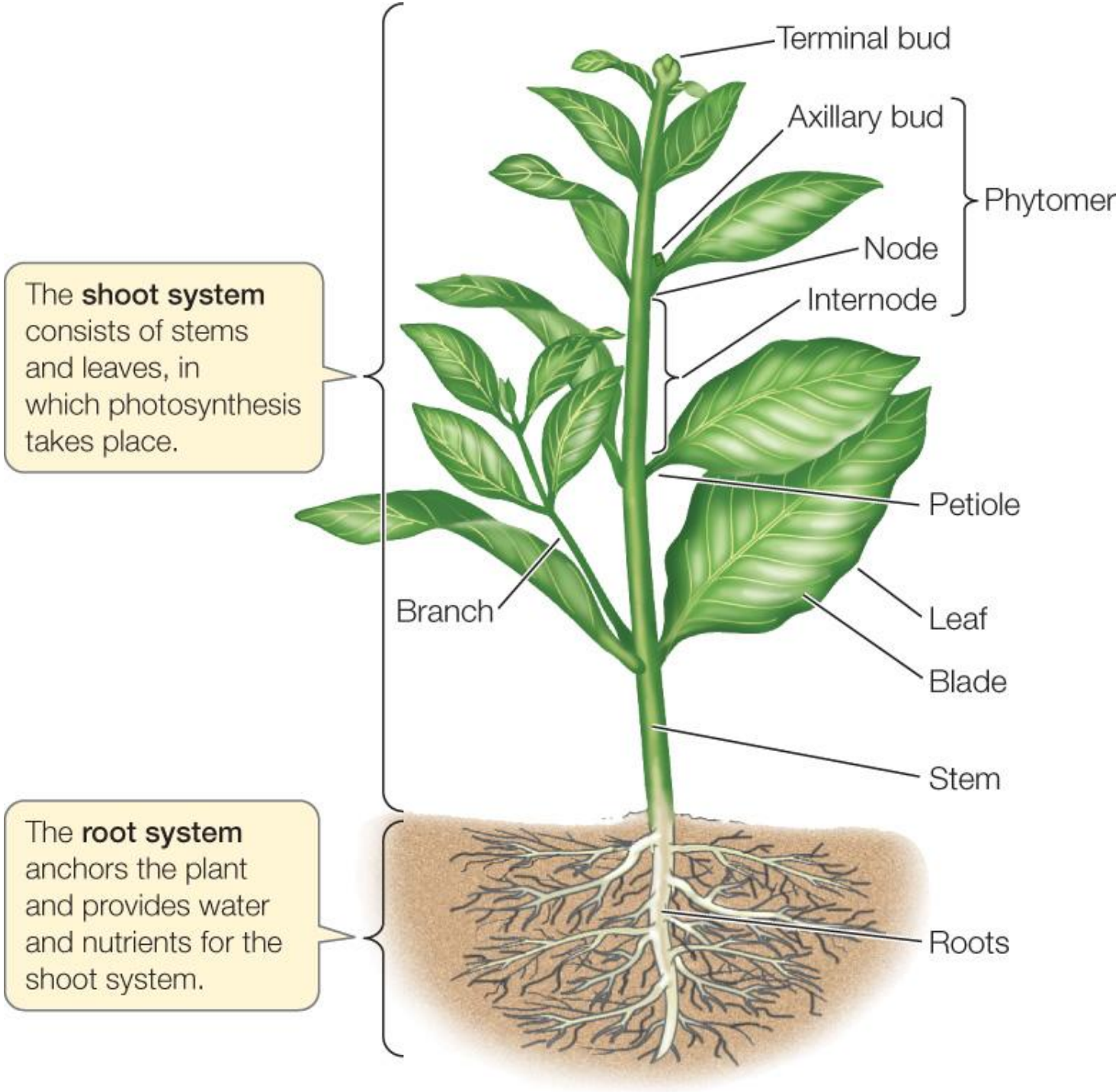
Morphology and anatomy of the root.

Plan.

- **The root is the axial organ of the plant**
- **Morphology of the root and root systems**
- **The functions of the root**
- **The zones of young root**
- **The primary anatomical structure of the root**
- **Transformation to the secondary structure of the root. The secondary structure of the root.**
-

- **Vegetative** organs provided up the body of the plant and perform the main functions of its vital activity, including vegetative reproduction. These include the root, stem and leaf. A stem with leaves and buds is called a shoot.

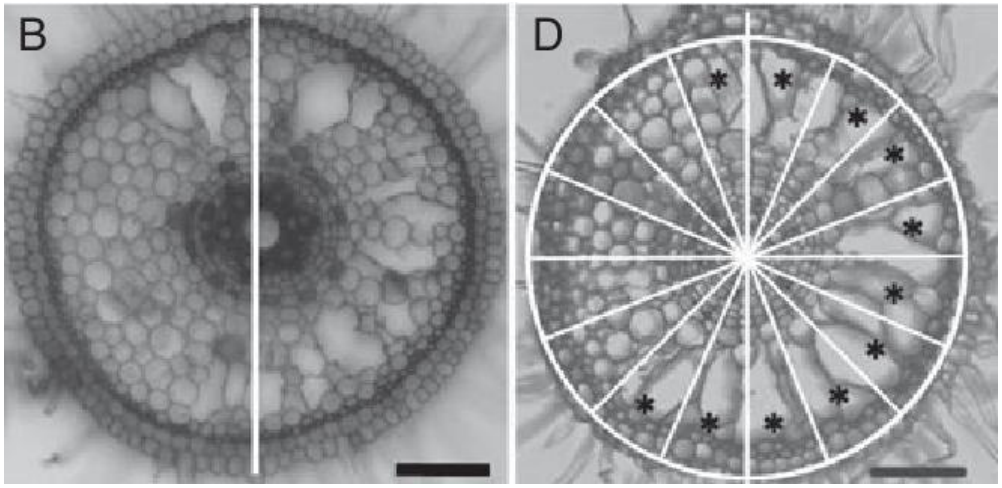
- **Reproductive** (generative) organs are intended for sexual or asexual reproduction itself. In angiosperms, they include a flower and its derivatives - a seed and a fruit.


Terminal bud
Axillary bud
Phytomer
Node
Internode
The shoot system consists of stems and leaves, in which photosynthesis takes place.
Petiole
Branch
Leaf
Blade
Stem
The root system anchors the plant and provides water and nutrients for the shoot system.
Roots

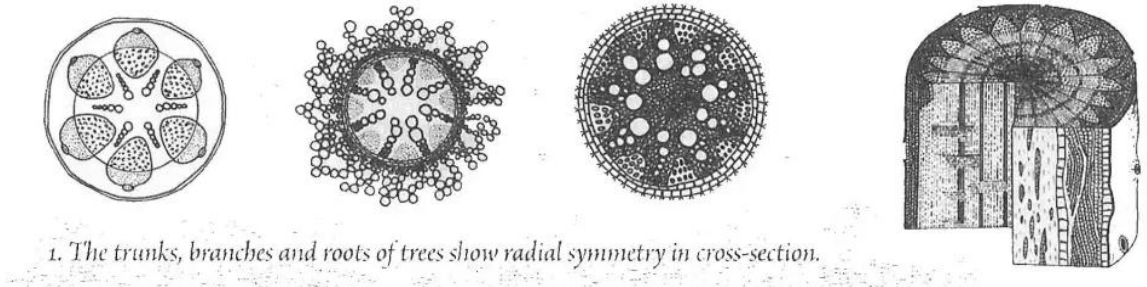
Plant organs are characterized by some general patterns.

- **The symmetry.**
- **The polarity.**
- **The geotropism.**
- **The metamorphoses (modifications)**

Radial symmetry of the root



Bilateral symmetry of the leaf of Pine



1. The trunks, branches and roots of trees show radial symmetry in cross-section.

GEOTROPISM

("Geo" – Earth)

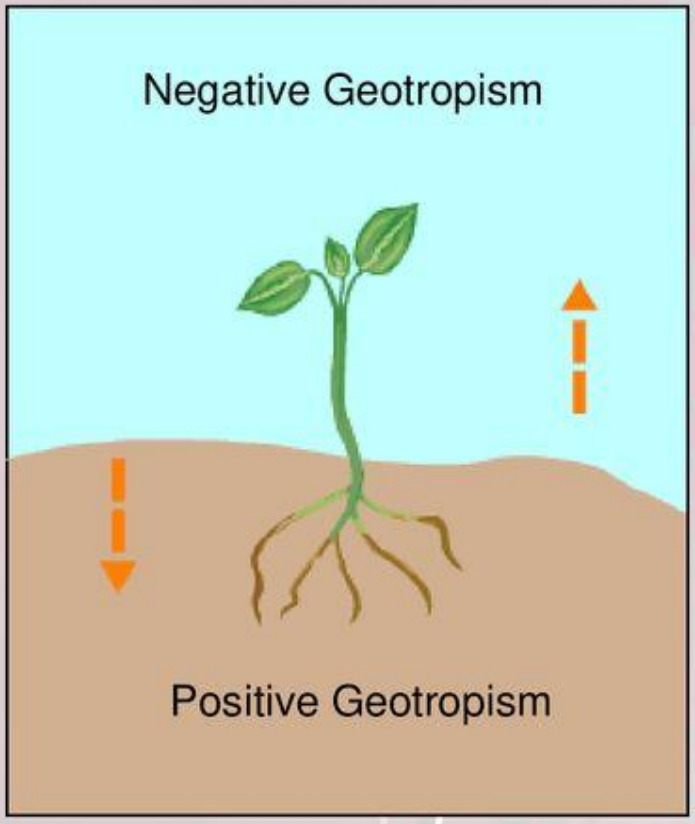
Geotropism is the growth of a plant in response to gravity.

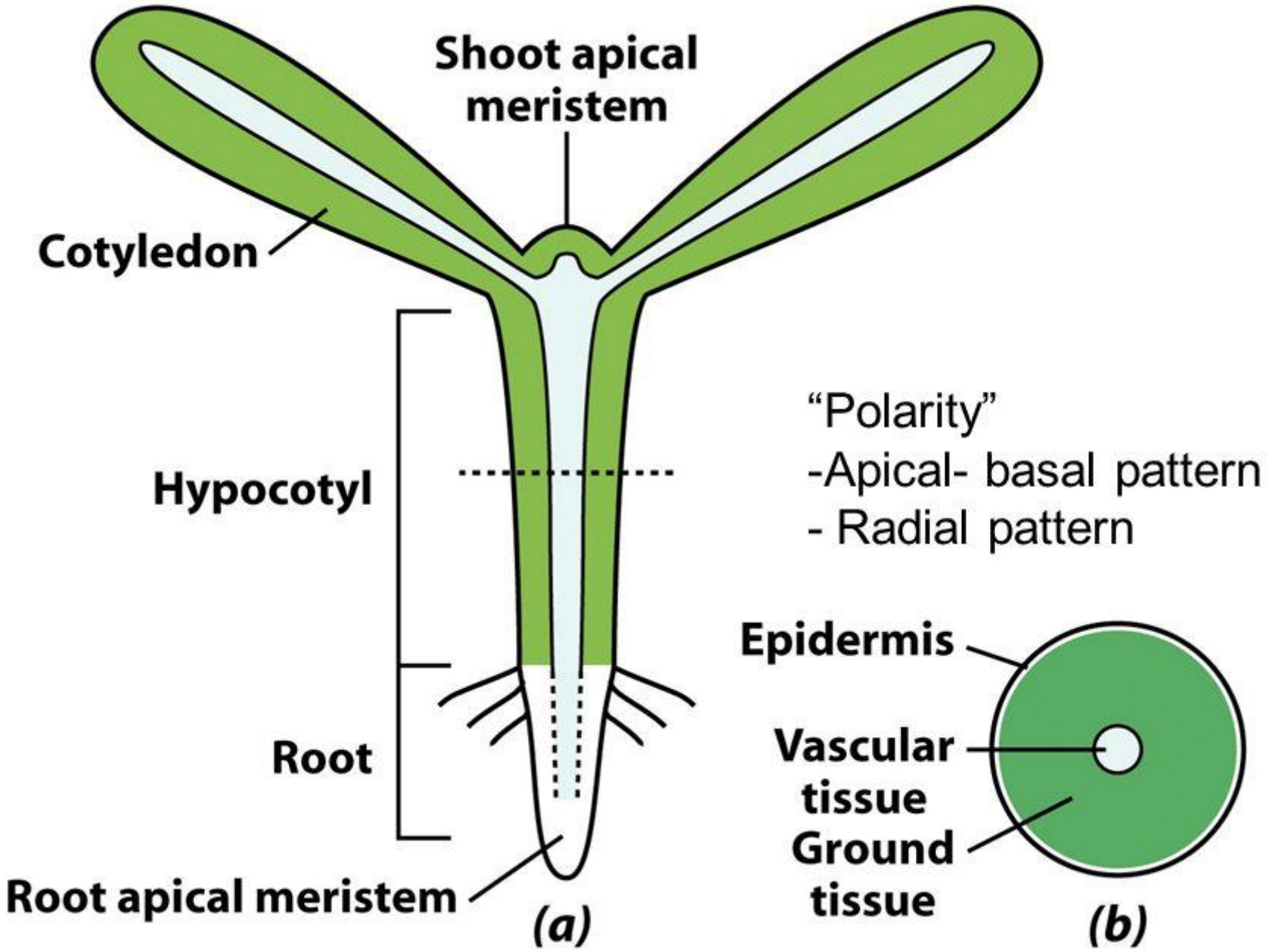
Positive Geotropism

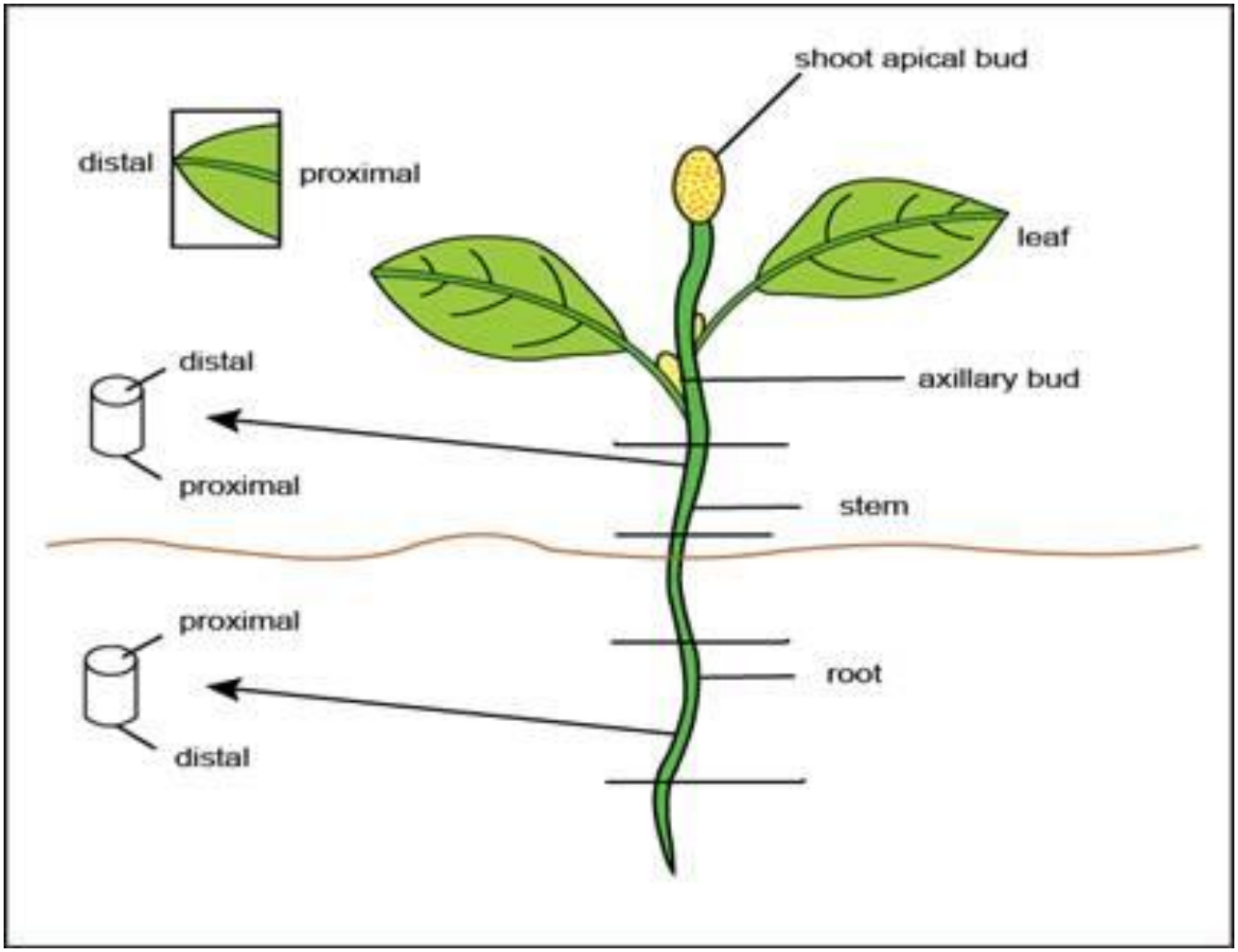
It is the growth of a plant towards the center of the earth-down with gravity.
Ex. roots growing down

