2018 CDB Part IB
Plant Development

Lecture 1

Plant architecture and embryogenesis

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Plant Development

Lecture 1: Plant architecture and embryogenesis.
Lecture 2: Polarity and auxin flow.
Lecture 3: Regulation of gene expression by auxin.
Lecture 4: Patterning of indeterminate growth.
Lecture 5: Formation and specification of lateral organs.
Lecture 6: Morphogenesis.

Web resources:

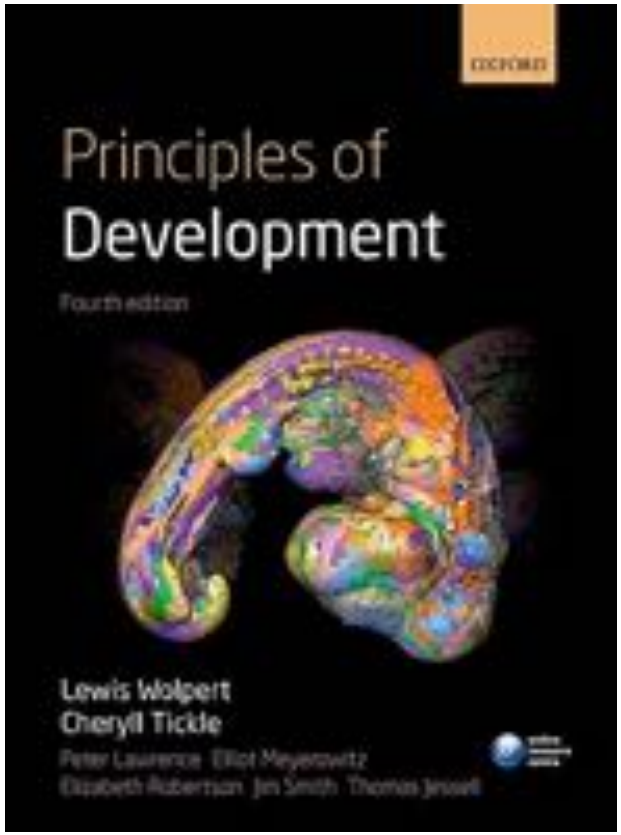
An electronic version of the lecture slides, a colour version of these notes and additional teaching materials including review papers and essay topics can be found on the web site: **http://haseloff.plantsci.cam.ac.uk** (click the "education" menu choice and navigate to the CDB Part 1B resources section).

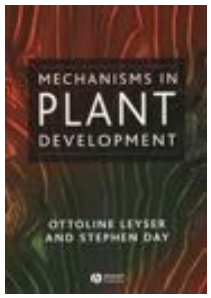
Recommended Text books:

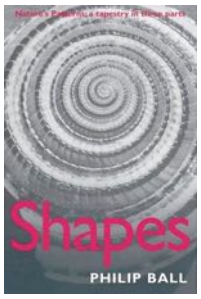
For an integrated overview of animal and plant development see:
***Principles of Development*, Lewis Wolpert and Cheryll Tickle, Oxford University Press, 2011.**
Chapter 7 provides a concise overview of the lecture content.

For coverage of plant development see:
***Mechanisms in Plant Development*, Ottoline Leyser & Stephen Day, Blackwell Science, UK, 2002.**

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.**

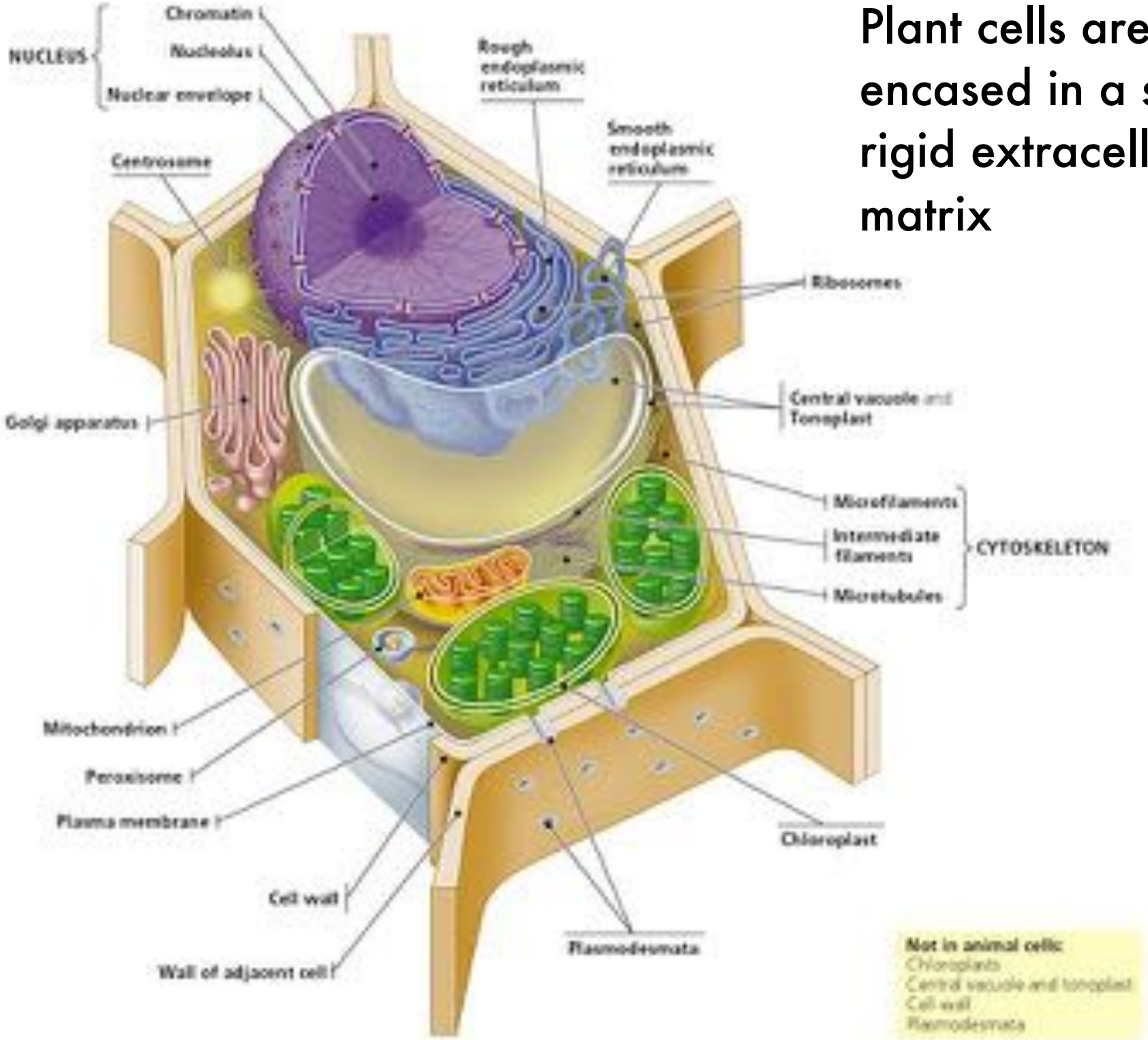


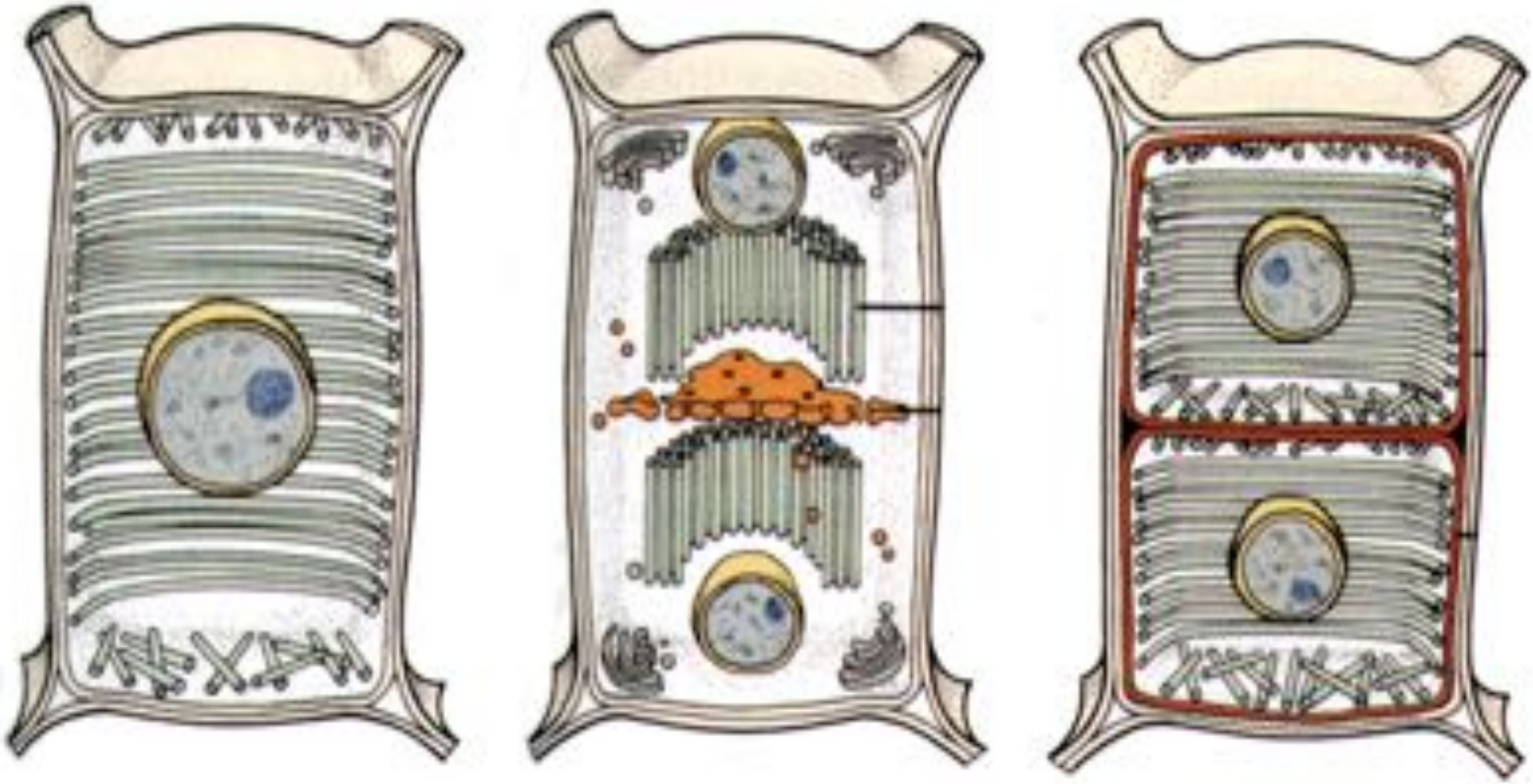




Immobile and Branched

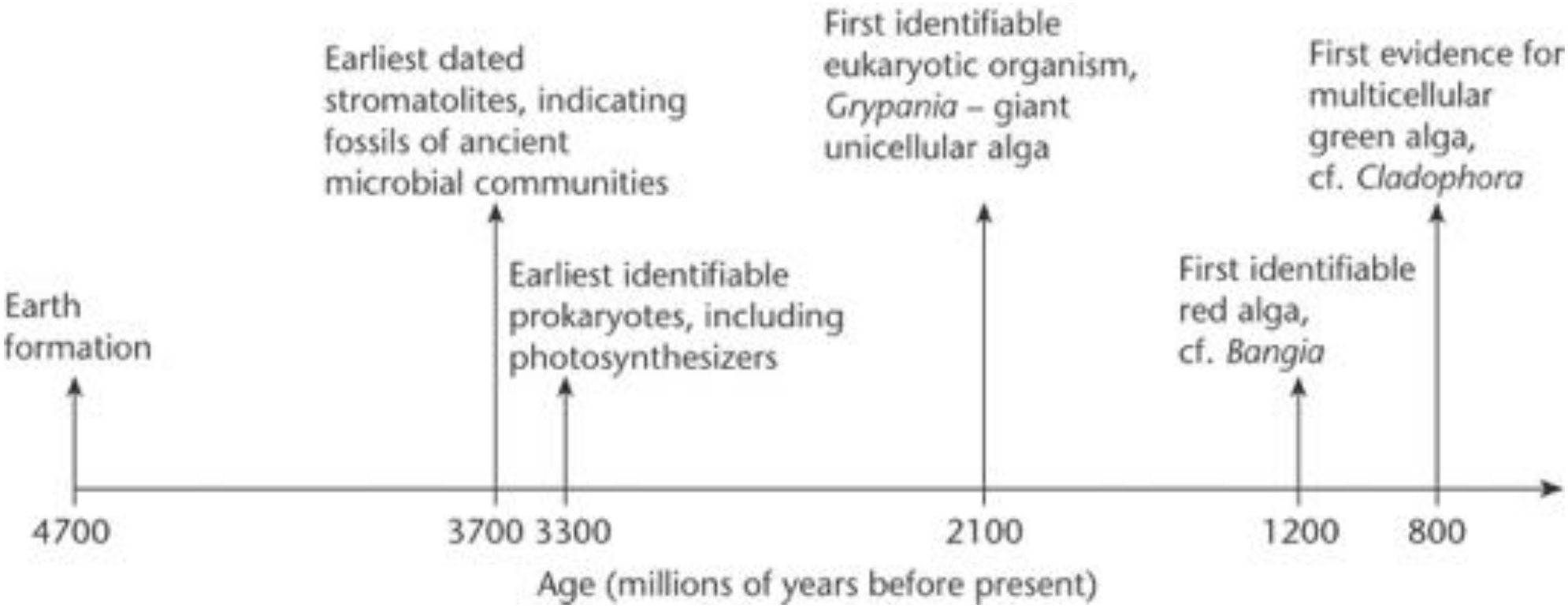
Plant cells are encased in a semi-rigid extracellular matrix



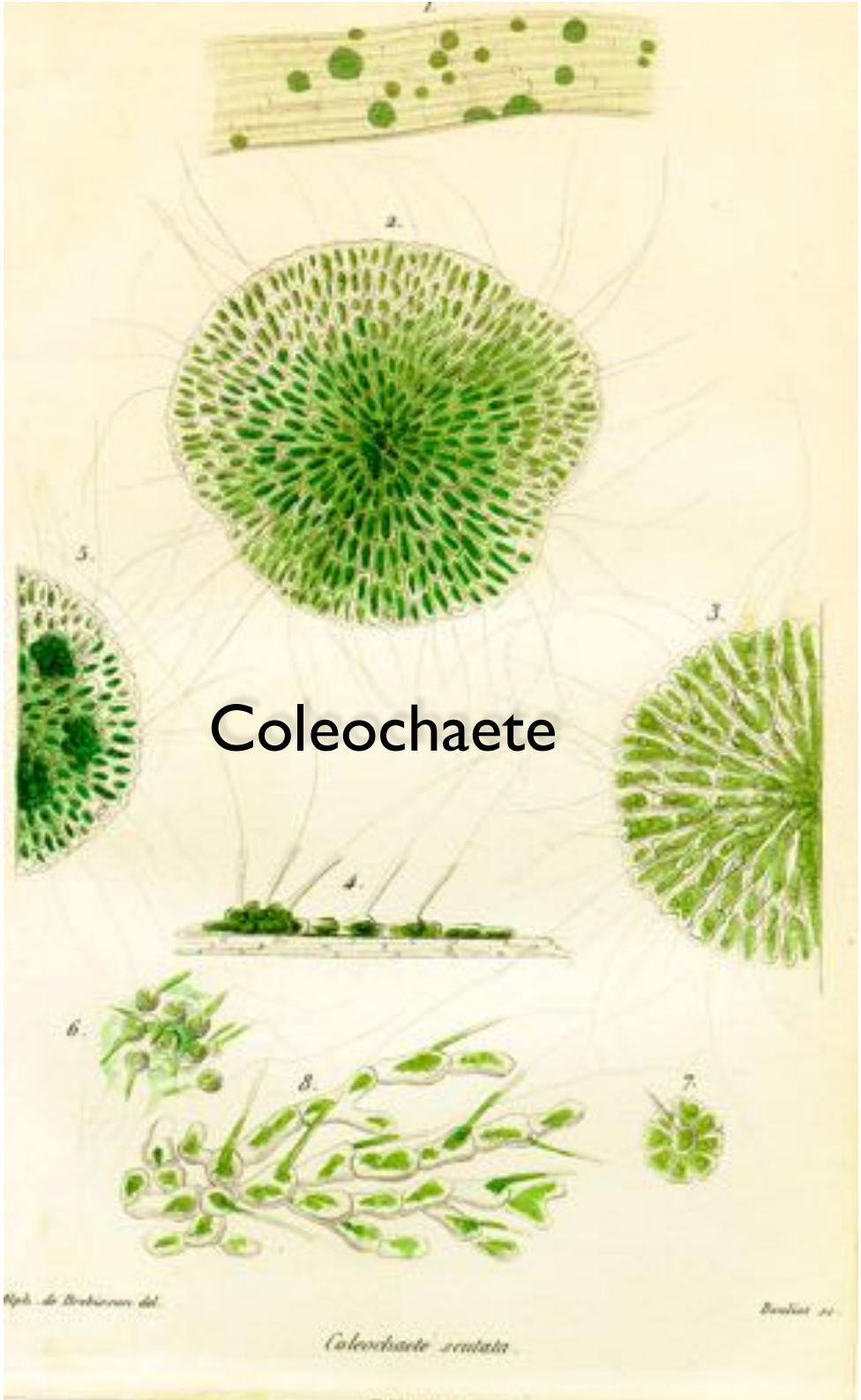


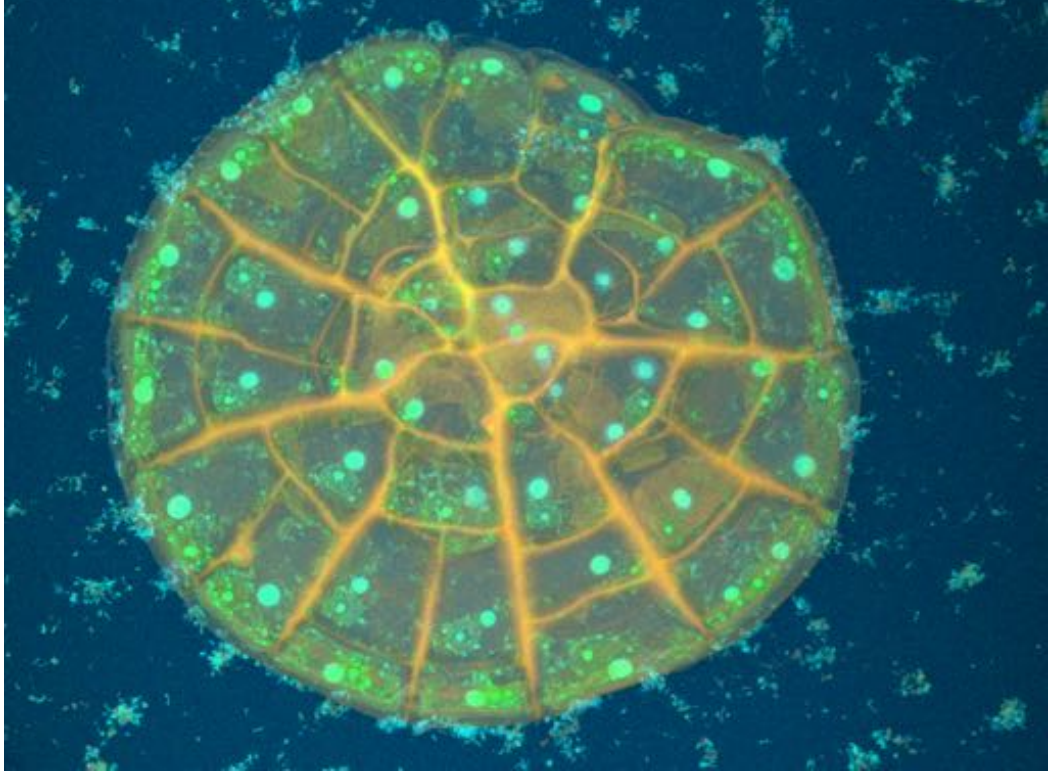
Deposition of new cell walls during plant cell division.

