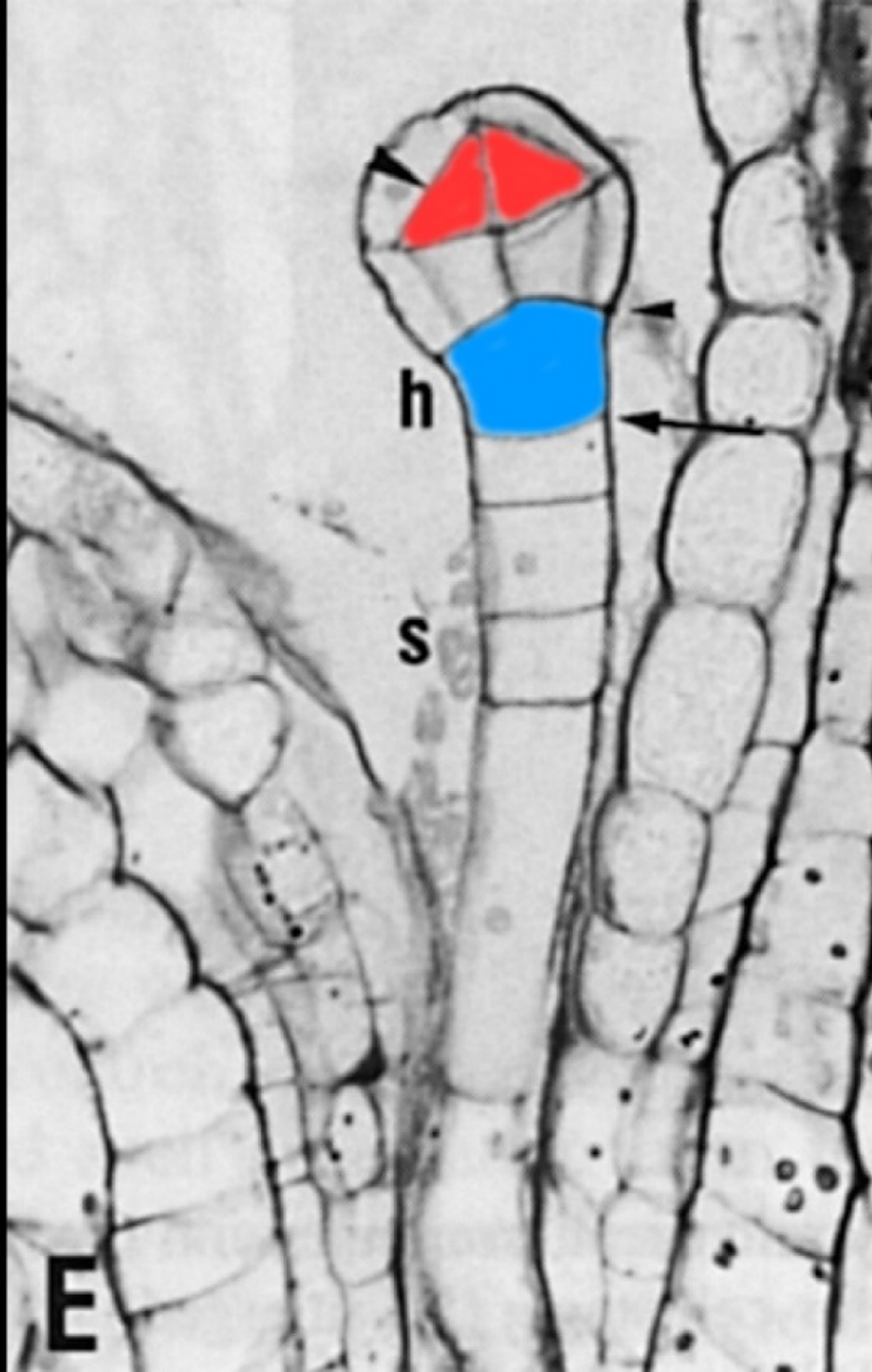
Anticlinal divisions





**Radial asymmetry in the
16-cell embryo**

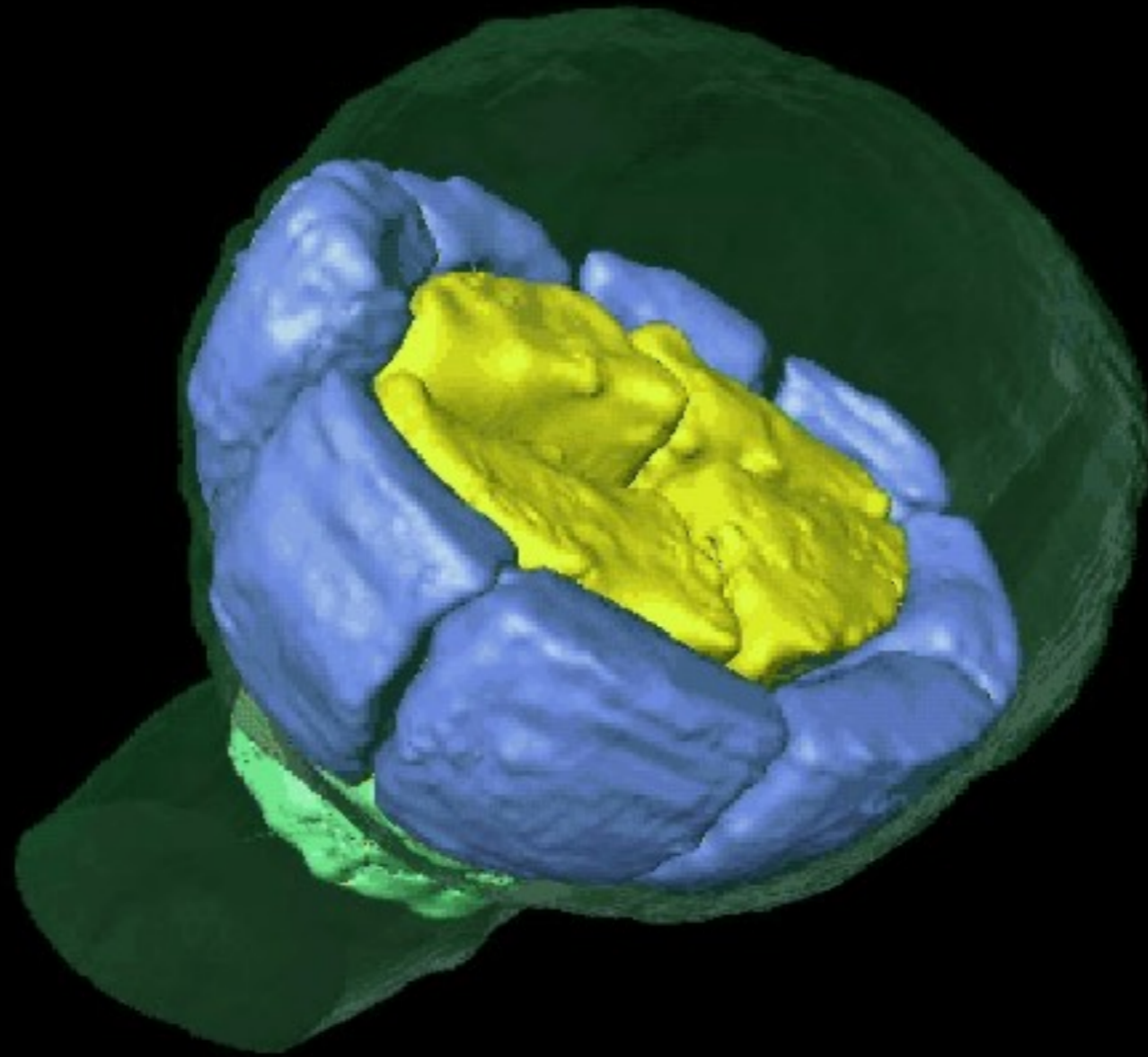
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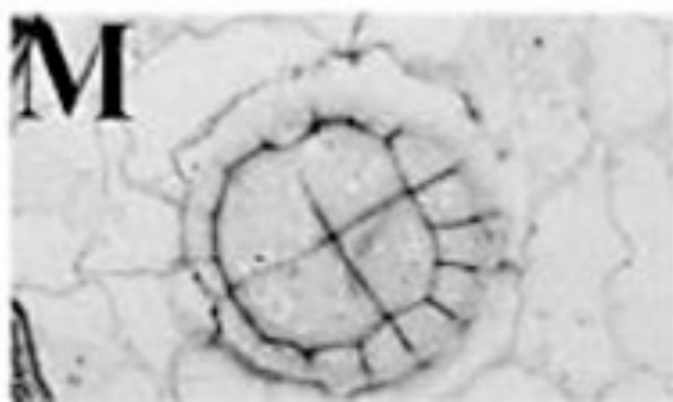
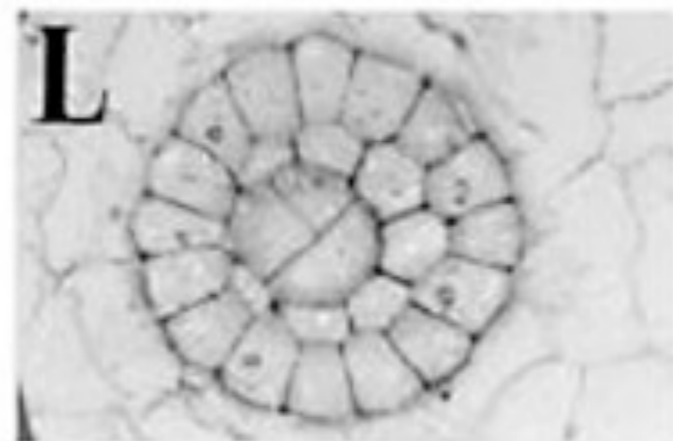
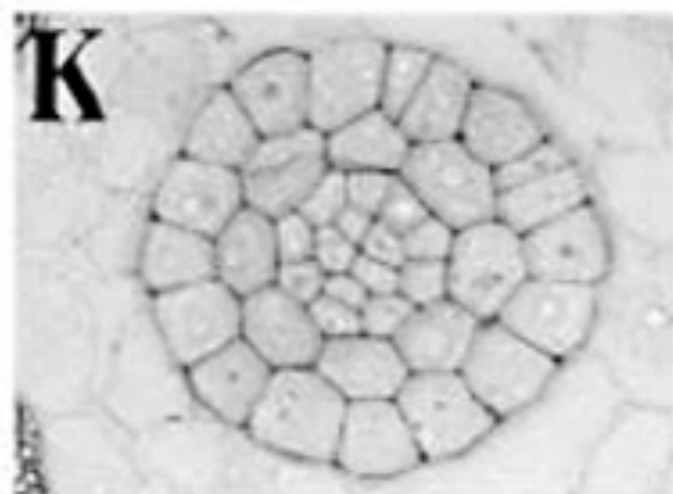
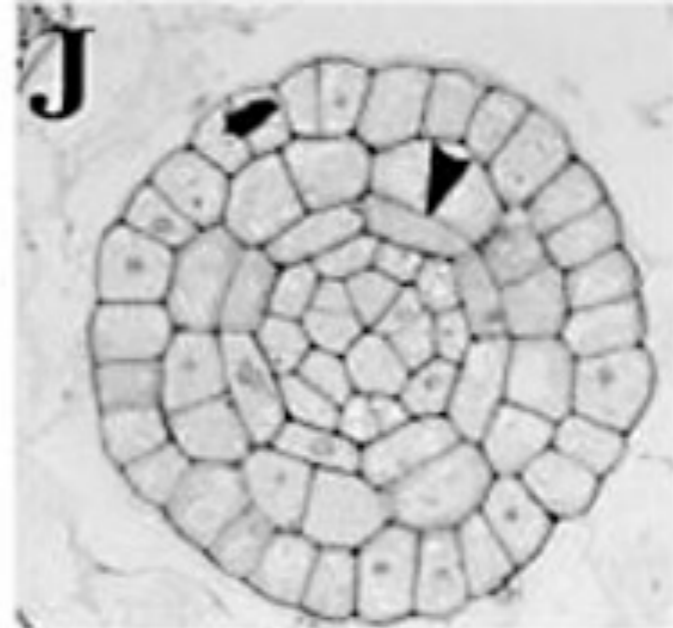
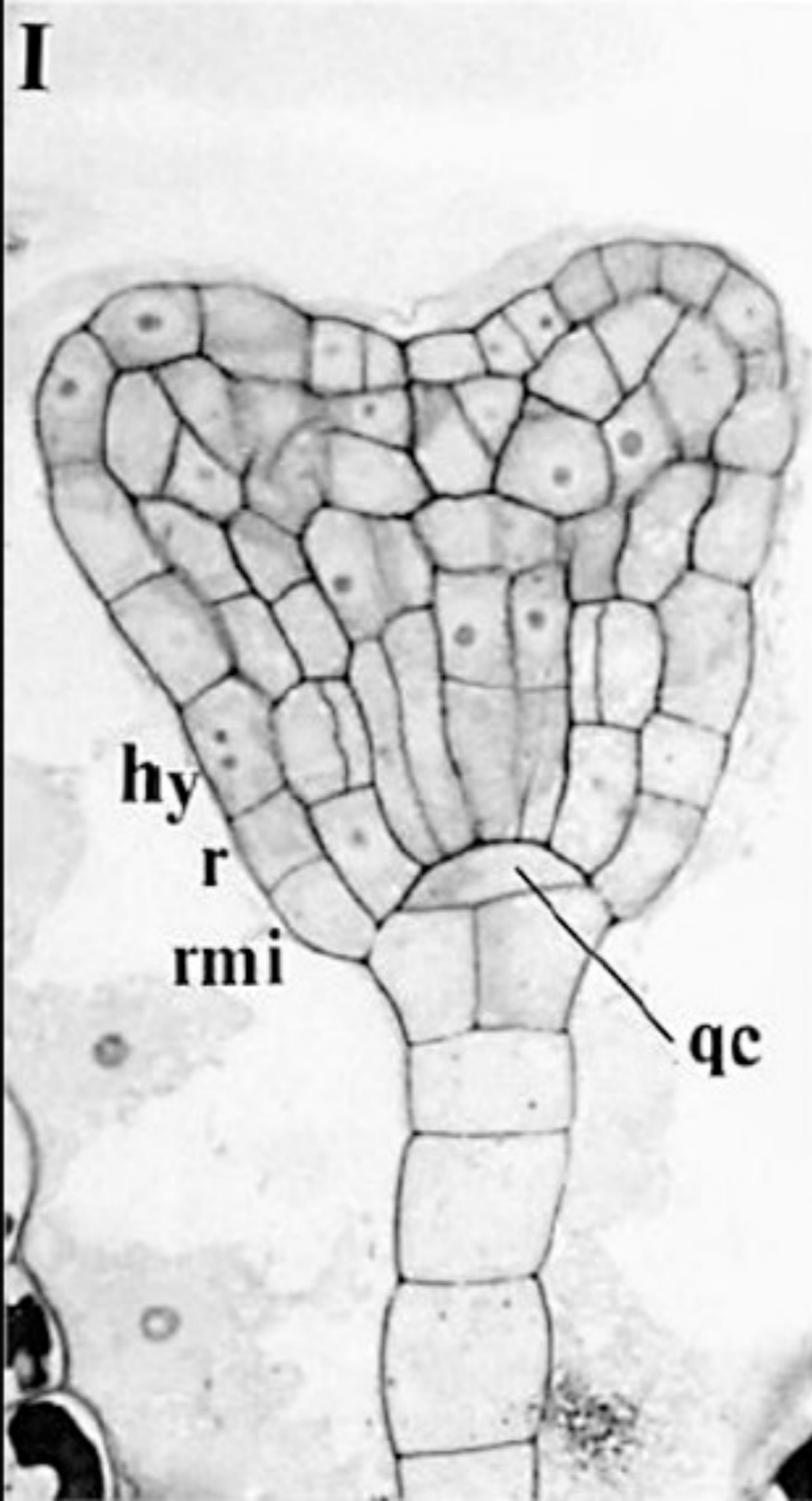