Negative Geotropism

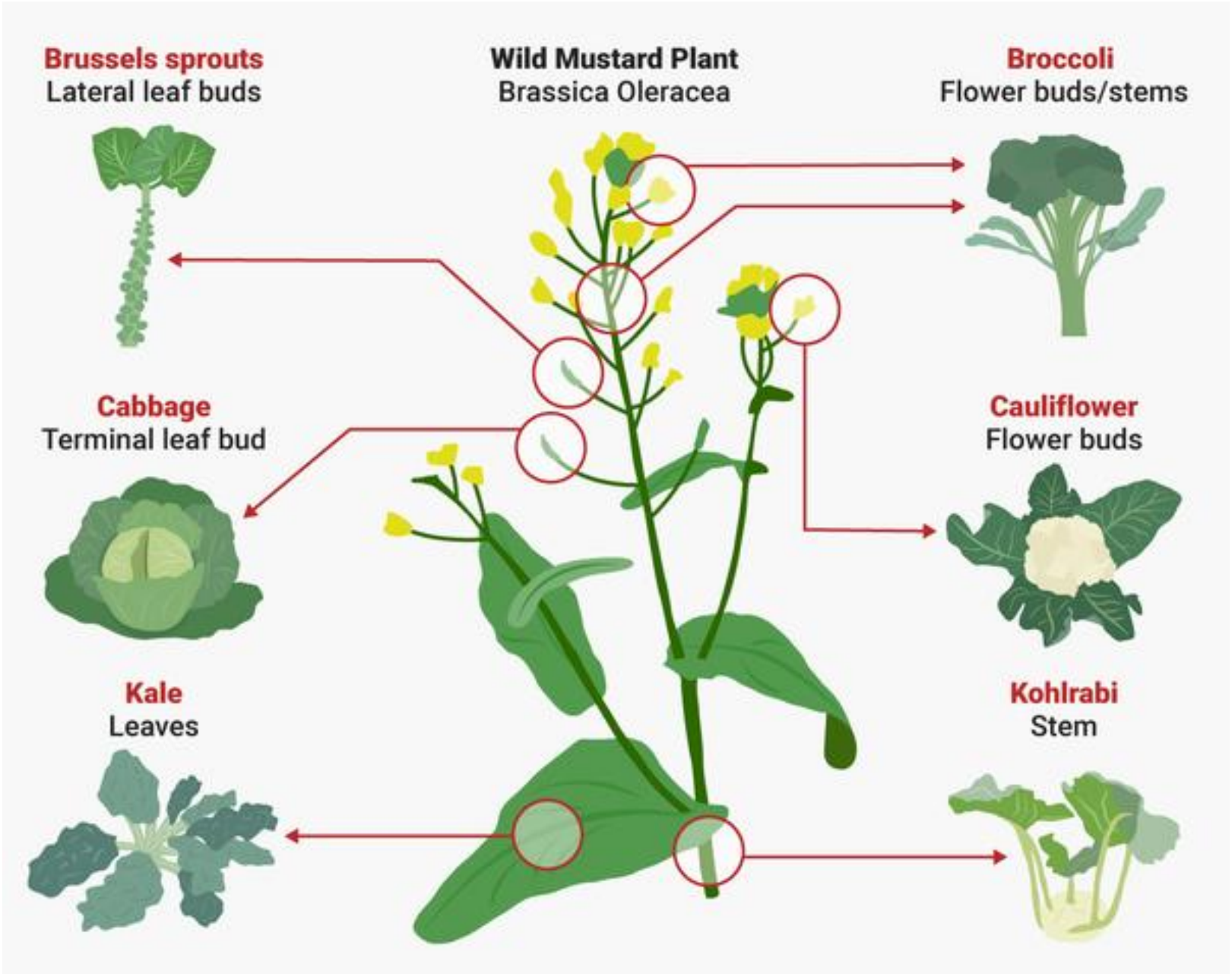
It is the growth of a plant away from the center of the earth-opposite from the pull of gravity
Ex. stems grow up



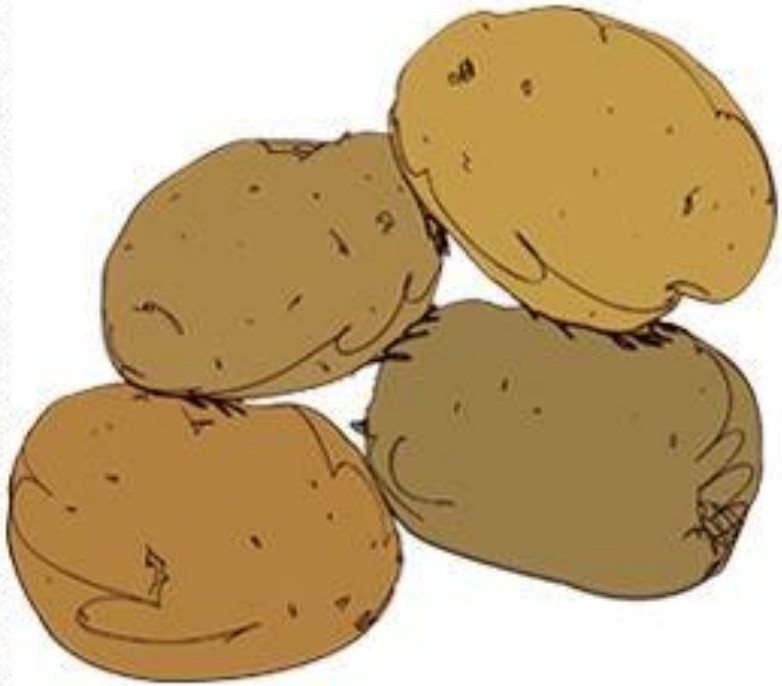

Shoot apical meristem
Cotyledon
Hypocotyl
Root
Root apical meristem
(a)
"Polarity"
-Apical- basal pattern
- Radial pattern
Epidermis
Vascular tissue
Ground tissue
(b)


shoot apical bud
distal
proximal
leaf
distal
axillary bud
proximal
stem
proximal
root
distal

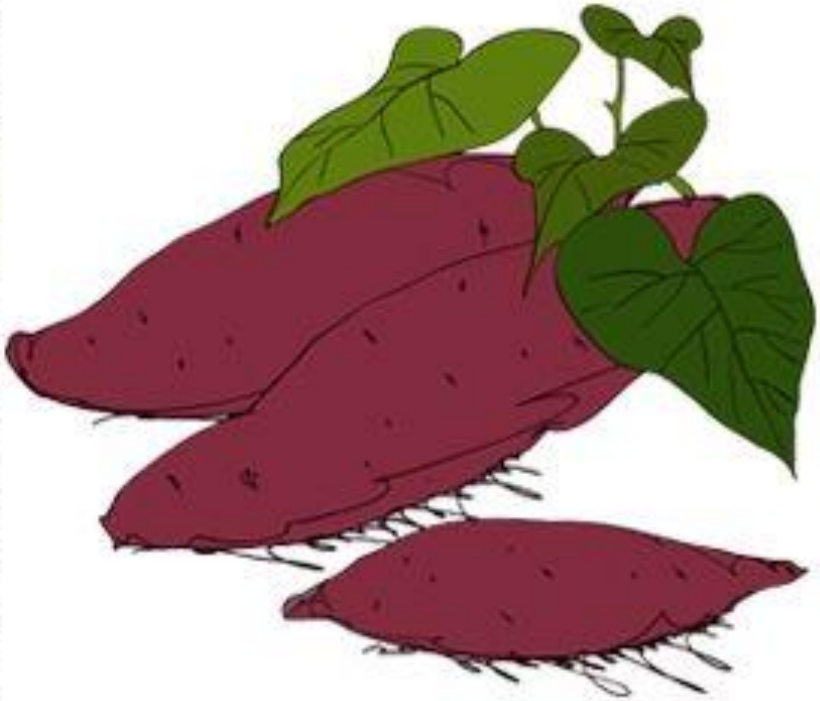
The metamorphoses (modifications)



Analogous Similarity Between **Potato** and **Sweet Potato**



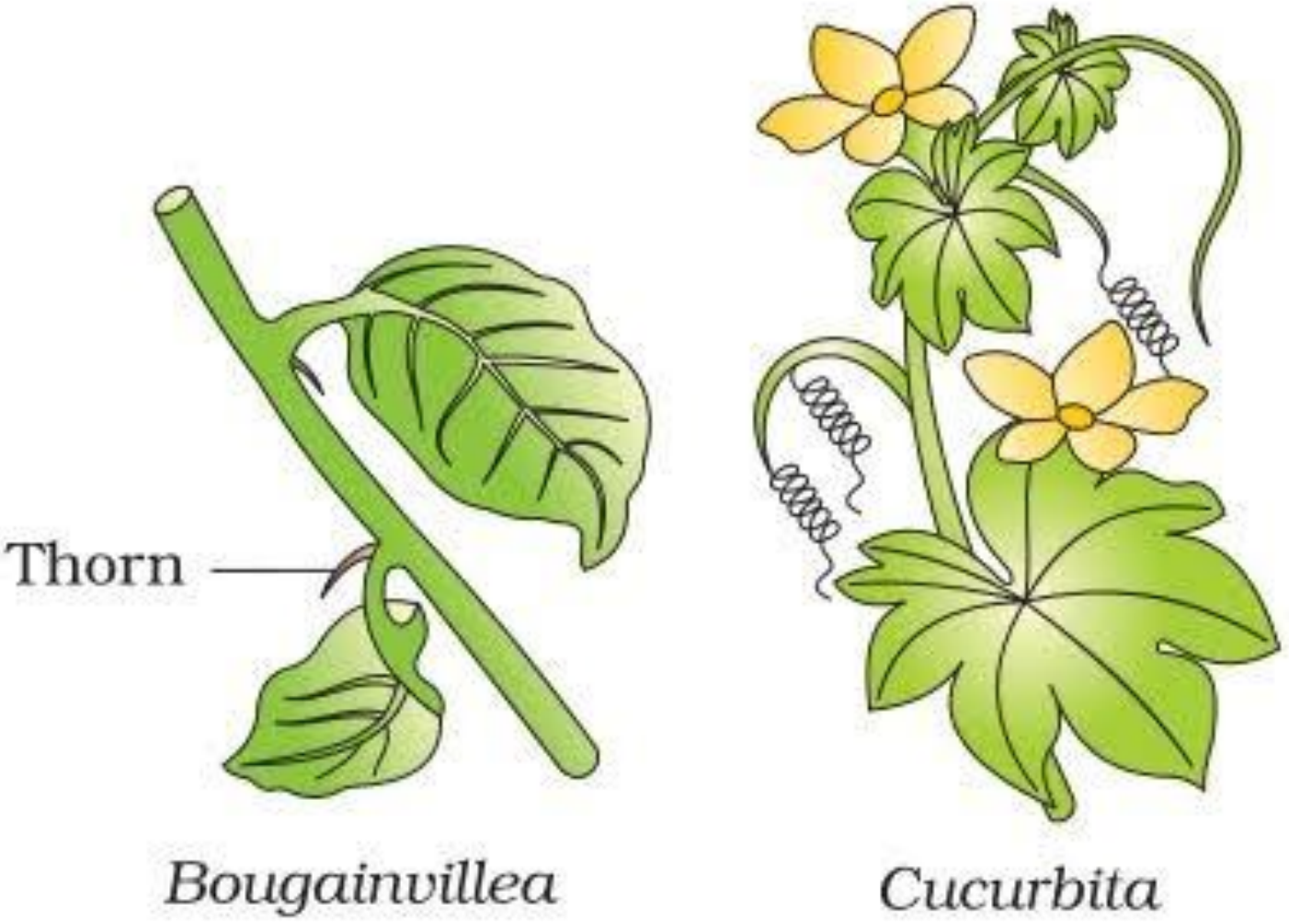
(underground stem)



(underground root)

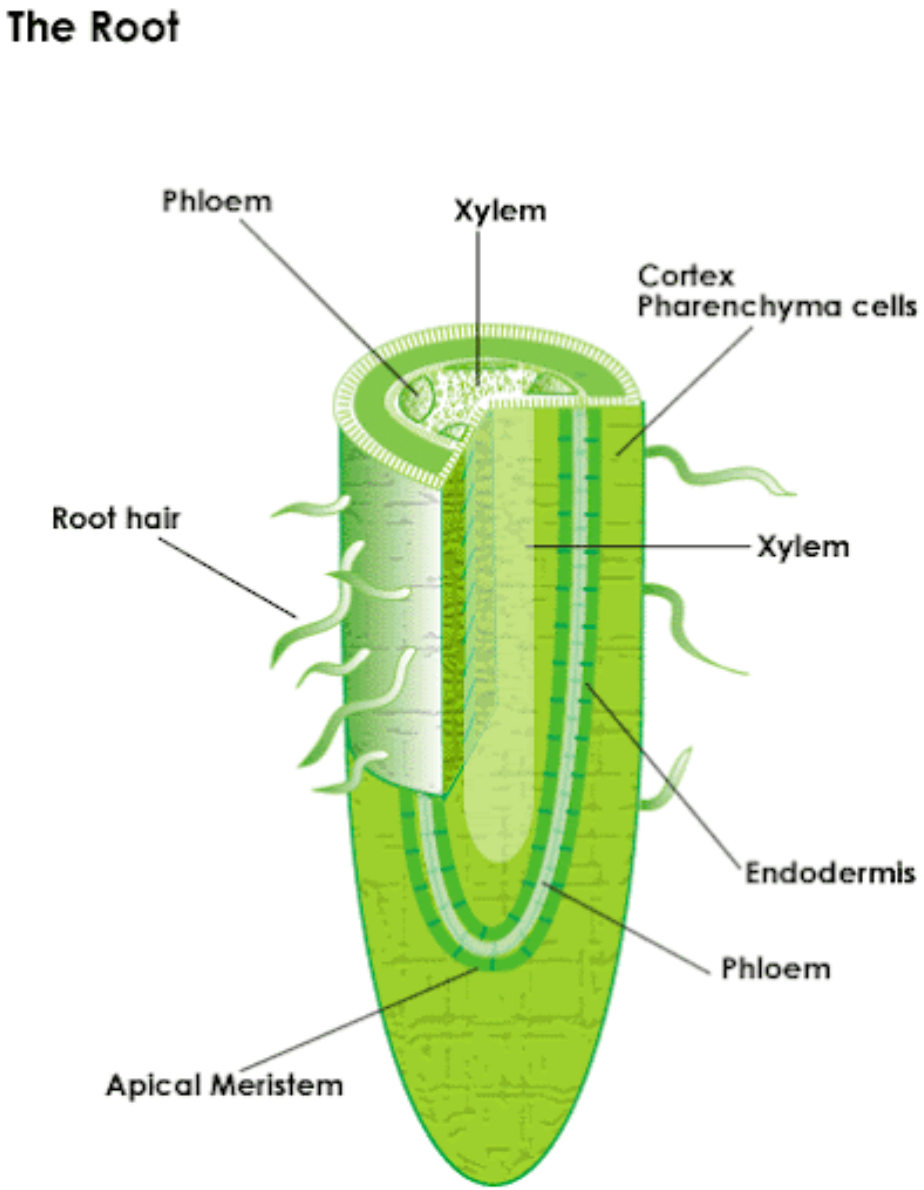
Both are starchy food items.

Organs that have the same origin are called homologous.



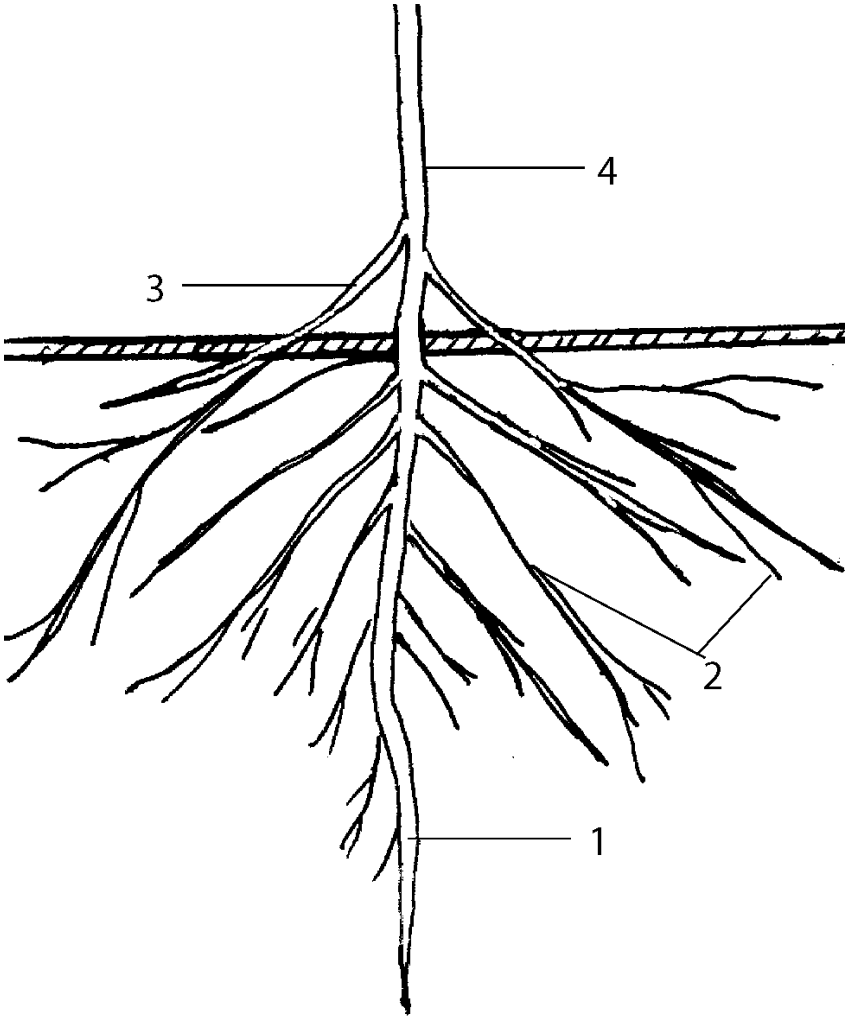
Root (Latin radix) is an axial, usually underground vegetative organ of higher vascular plants with unlimited growth in length and positive geotropism. The root anchors the plant in the soil and provides absorption and conduction of water with dissolved mineral substances to the stem and leaves.