Plant Morphogenesis



Origin of terrestrial plants


Coleochaete



Colonisation of the land by plants

Different conditions faced by algae and plants

Supportive medium (water)

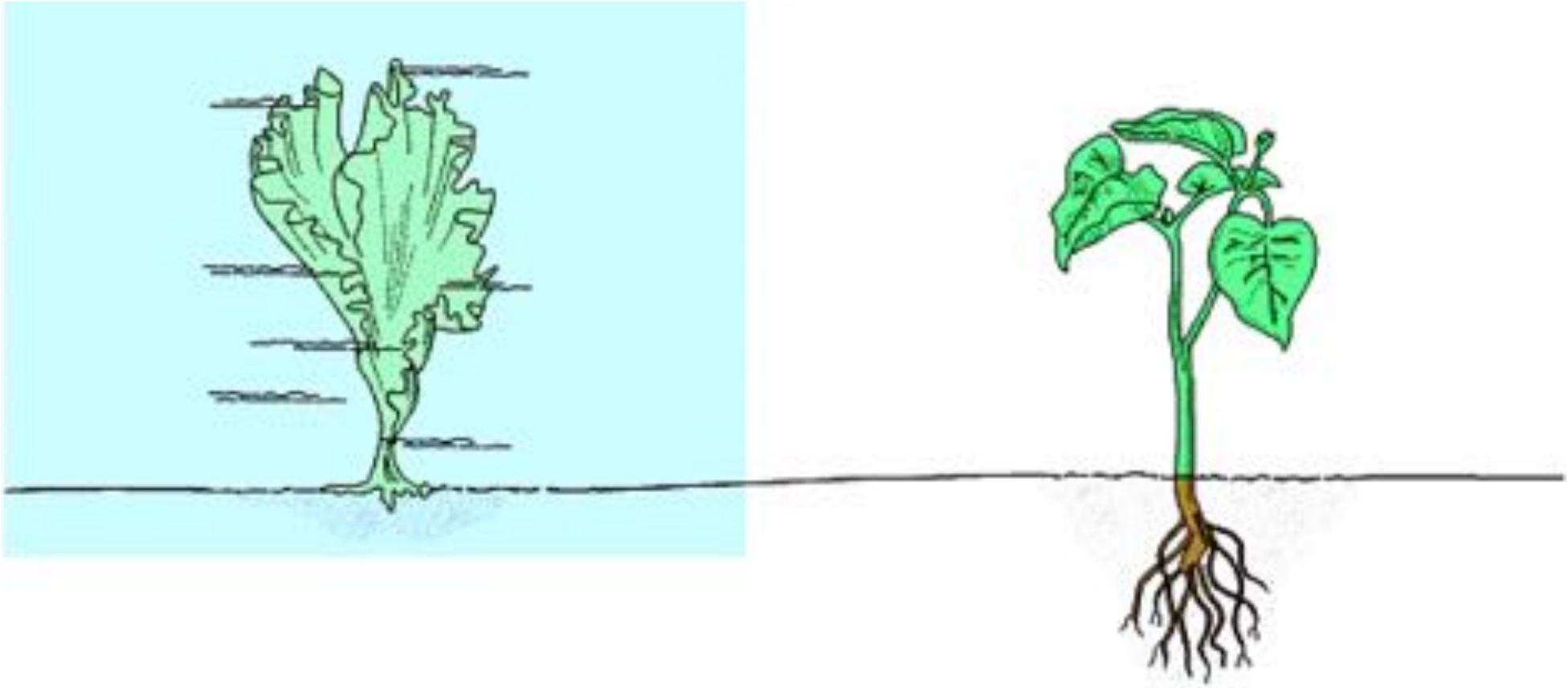
Photosynthesis in most cells

Direct access to minerals and water

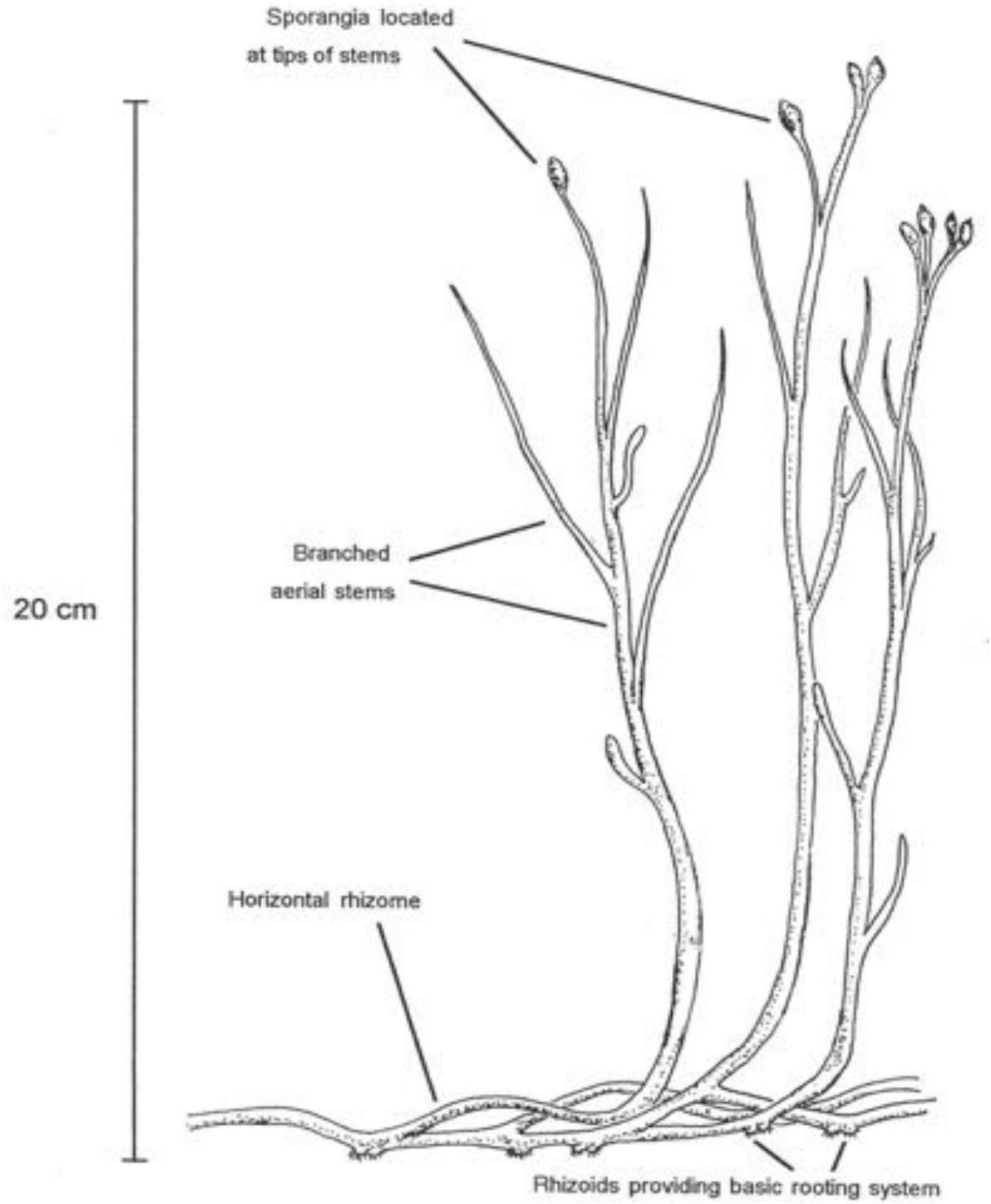
Non supportive medium (air)

No photosynthesis in root cells

Aerial parts not in direct contact with minerals and water



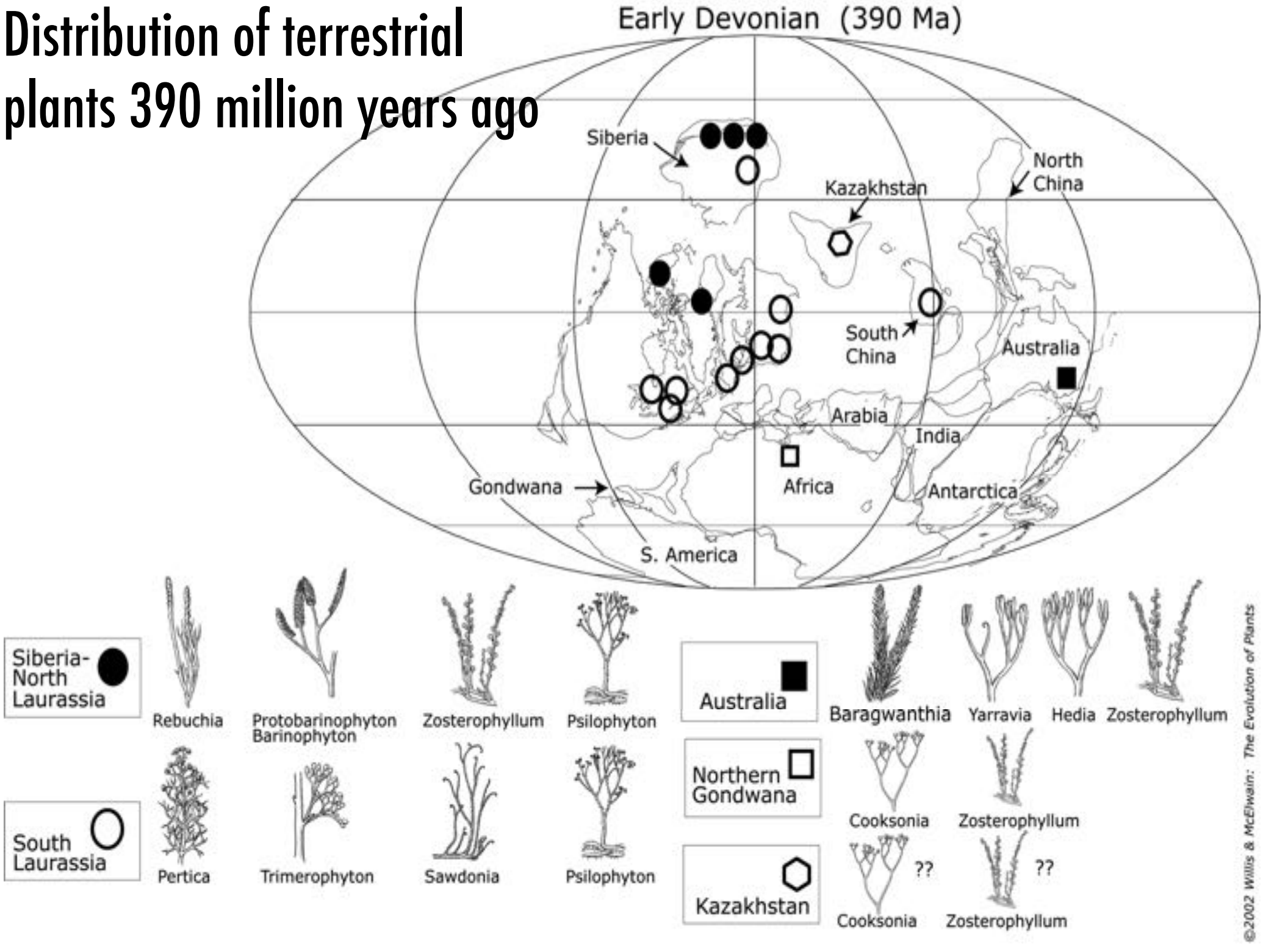

400 mya



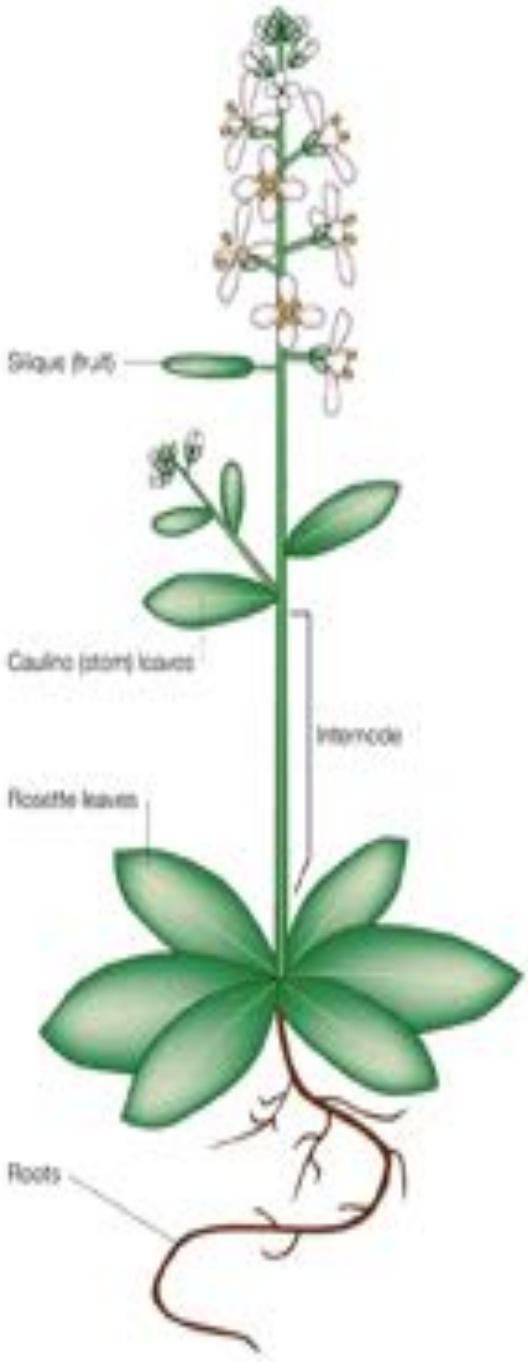
Early terrestrial plants

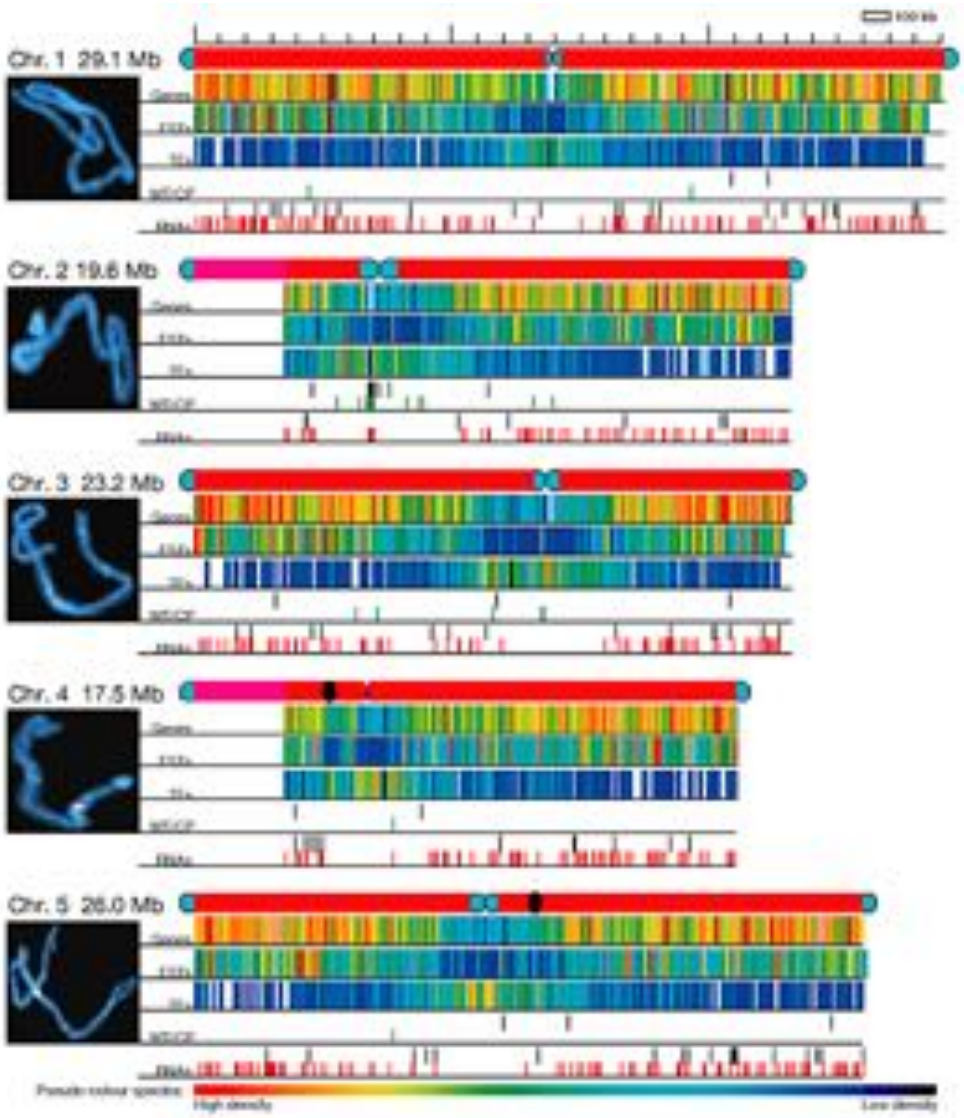
Aglaophyton major

Distribution of terrestrial plants 390 million years ago

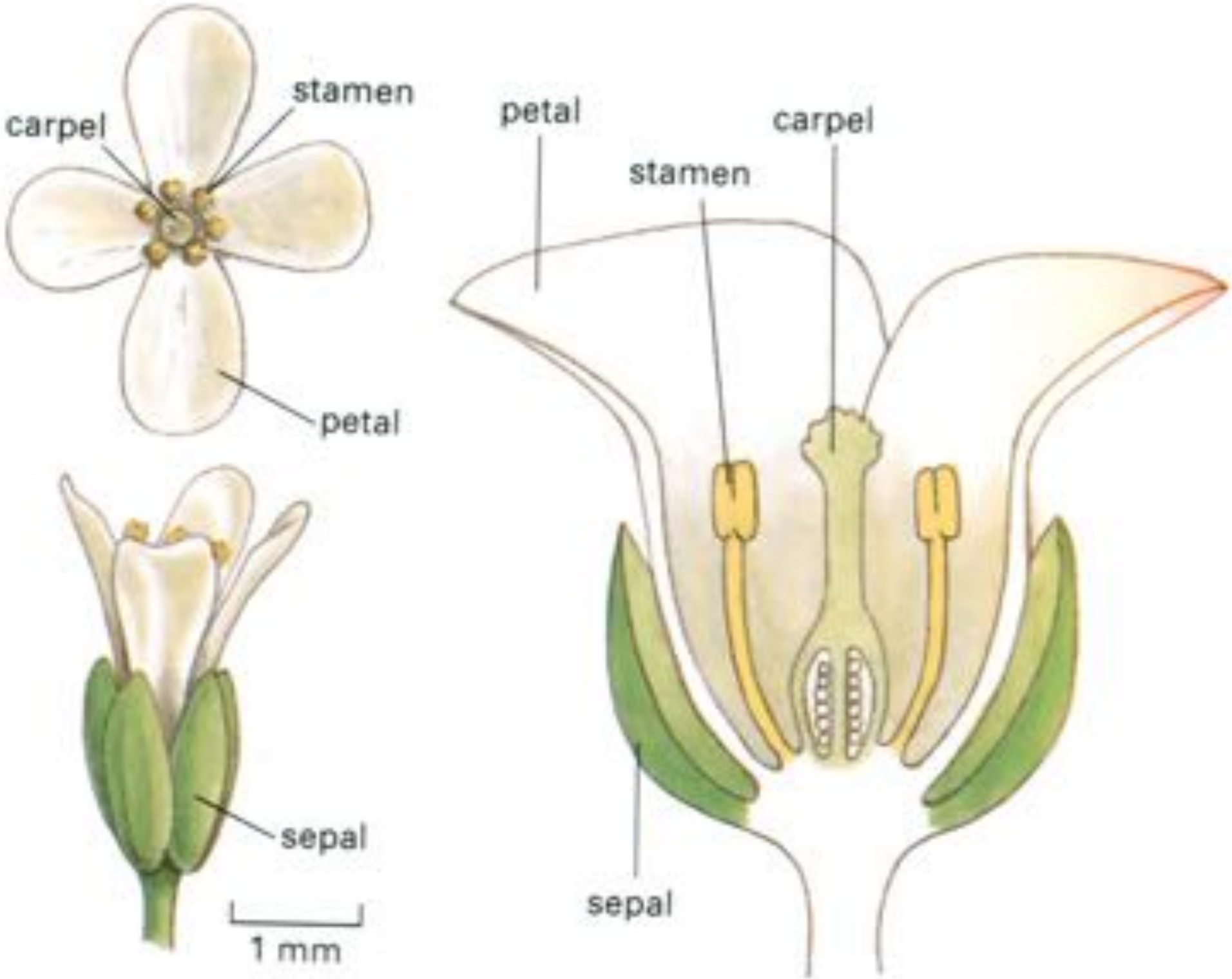


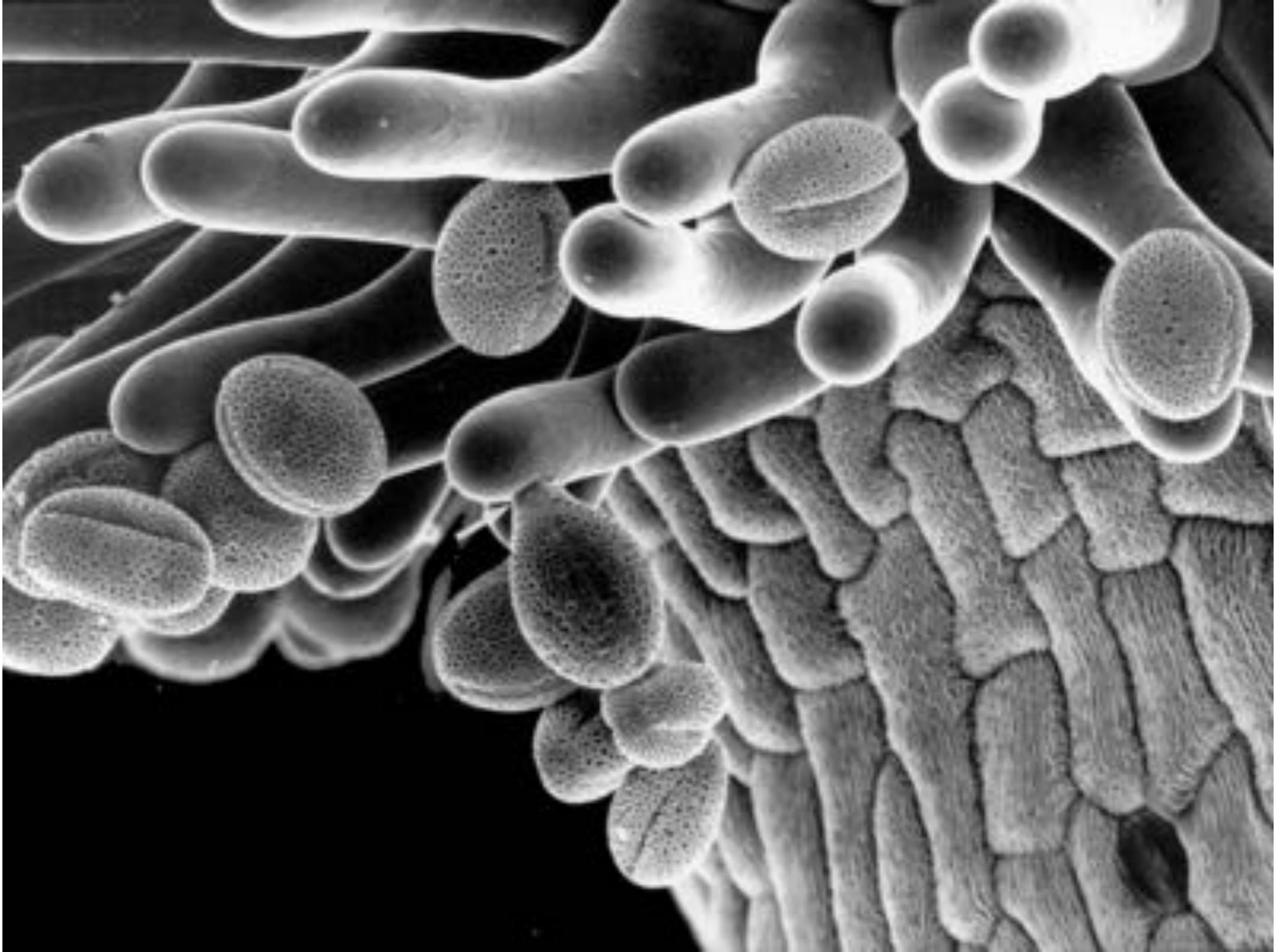
Arabidopsis thaliana as a model plant system