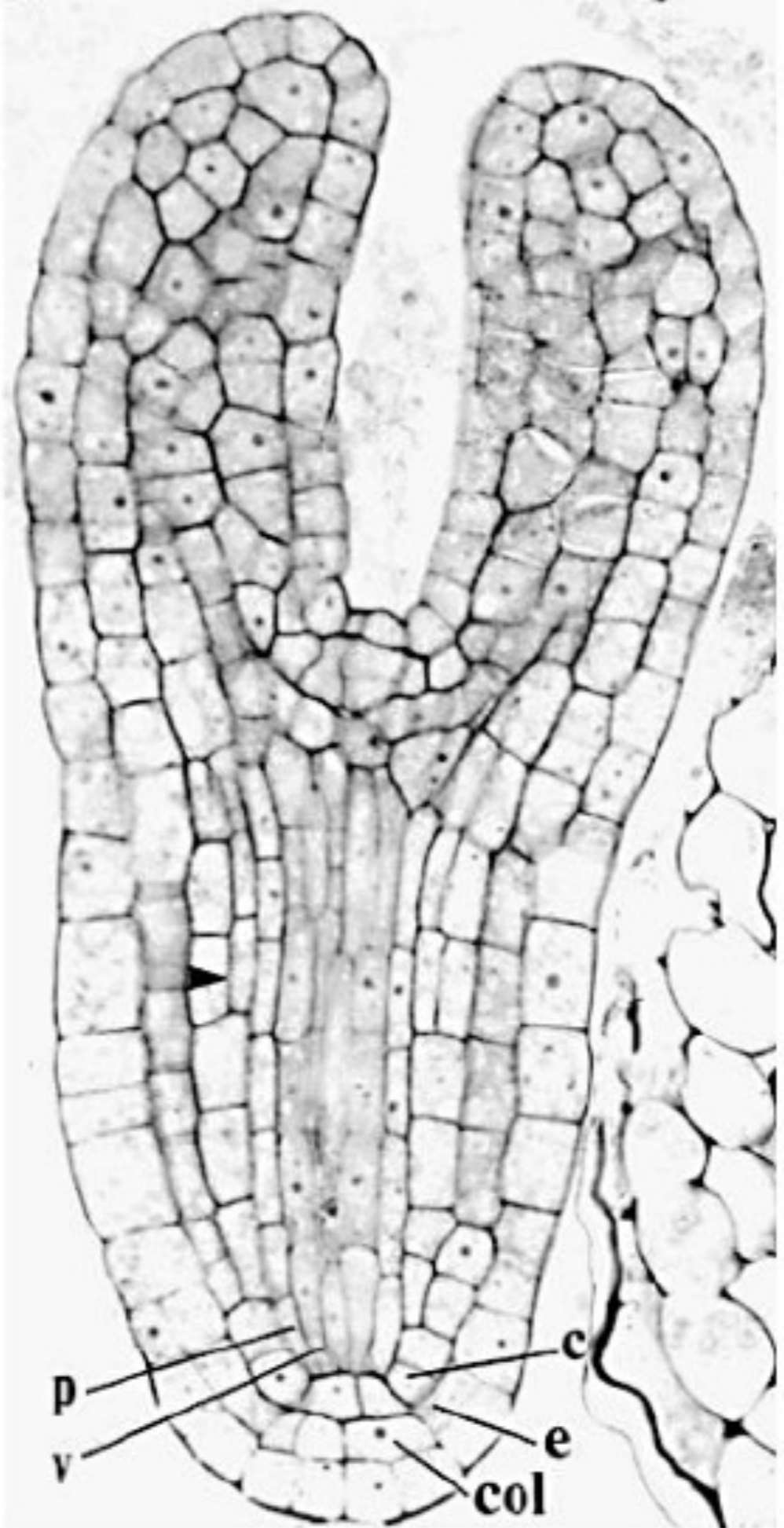
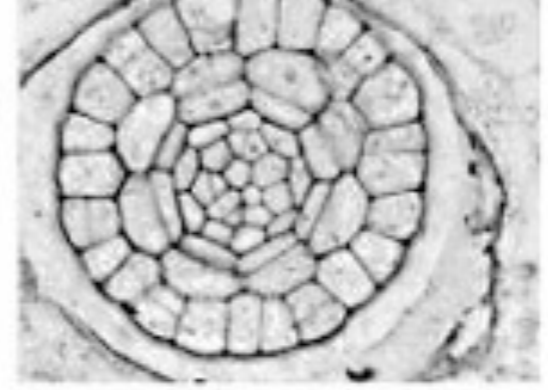
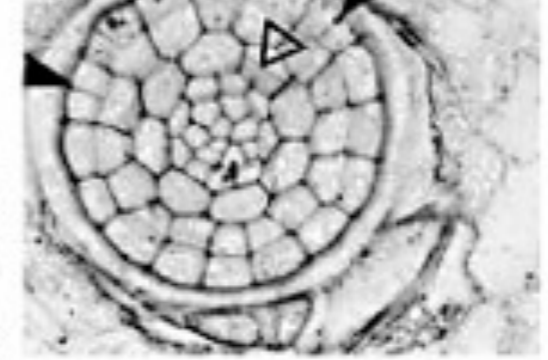
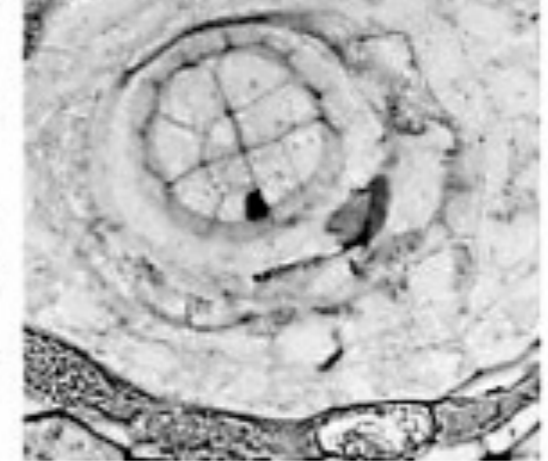
**Radial asymmetry in the
16-cell embryo**

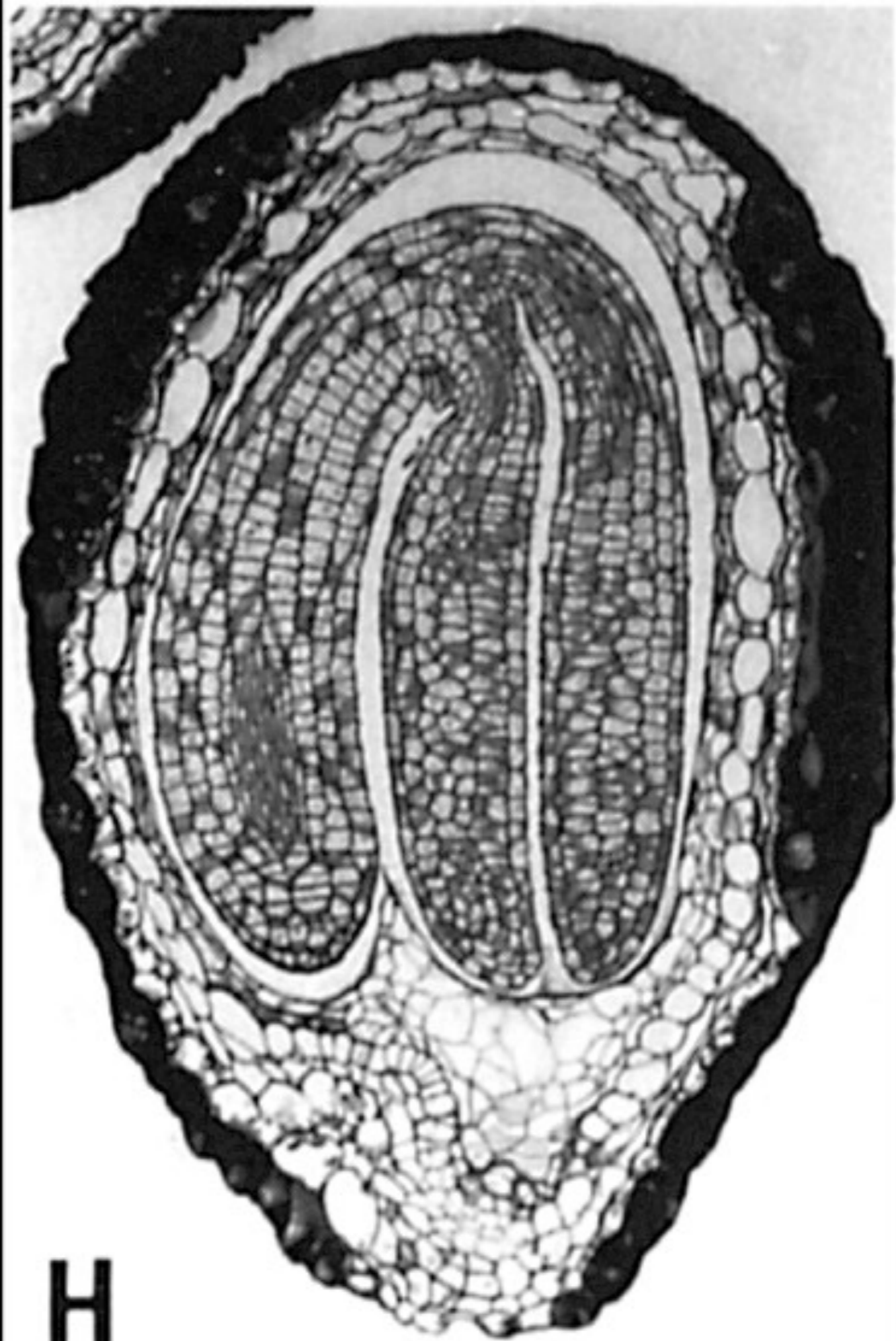
**Specification of shoot and
root meristems**