The symmetry of root



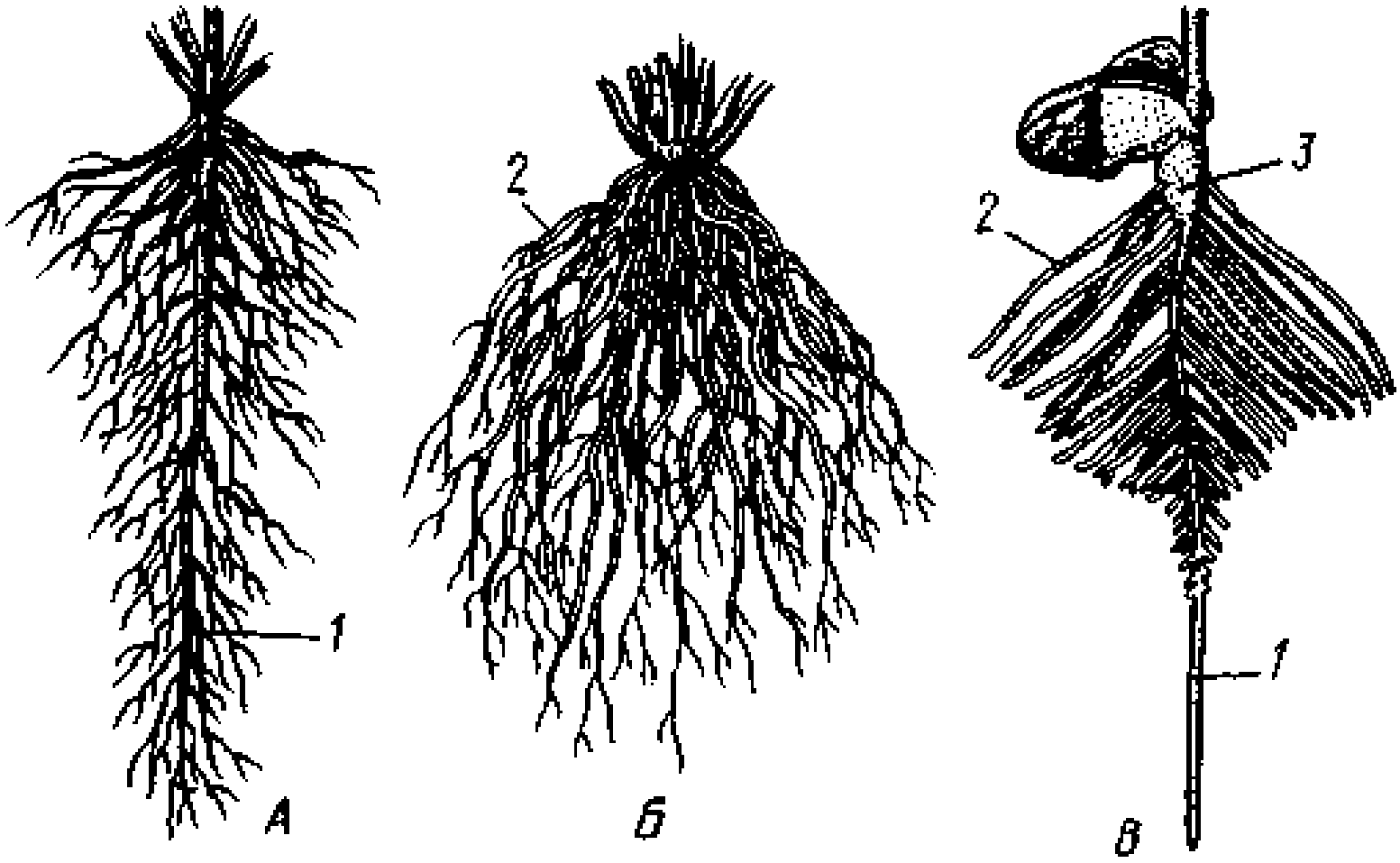
Root functions

- 1. Mineral and water nutrition.
- 2. Fixing the plant in the soil.
- 3. Synthesis of organic substances.
- 4. Synthesis of alkaloids, phytohormones and other active compounds.
- 5. Accumulation of substances.
- 6. Vegetative reproduction.
- 7. Symbiosis with bacteria.
- 8. Symbiosis with fungi (mycorrhiza)

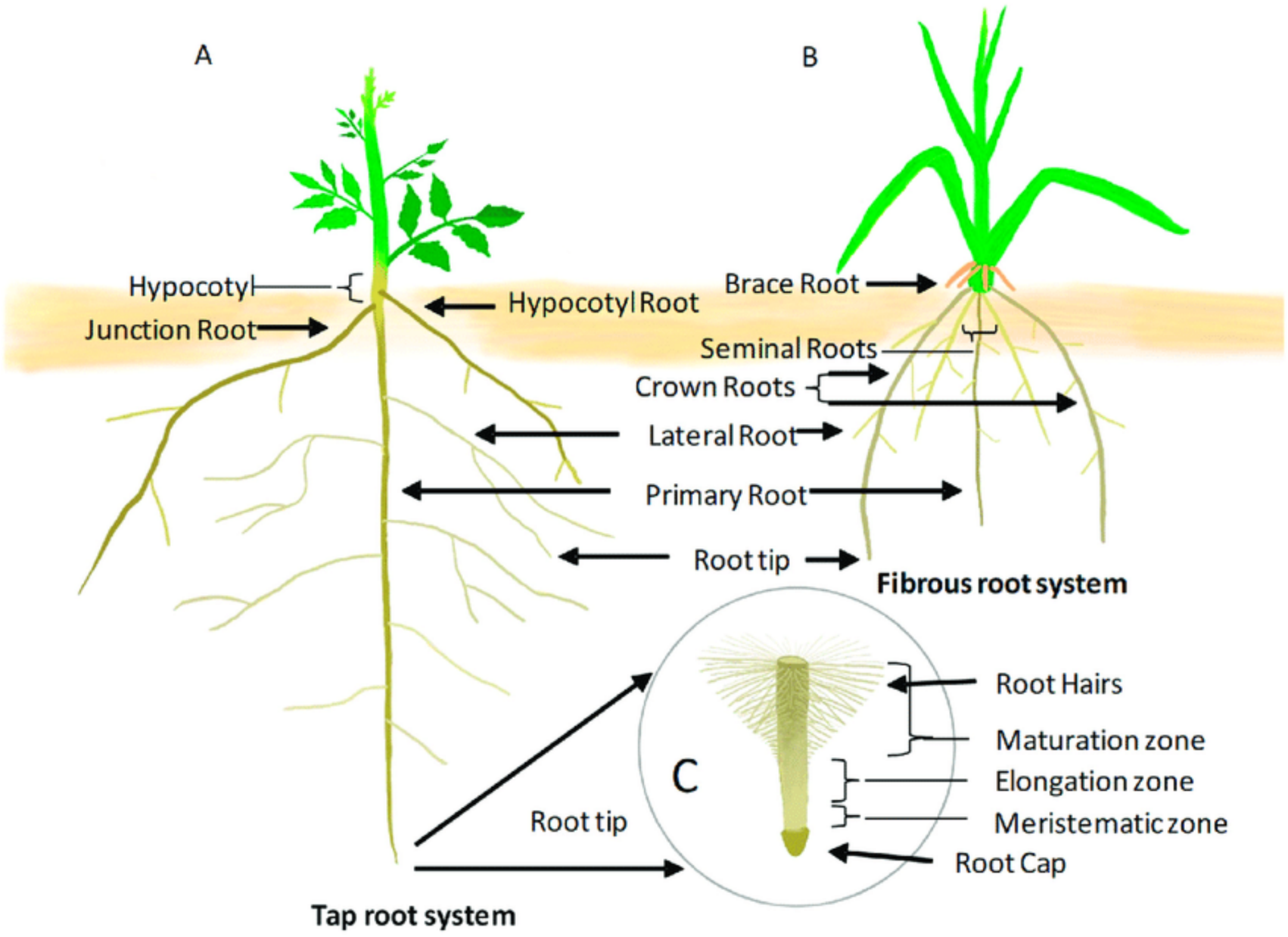


1 – the tap root, 2 – the lateral root, 3 – the adventitious root, 4 – the stems.

The root system is a set of roots of one plant. The general form and character of which is determined by the ratio of the growth of the tap, lateral and adventitious roots.



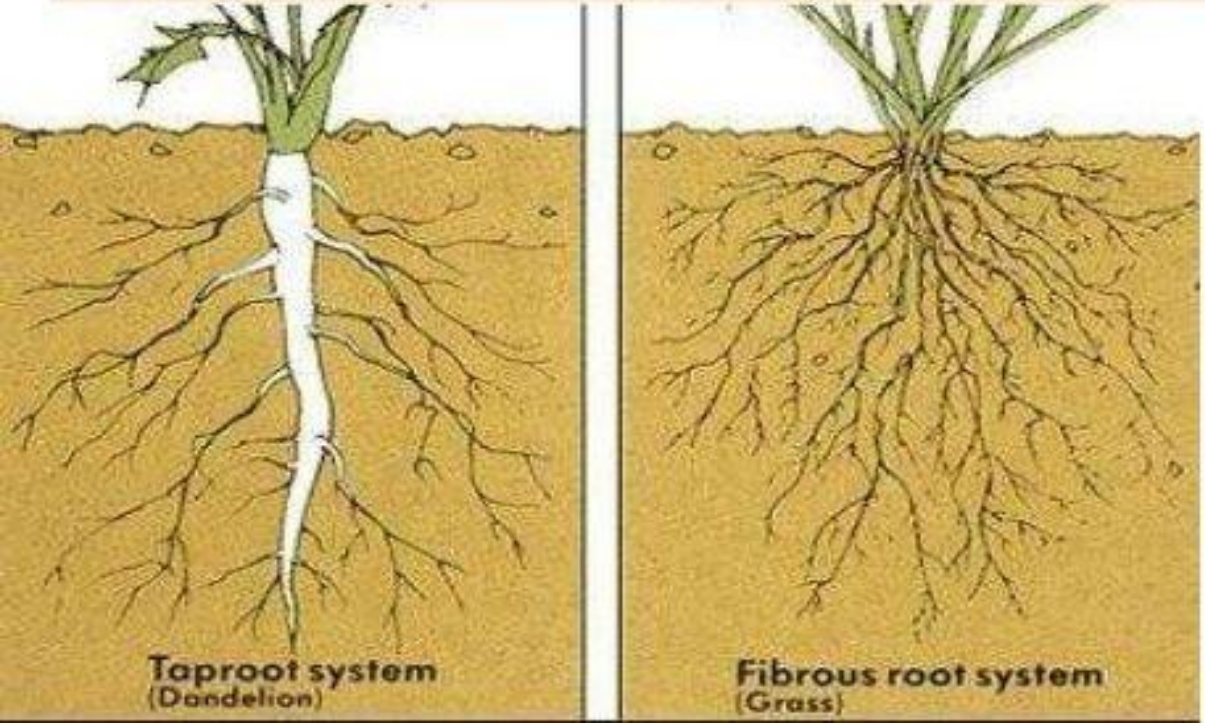
А — pivotal root system , *Б* — fibrous root system , *В* — mixed root systems ; *1* — tap root, *2* — adventitious rot, *3* — hypocotyl.

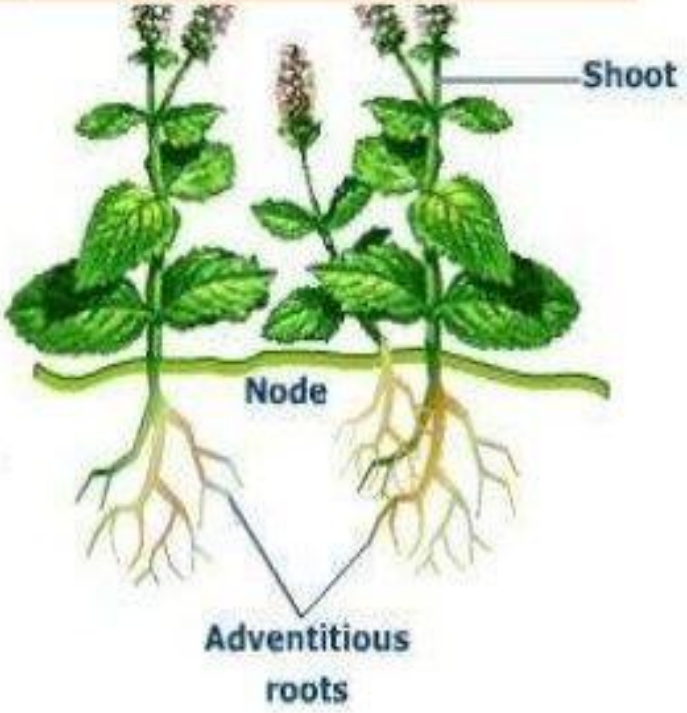

A
B
Hypocotyl
Junction Root
Hypocotyl Root
Brace Root
Seminal Roots
Crown Roots
Lateral Root
Primary Root
Root tip
Fibrous root system
C
Root Hairs
Maturation zone
Elongation zone
Meristematic zone
Root Cap
Root tip
Tap root system


Corn root
Adventitious root
Orchid root

TYPES OF ROOT SYSTEMS

TAP ROOTS	FIBROUS ROOTS	ADVENTIOUS ROOTS
•Prominent in dicot	•Prominent in monocots	•They develop from organs
•Primary roots grow & becomes stout.	•Roots develop from lower nodes	Of shoot system
•Secondary & tertiary grow from primary root	•They have same length & diameter	

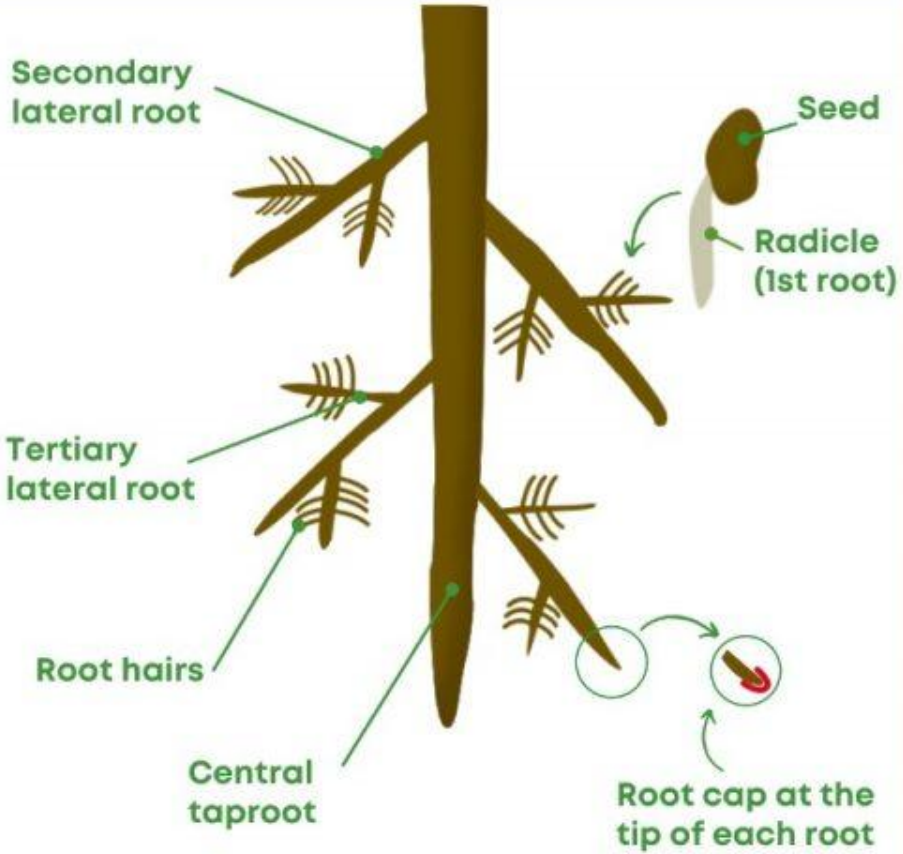




ROOT SYSTEMS

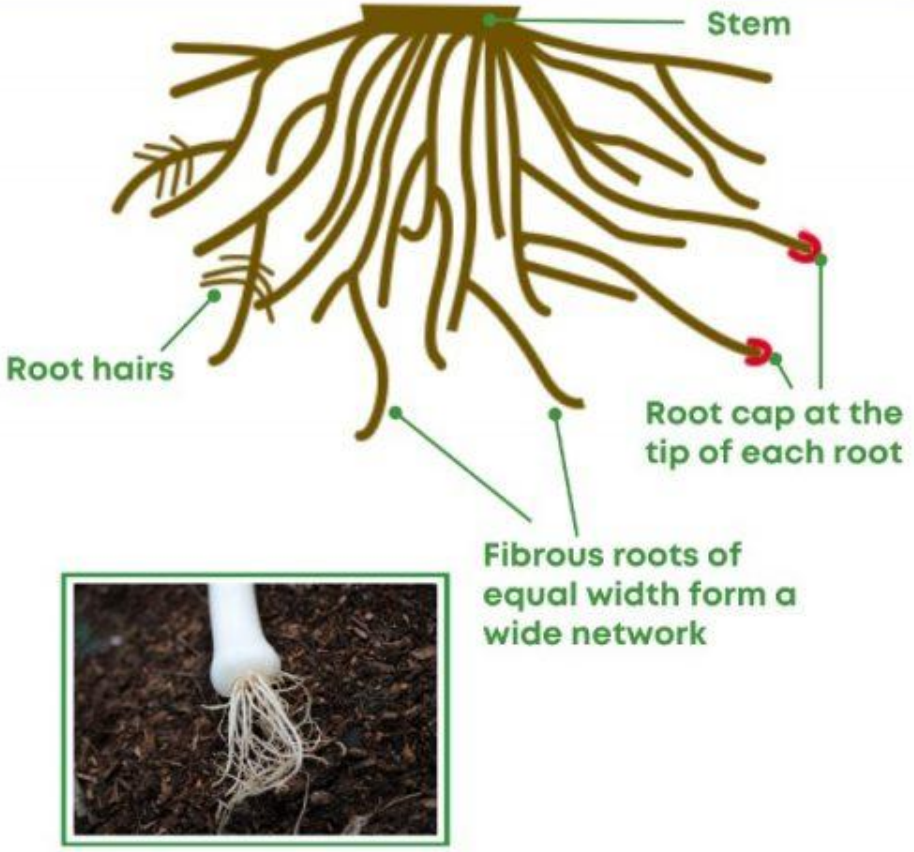
TYPICAL EUDICOTYLEDON ROOT SYSTEM

(Taproot and Lateral branching roots)