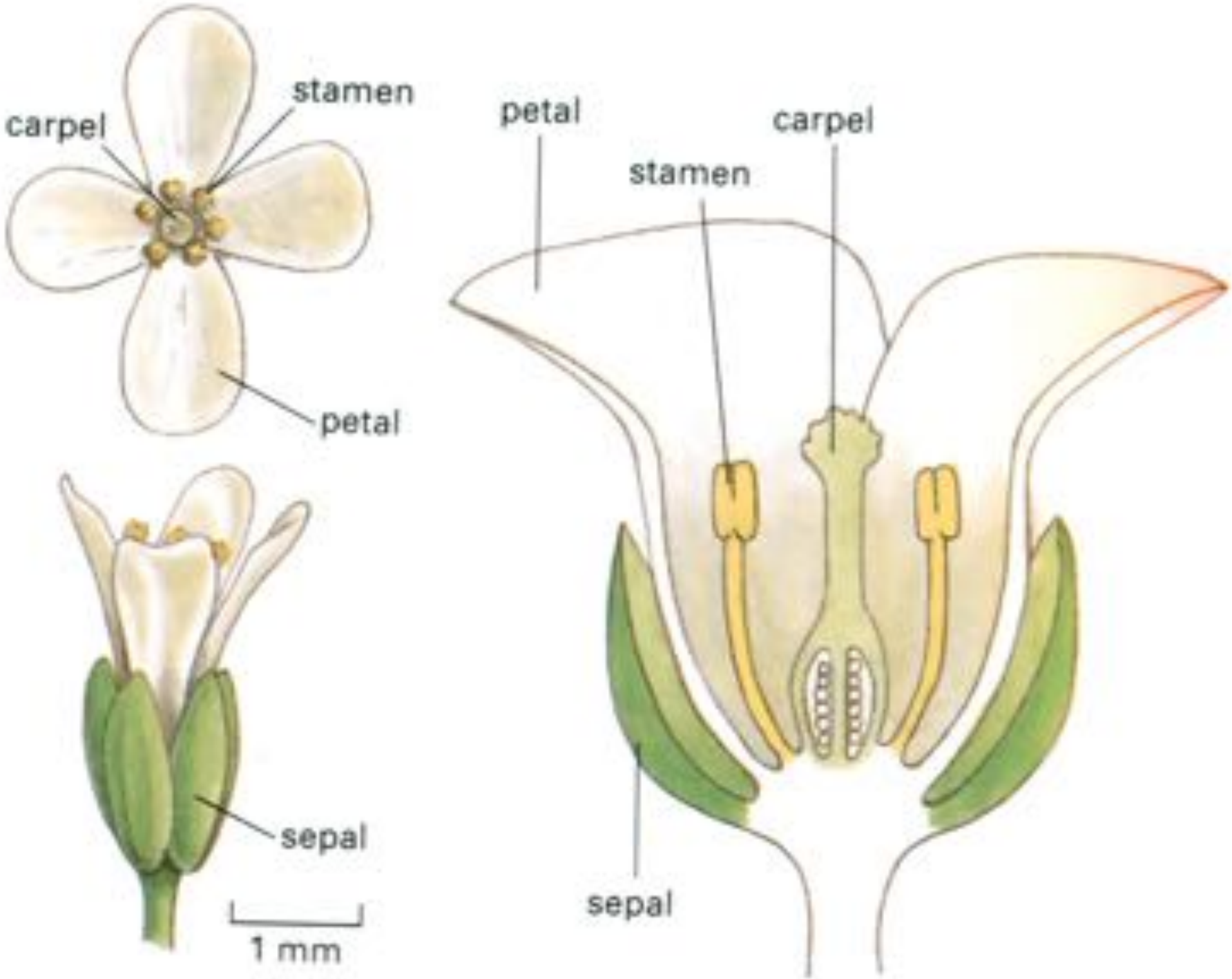




Arabidopsis thaliana has the best characterised plant genome.


carpel
stamen
petal
sepal
1 mm
petal
carpel
stamen
sepal




carpel
stamen
petal
sepal
1 mm
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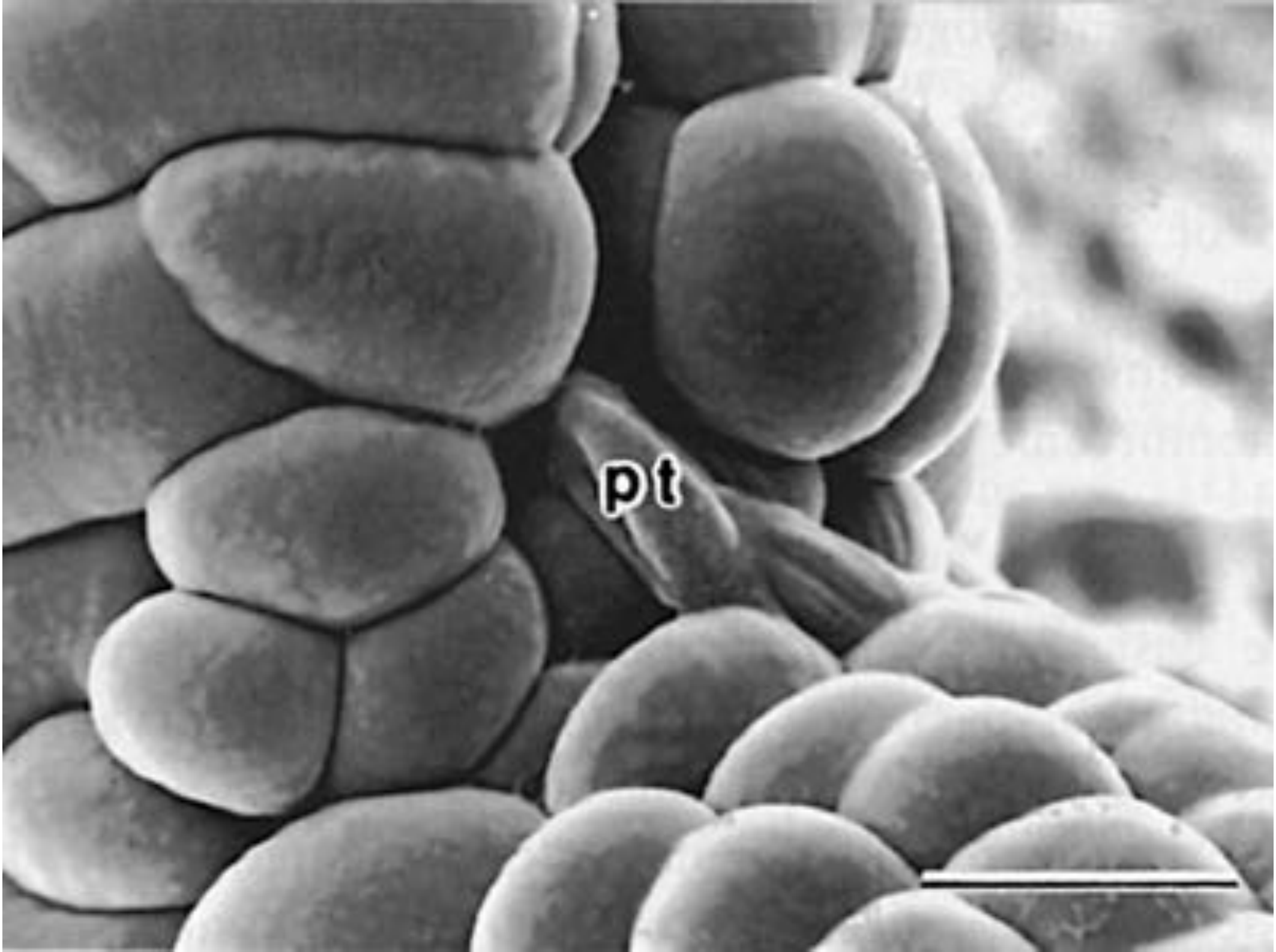
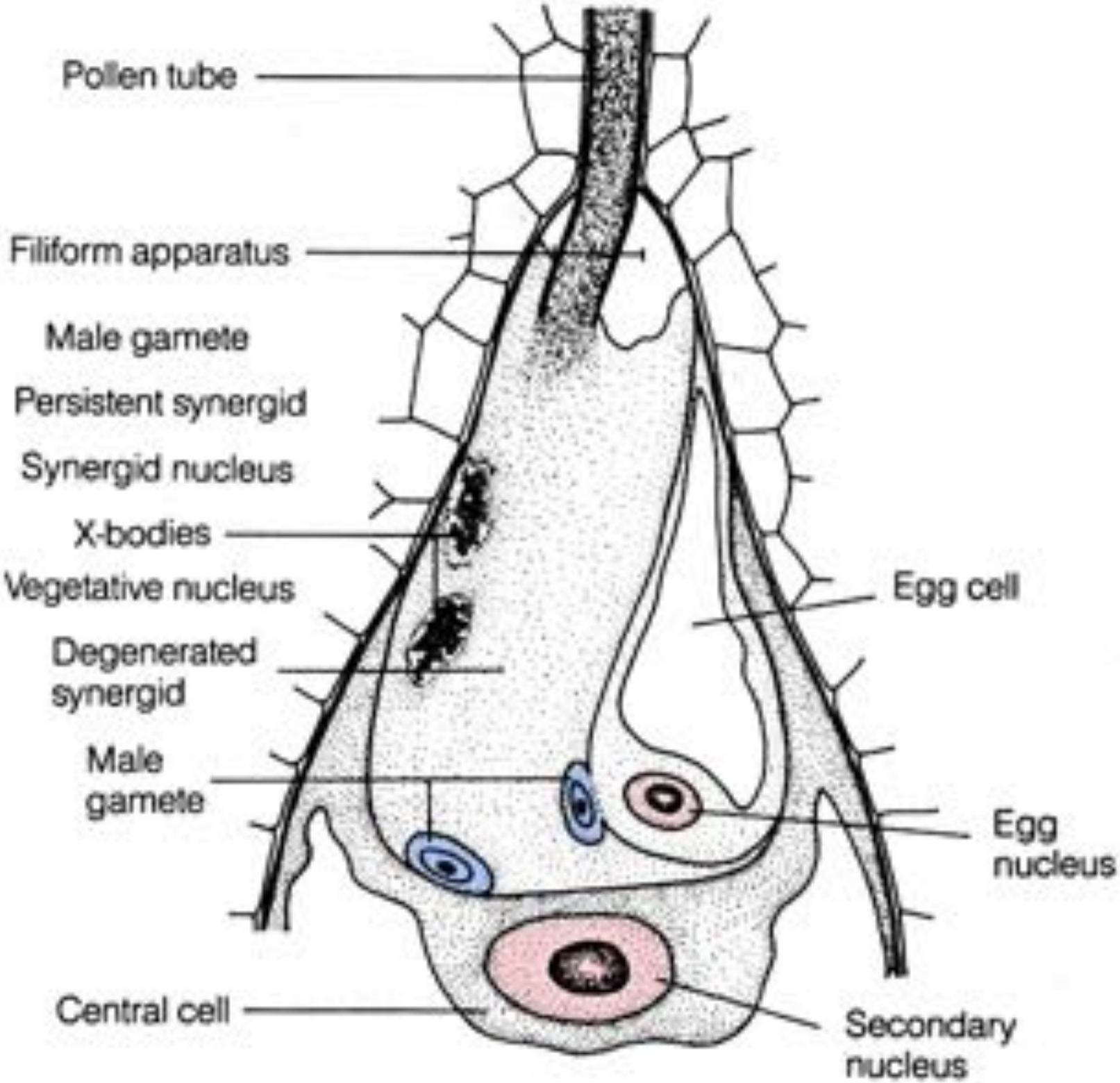
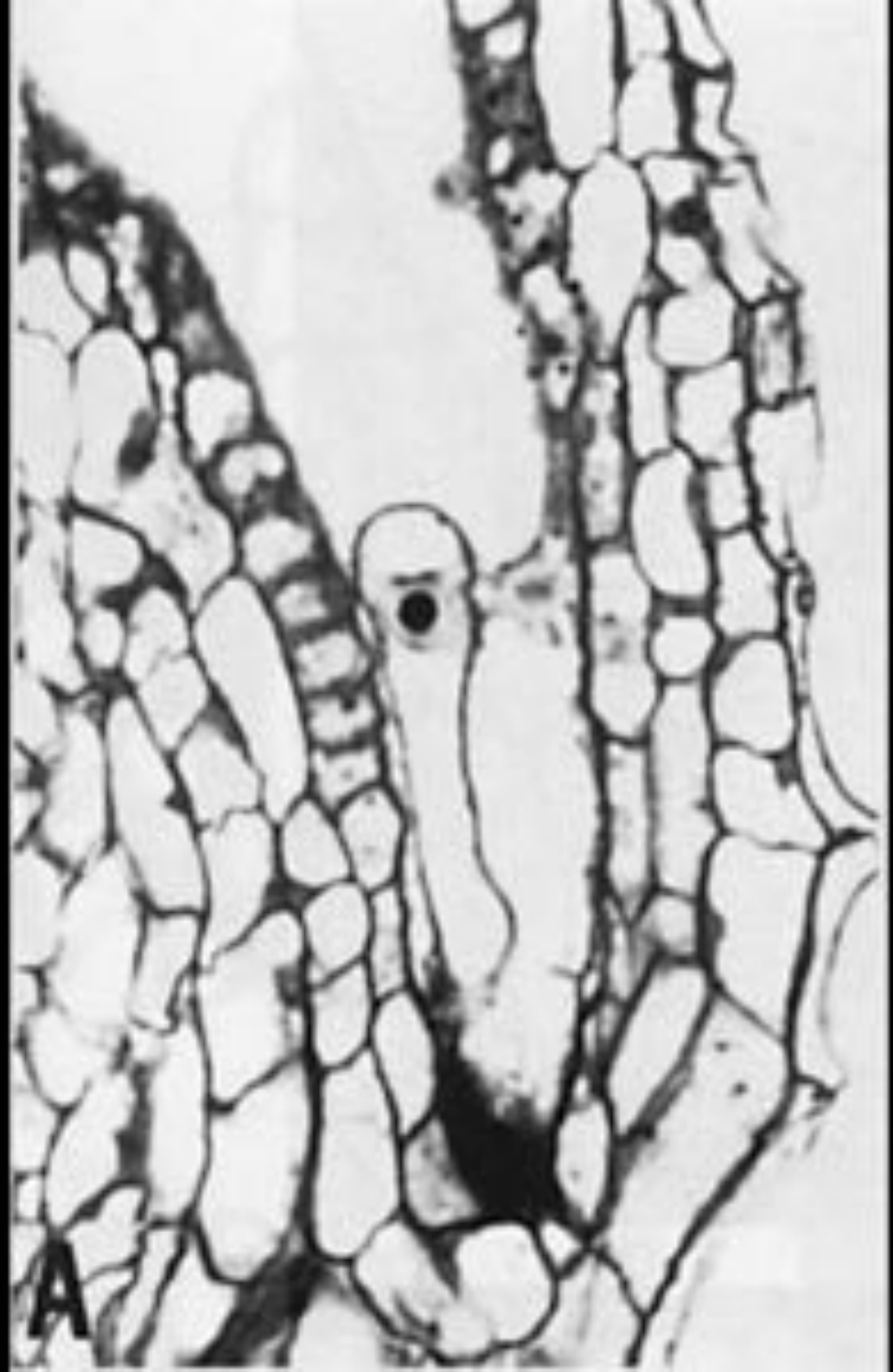
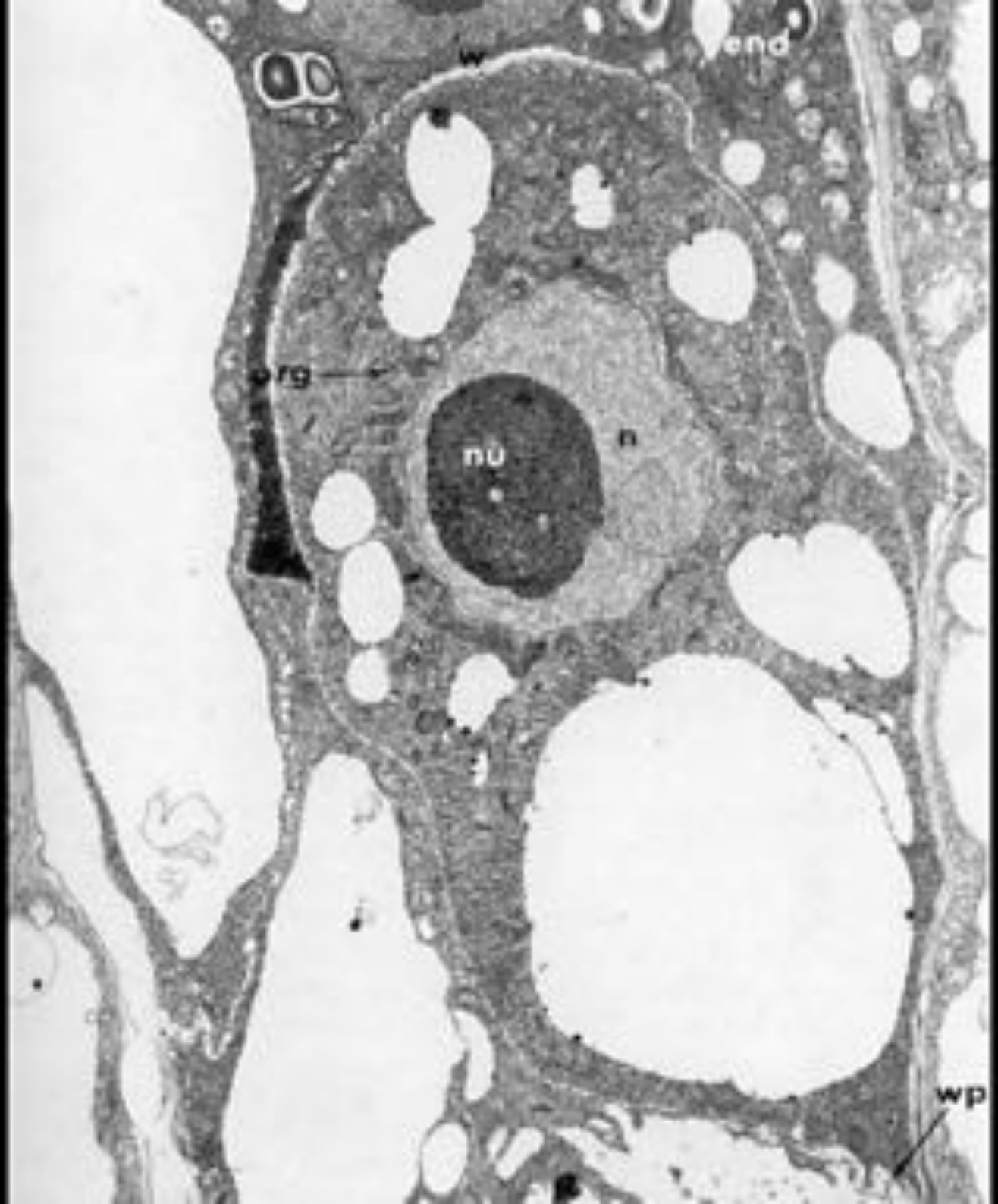
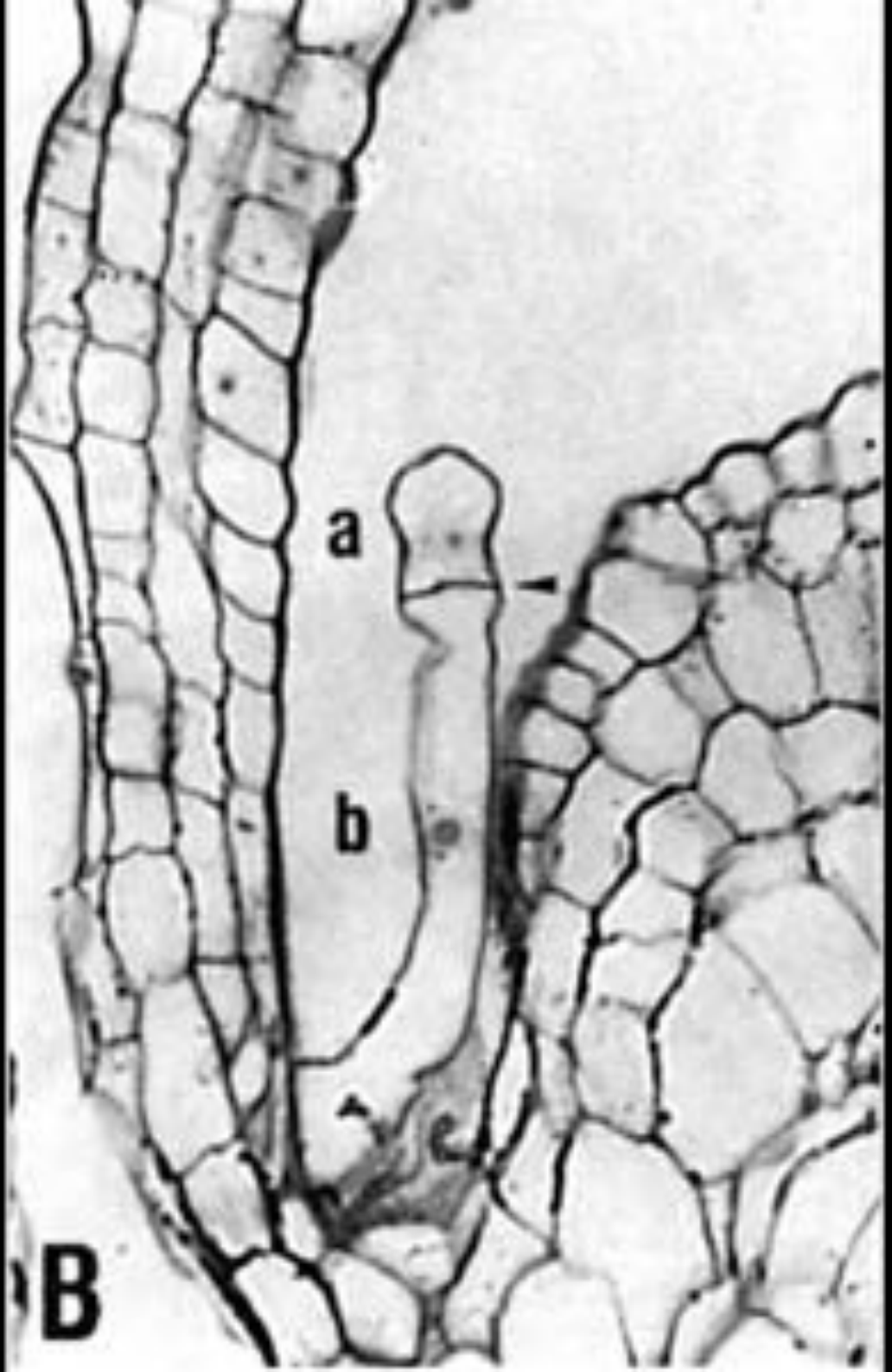