Protoderm stage embryo



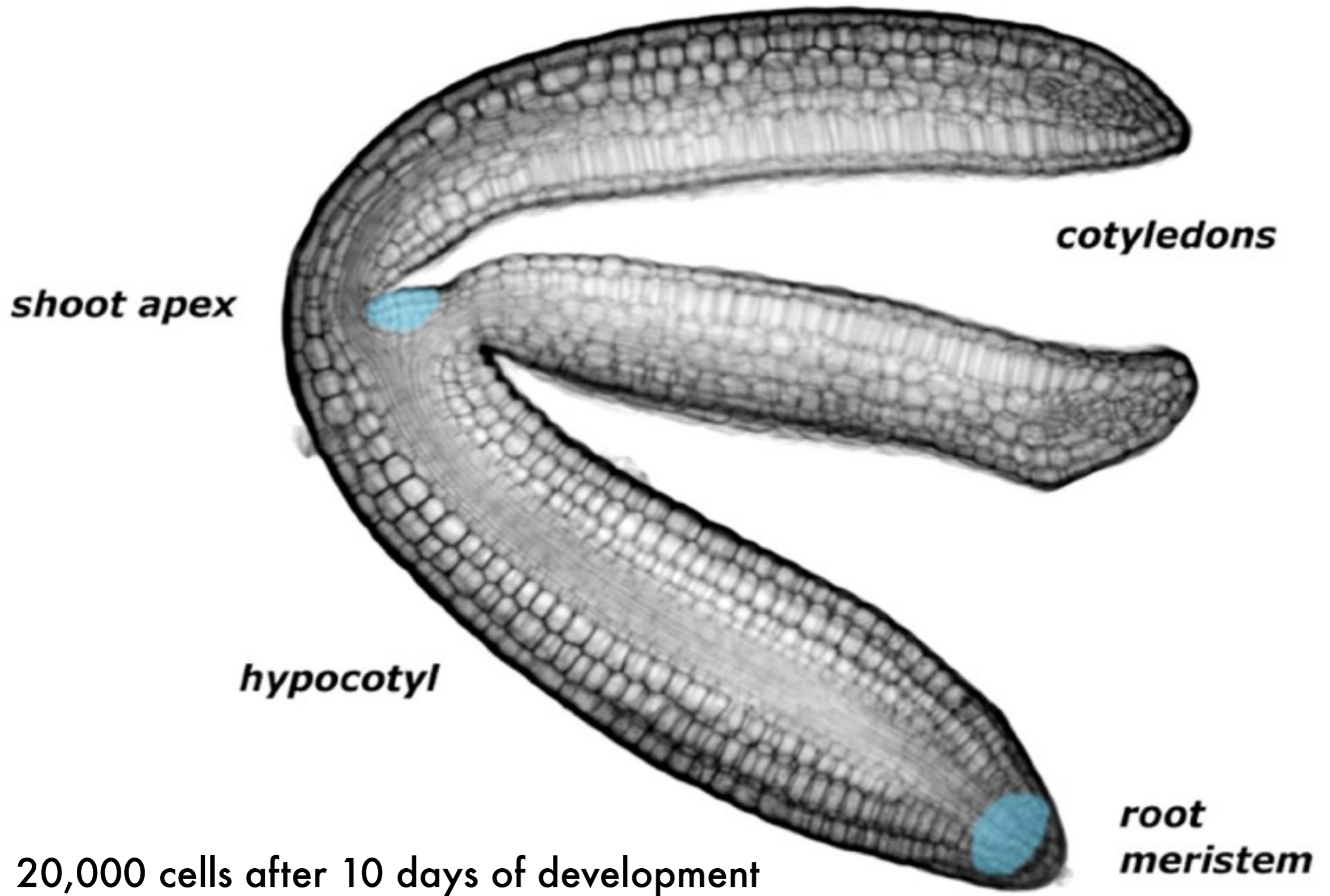


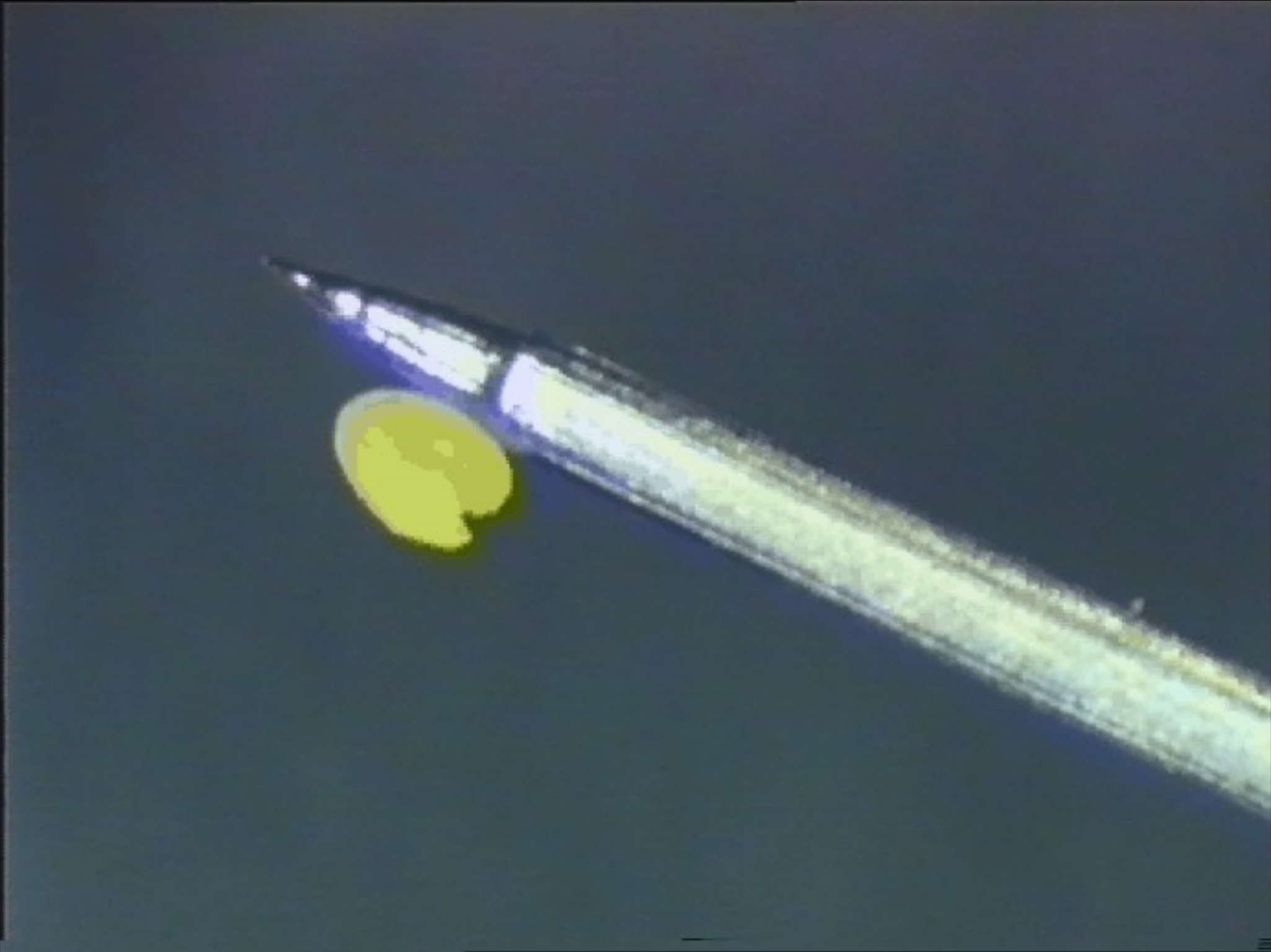
N**O****P****Q****R**



H

mature embryo









Arabidopsis thaliana
germinating seed

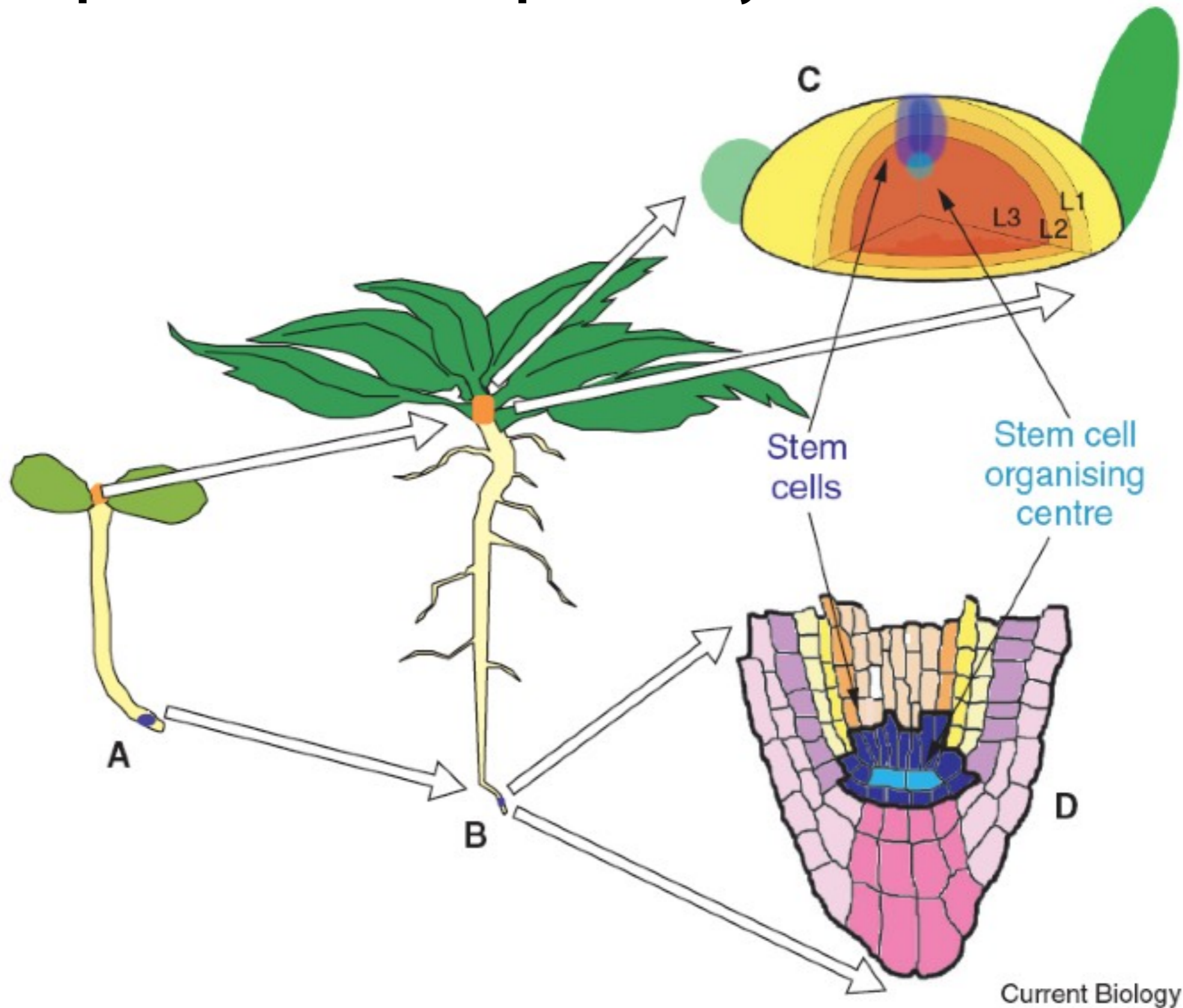


4 days



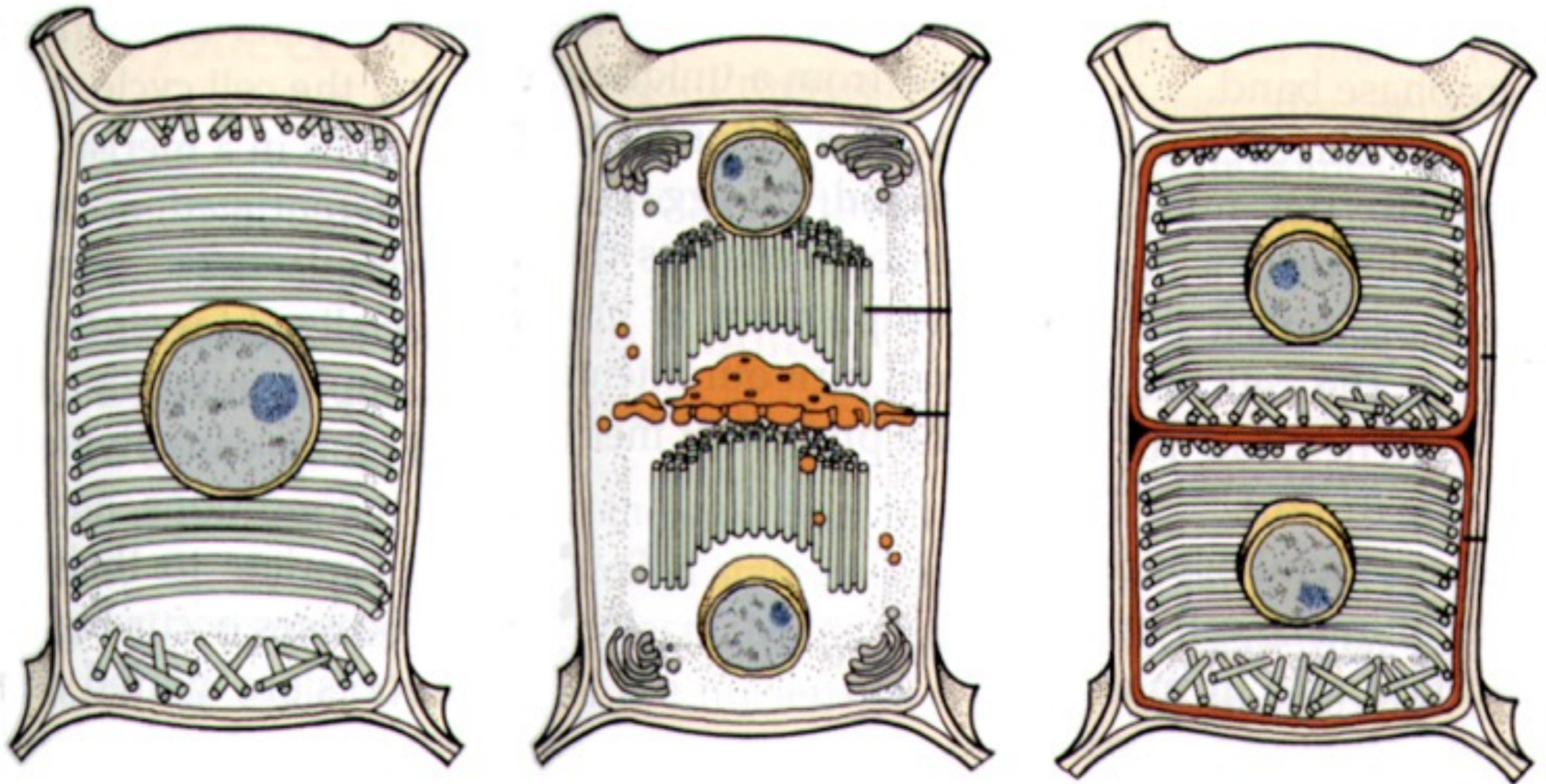
45 days

Continued growth of shoot and root meristems produces the adult plant body



Plant Morphogenesis





Deposition of new cell walls during plant cell division.

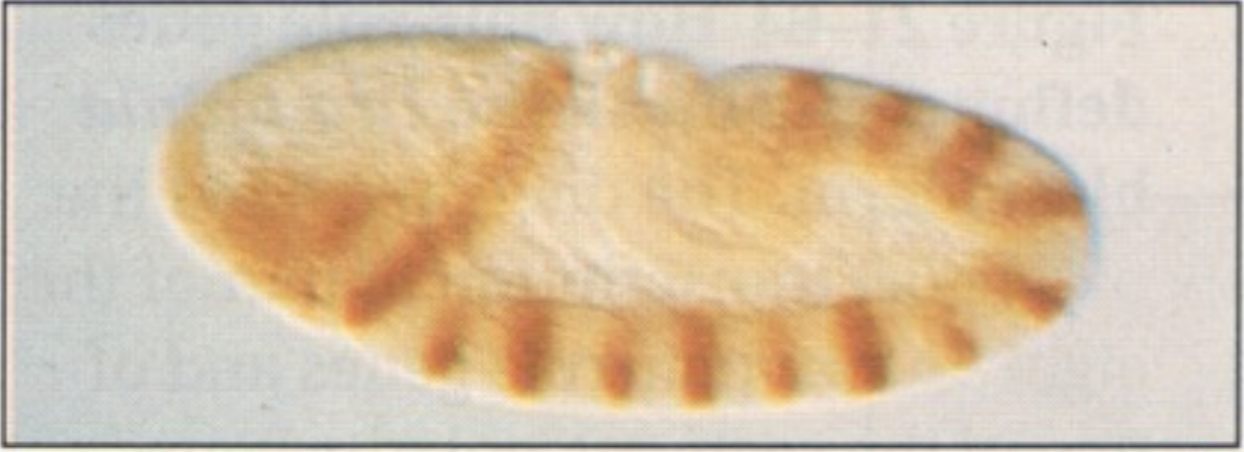
How is an adult body plan built?

Precise sequence of divisions during early embryogenesis.

Are plant cell fates controlled by

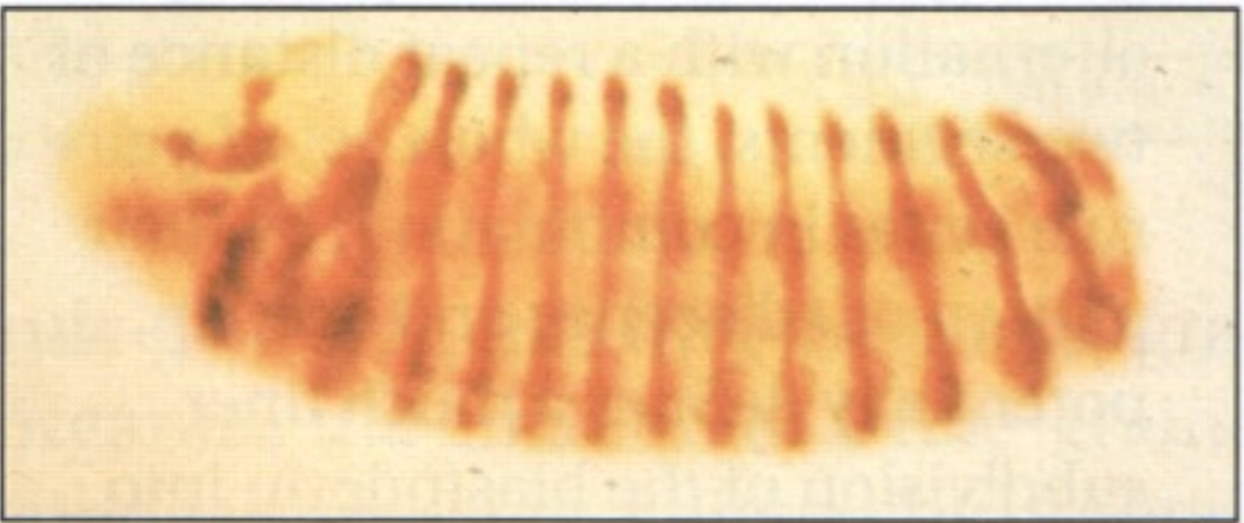
(1) segregation of determinants?