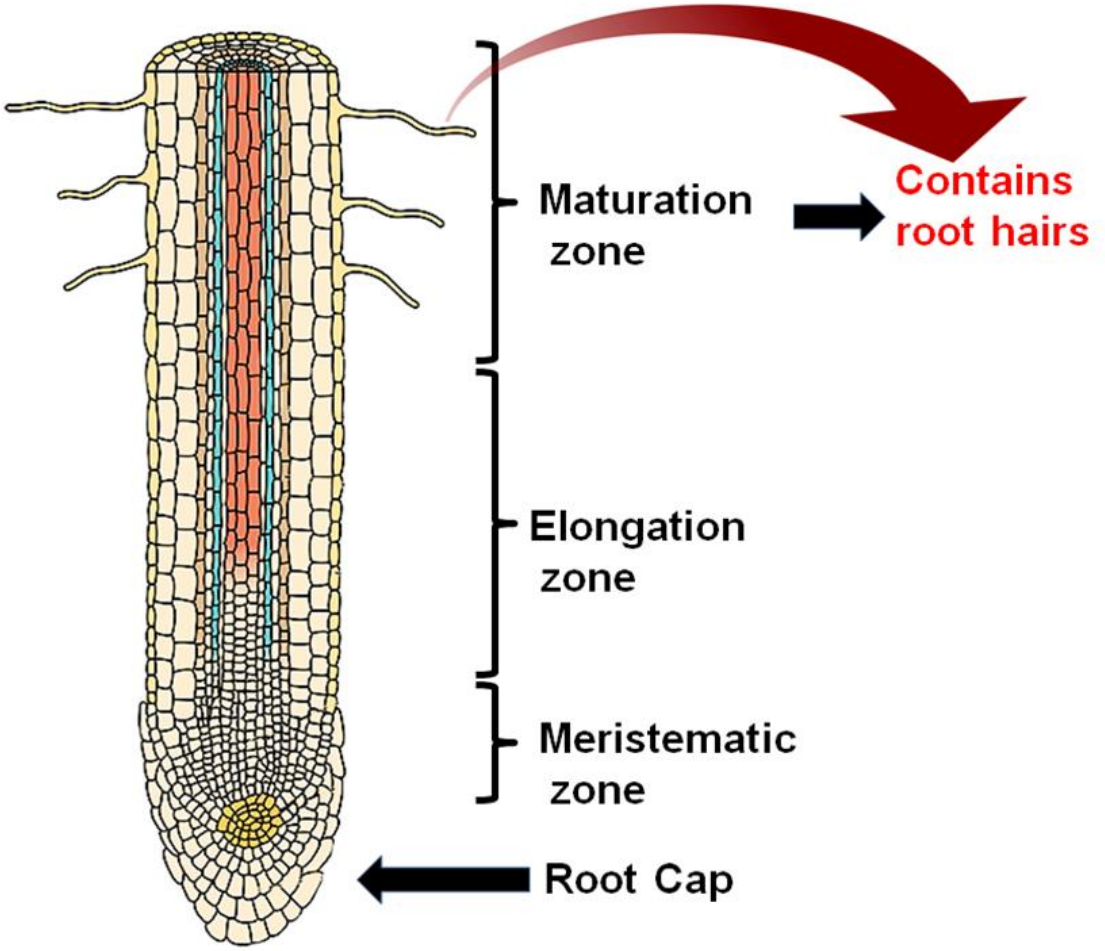


TYPICAL MONOCOTYLEDON ROOT SYSTEM

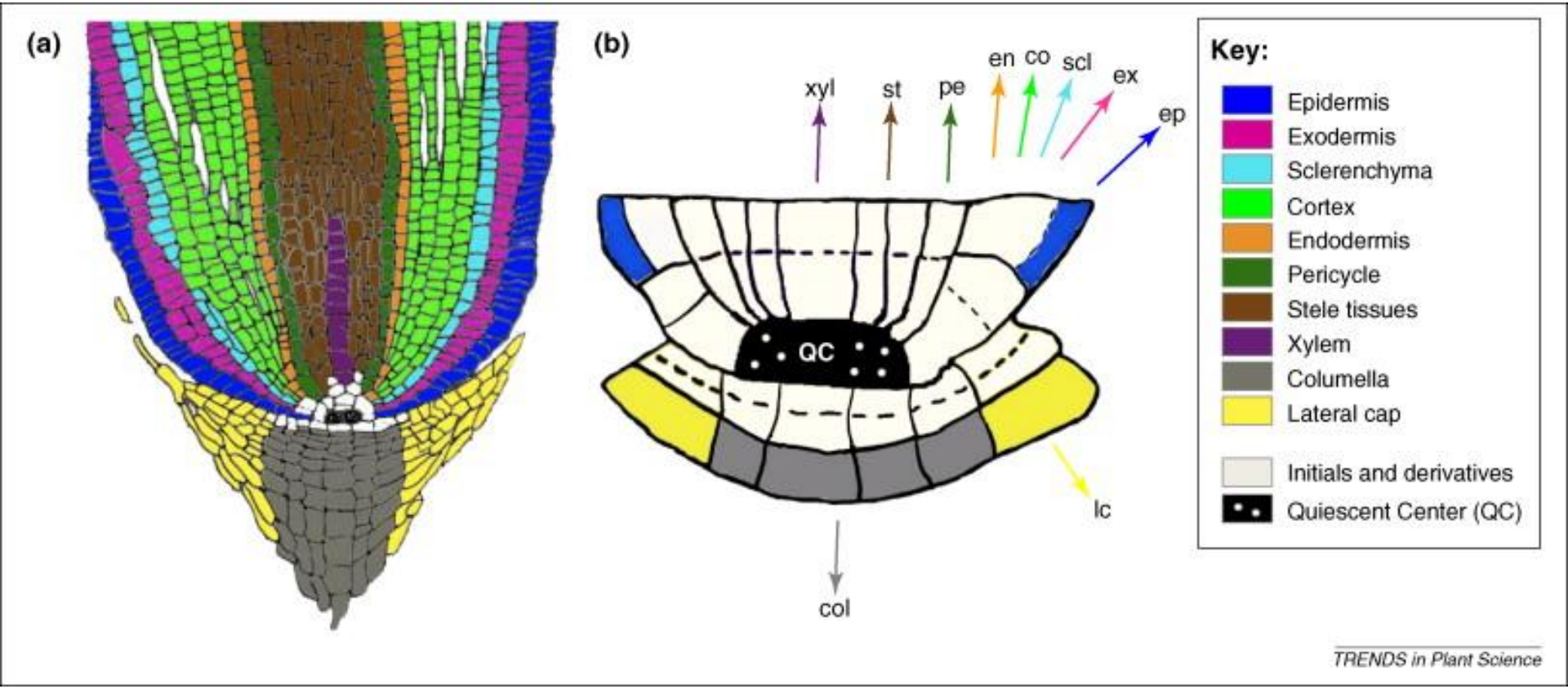
(Fibrous roots)

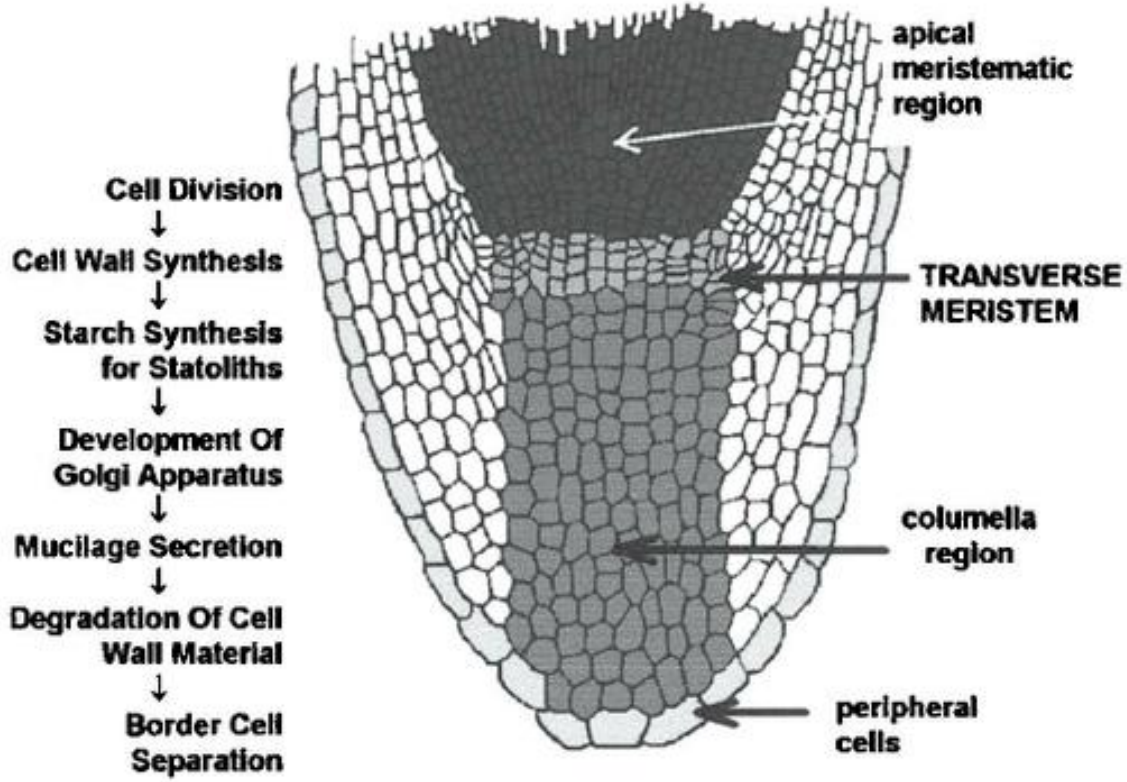


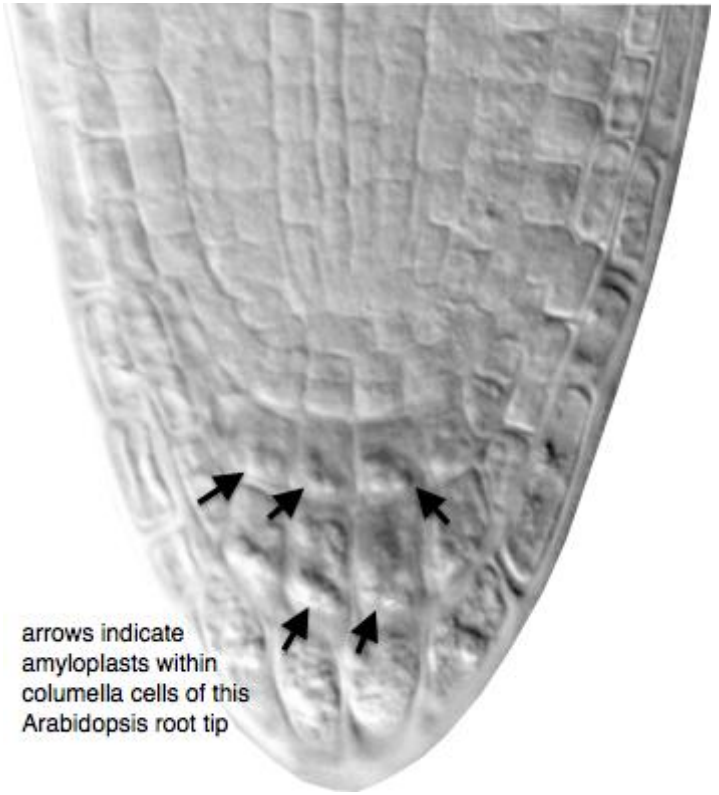
Zone of root

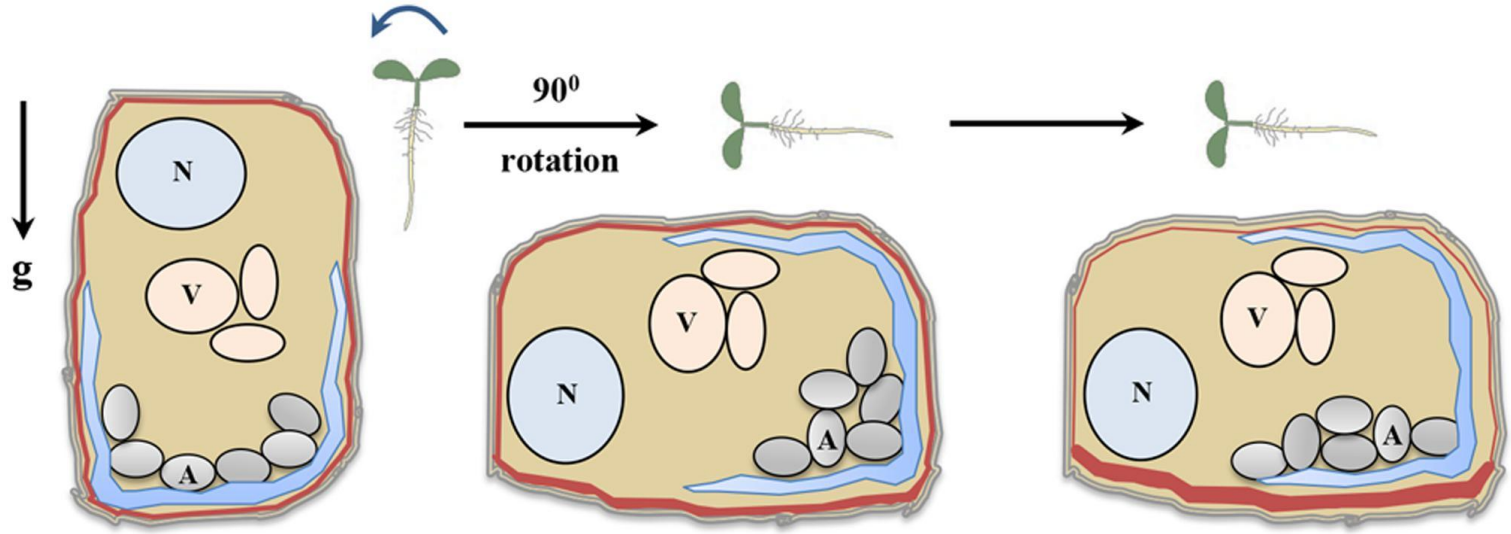

Maturation zone
Contains root hairs
Elongation zone
Meristematic zone
Root Cap

The zone of cell divisions (meristematic zone)

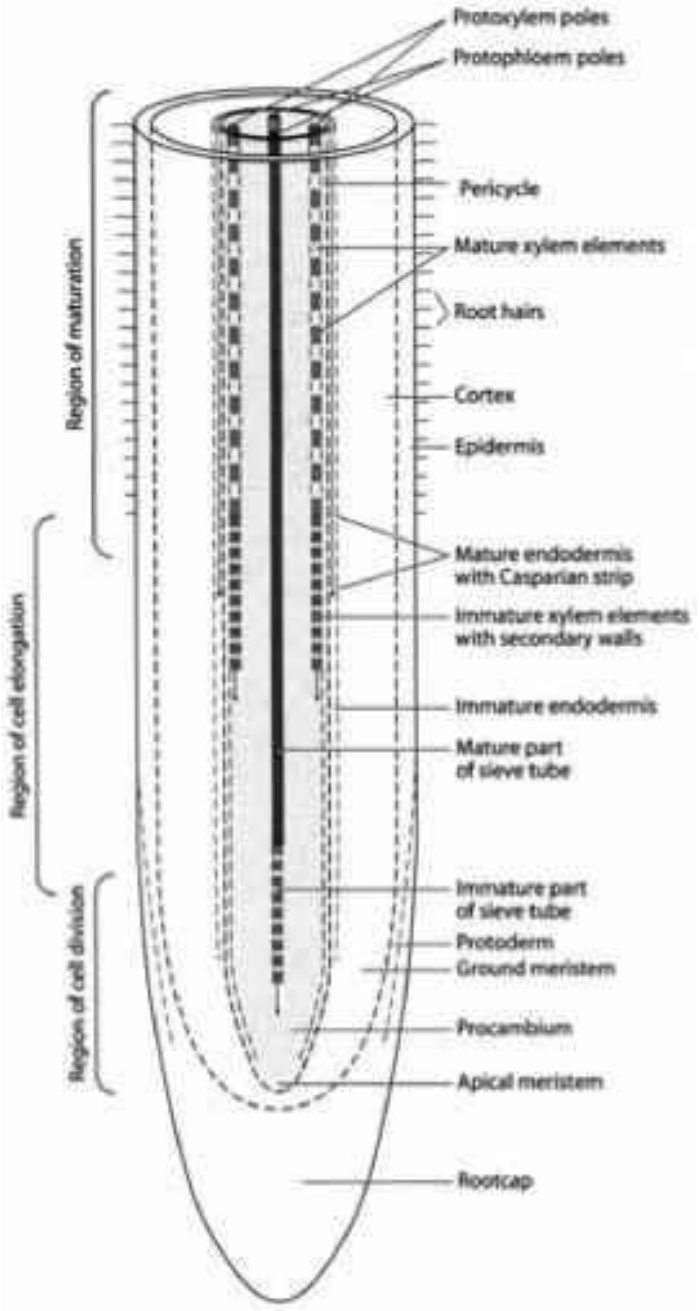


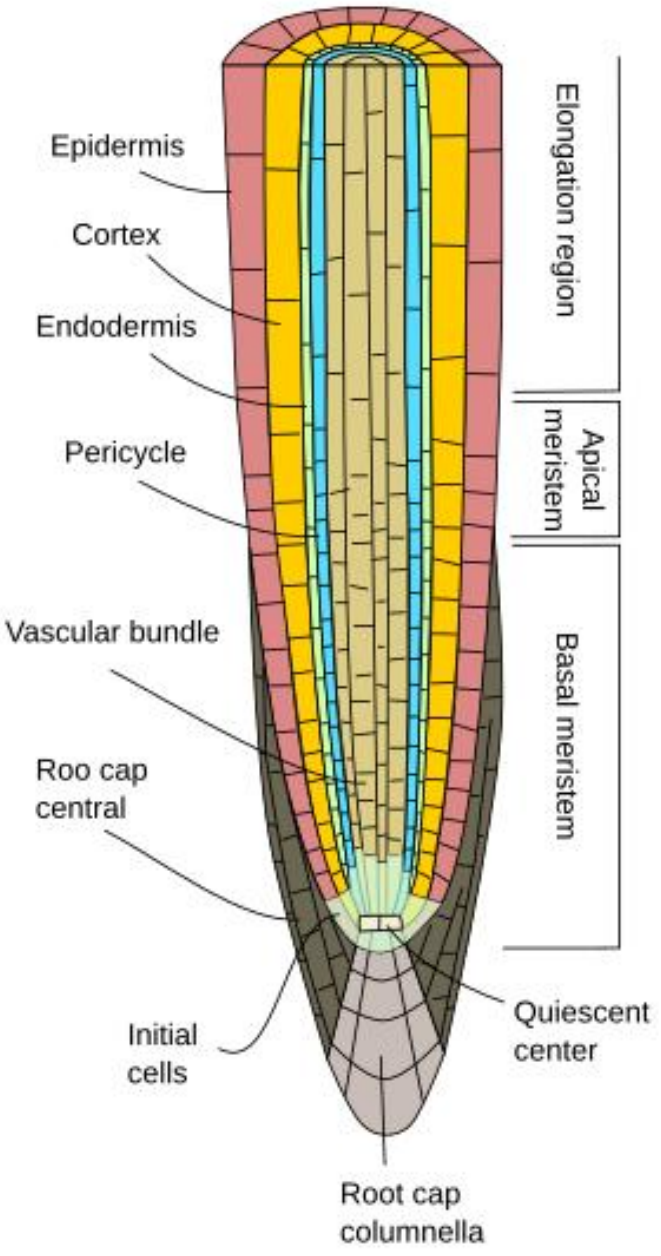

Cell Division
↓
Cell Wall Synthesis
↓
Starch Synthesis for Statoliths
↓
Development Of Golgi Apparatus
↓
Mucilage Secretion
↓
Degradation Of Cell Wall Material
↓
Border Cell Separation
apical meristematic region
TRANSVERSE MERISTEM
columella region
peripheral cells