pt

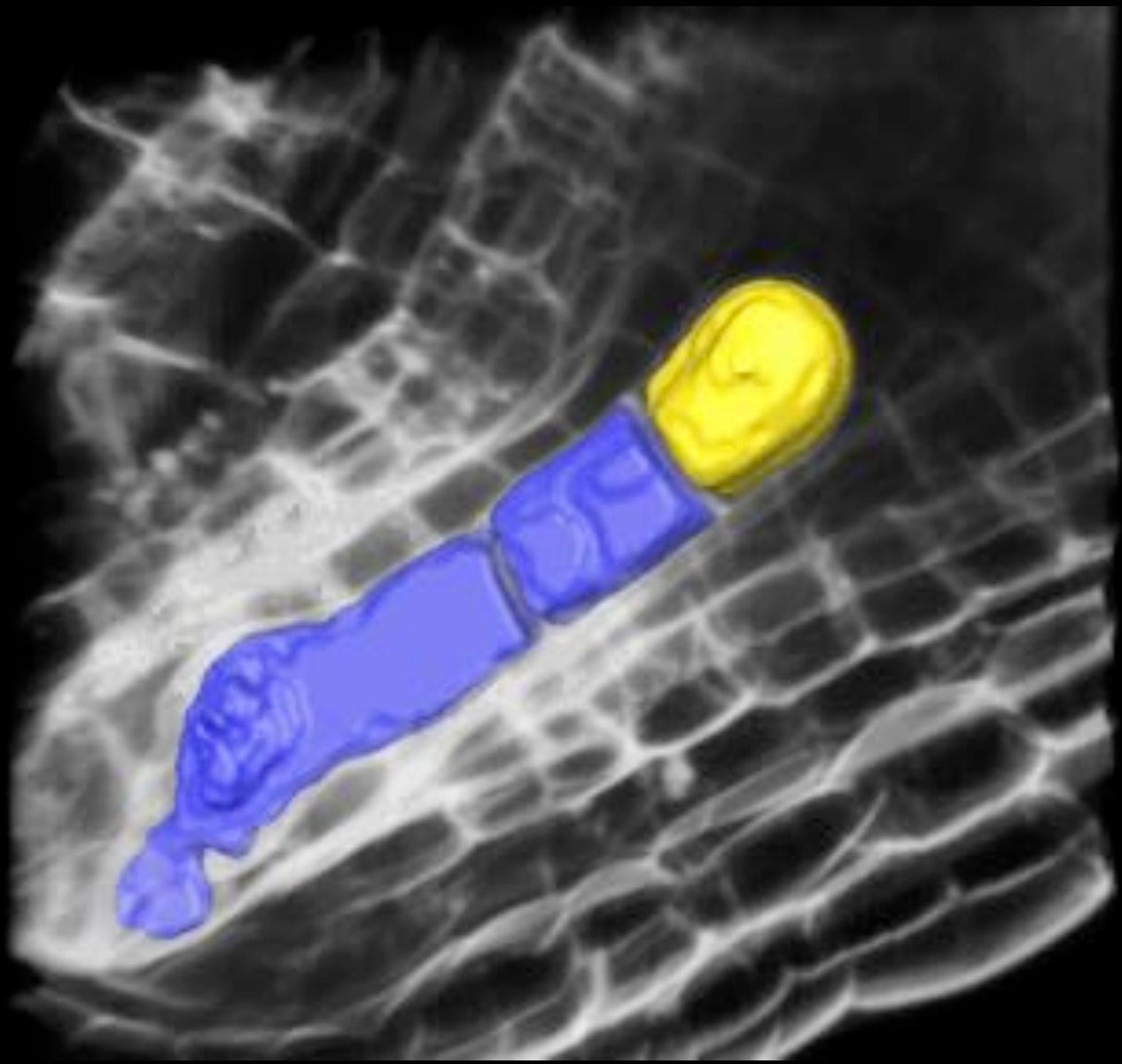

Pollen tube
Filiform apparatus
Male gamete
Persistent synergid
Synergid nucleus
X-bodies
Vegetative nucleus
Degenerated synergid
Male gamete
Central cell
Egg cell
Egg nucleus
Secondary nucleus