(2) positional information?



5-hour embryo

100 μm






10-hour embryo

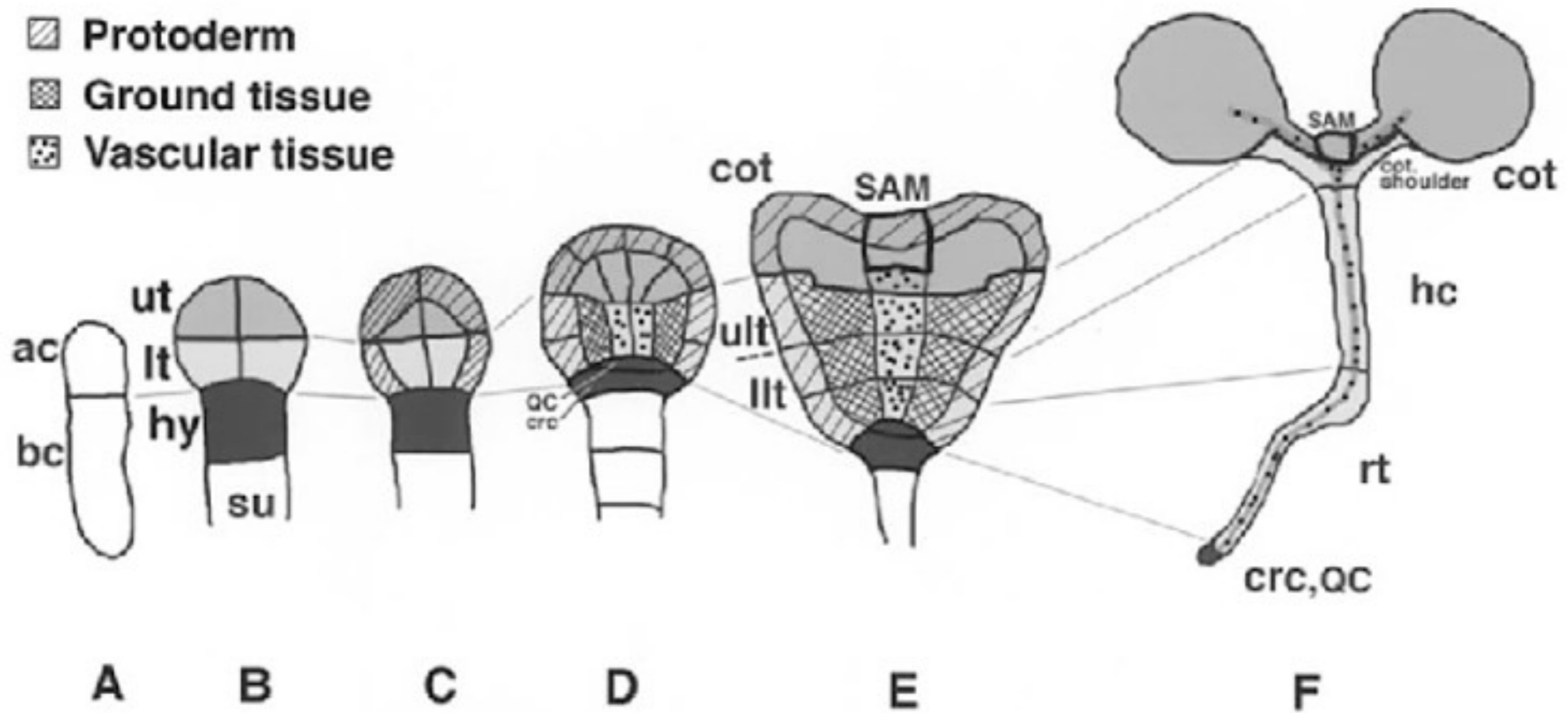
100 μm



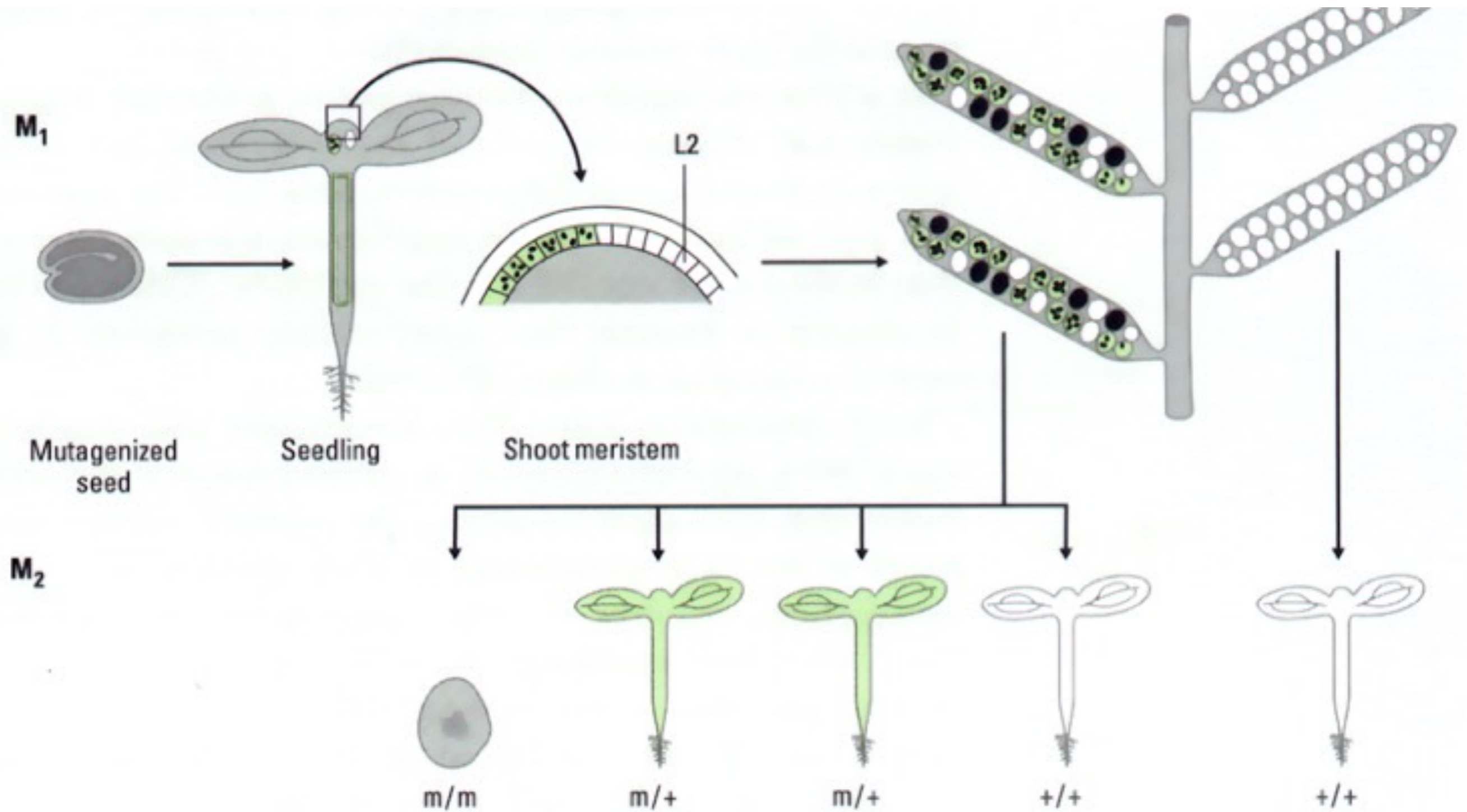
adult

500 μm

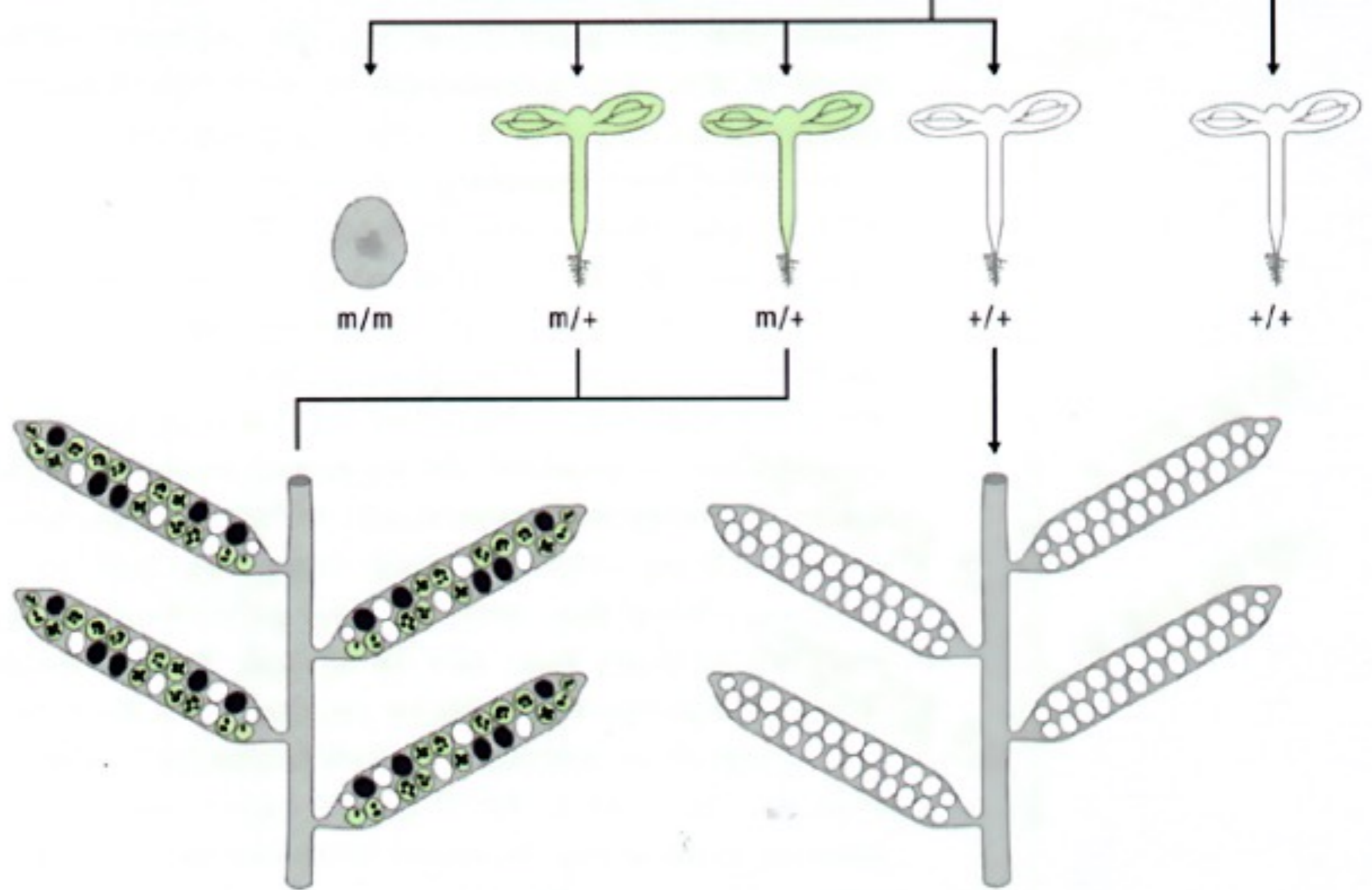
-  **Protoderm**
-  **Ground tissue**
-  **Vascular tissue**



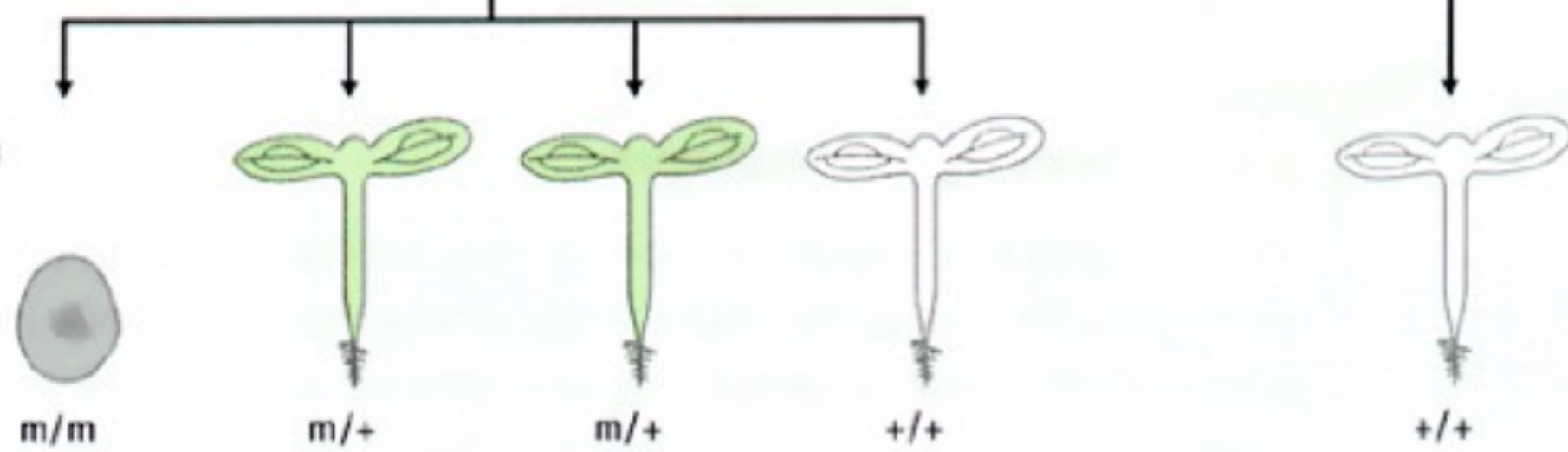
Genetic screening for mutants in Arabidopsis development