arrows indicate amyloplasts within columella cells of this Arabidopsis root tip

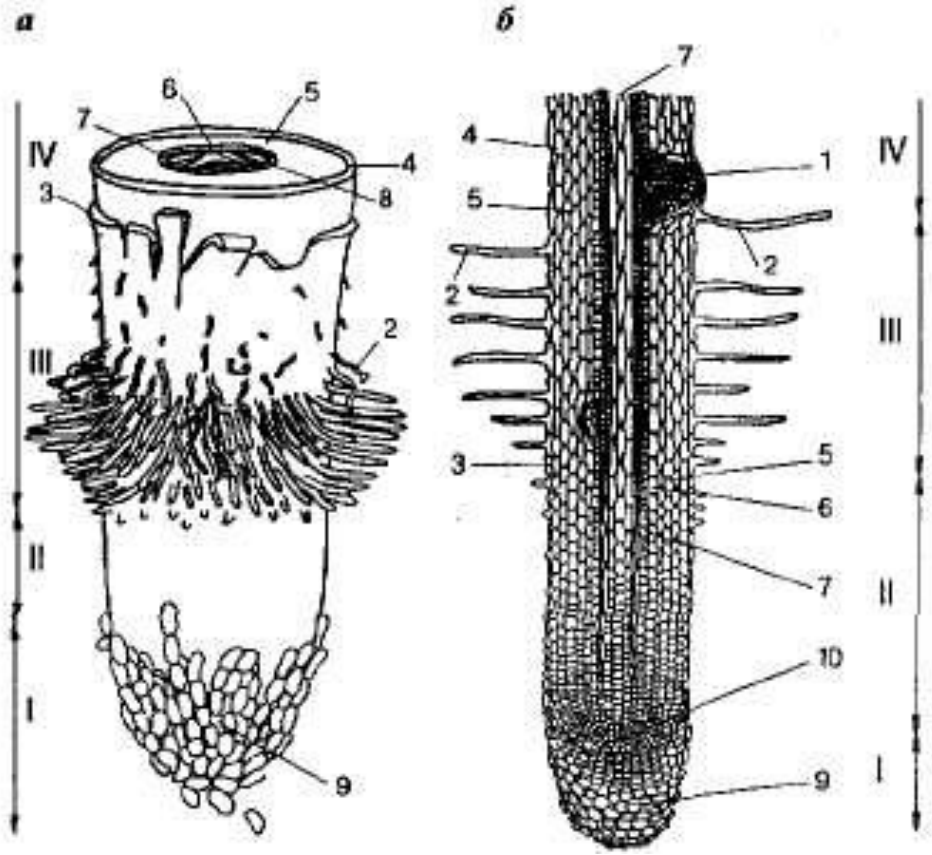

g
N
V
A
90⁰
rotation
0 min
1-2 min
2-4 min

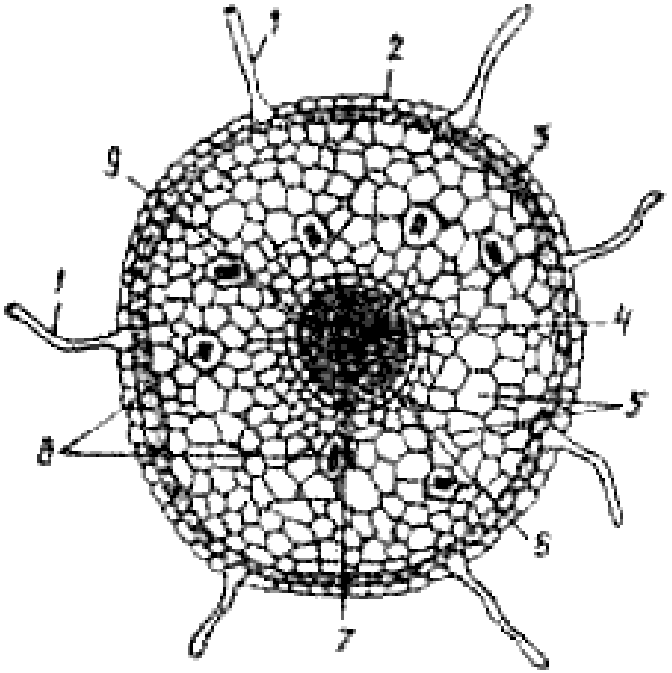
The zone of elongation (growth) of root



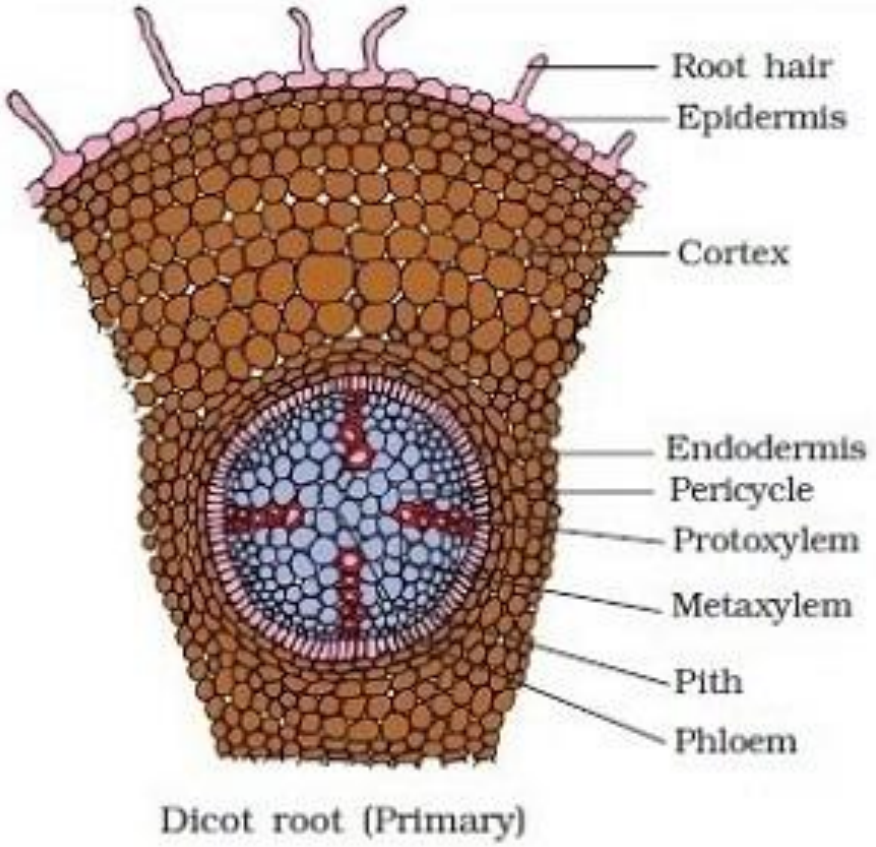


The zone maturation (the absorption zone)

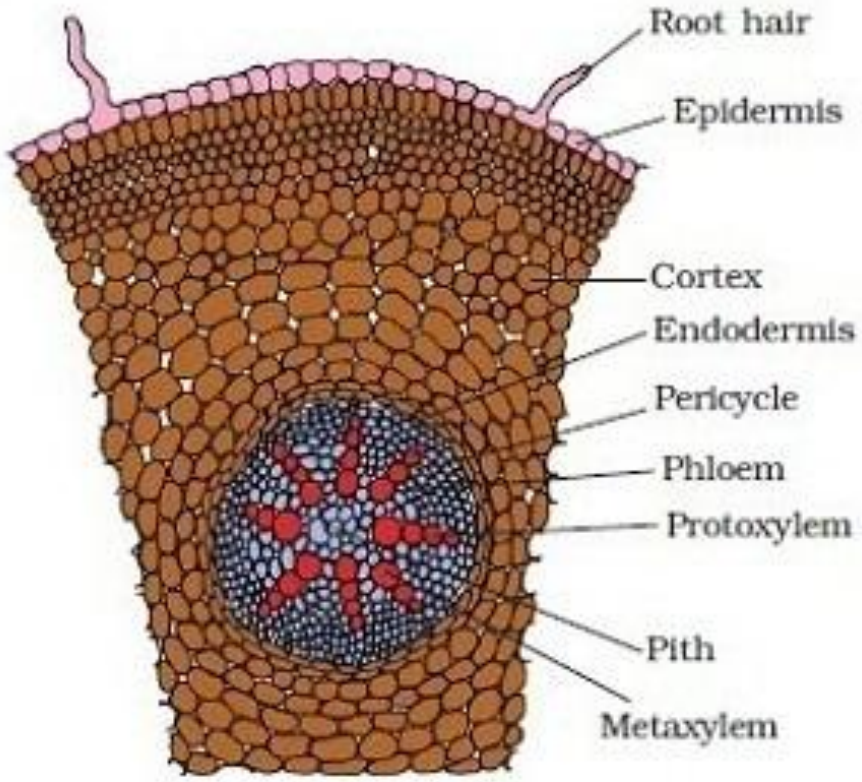




The primary anatomical structure of the root

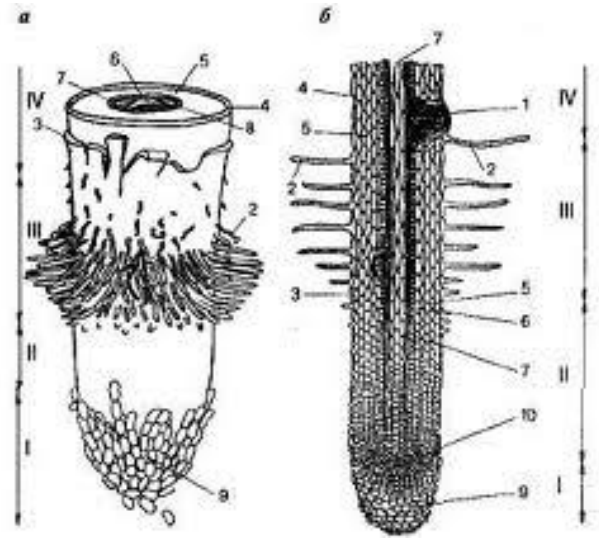


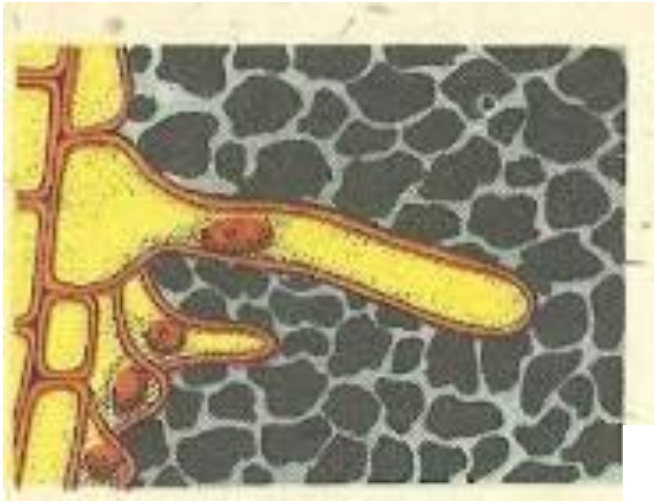
Dicot root (Primary)