A

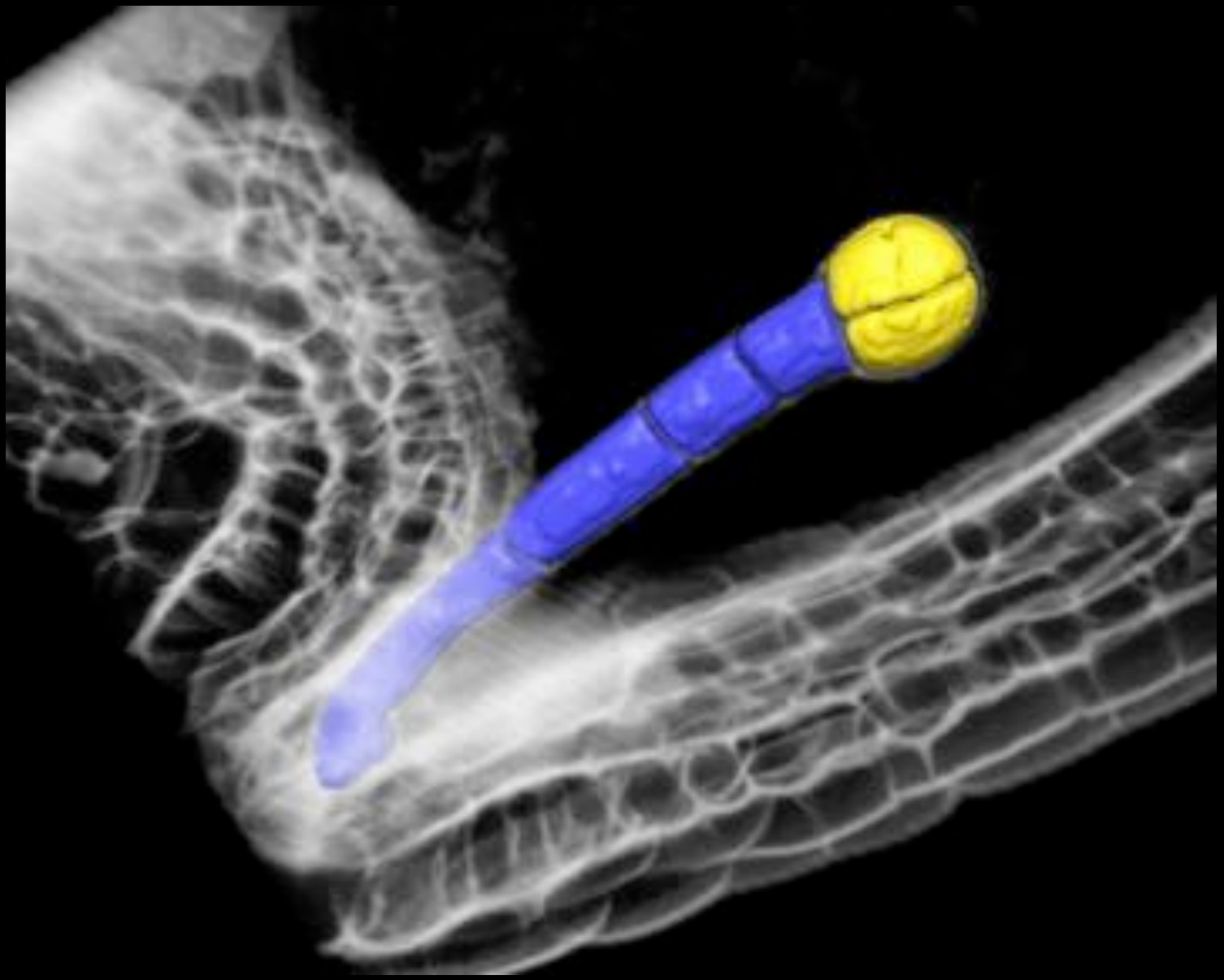

end
org
nu
n
wp


a
b
B

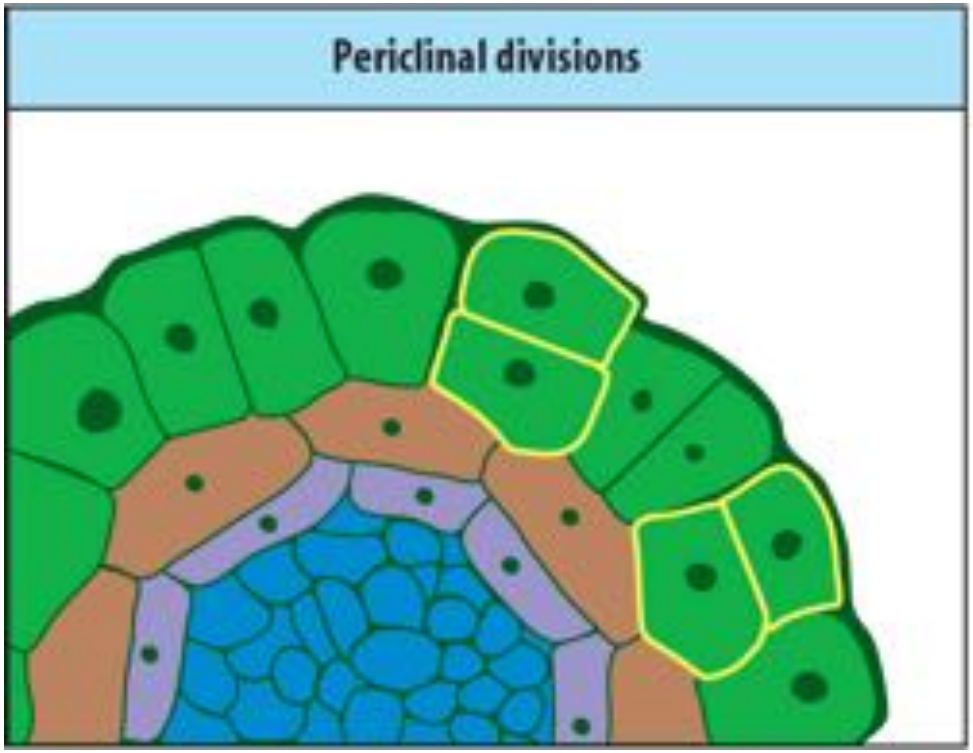
1 cell embryo

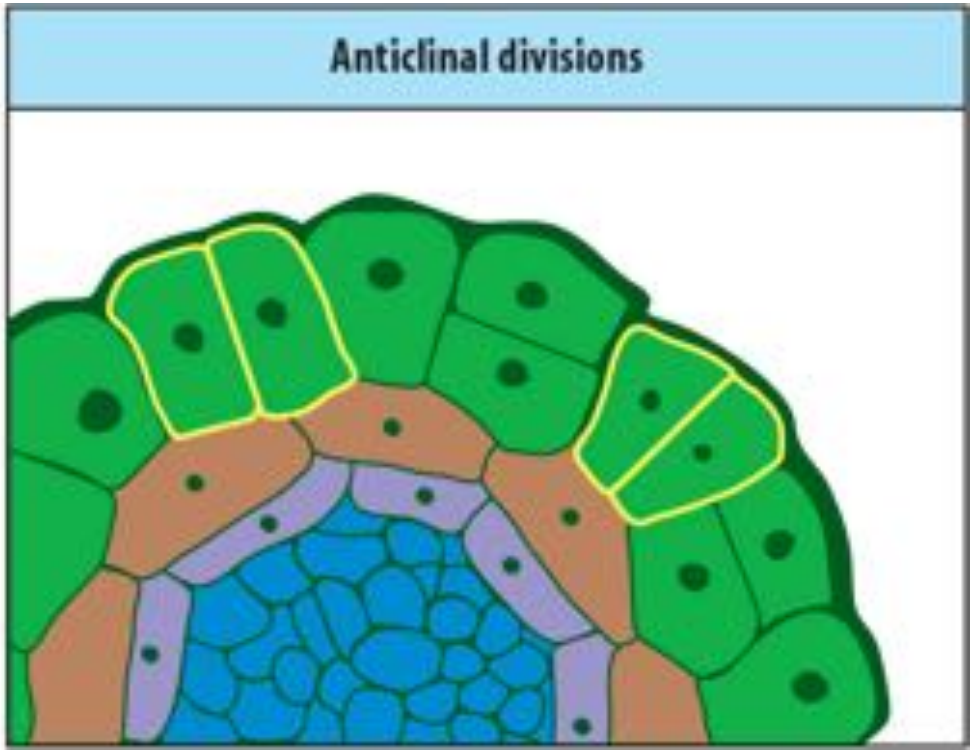


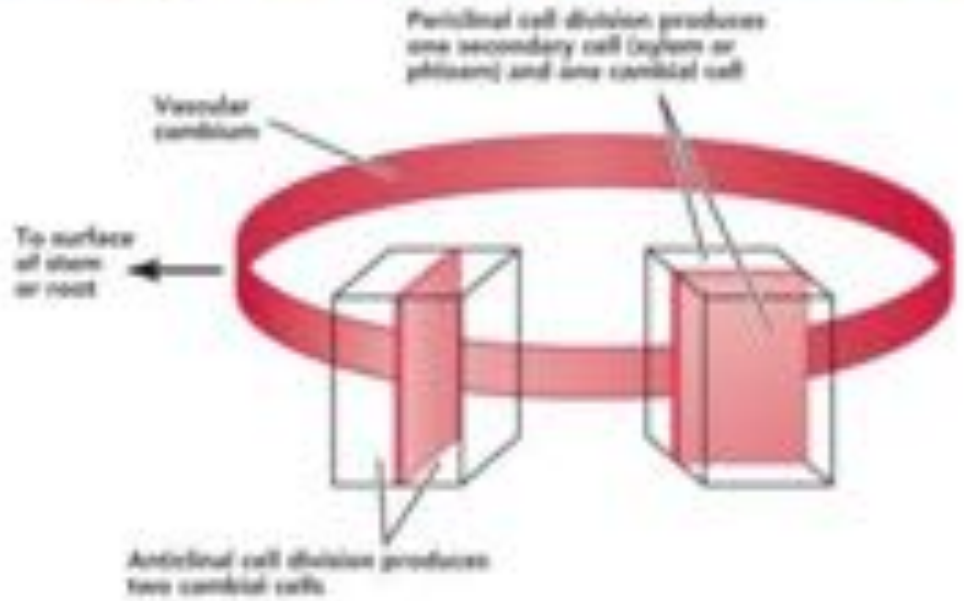
4 cell embryo

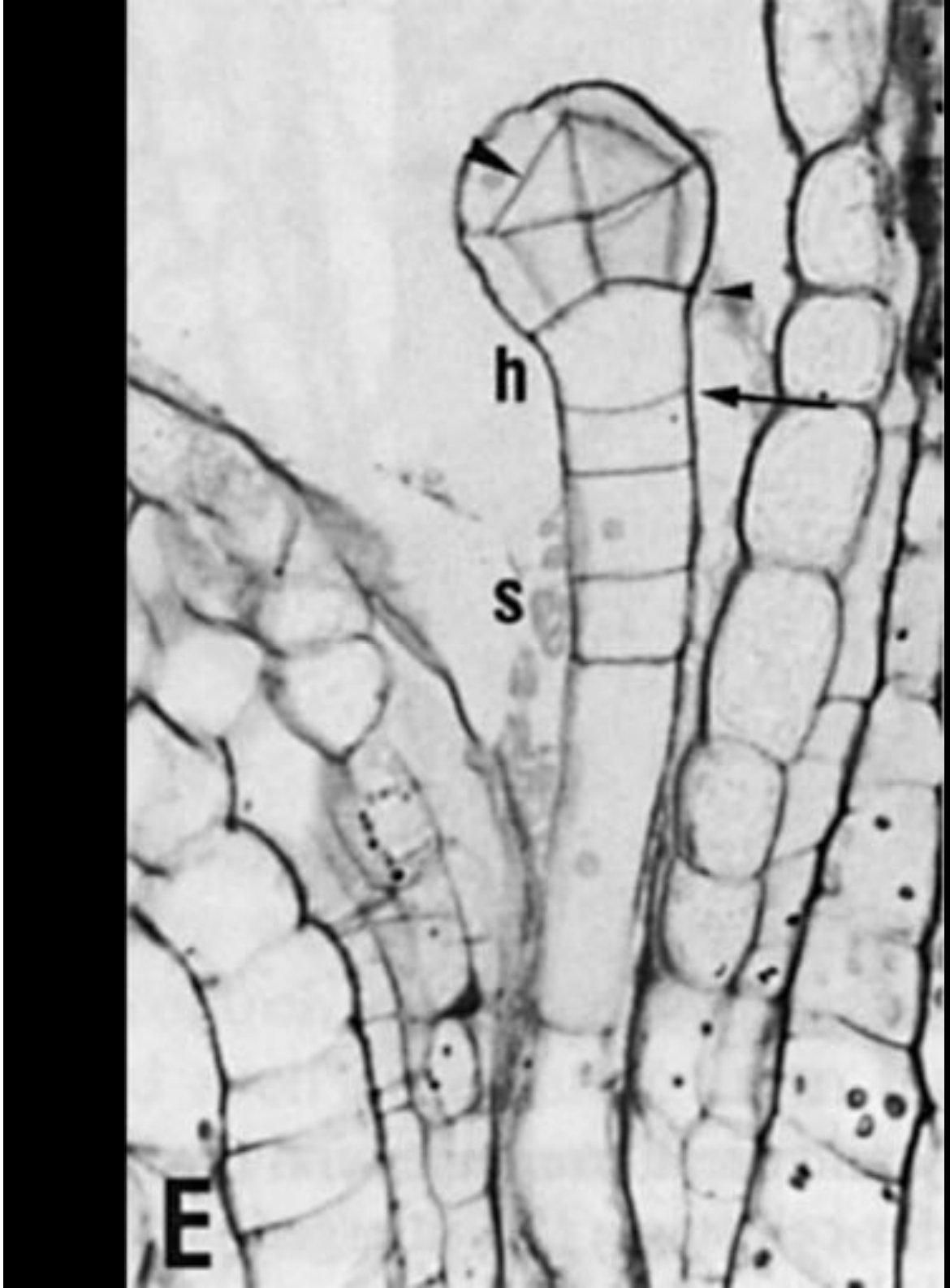


Octant stage embryo

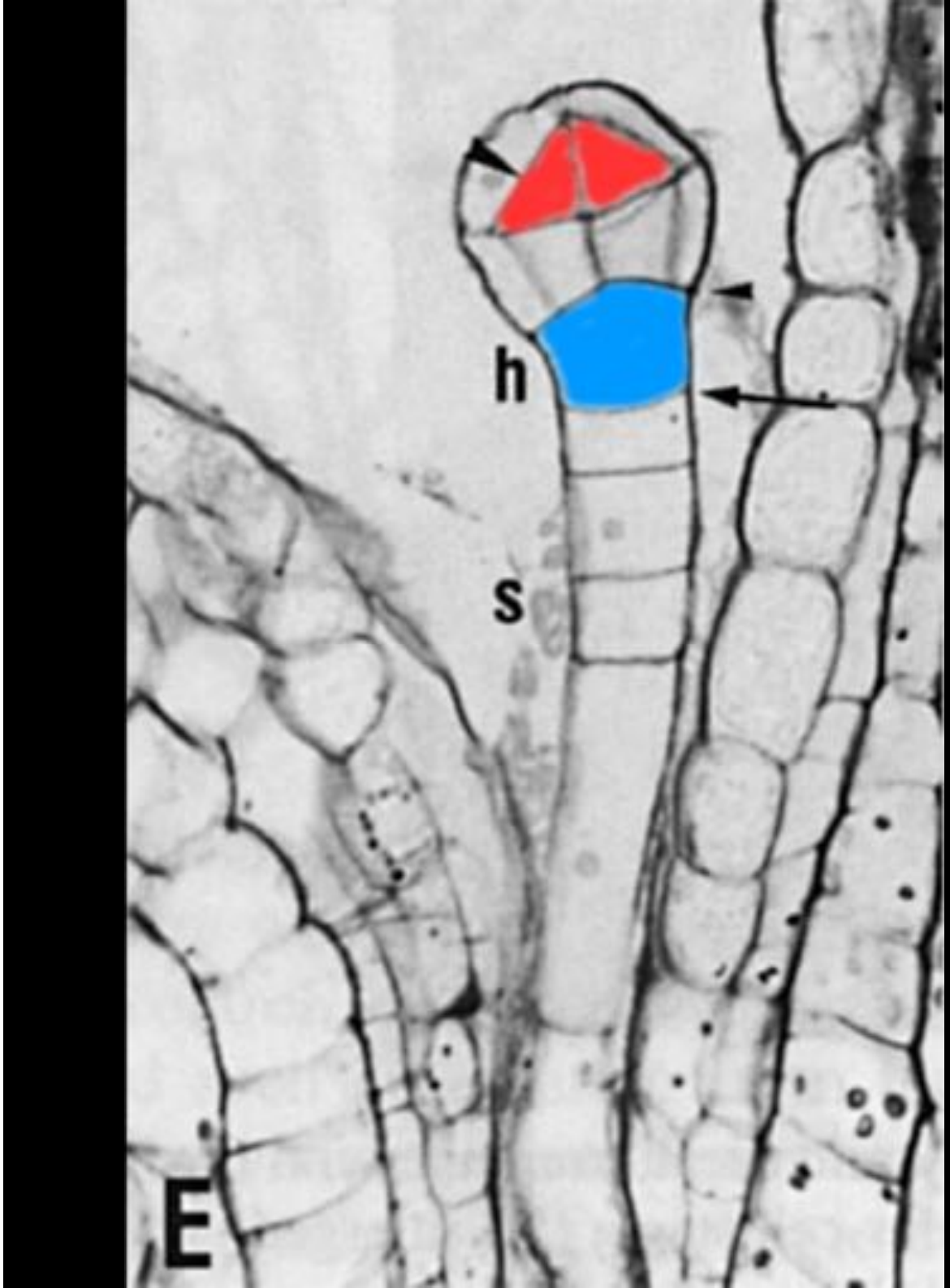

Periclinal divisions


Anticlinal divisions


Vascular cambium
To surface of stem or root



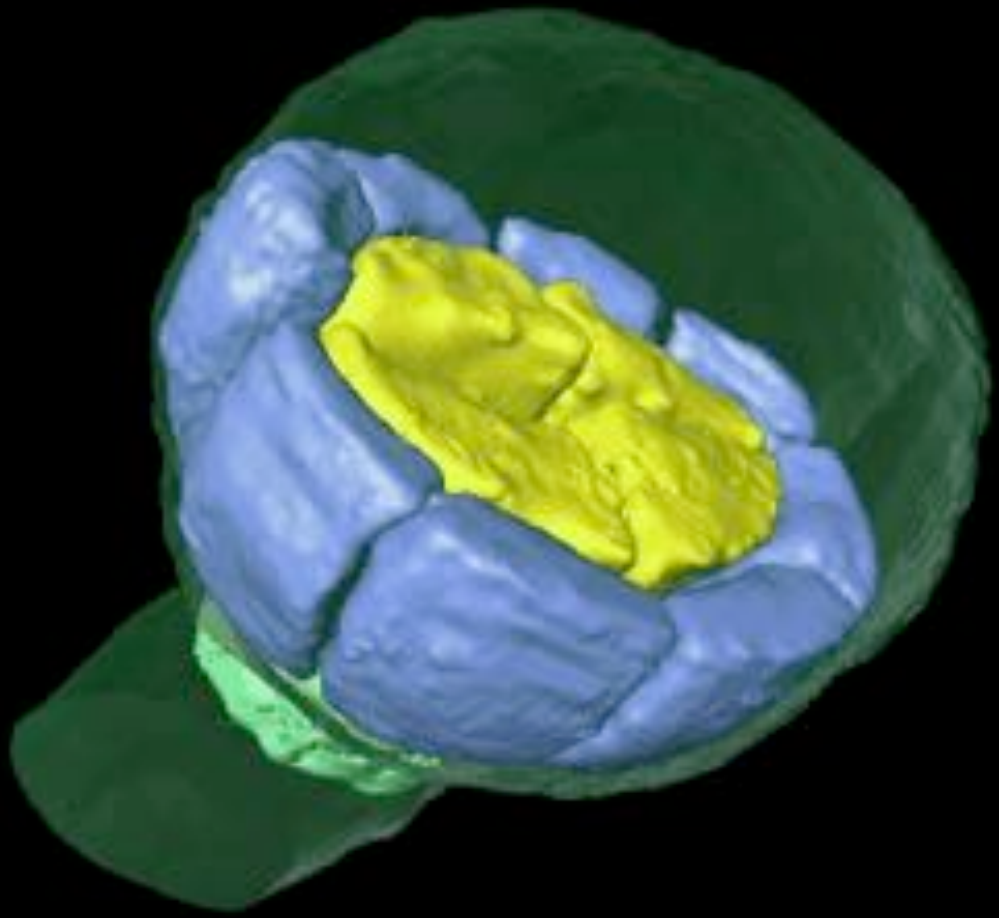
Radial asymmetry in the 16-cell embryo



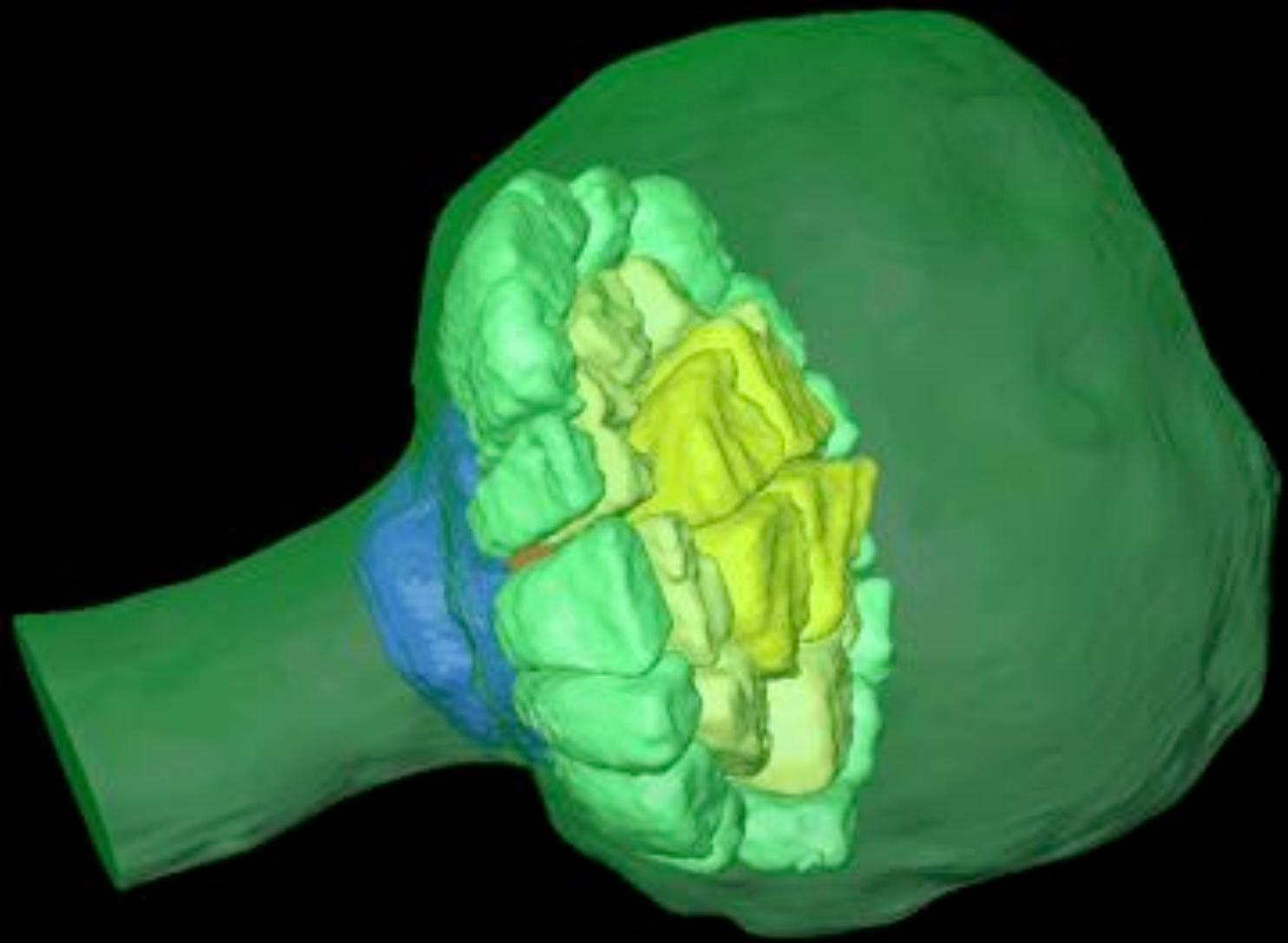
Radial asymmetry in the 16-cell embryo

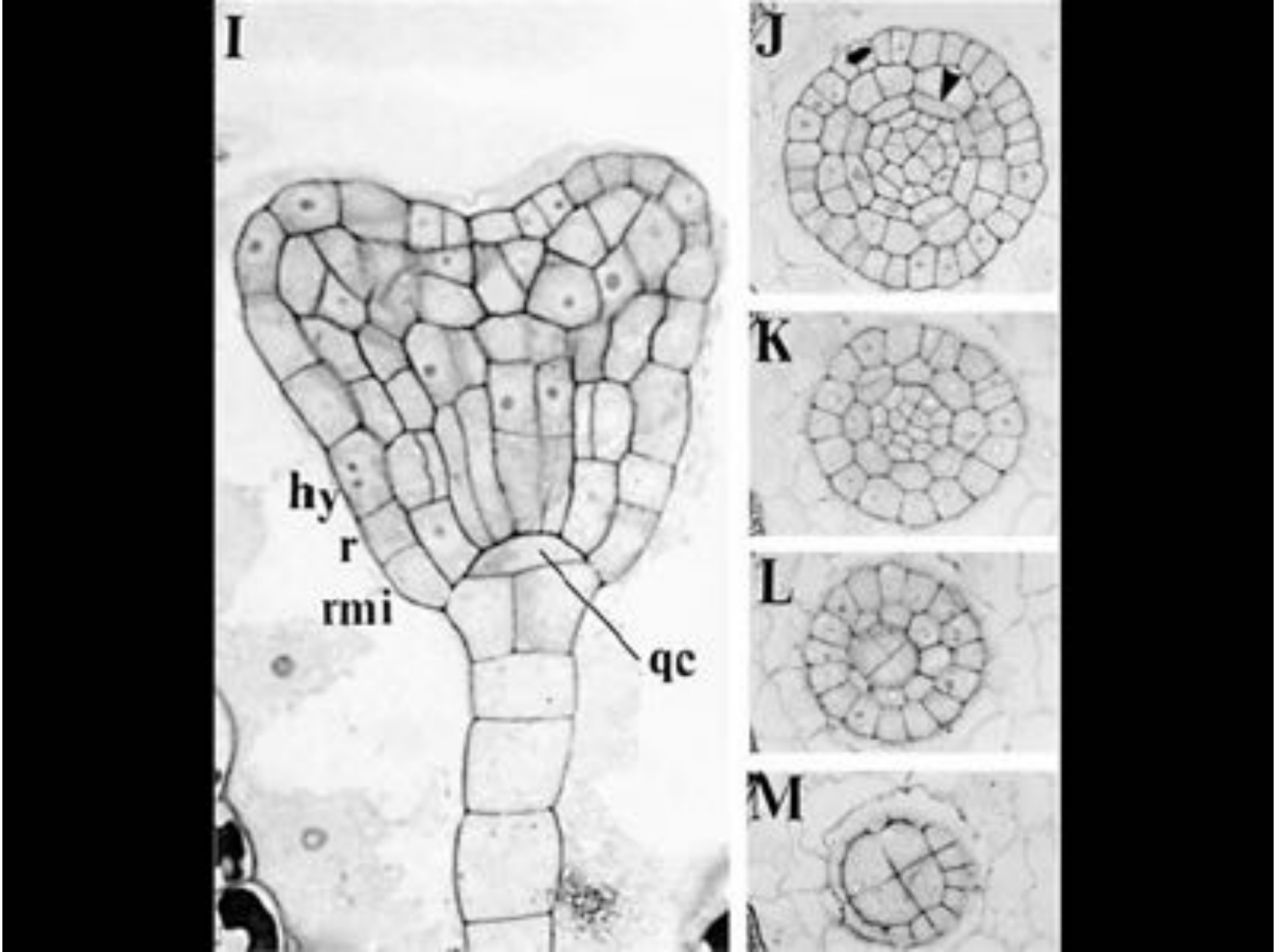
Specification of shoot and root meristems