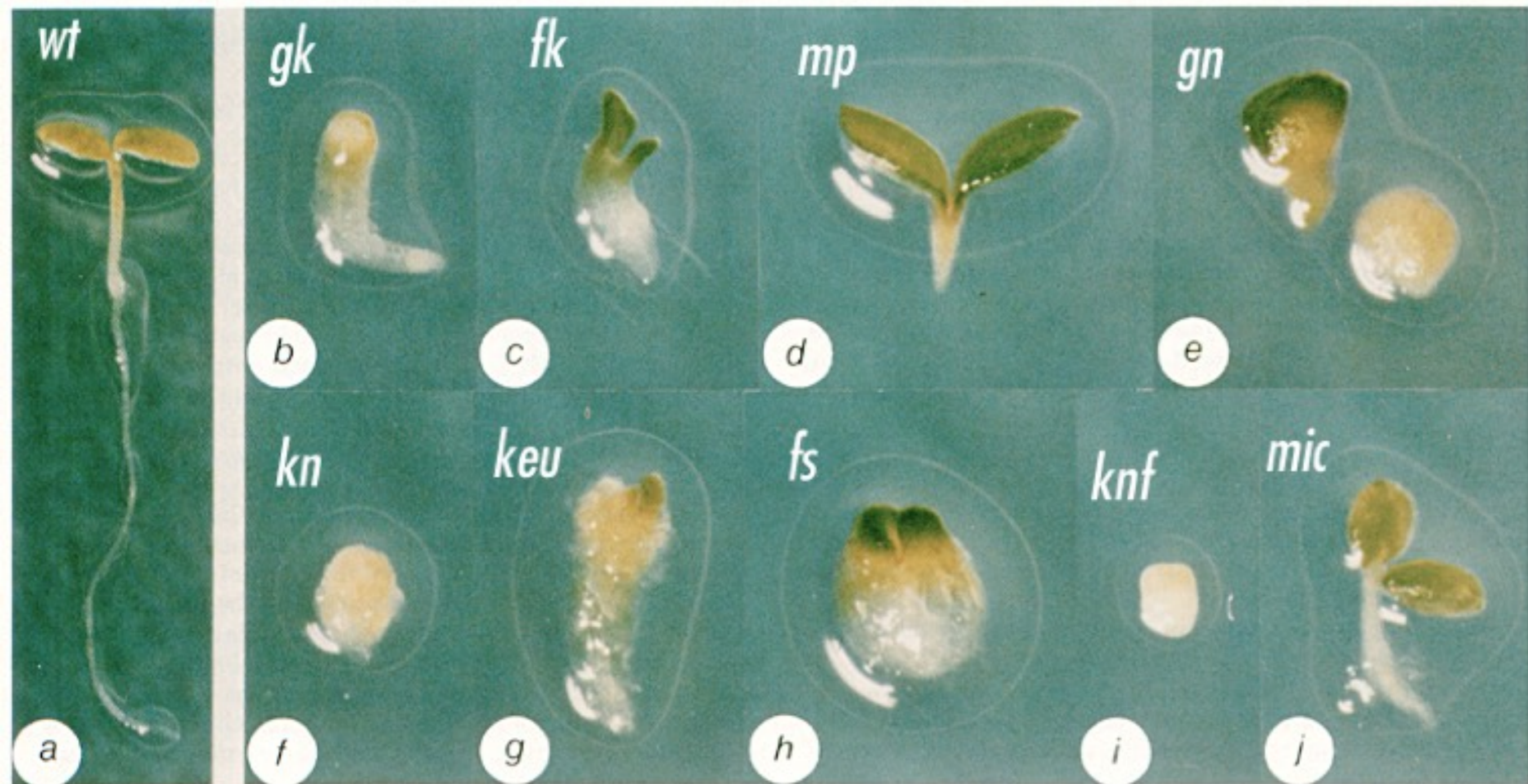


M₂



M₃





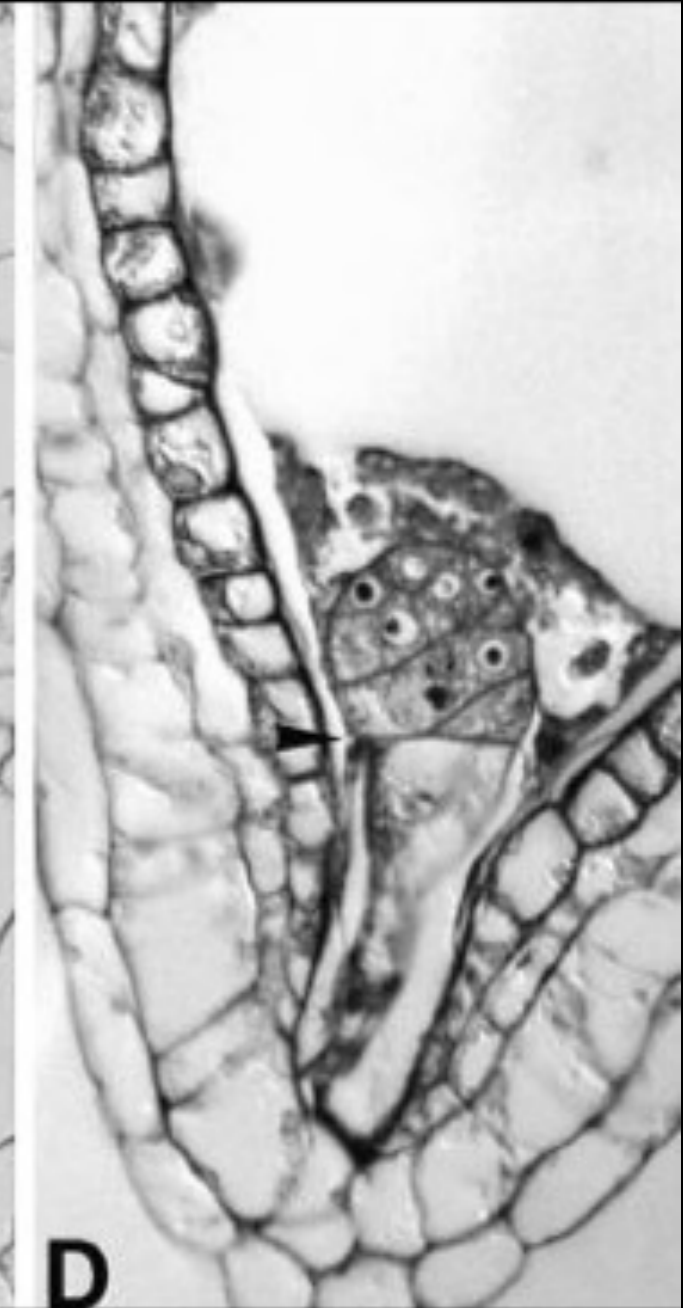
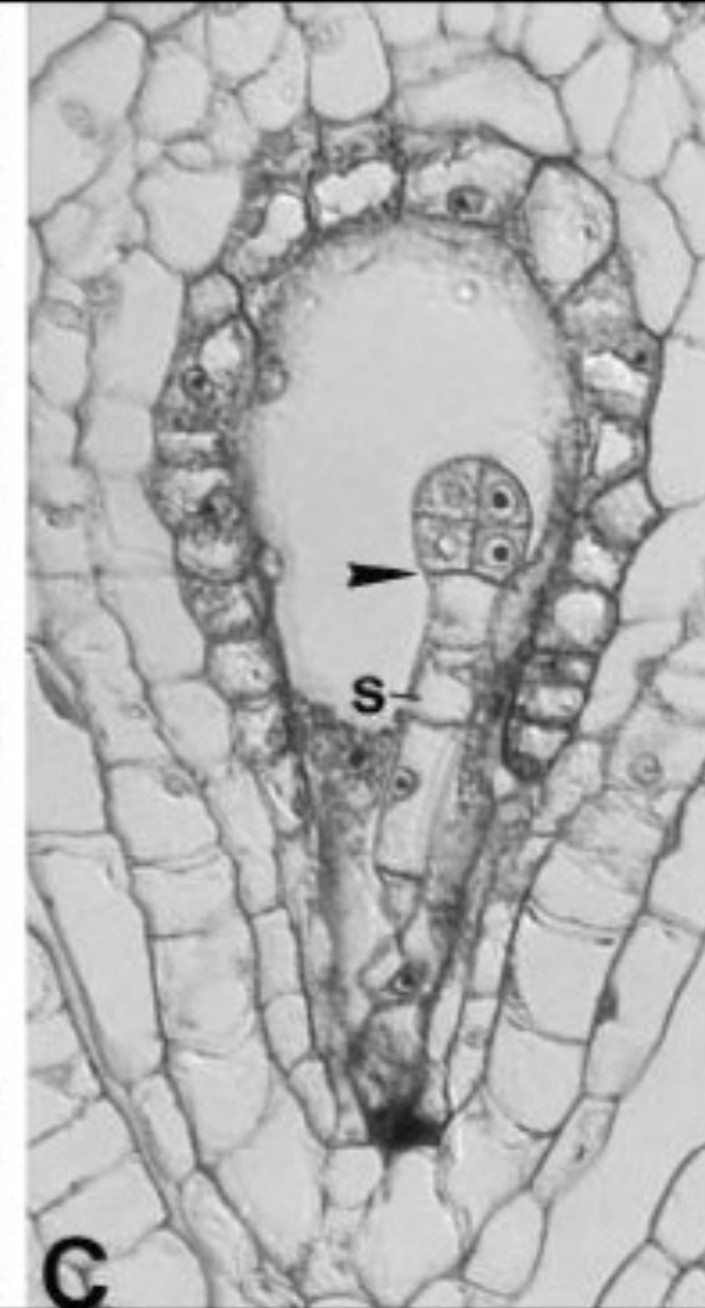
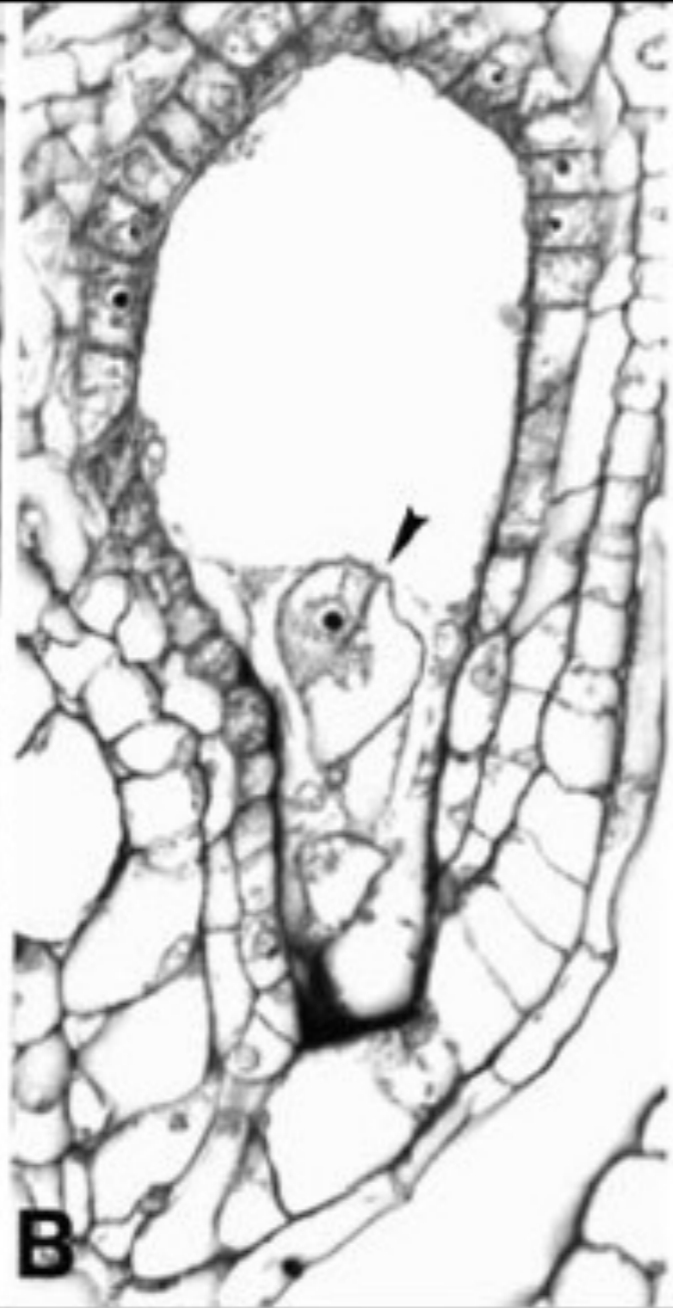
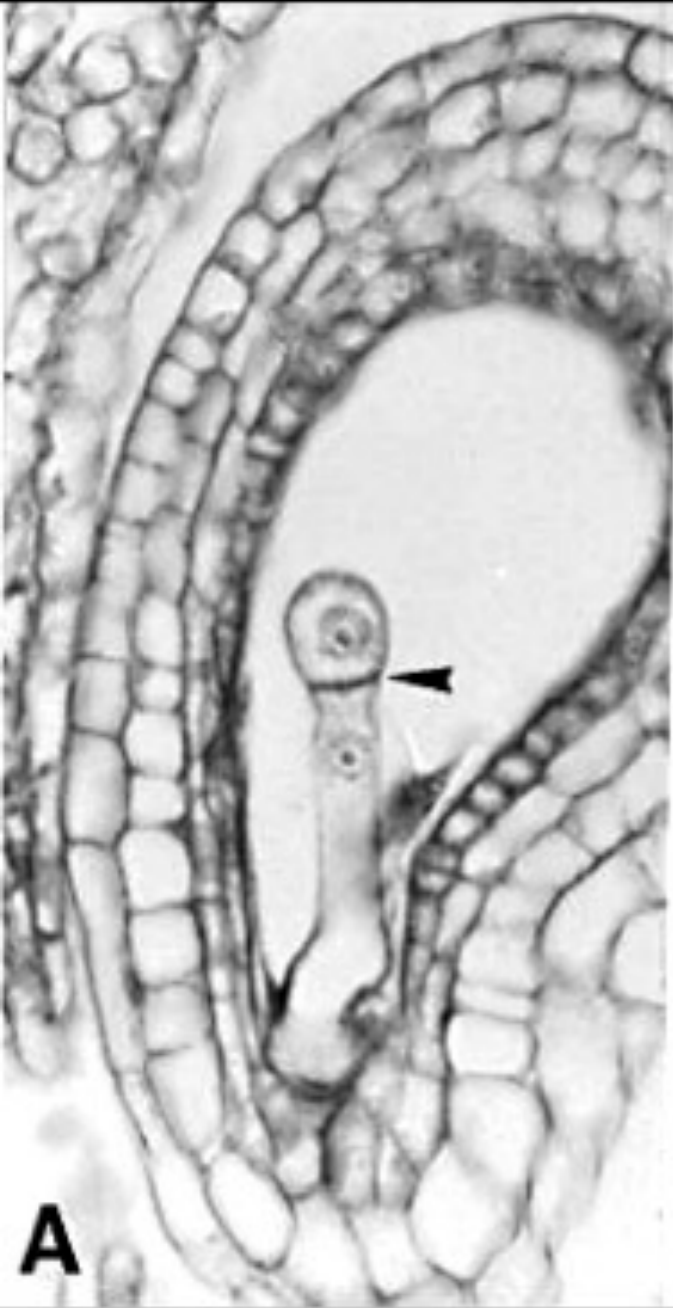
***fass* mutants have cytoskeletal defects, with altered cell division**