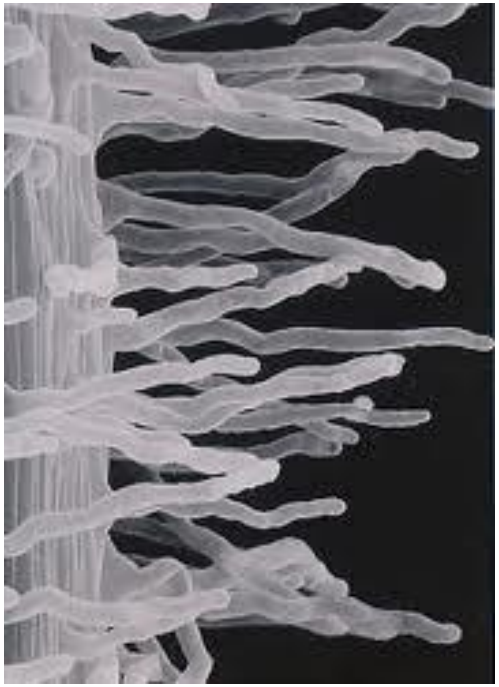


Monocot root

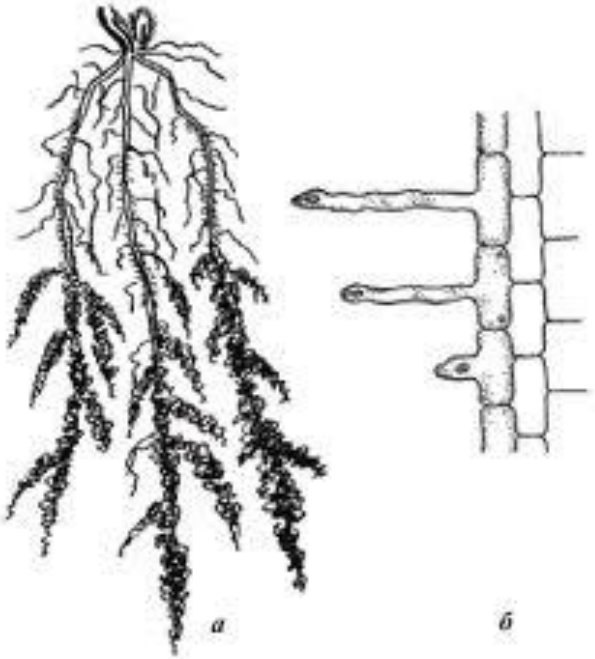
Epiblema



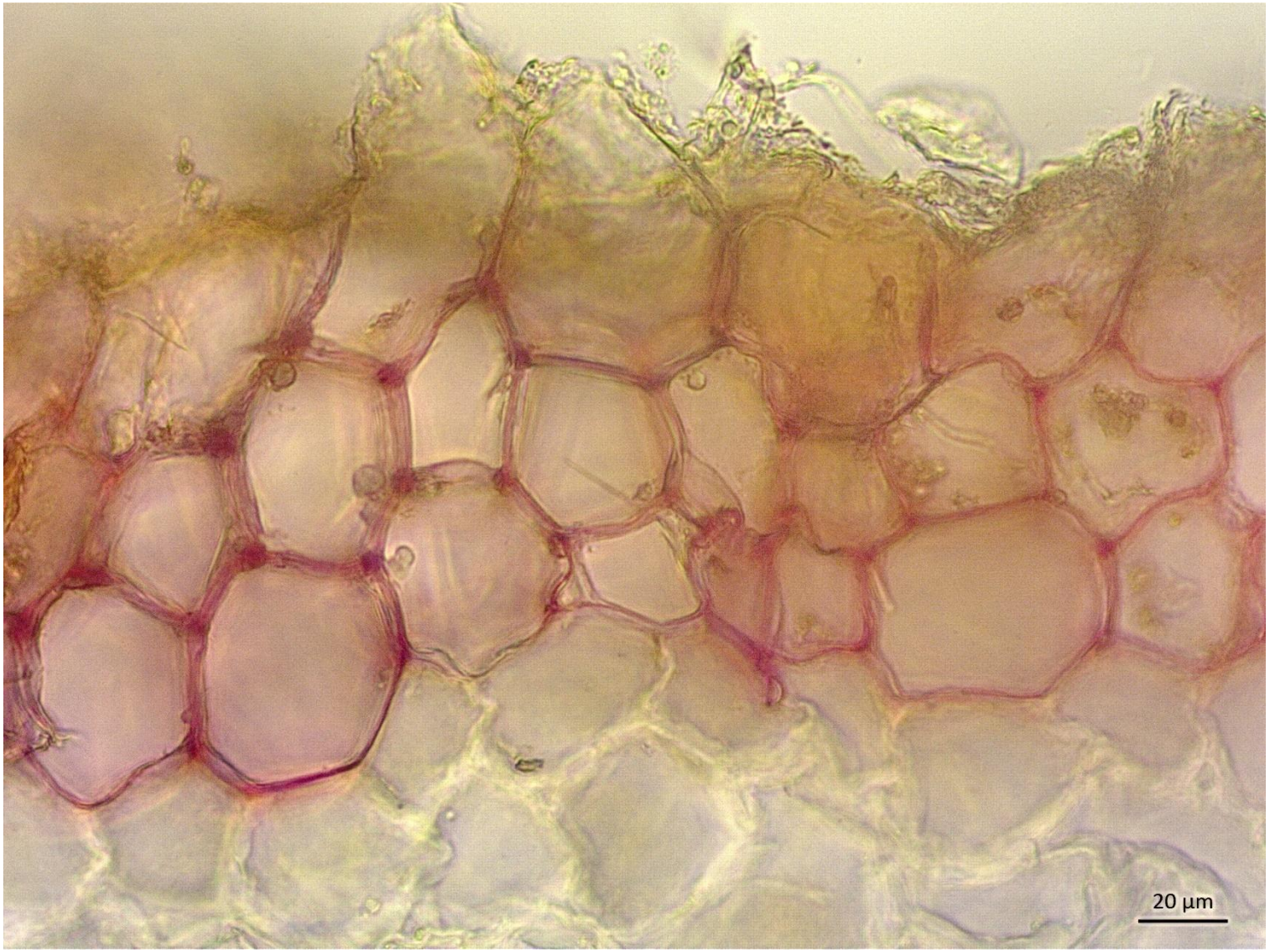


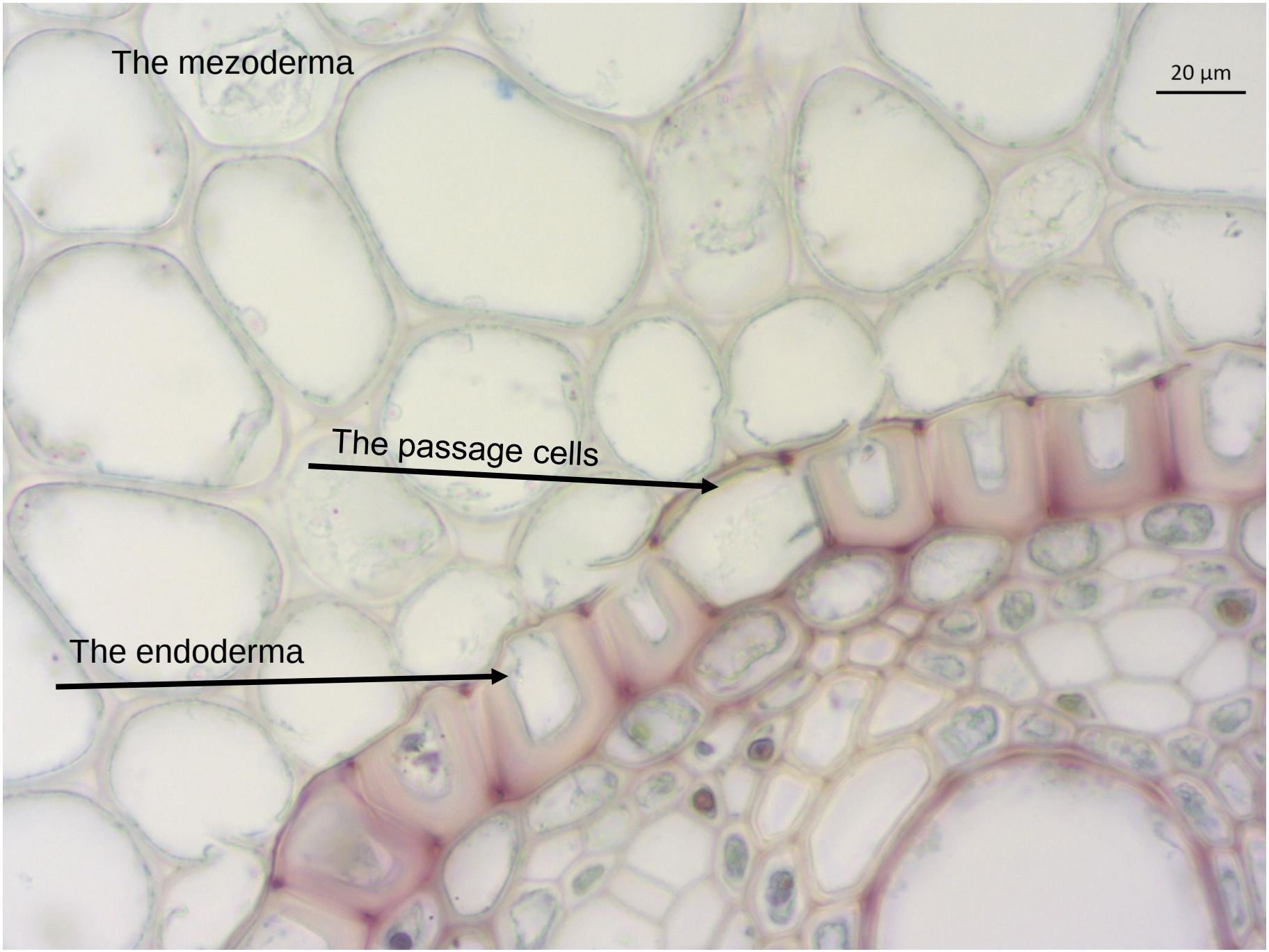


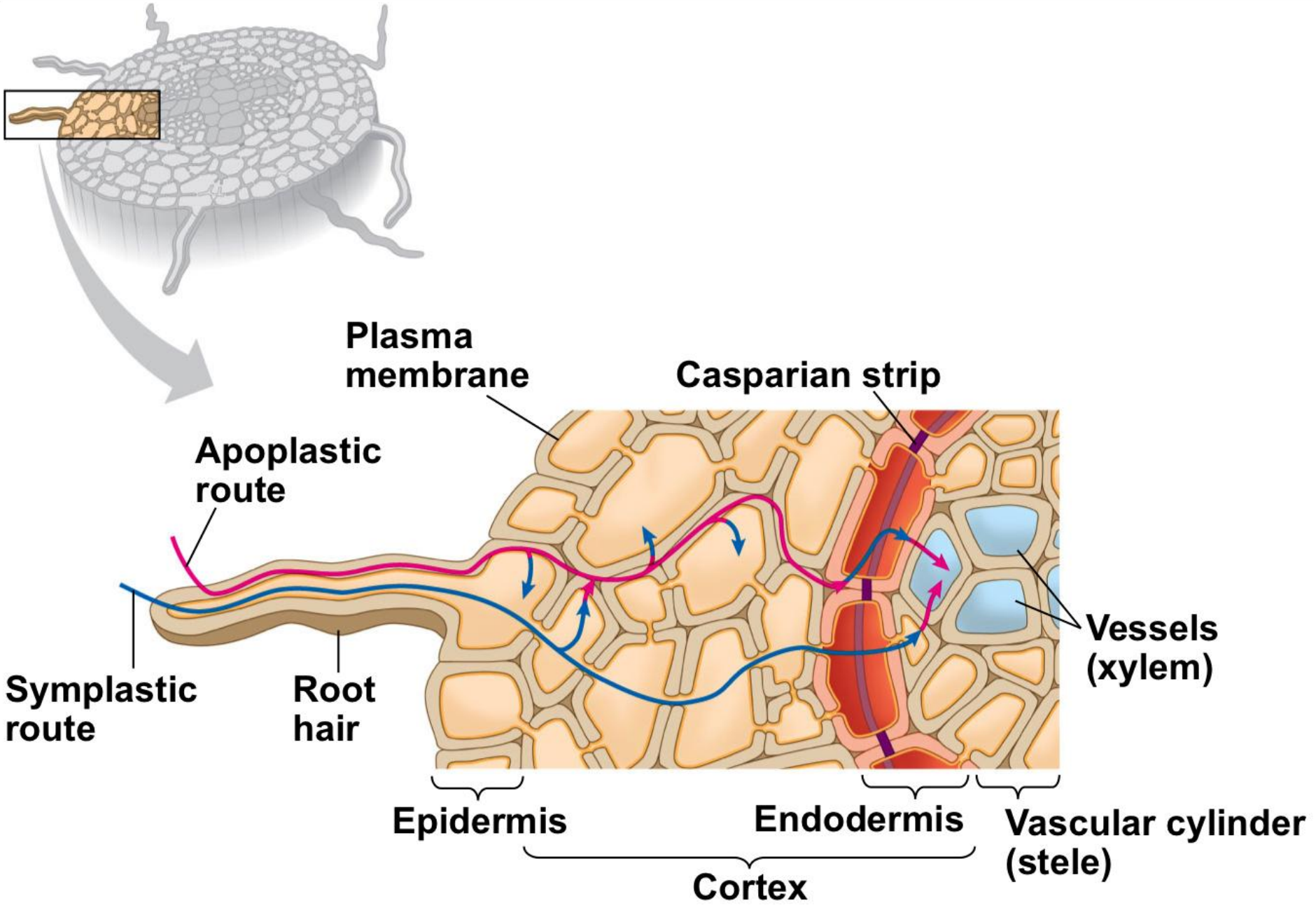
The trichoblasts (root hairs)

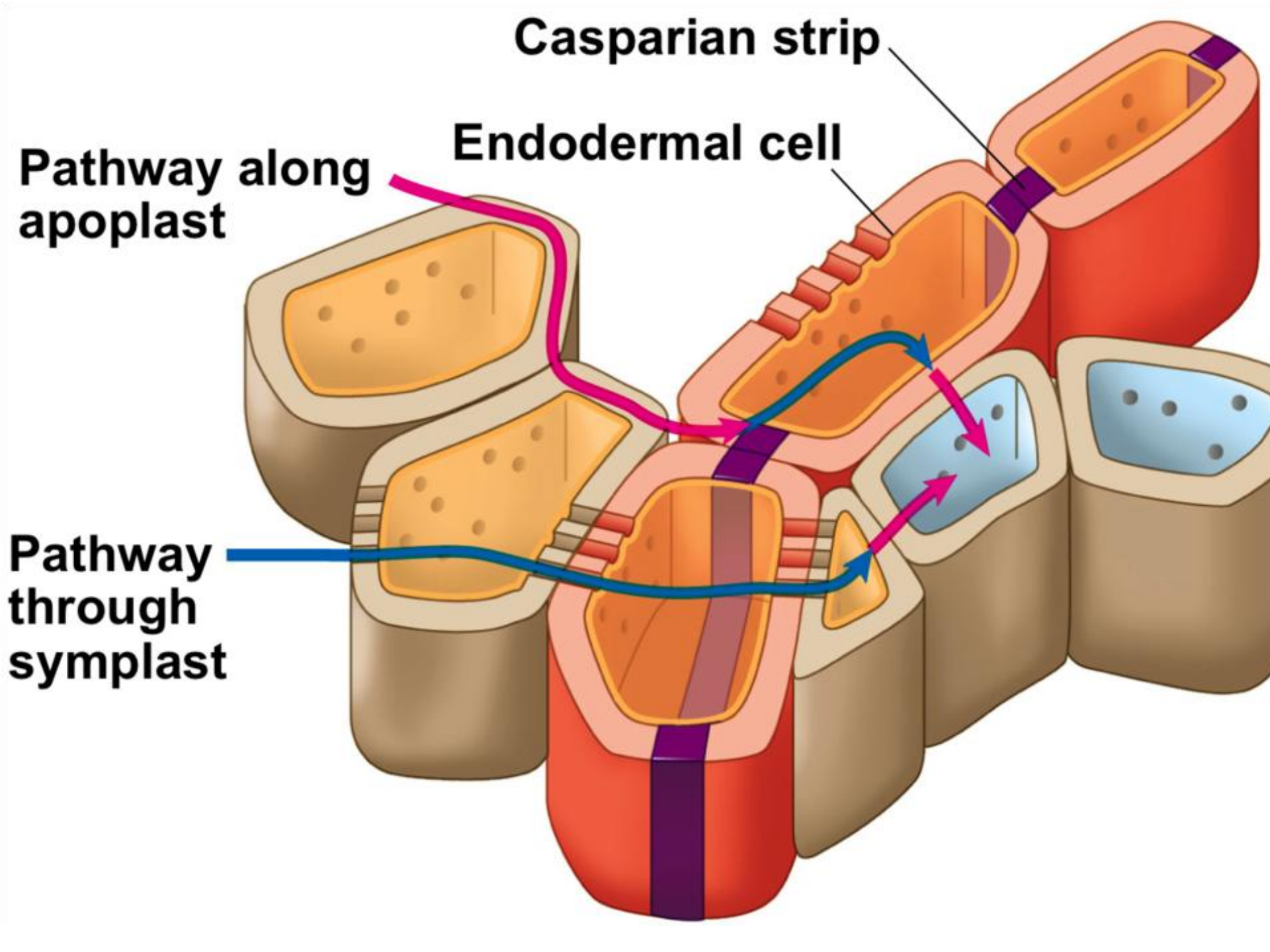


The exodermis cells in root of Iris germanica

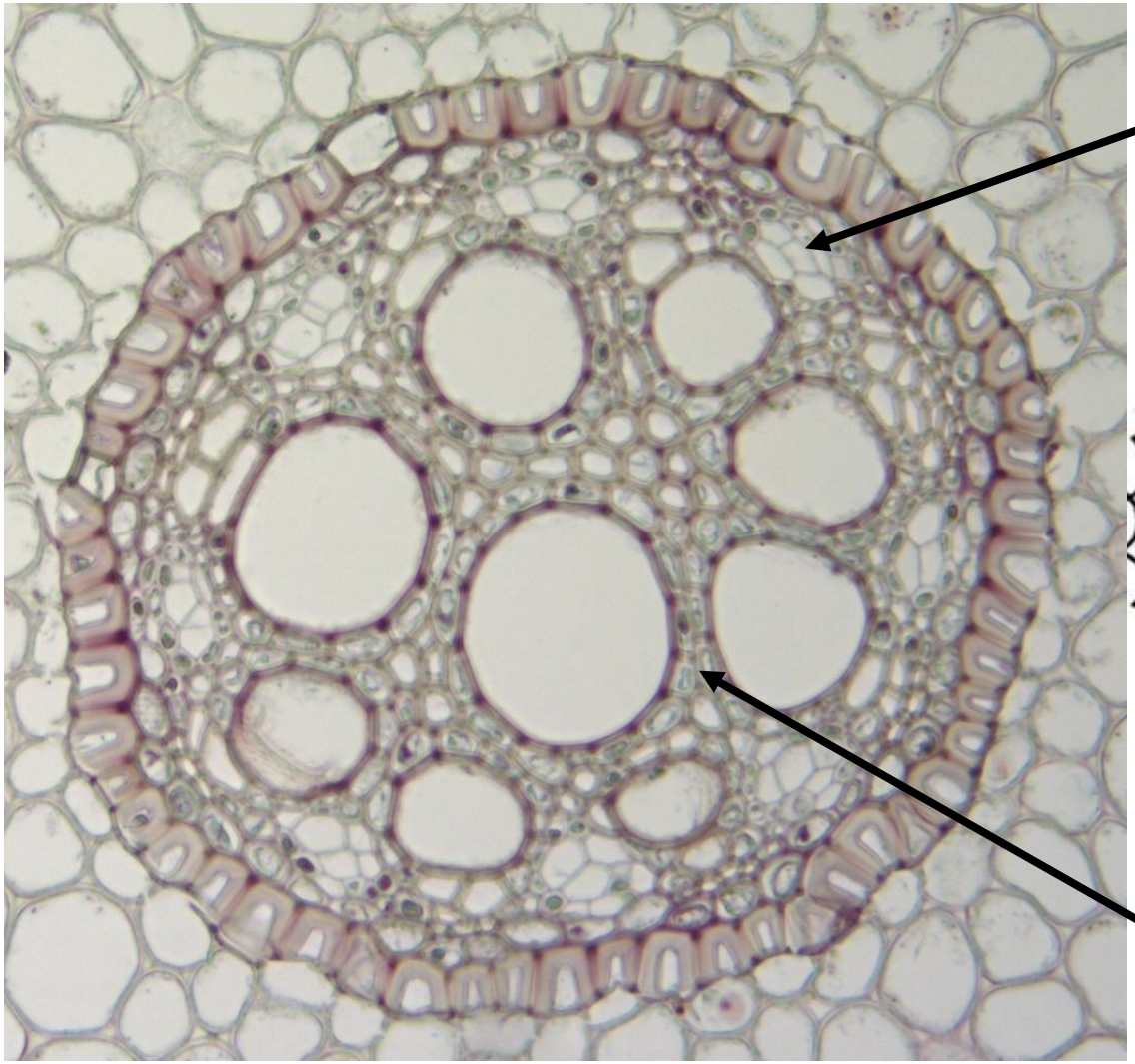



The mezoderma
20 µm
The passage cells
The endoderma

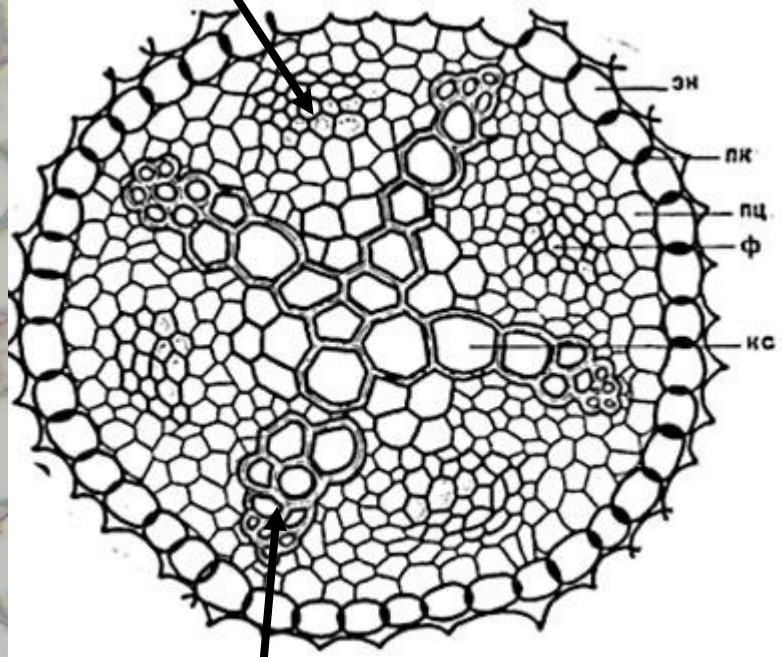

Plasma membrane
Casparian strip
Apoplastic route
Symplastic route
Root hair
Vessels (xylem)
Epidermis
Endodermis
Vascular cylinder (stele)
Cortex