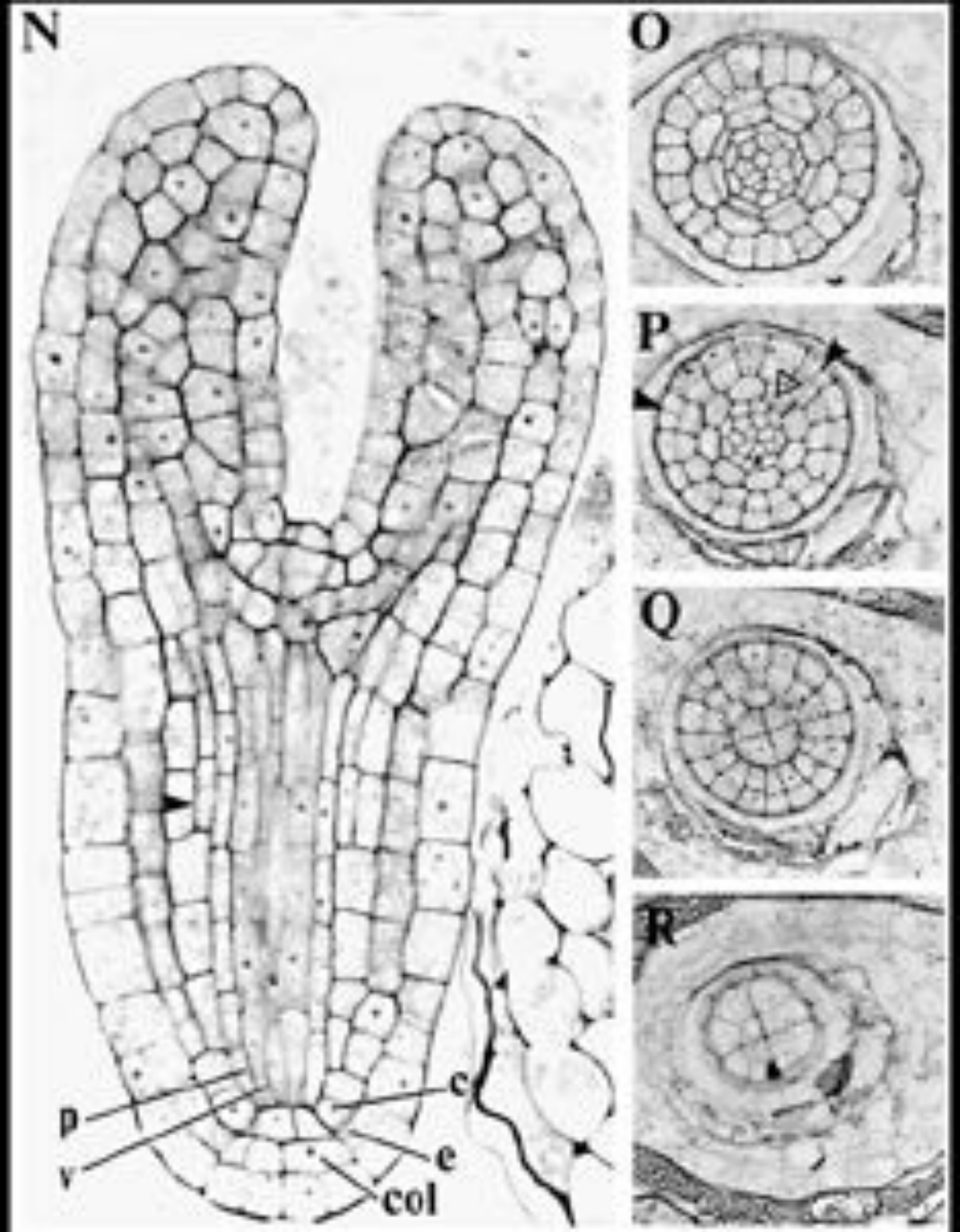
Protoderm stage embryo



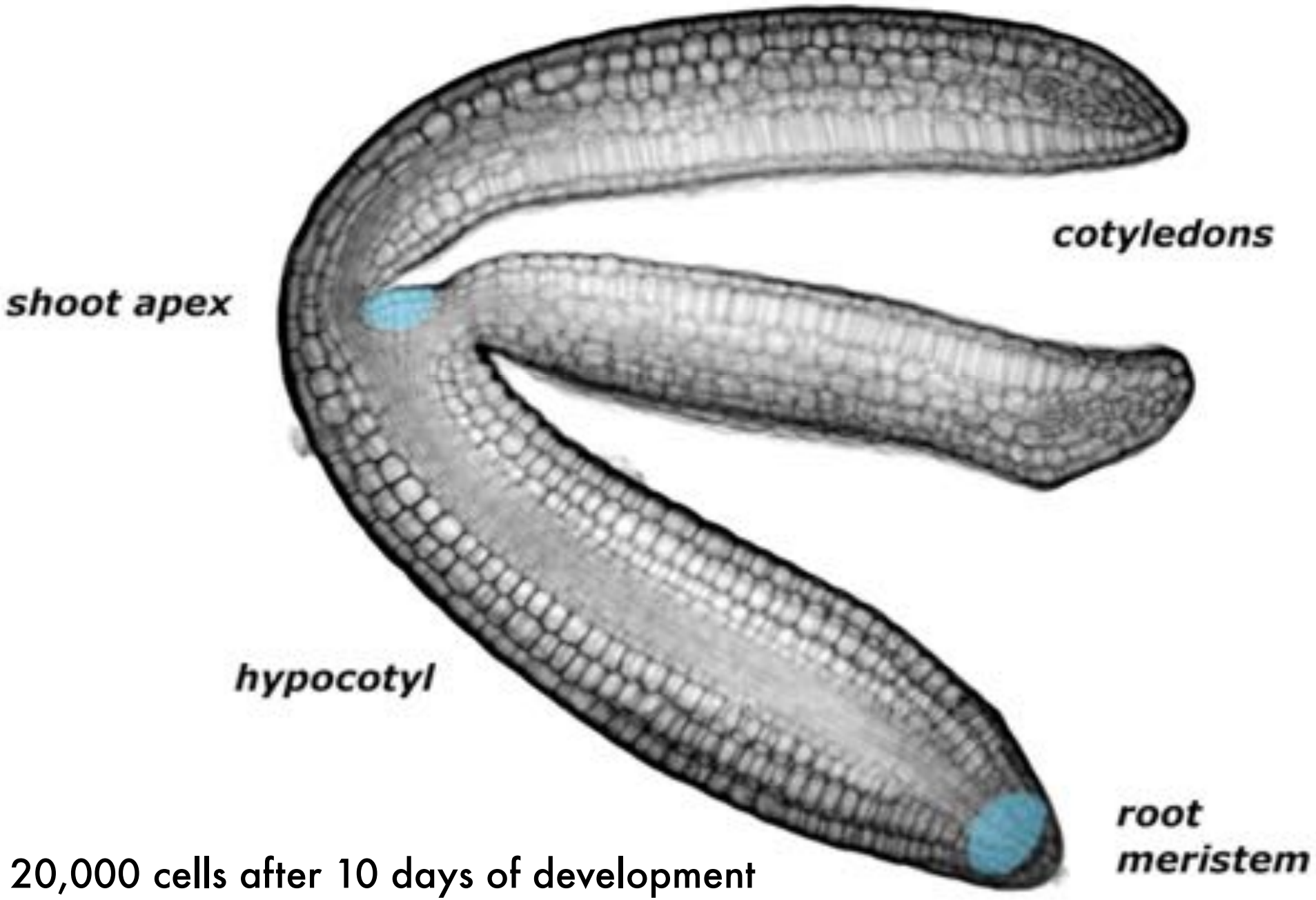
Globular stage embryo




I
hy
r
rmi
qc
J
K
L
M


N
O
P
Q
R
p
v
c
e
col

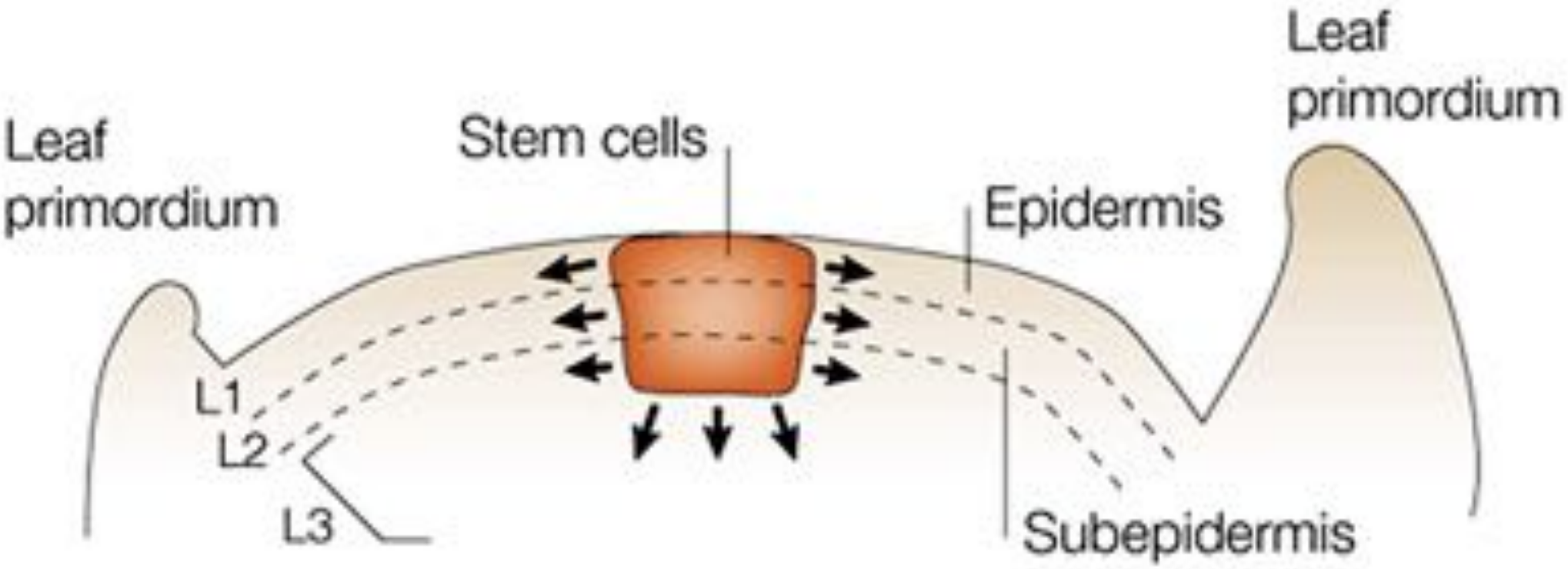
mature embryo



20,000 cells after 10 days of development

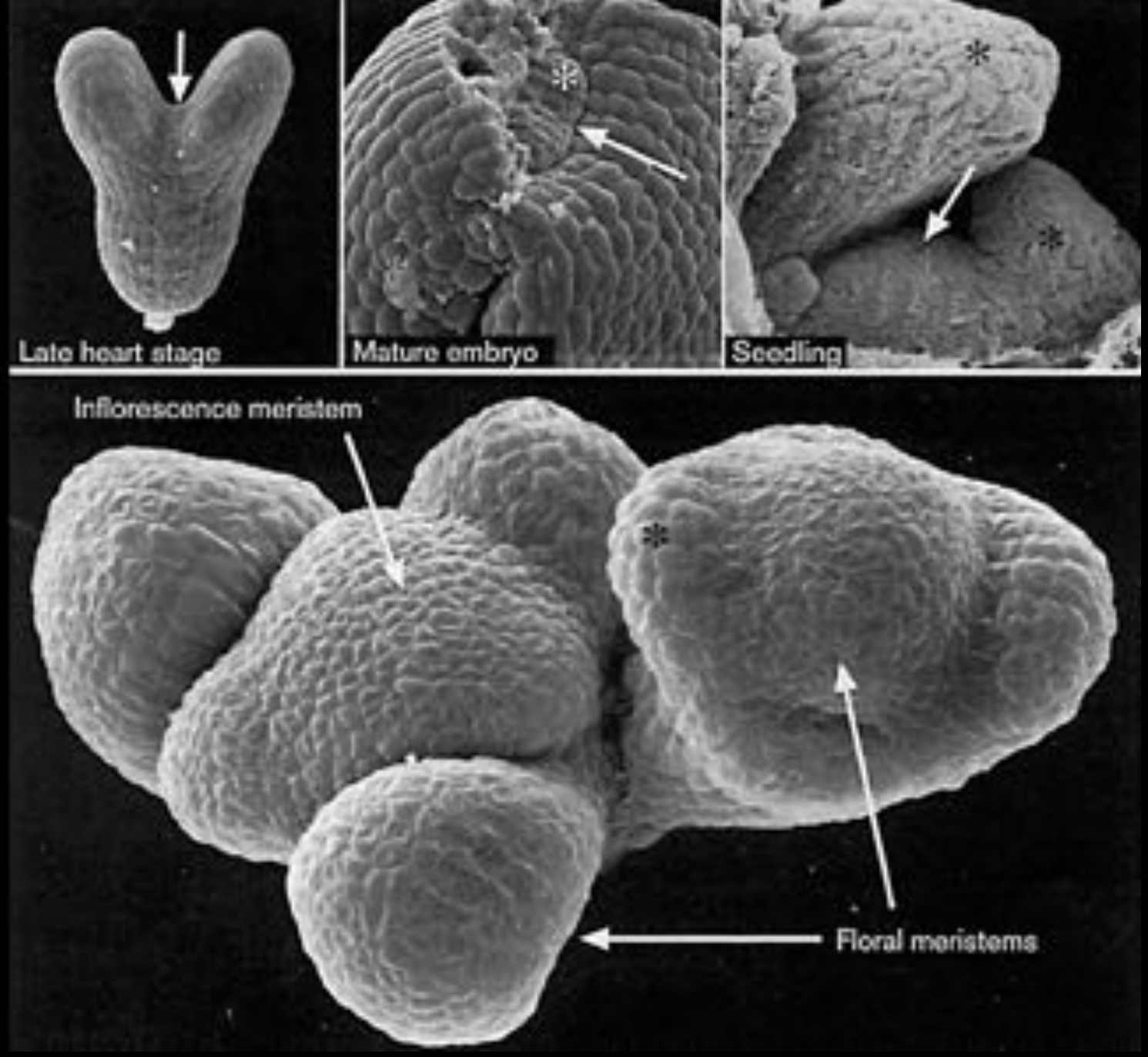
Arabidopsis thaliana
germinating seed

Arabidopsis thaliana seeding
4 days after germination

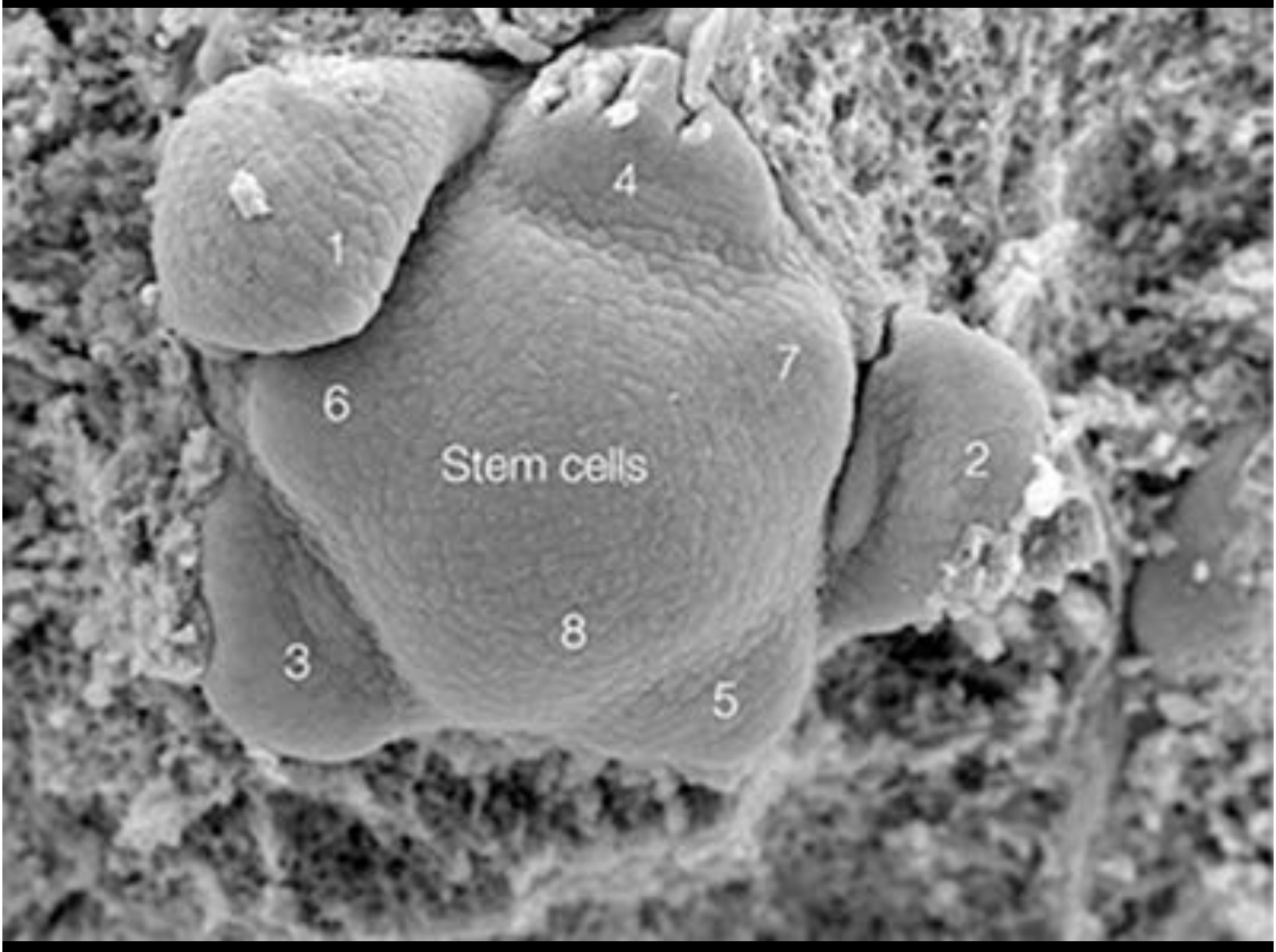


A meristem is self-organising and renews itself.

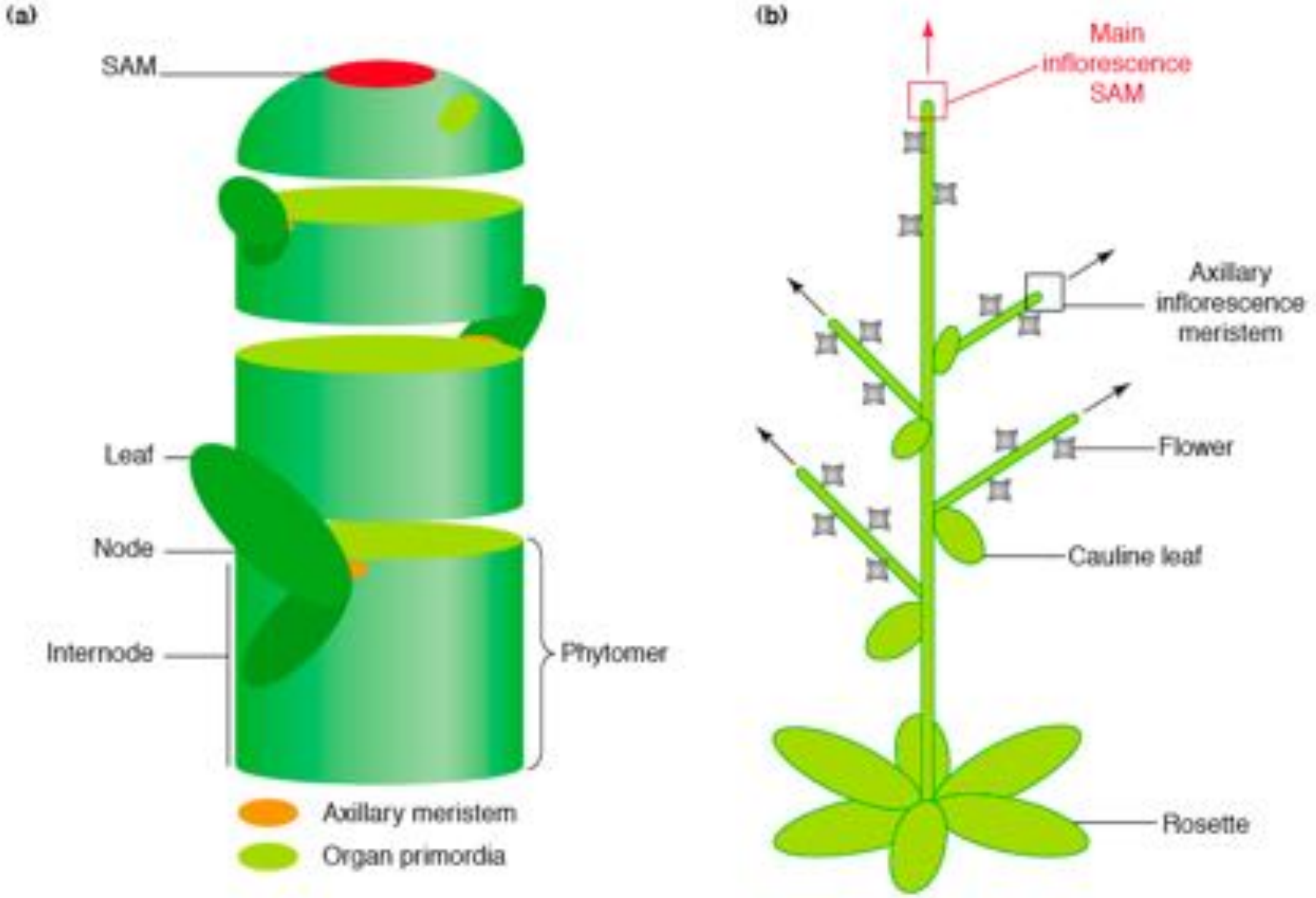
Arabidopsis apical meristems

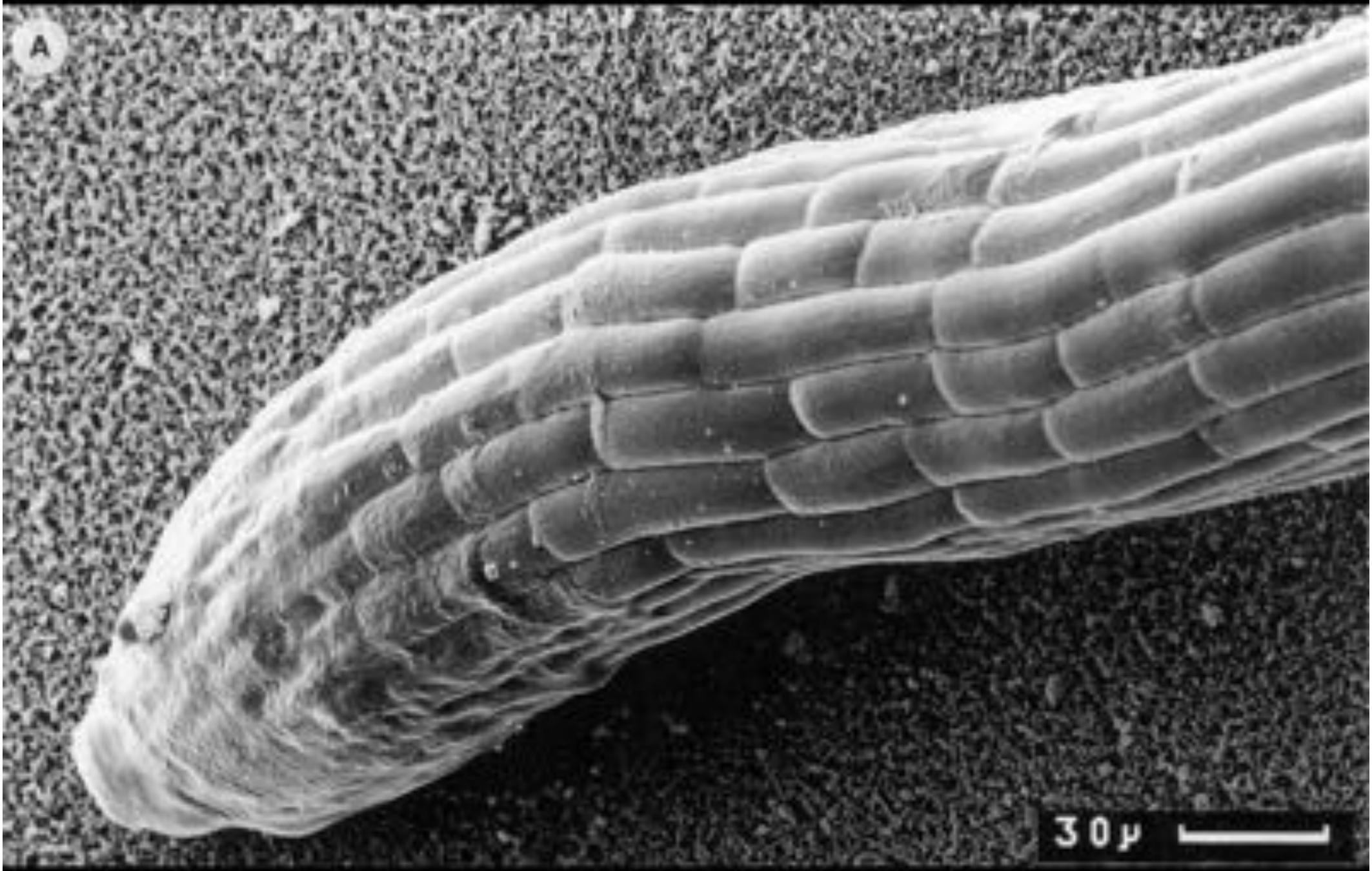


The shoot meristem is branched and indeterminate, capable of producing lateral primordia at the flanks of the meristem.


1
4
6
7
Stem cells
2
8
3
5

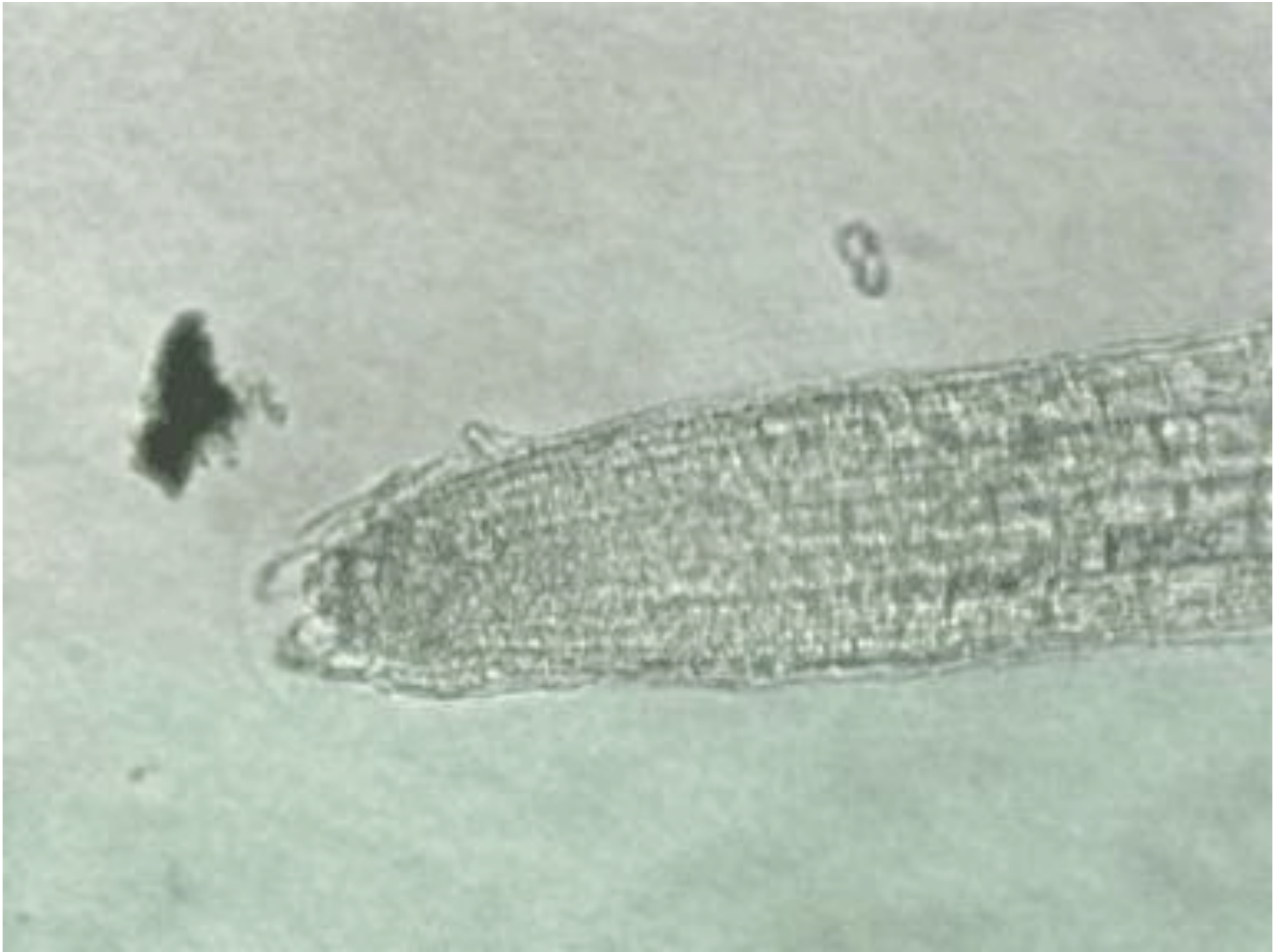
Modular growth and production of lateral organs