WT

fass

WT

fass



2-cell stage

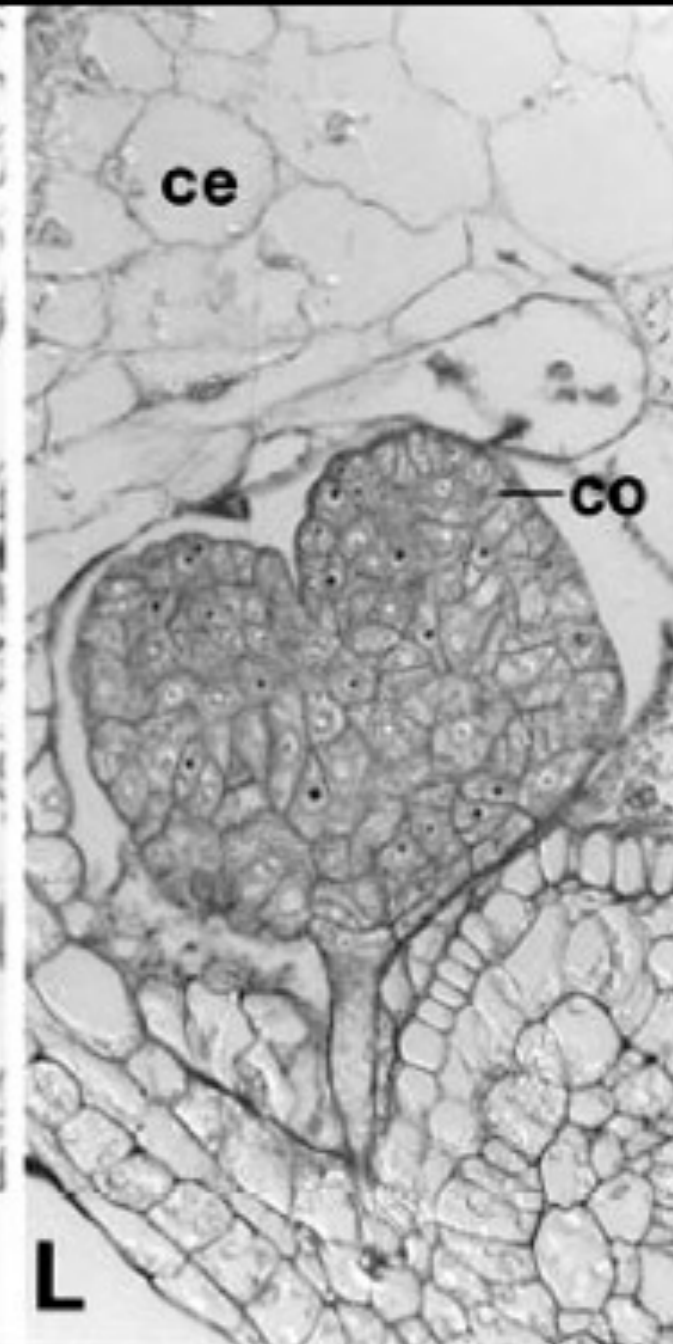
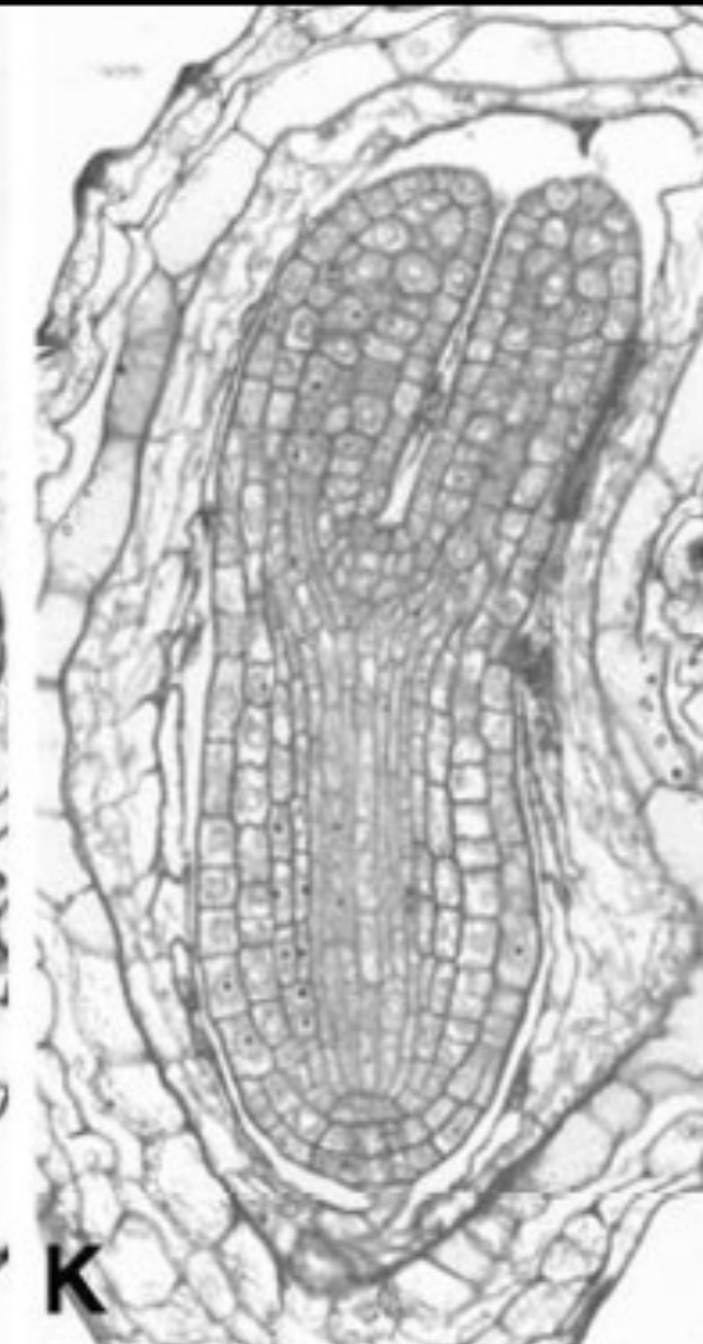
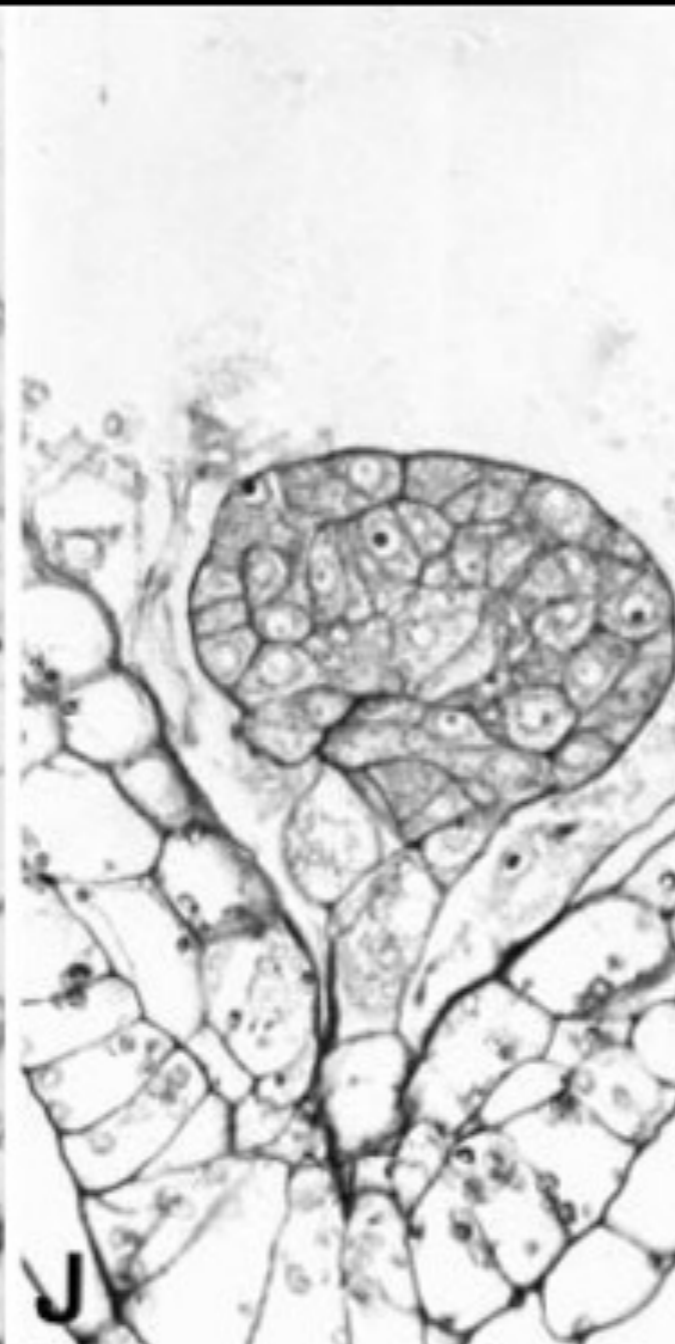
octant stage