Casparian strip
Endodermal cell
Pathway along apoplast
Pathway through symplast

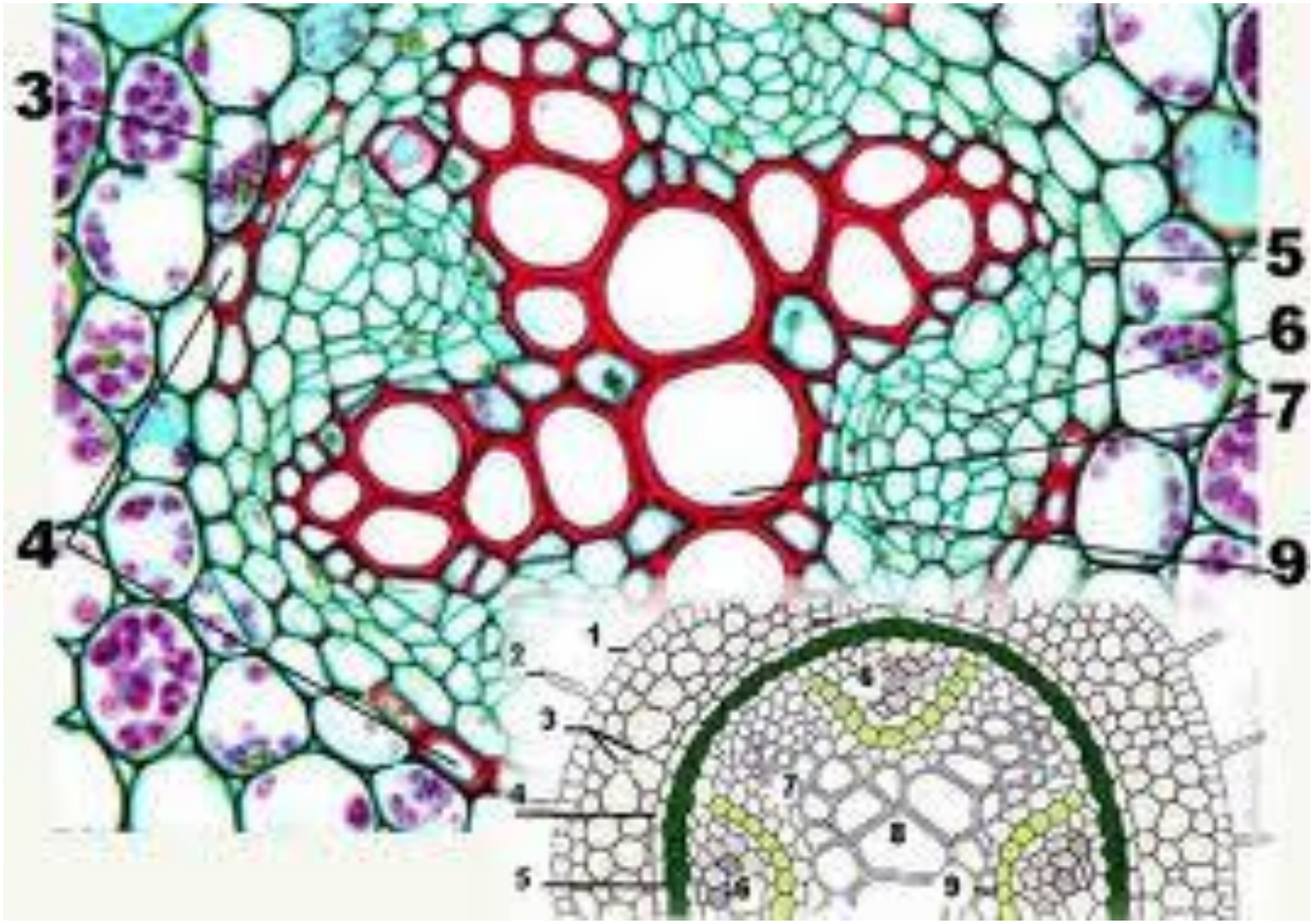
Central axial cylinder

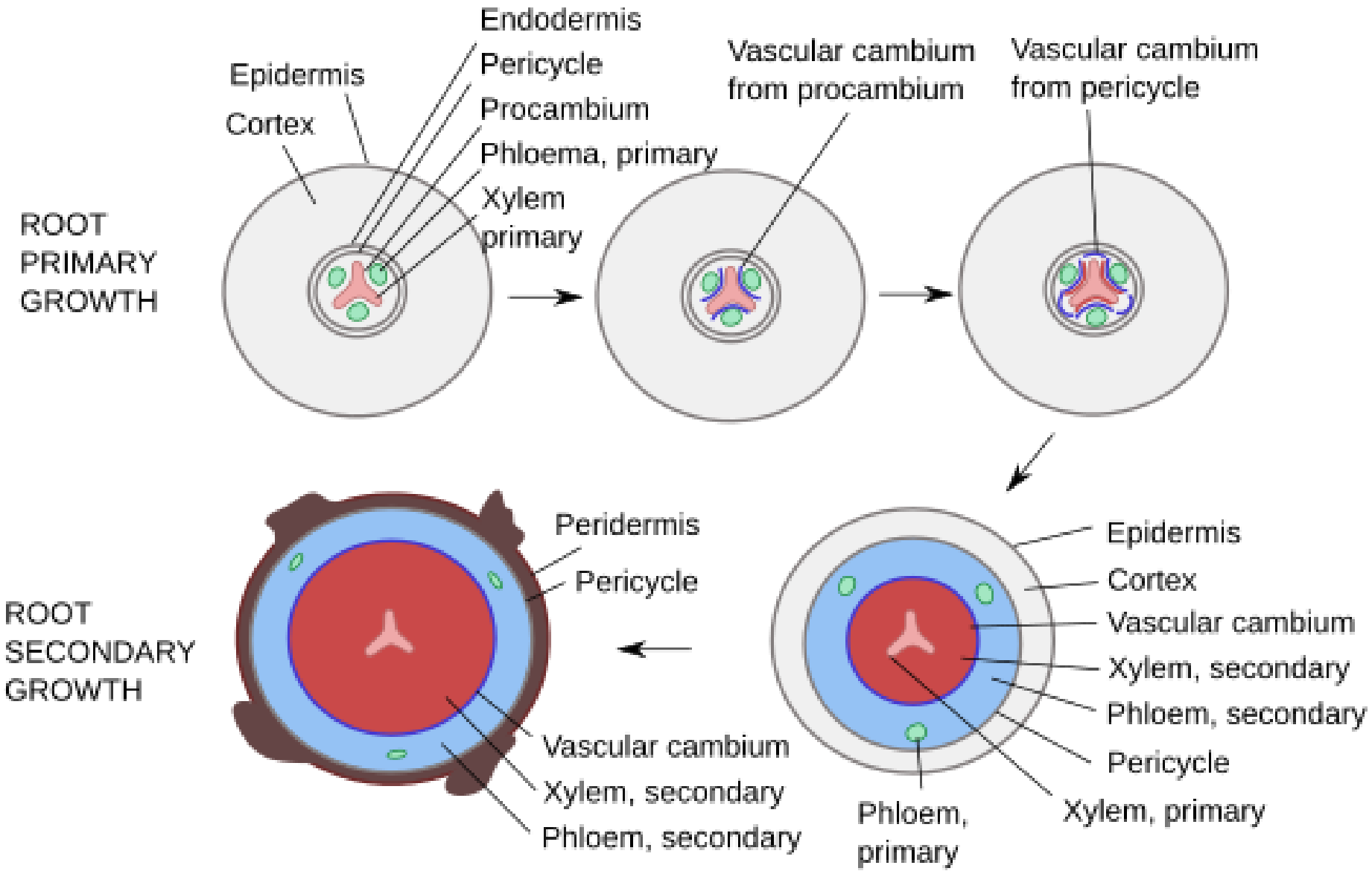


The phloem

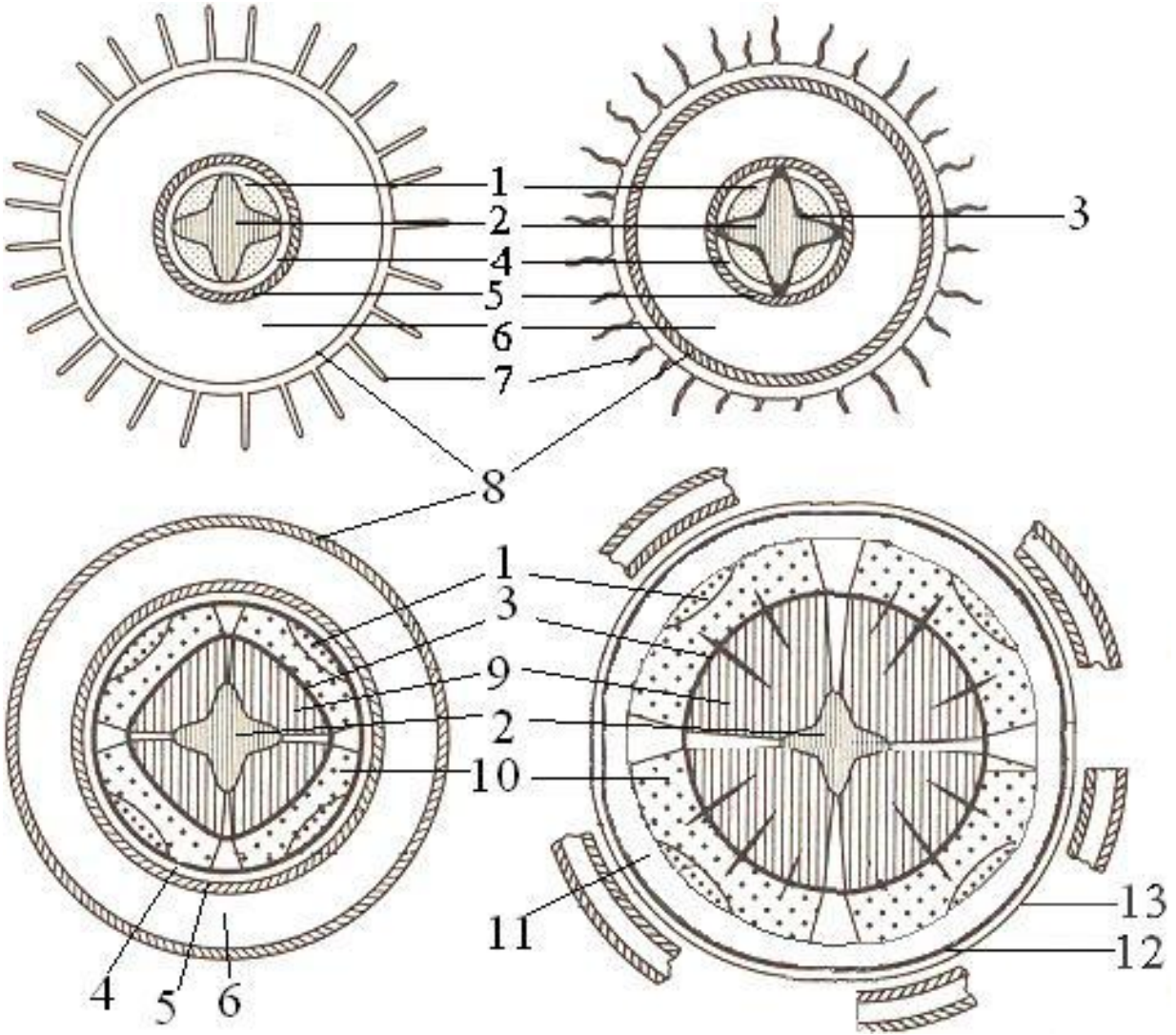


The xylem


3
4
5
6
7
9
1
2
3
4
5
6
7
8
9

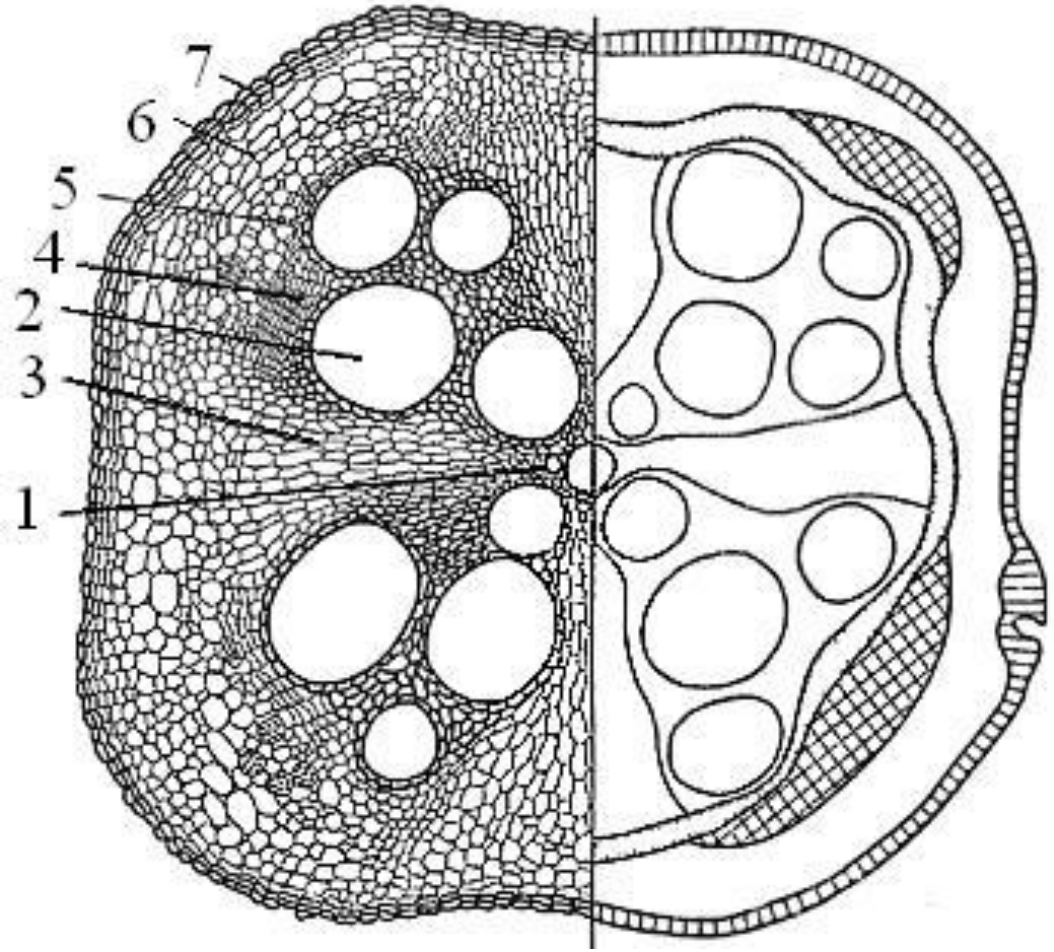

ROOT
PRIMARY
GROWTH
Epidermis
Cortex
Endodermis
Pericycle
Procambium
Phloema, primary
Xylem
primary
Vascular cambium
from procambium
Vascular cambium
from pericycle
ROOT
SECONDARY
GROWTH
Peridermis
Pericycle
Vascular cambium
Xylem, secondary
Phloem, secondary
Epidermis
Cortex
Vascular cambium
Xylem, secondary
Phloem, secondary
Pericycle
Phloem,
primary
Xylem, primary

The transformation to the secondary structure of the root



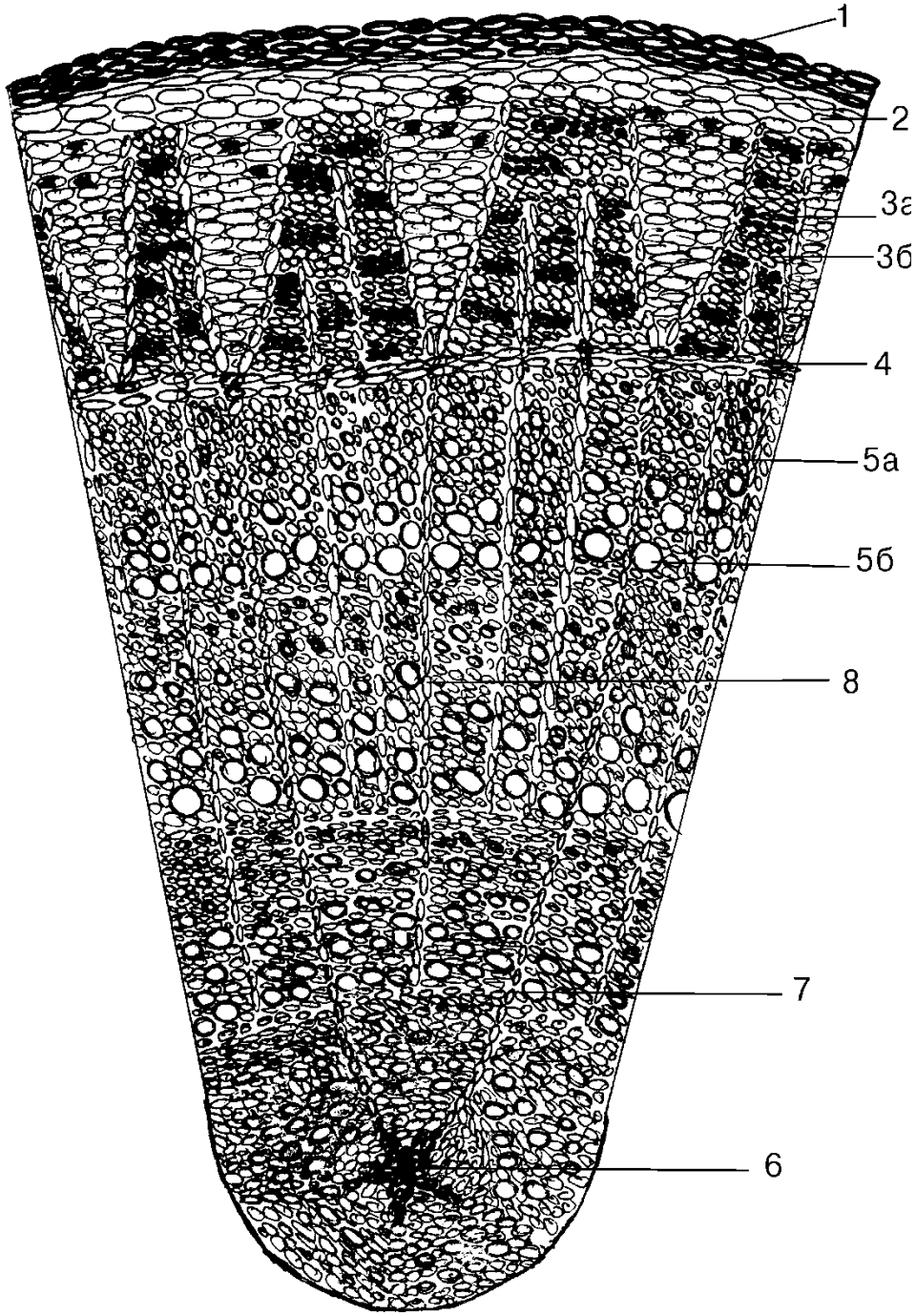
1-primary phloem, 2-primary xylem, 3- vascular cambium, 4-pericycle,5-endoderm, 6-mesoderm, 7-rhizoderm, 8-exoderm, 9-secondary xylem, 10-secondary phloem, 11-secondary cortex, 12-phellogen, 13-fellema.