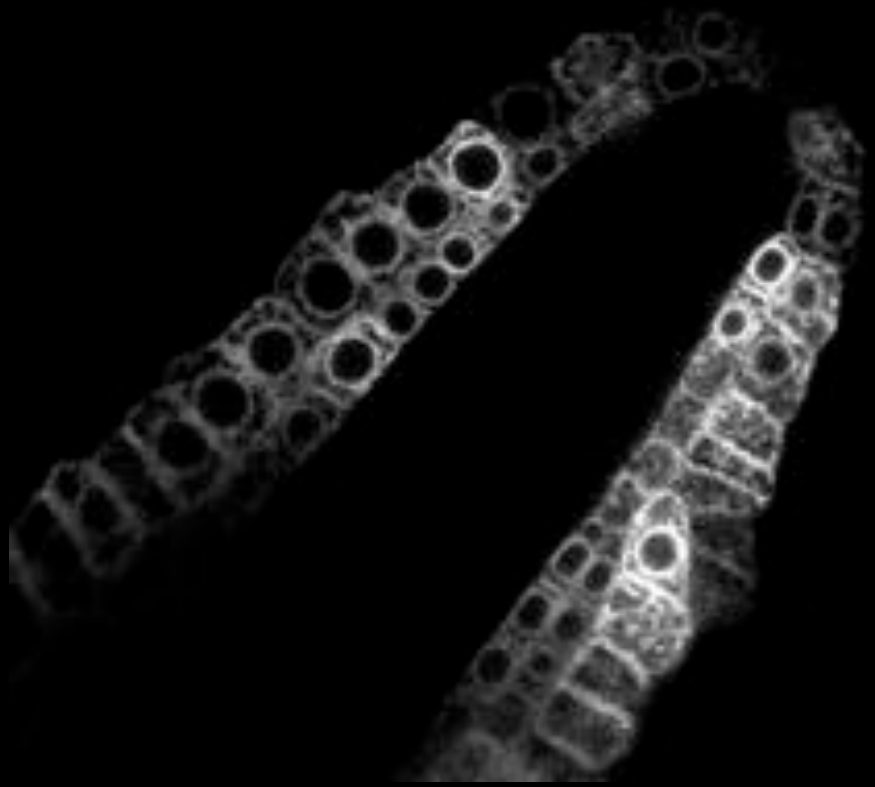


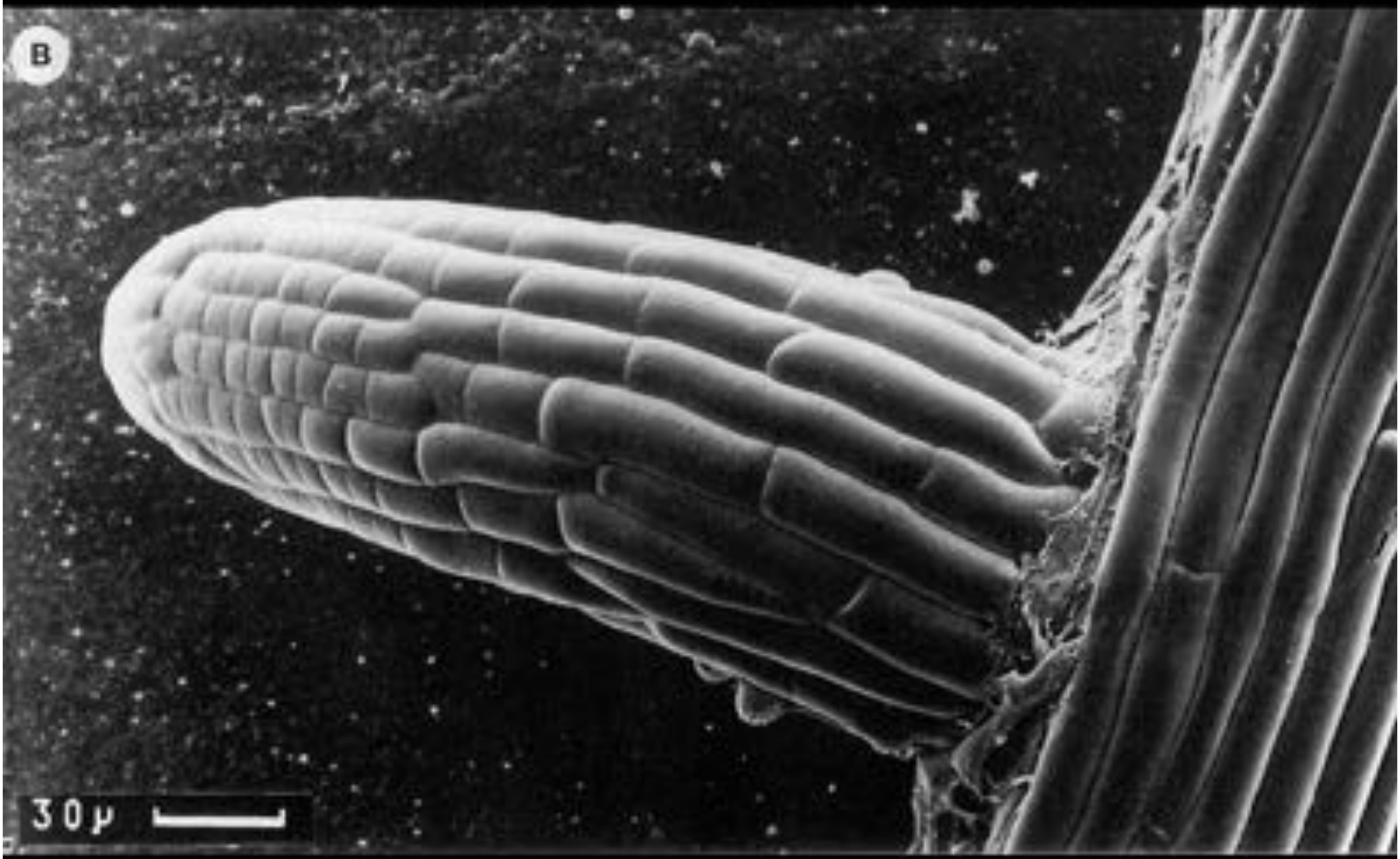


Arabidopsis root tip

Indeterminate growth of the Arabidopsis root meristem

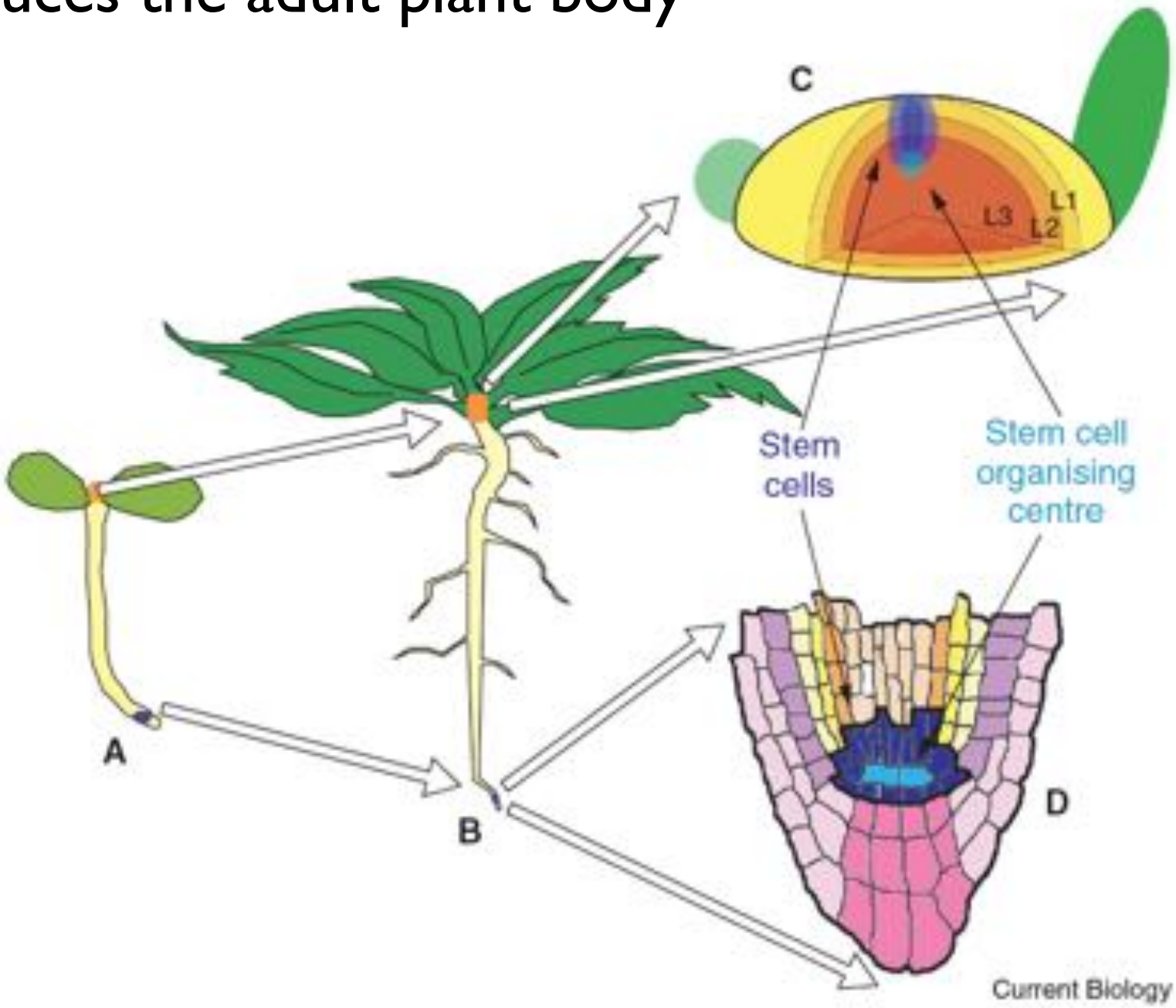






Arabidopsis lateral root

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



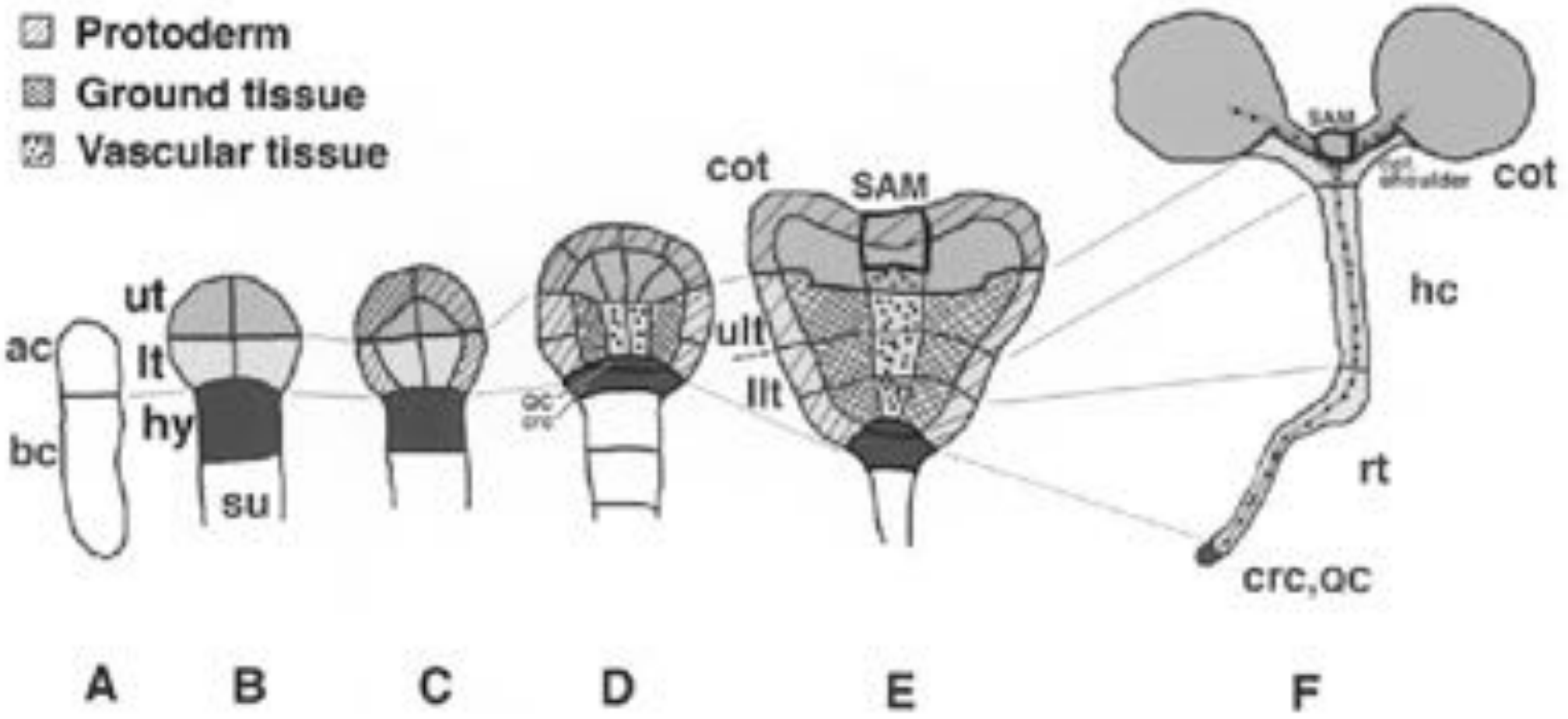
How is an adult body plan built?

Precise sequence of divisions during early embryogenesis.

Are plant cell fates controlled by

(1) segregation of determinants?

(2) positional information?


Protoderm
Ground tissue
Vascular tissue
ac
bc
ut
lt
hy
su
cot
SAM
ult
llt
qc
crc
hc
rt
crc,qc
A
B
C
D
E
F

5-hour embryo

100 µm

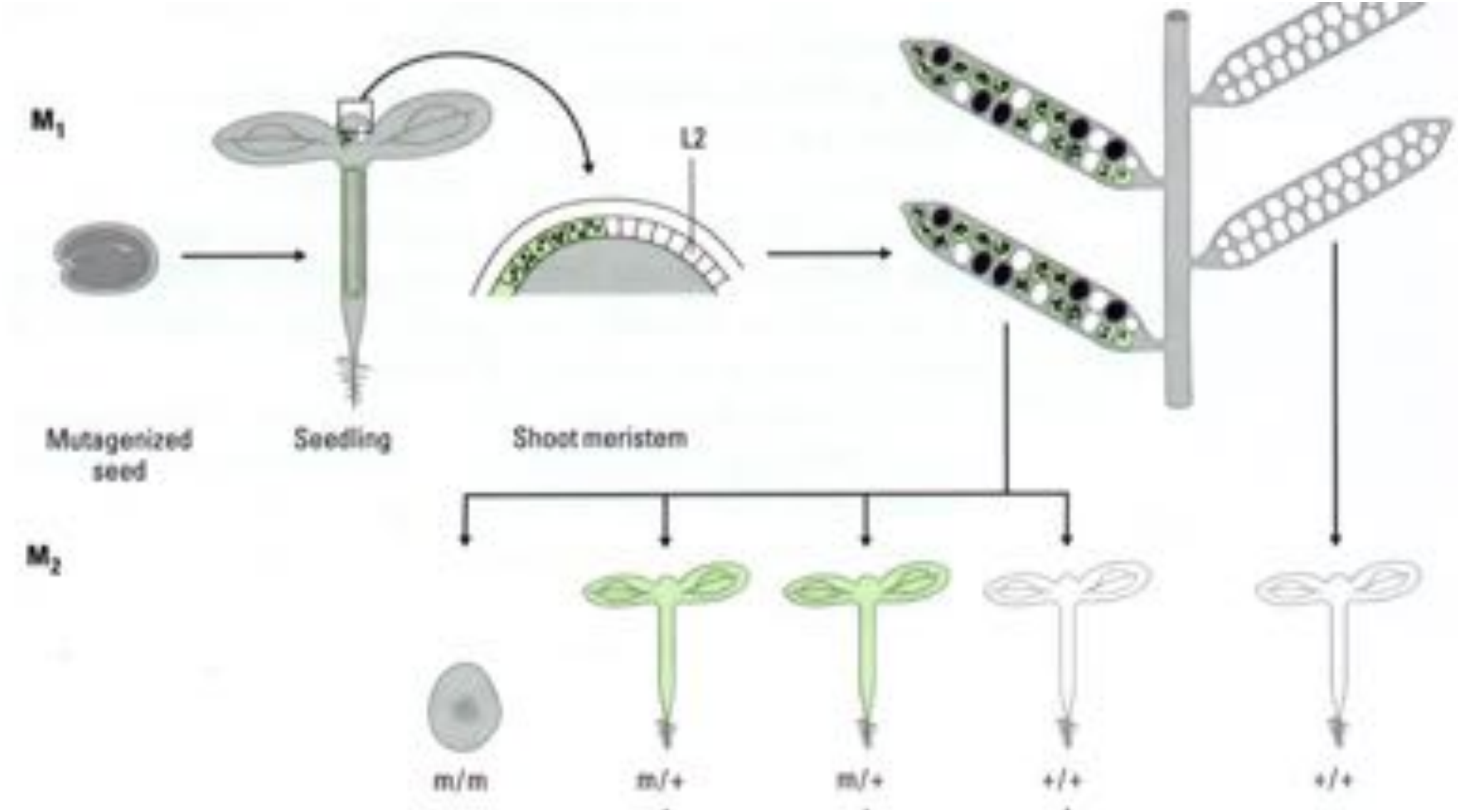
10-hour embryo

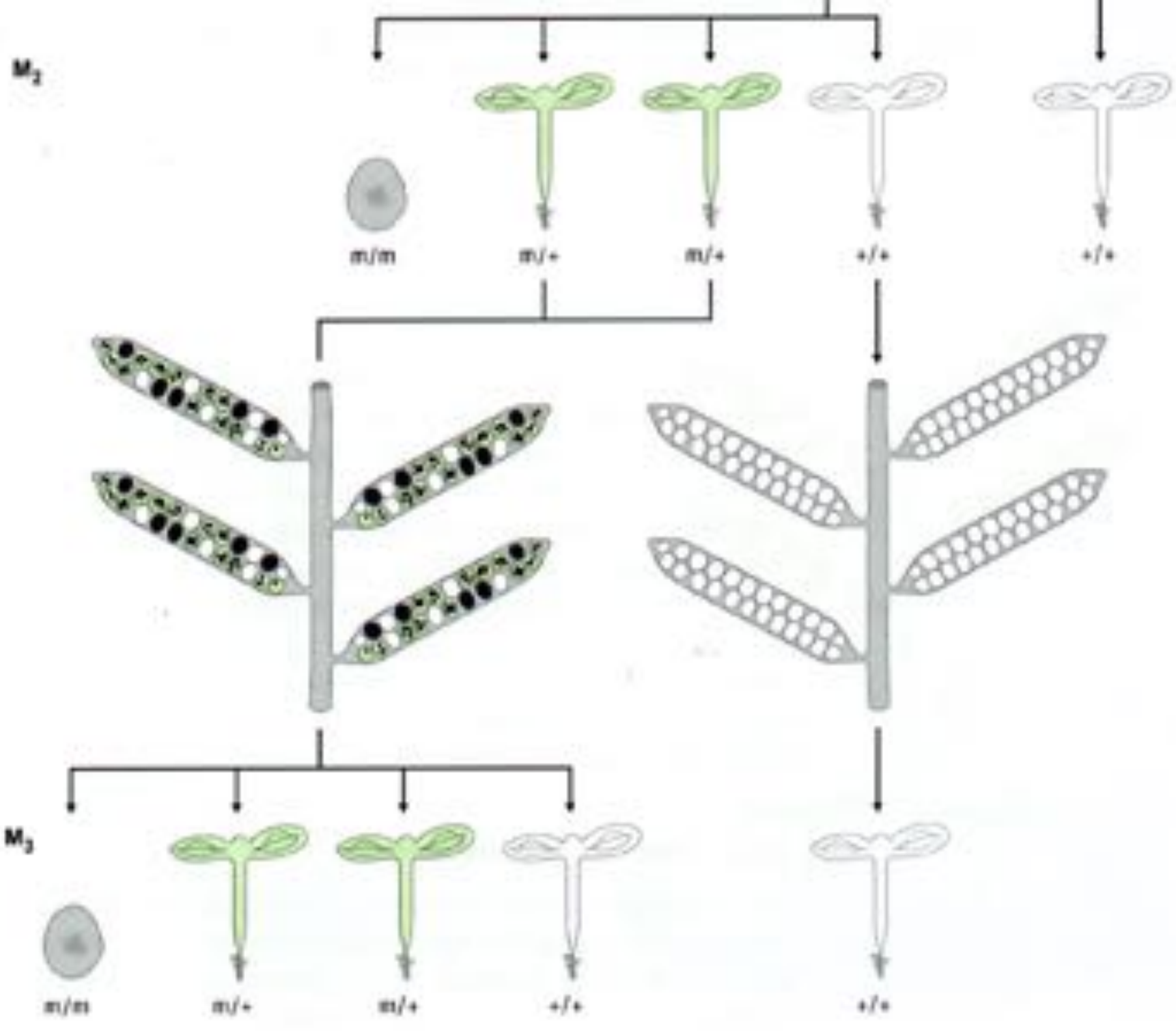
100 µm

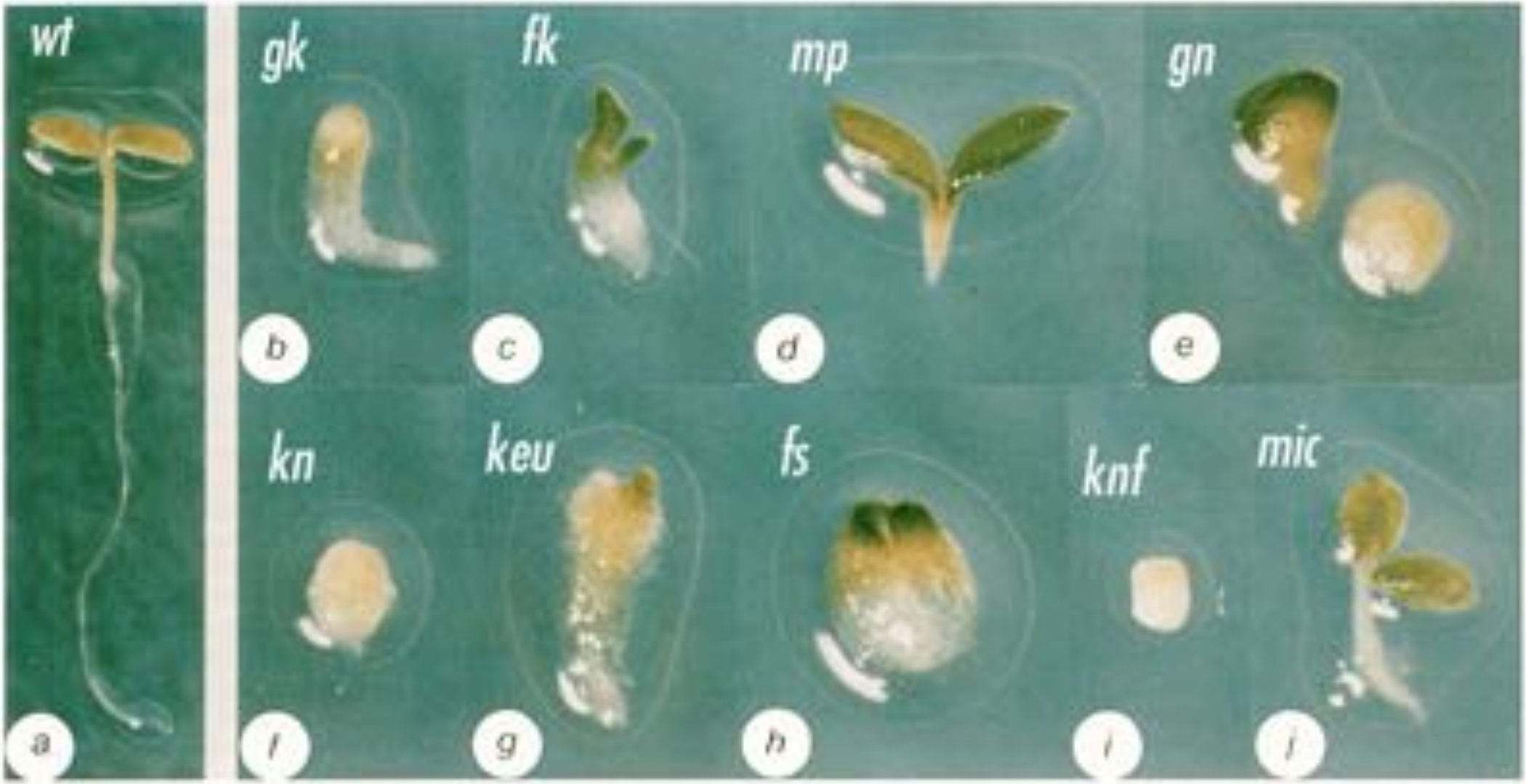
adult

500 µm

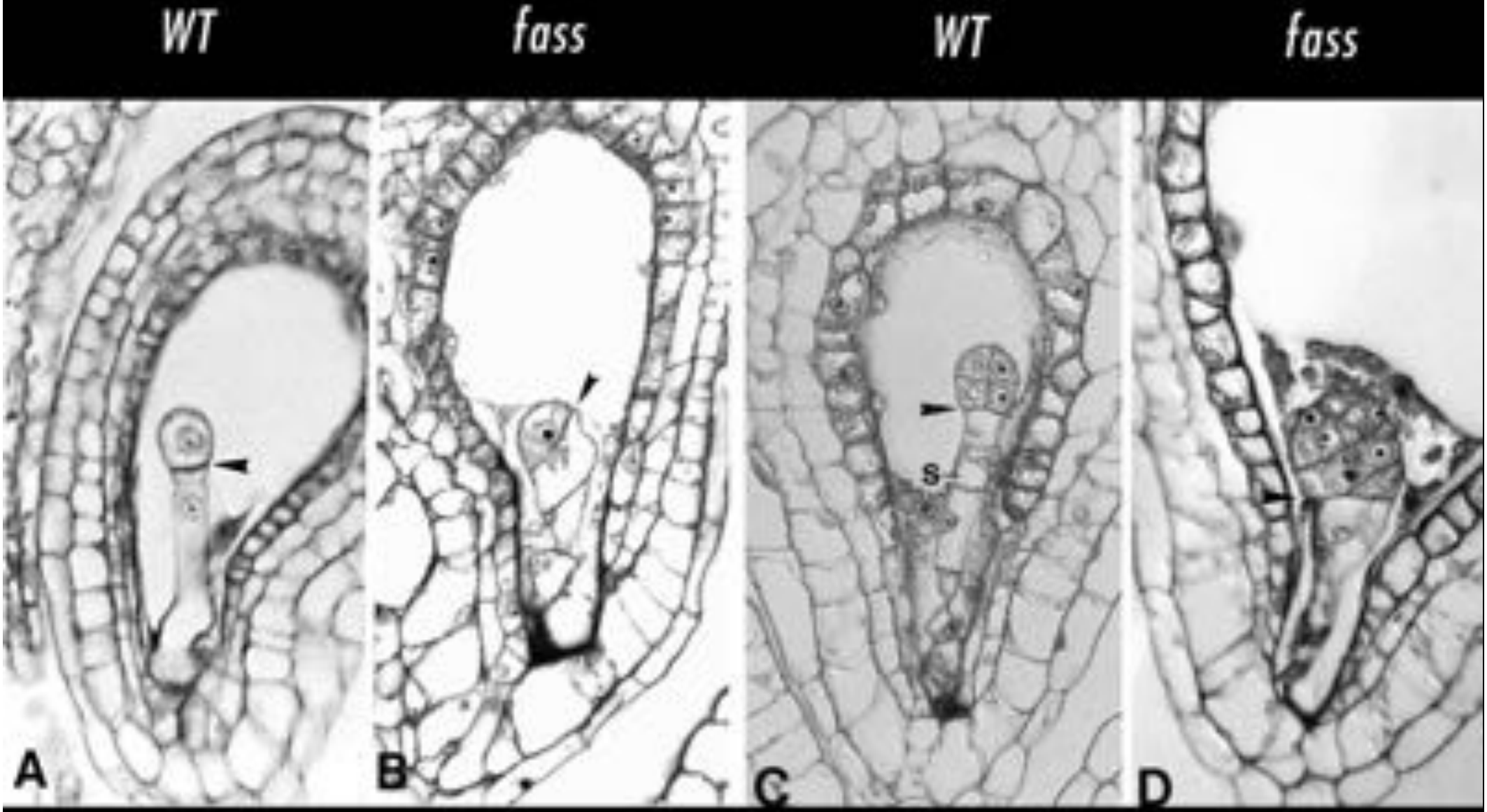
Genetic screening for mutants in Arabidopsis development