WT

fass

WT

fass

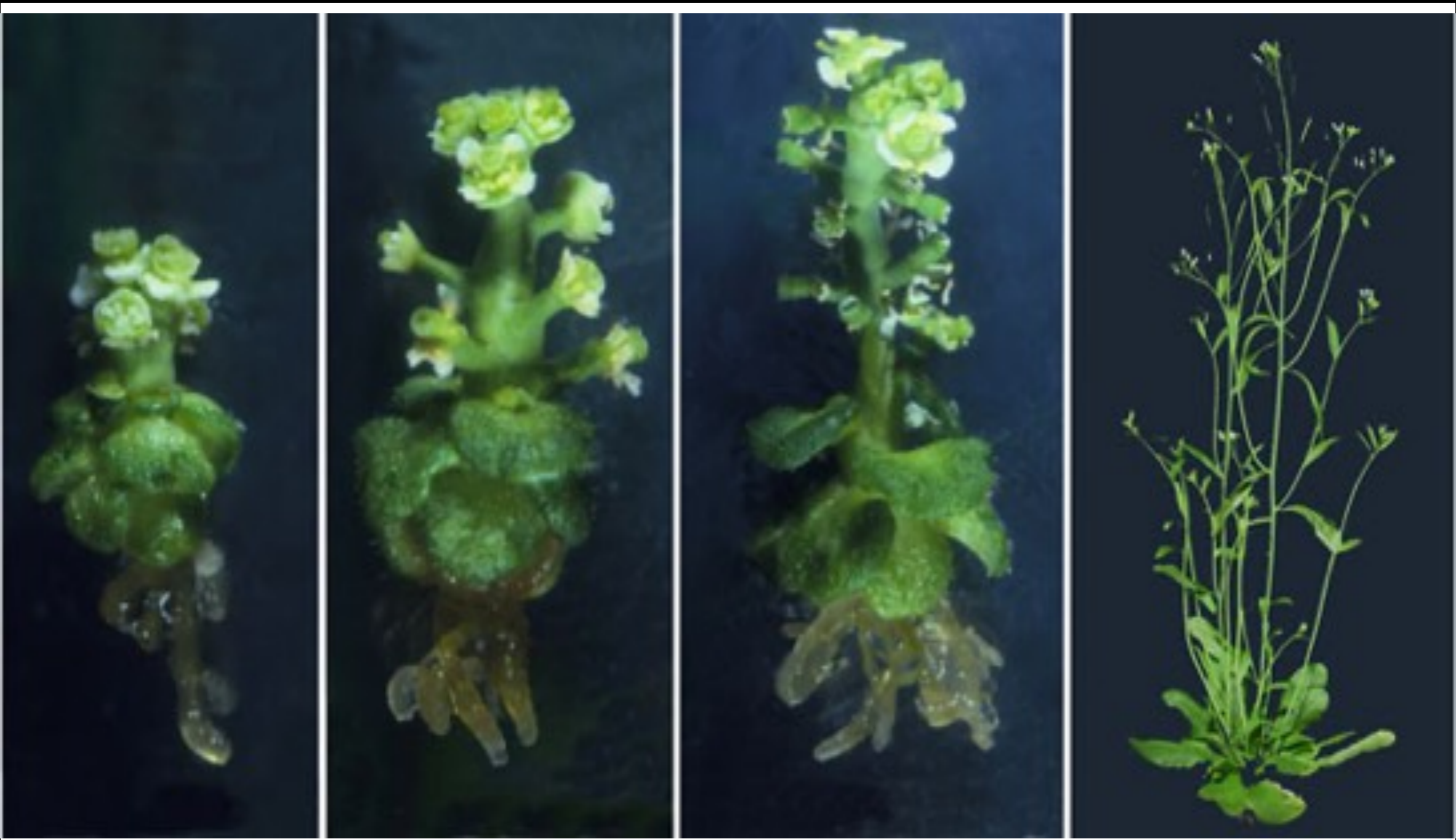


heart stage

torpedo stage

***fass* alleles**

wild type



***fass* plants form organised tissues despite deranged cell divisions**

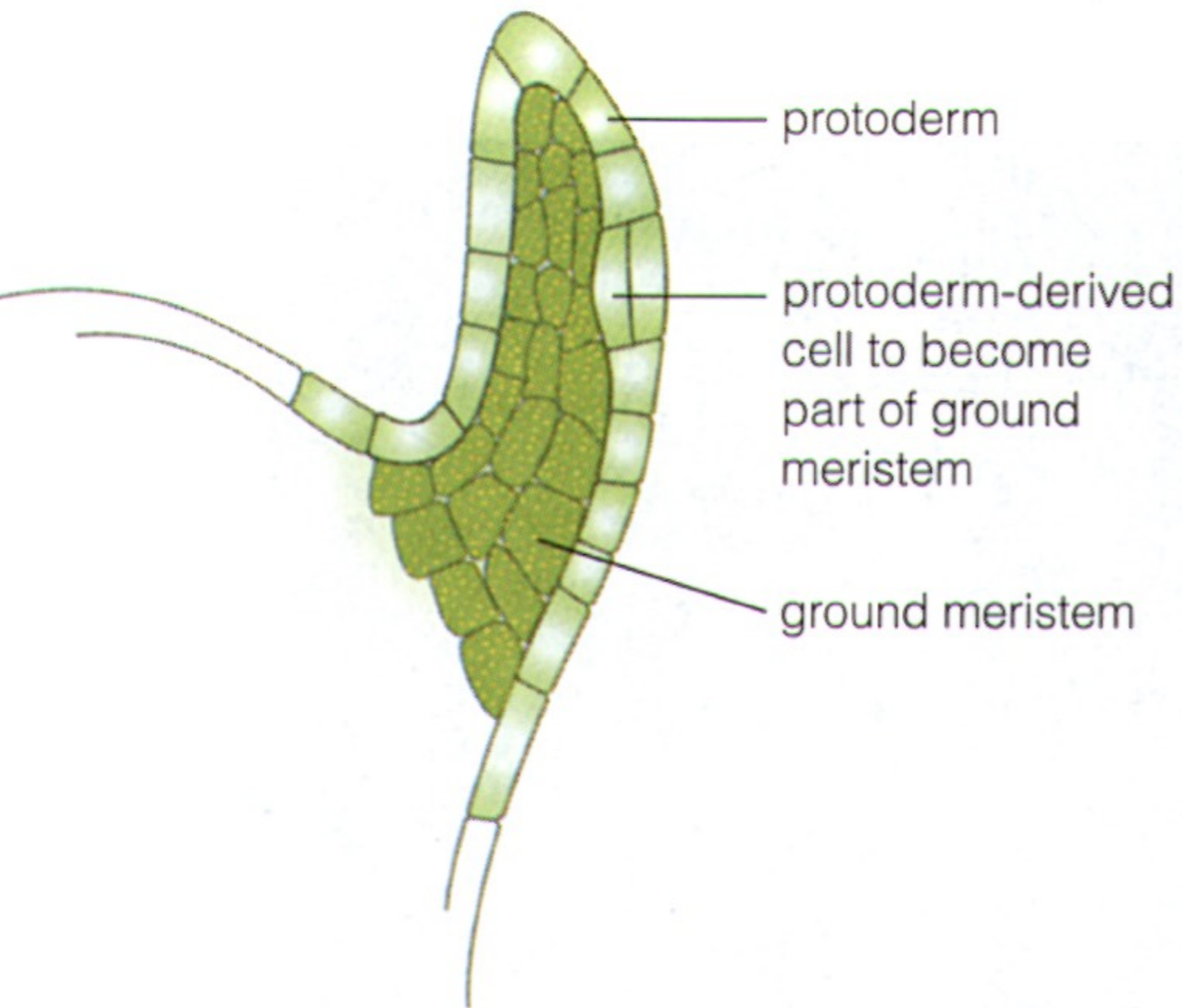
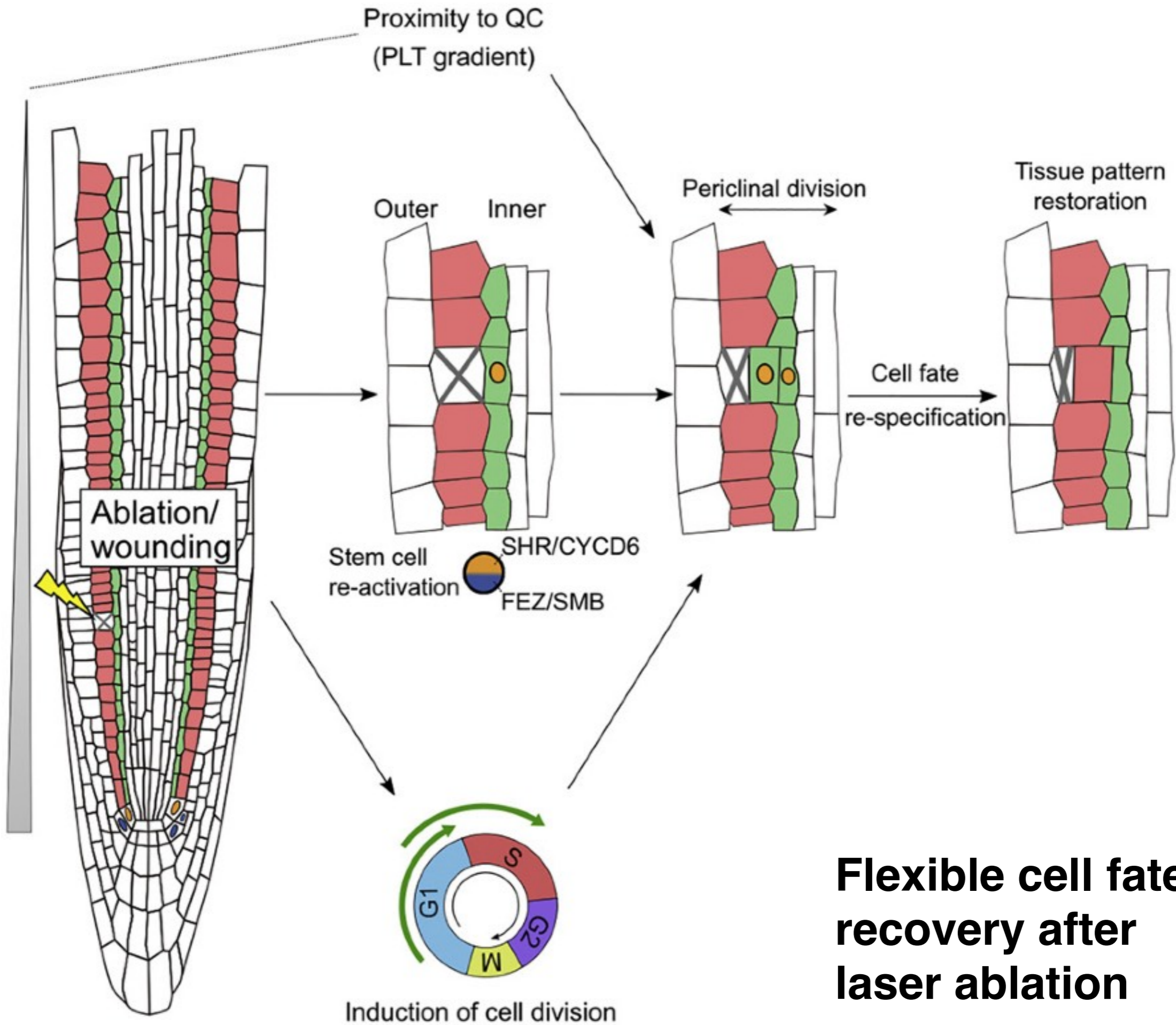


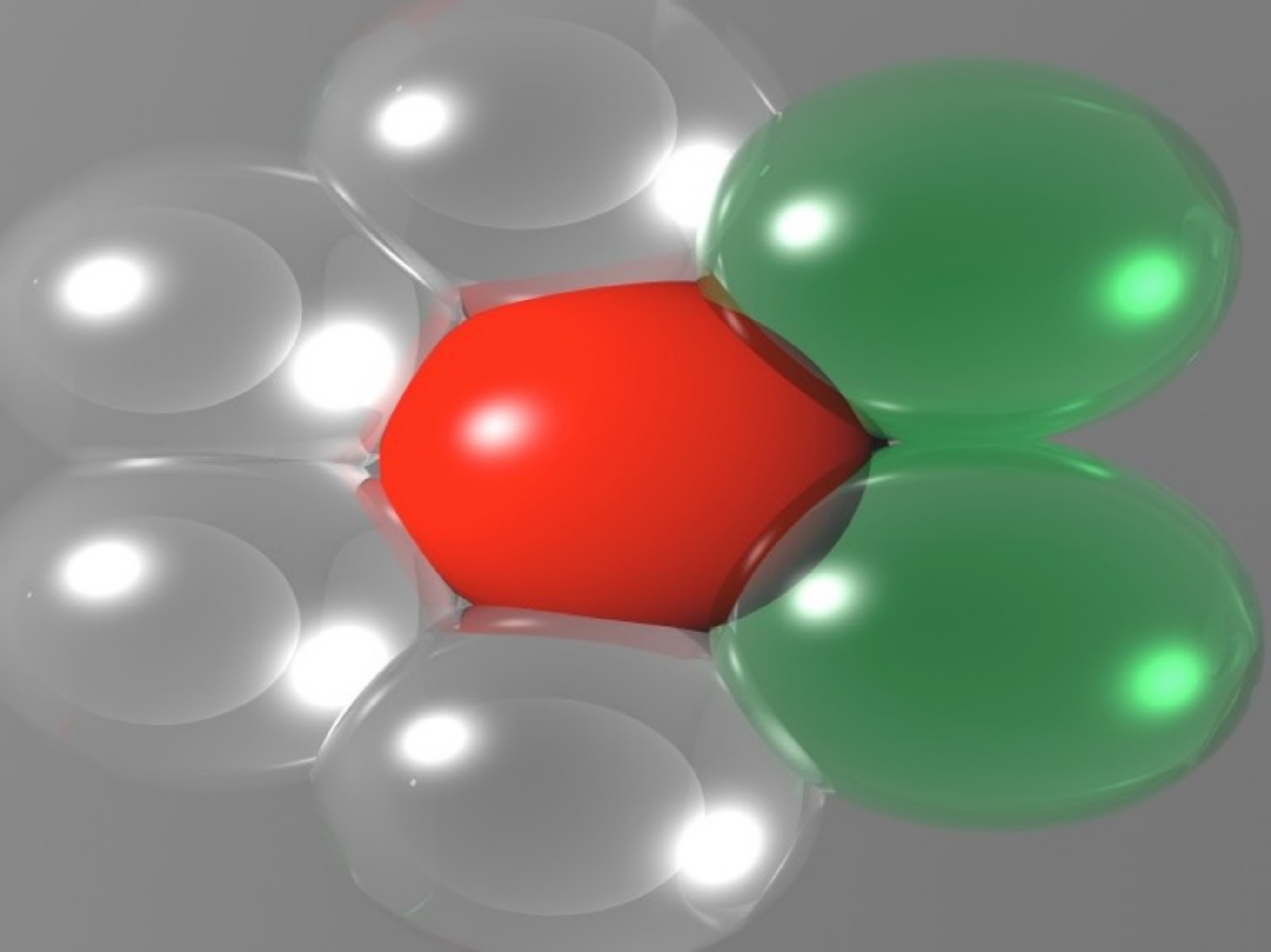
Figure 15.2 An example of reversible determination in plant cells. The protoderm and epidermal cells of English ivy (*Hedera helix*) lack the ability to make chlorophyll, but the ground meristem and its derivatives in a leaf produce chlorophyll normally. When a protoderm cell divides so that one of its 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.

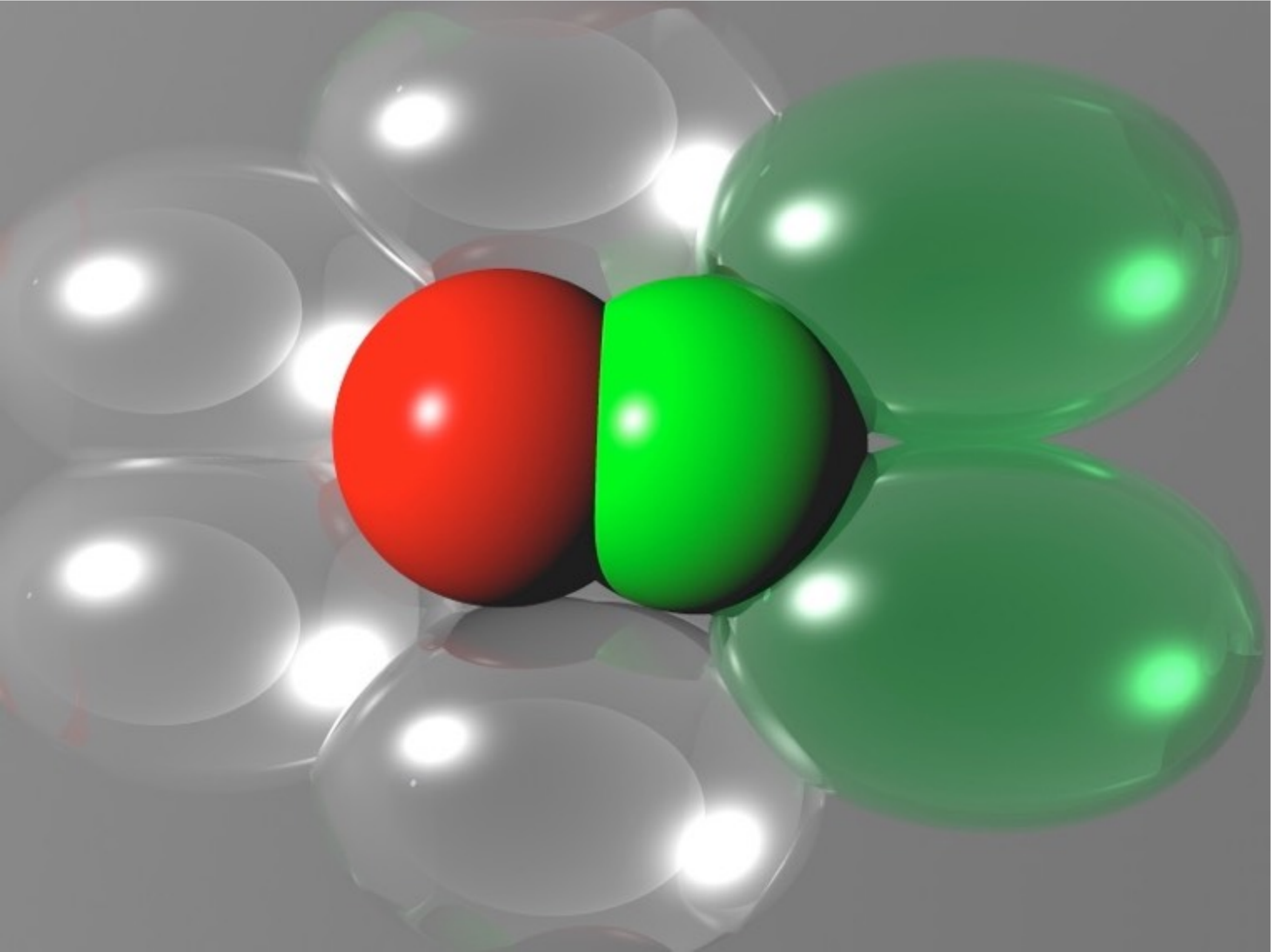
Chimeric plants: cell fate determined by position

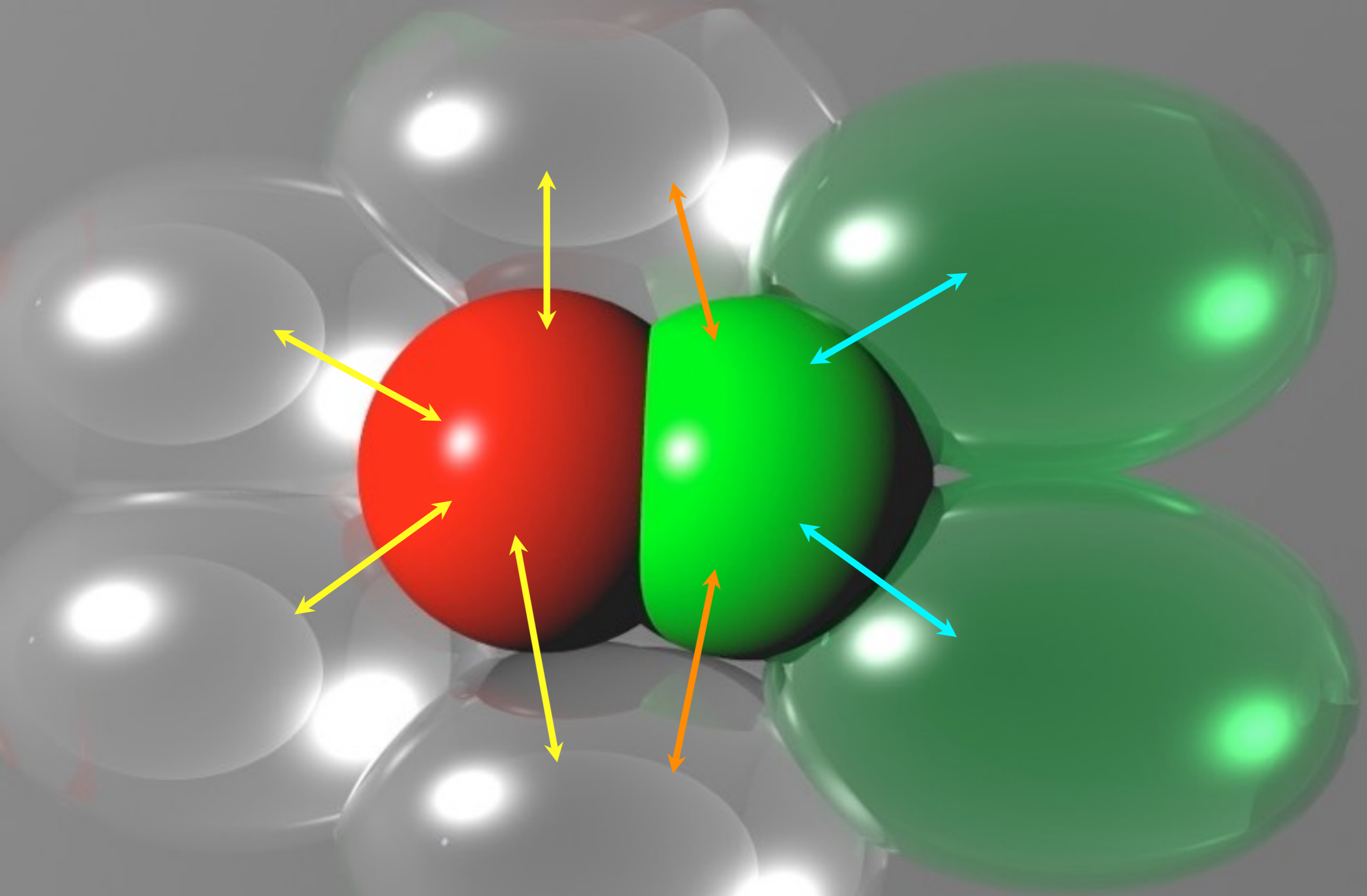




**Flexible cell fates:
recovery after
laser ablation**



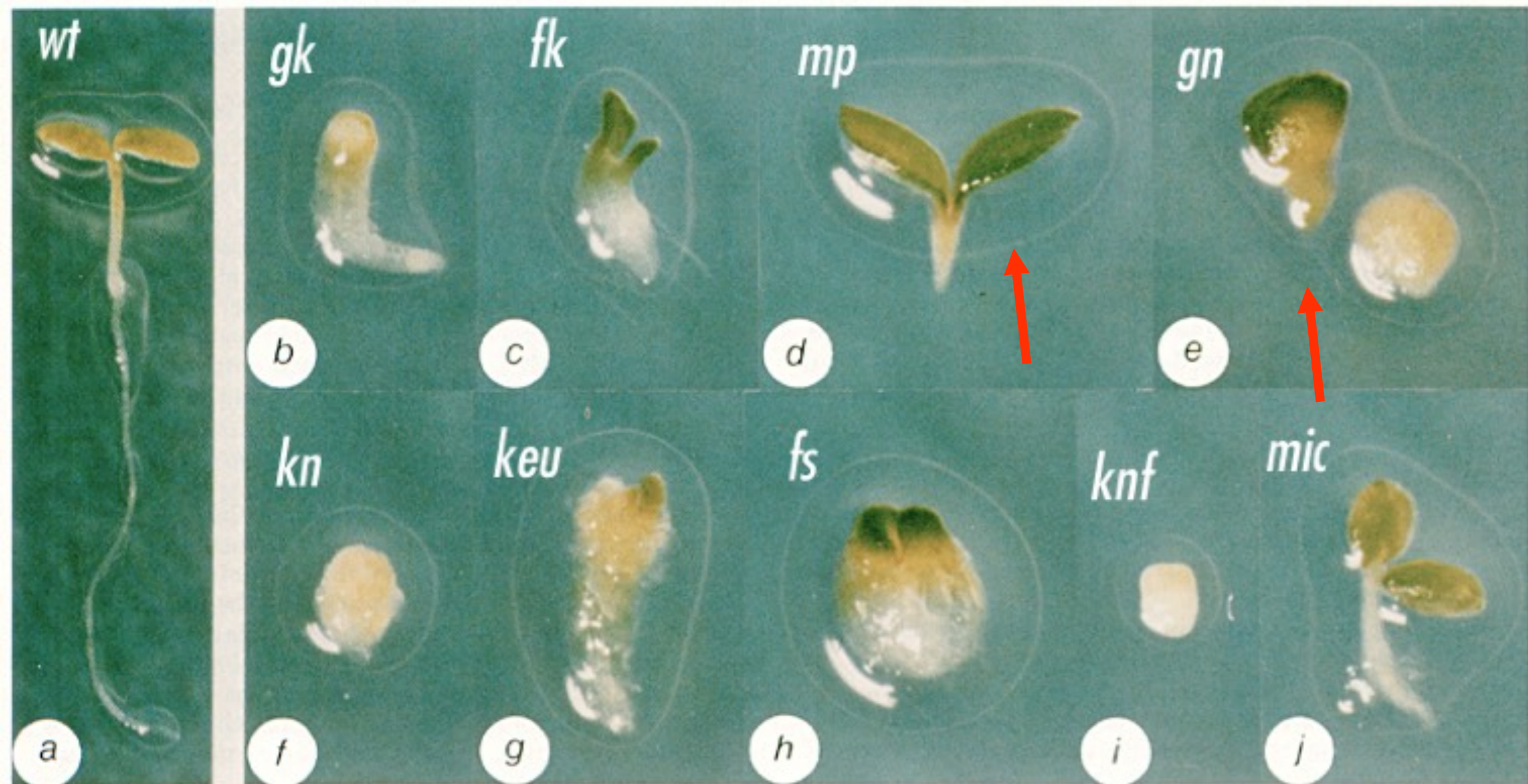




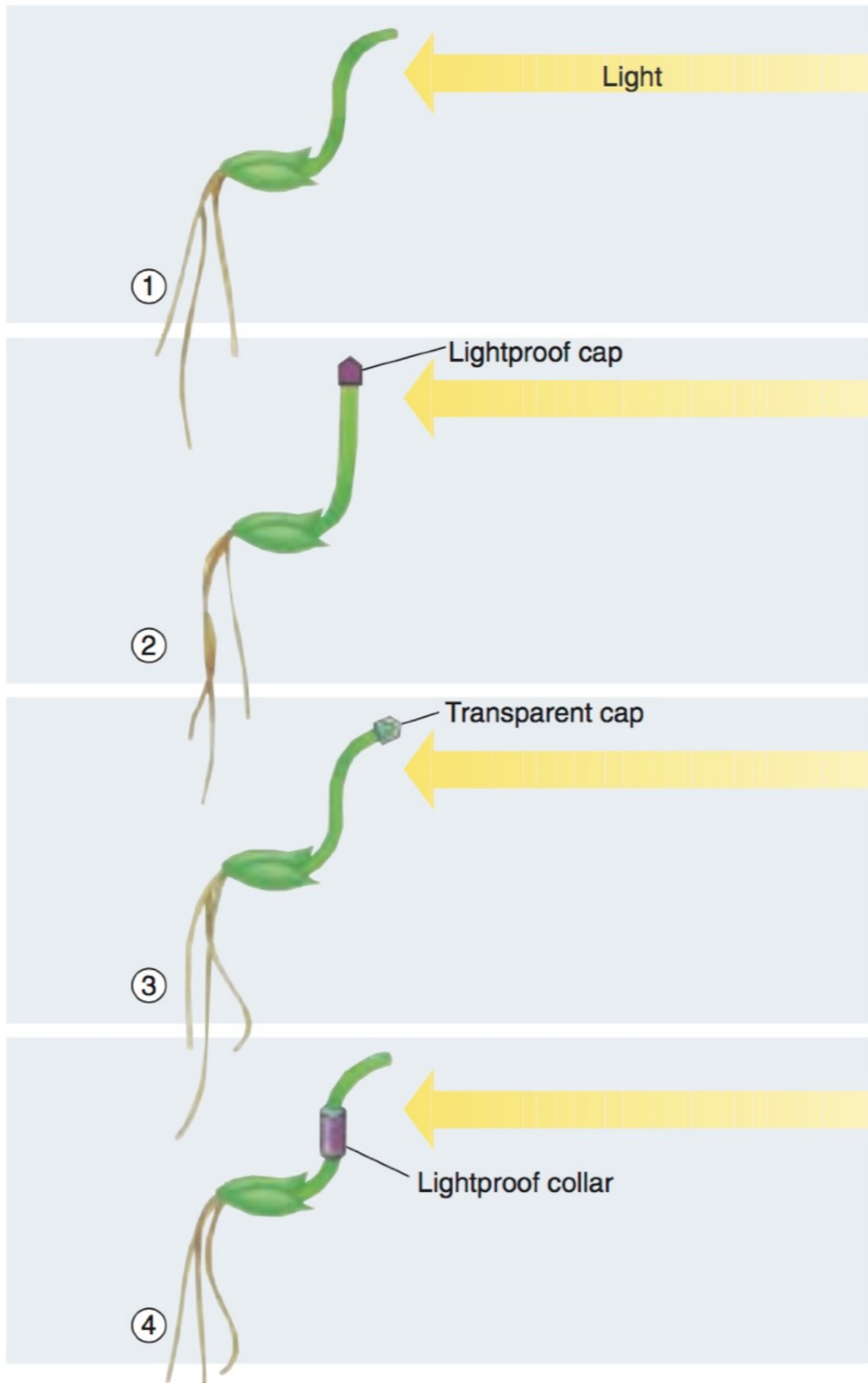
Exchange of positional information

2 classes of embryonic defects:

(i) cell wall positioning and deposition, and (ii) auxin traffic and response



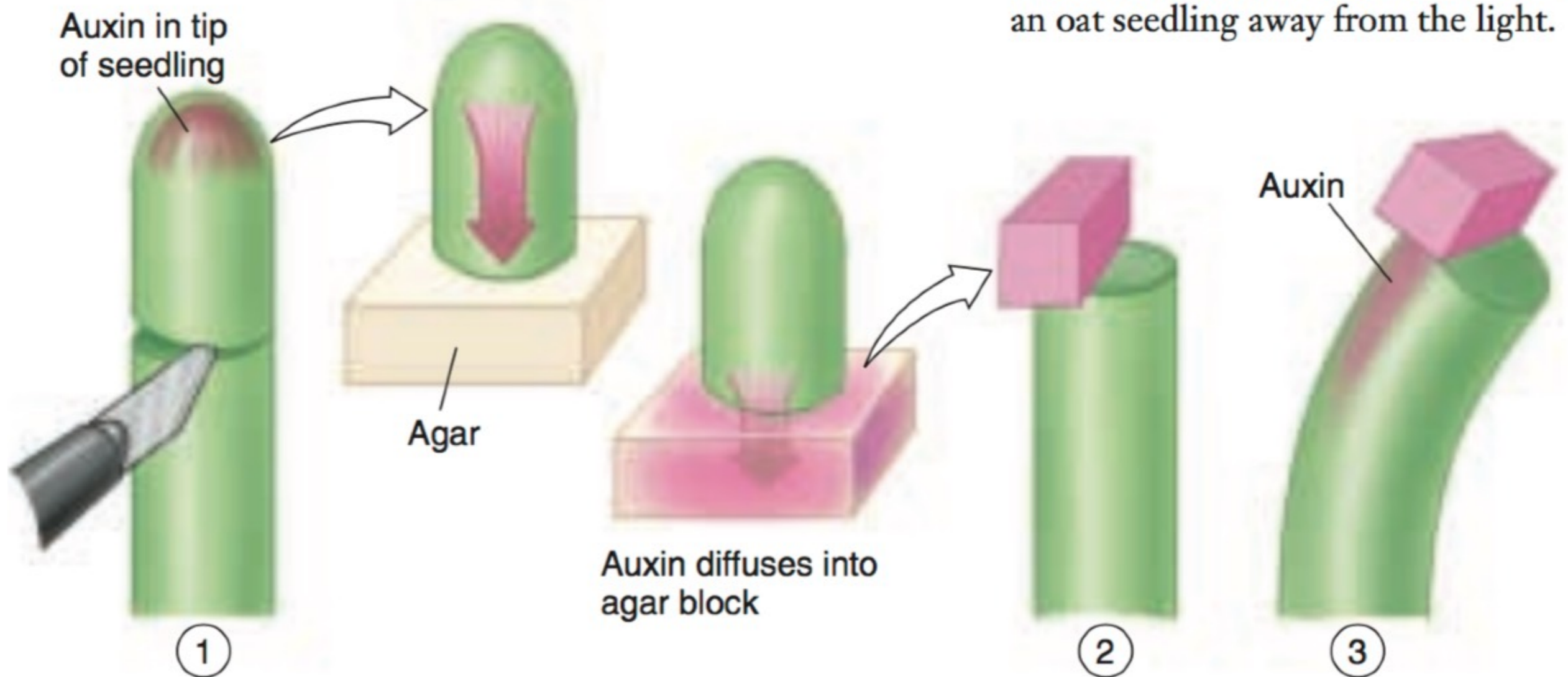
Charles and Francis Darwin's experiments on signalling during plant phototropism



The Darwins' experiment. (a) Young grass seedlings normally bend toward the light. (b) The bending (1) did not occur when the tip of a seedling was covered with a lightproof cap (2), but did occur when it was covered with a transparent one (3). When a collar was placed below the tip (4), the characteristic light response took place. From these experiments, the Darwins concluded that, in response to light, an "influence" that caused bending was transmitted from the tip of the seedling to the area below, where bending normally occurs.

Demonstration of auxin signaling in plant tissues

Frits Went's experiment. (1) Went removed the tips of oat seedlings and put them in agar, an inert, gelatinous substance. (2) Blocks of agar were then placed off-center on the ends of other oat seedlings from which the tips had been removed. (3) The seedlings bent away from the side on which the agar block was placed. Went concluded that the substance that he named *auxin* promoted the elongation of the cells and that it accumulated on the side of an oat seedling away from the light.



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Lecture 2: Polarity, auxin traffic and auxin response.

Lecture 3: Regulation of root initiation and growth by auxin.

Lecture 4: Patterning of shoot growth.