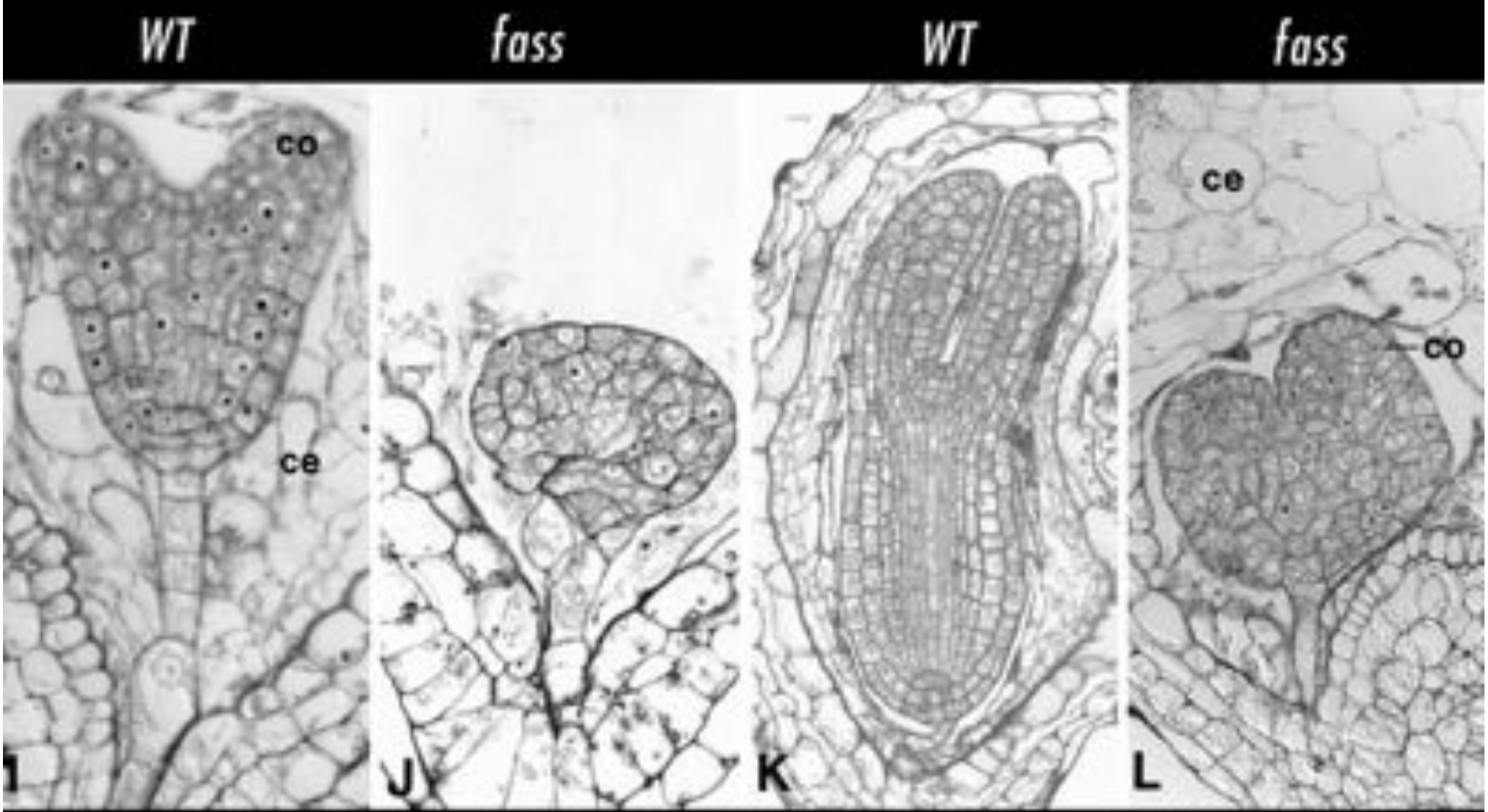



M2
m/m
m/+
m/+
+/+
+/+
M3
m/m
m/+
m/+
+/+
+/+


wt
gk
fk
mp
gn
kn
keu
fs
knf
mic
a
b
c
d
e
f
g
h
i
j

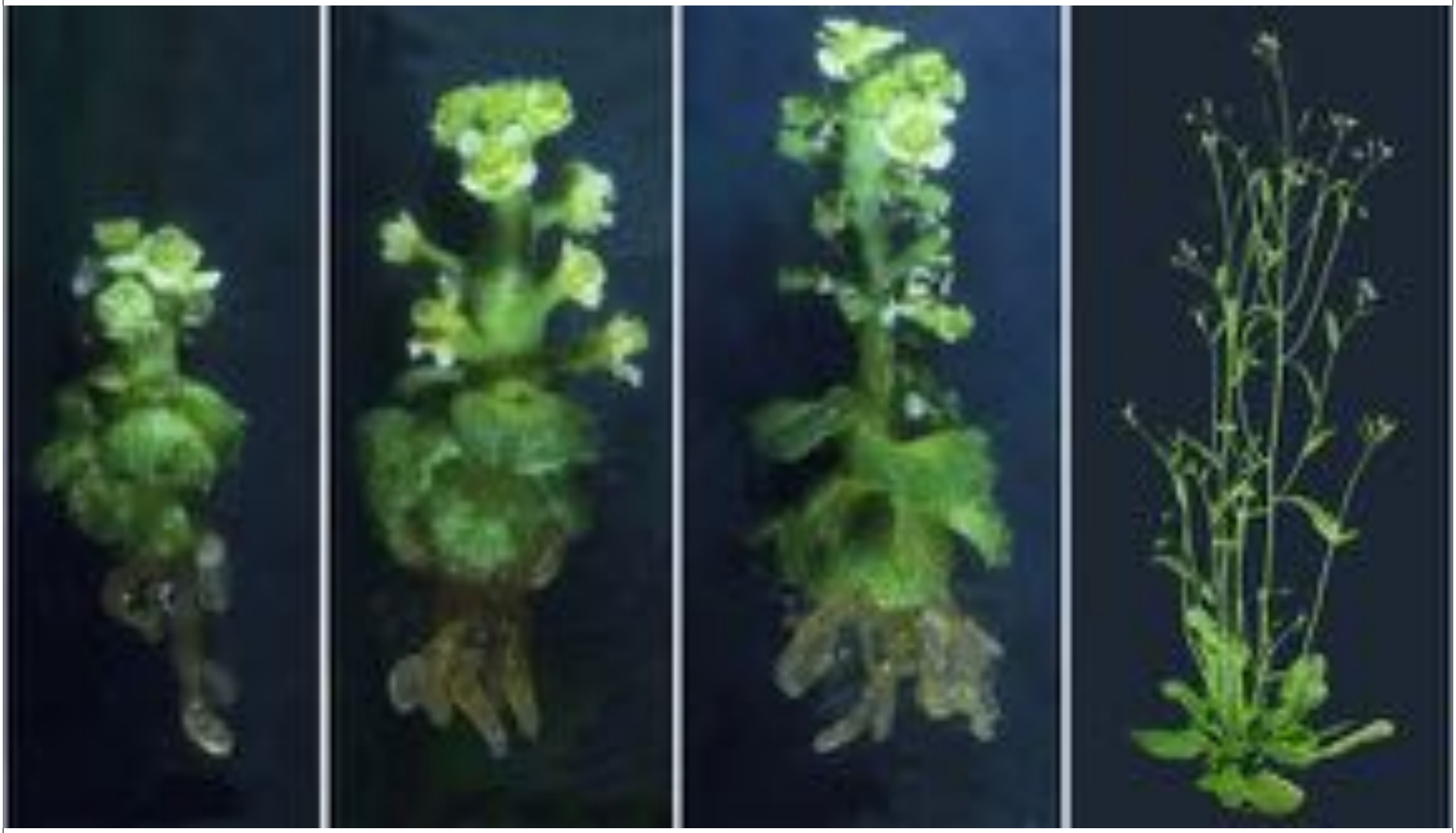
fass mutants have cytoskeletal defects, with altered patterns of cell division



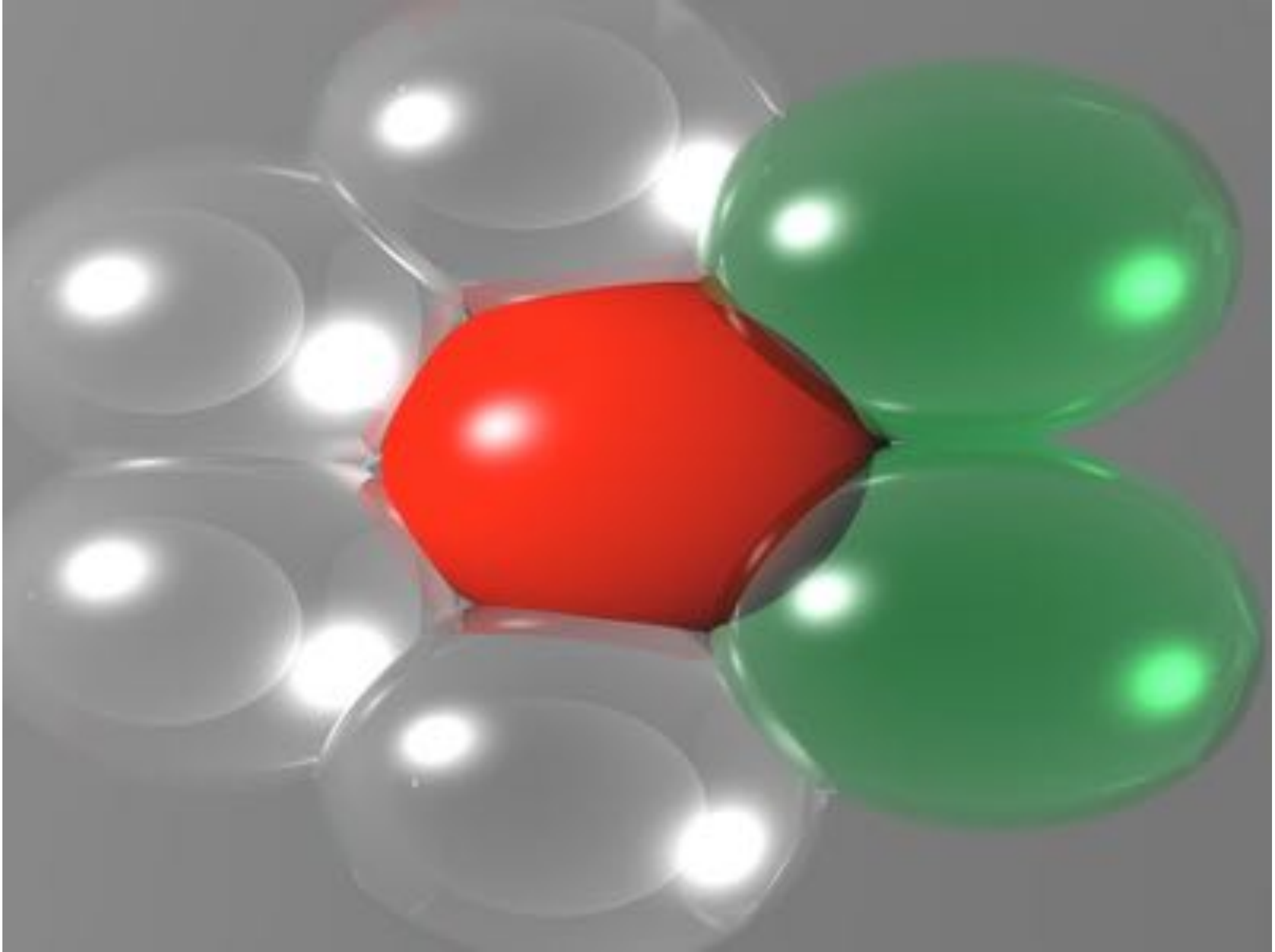

WT
fass
WT
fass
co
ce
ce
co
I
J
K
L
heart stage
torpedo stage

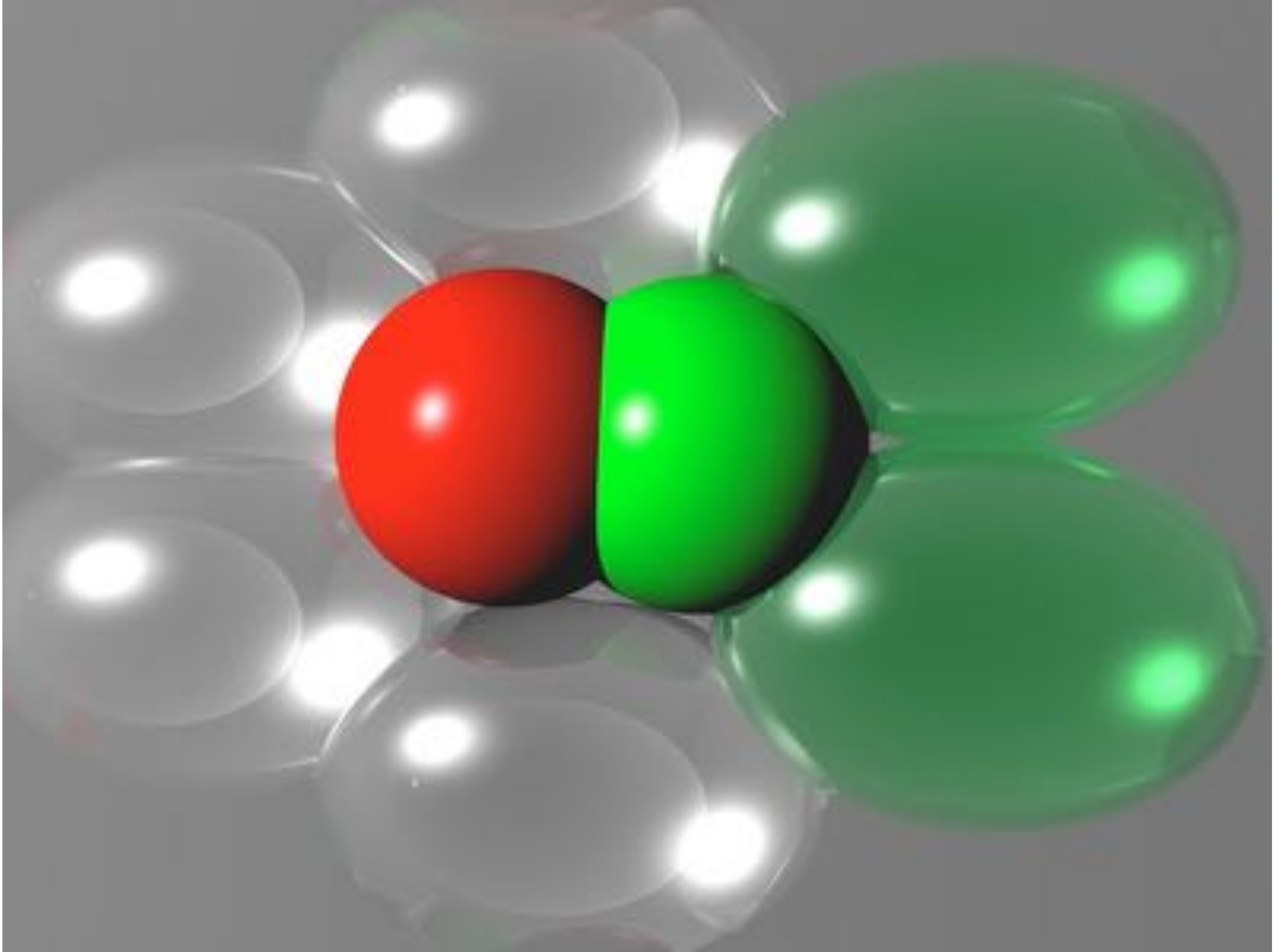
fass alleles

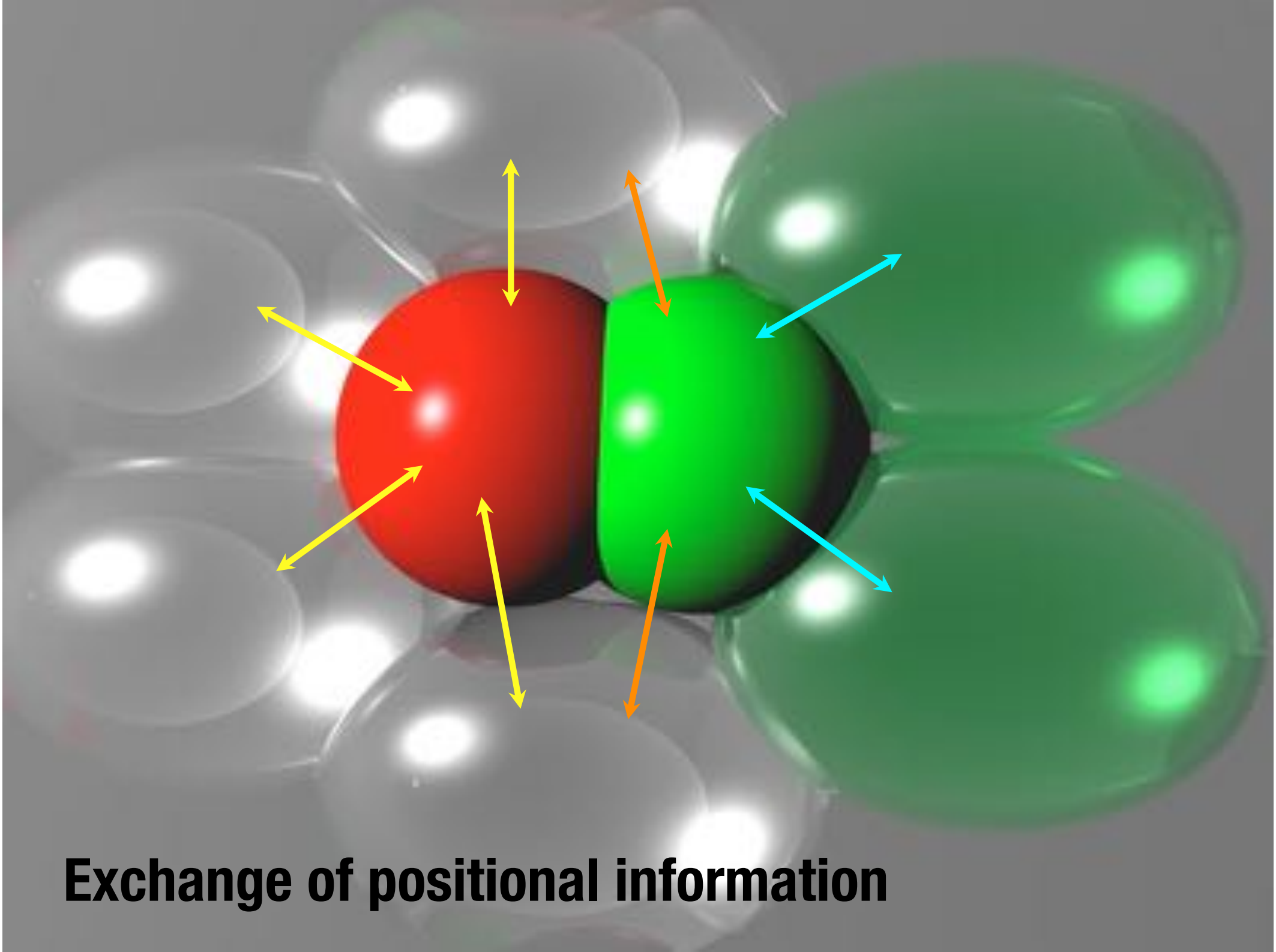
Wild type



fass plants form organised tissues despite deranged cell divisions






Exchange of positional information

http://haseloff.plantsci.cam.ac.uk