The secondary structure of the root



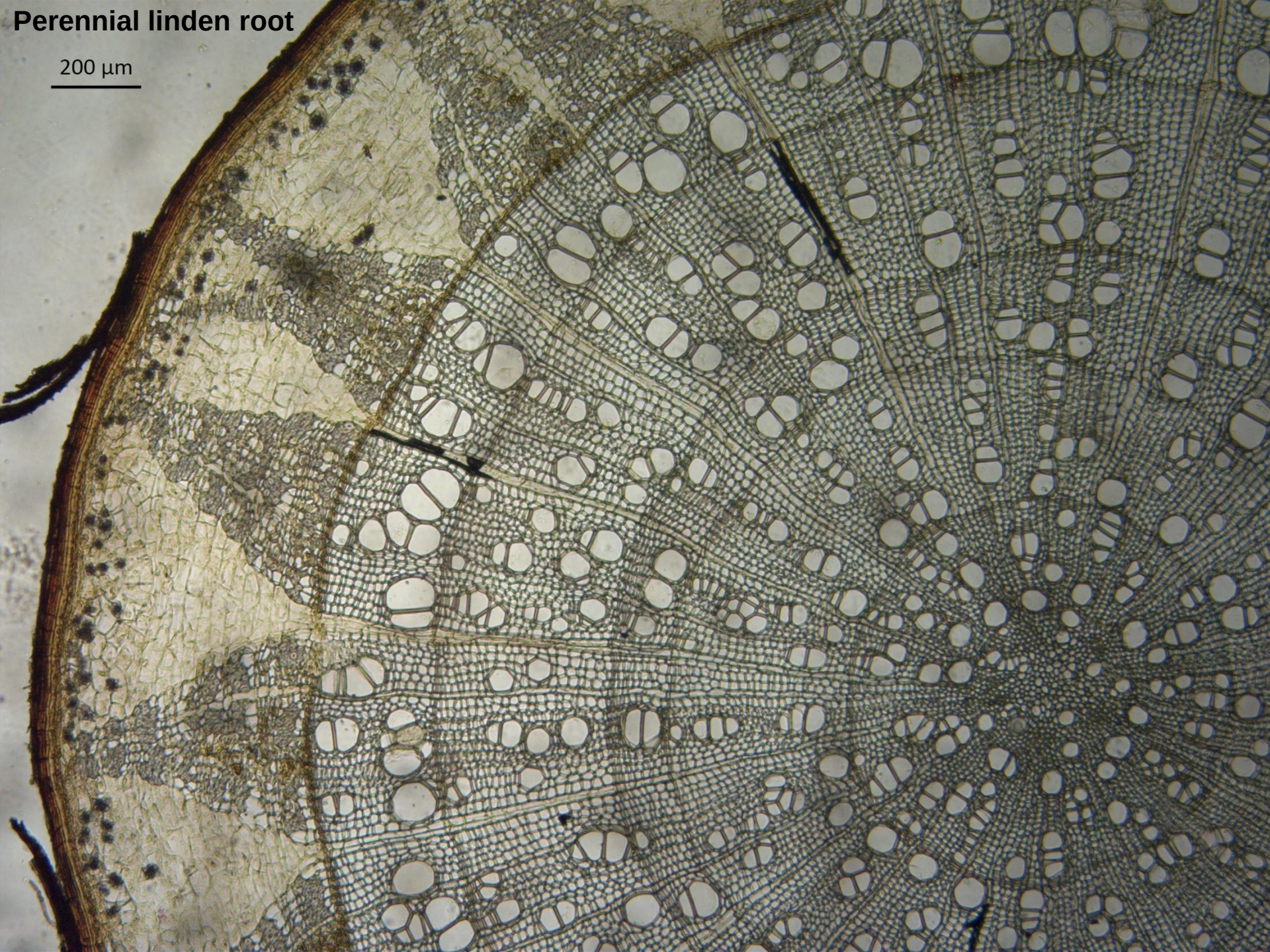
The secondary structure of the pumpkin root: 1-primary xylem, 2-secondary xylem, 3-pith ray, 4- vascular cambium, 5-primary and secondary phloem, 6- parenchyma of the secondary cortex, 7- periderm (1-3-xylem, 5-7-secondary cortex)

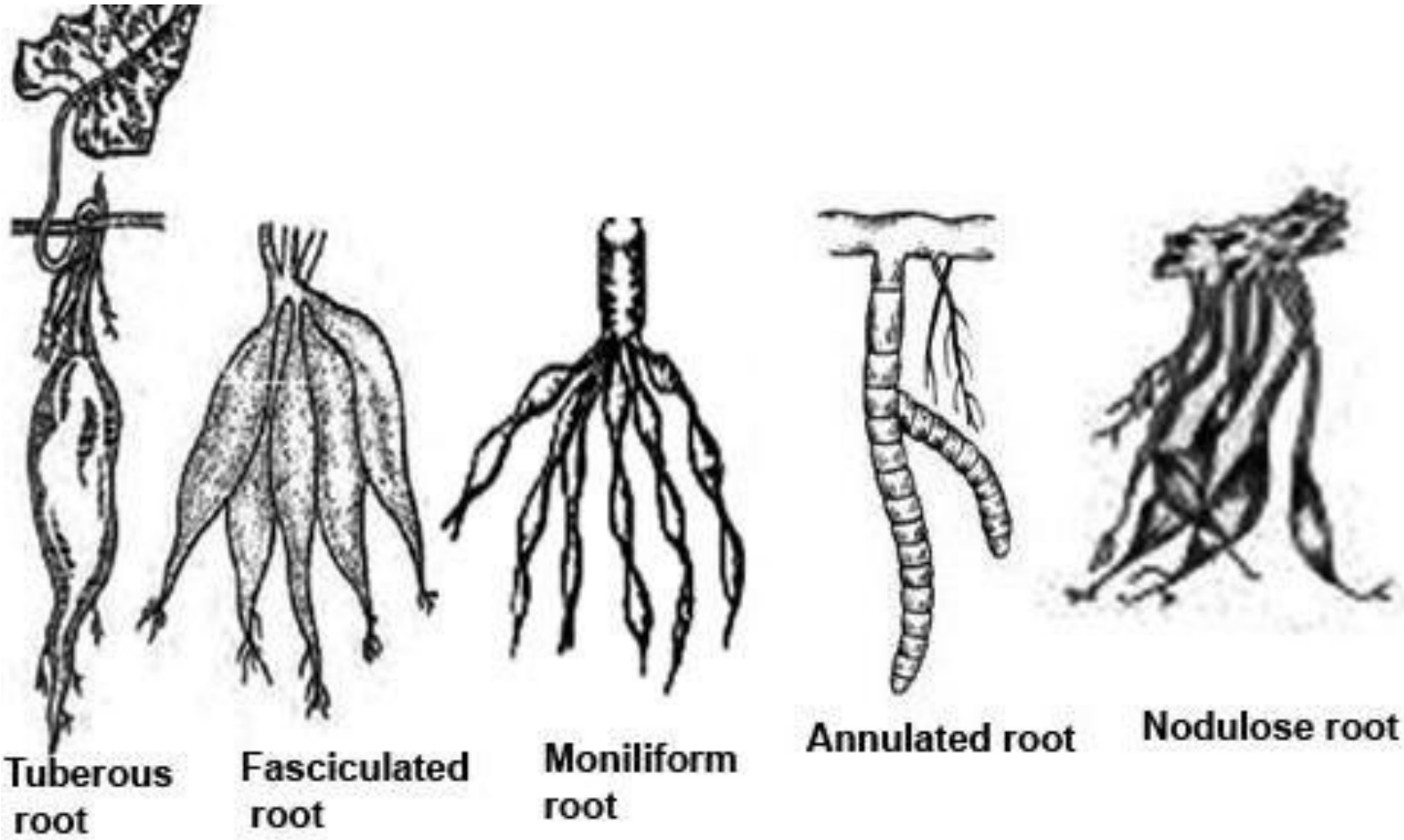
The secondary structure of the pumpkin root



Perennial linden root:

1-periderm, 2-core parenchyma of pericyclic origin, 3-phloem 4- vascular cambium, 5-secondary xylem 6-primary xylem, 7-primary pith ray, 8-secondary pith ray, 9-idioblasts with calcium oxalate crystals


Perennial linden root
200 µm


Tuberous root
Fasciculated root
Moniliform root
Annulated root
Nodulose root

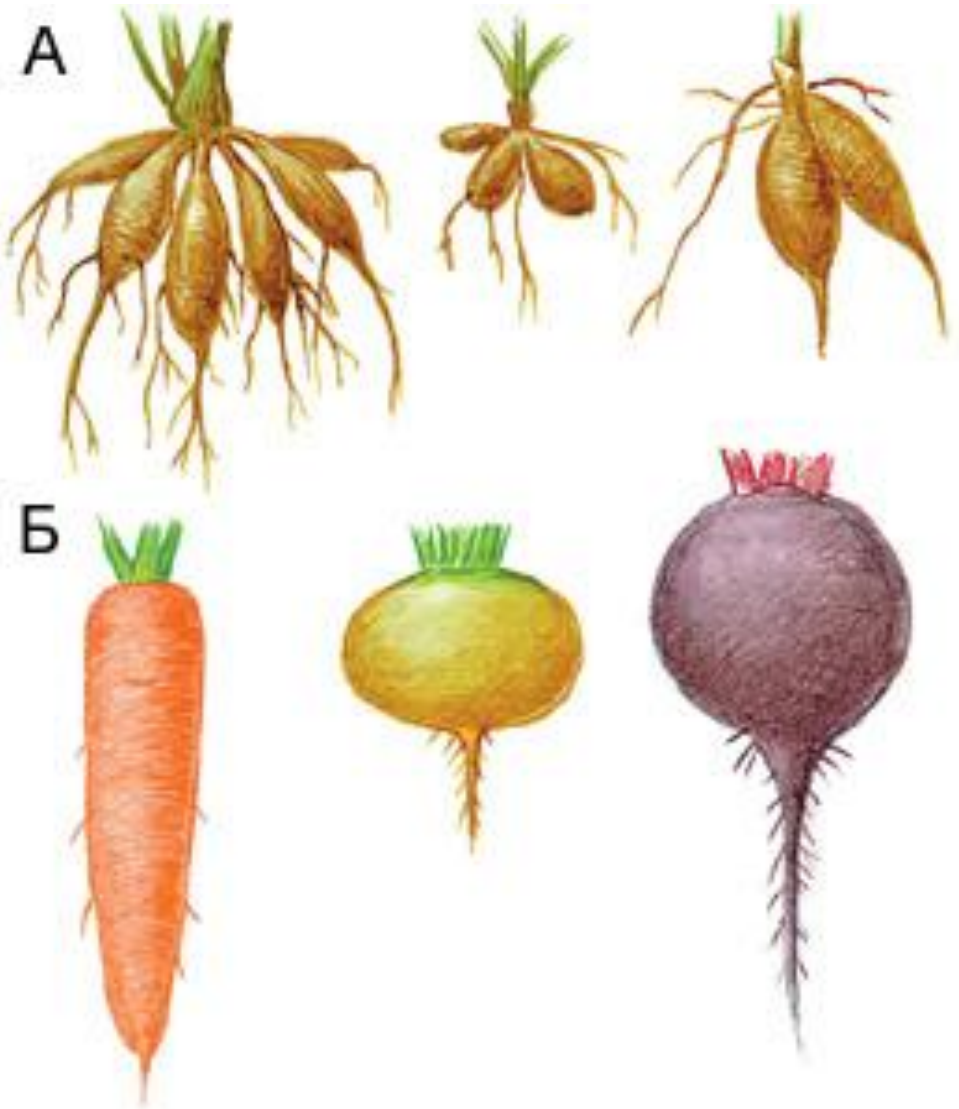
The Banyan Tree is a species of fig tree that grows aerial prop roots; thick supporting trunks. Prop roots allow the Banyan Tree to provide additional anchorage and support. The circling of prop roots allows these enormous trees to not only grow taller but also wider. A large Banyan Tree can be over 100 feet(30 meters) wide.

Buttress roots of Fig trees arise from the base of a stem and support the plant.

Roots of mangrove trees

Ivy roots of Hedera helix

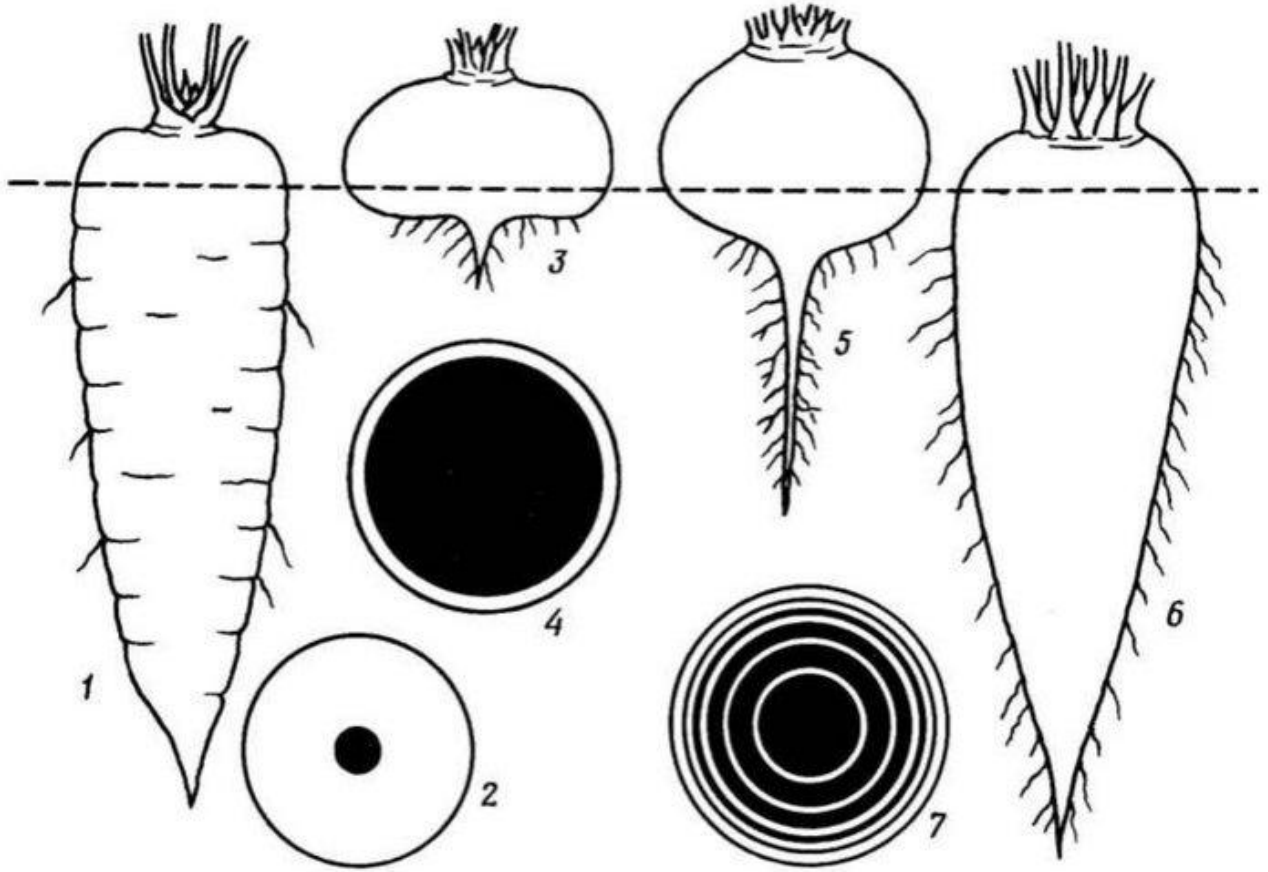
Root crops and root tubers



A-root tubers

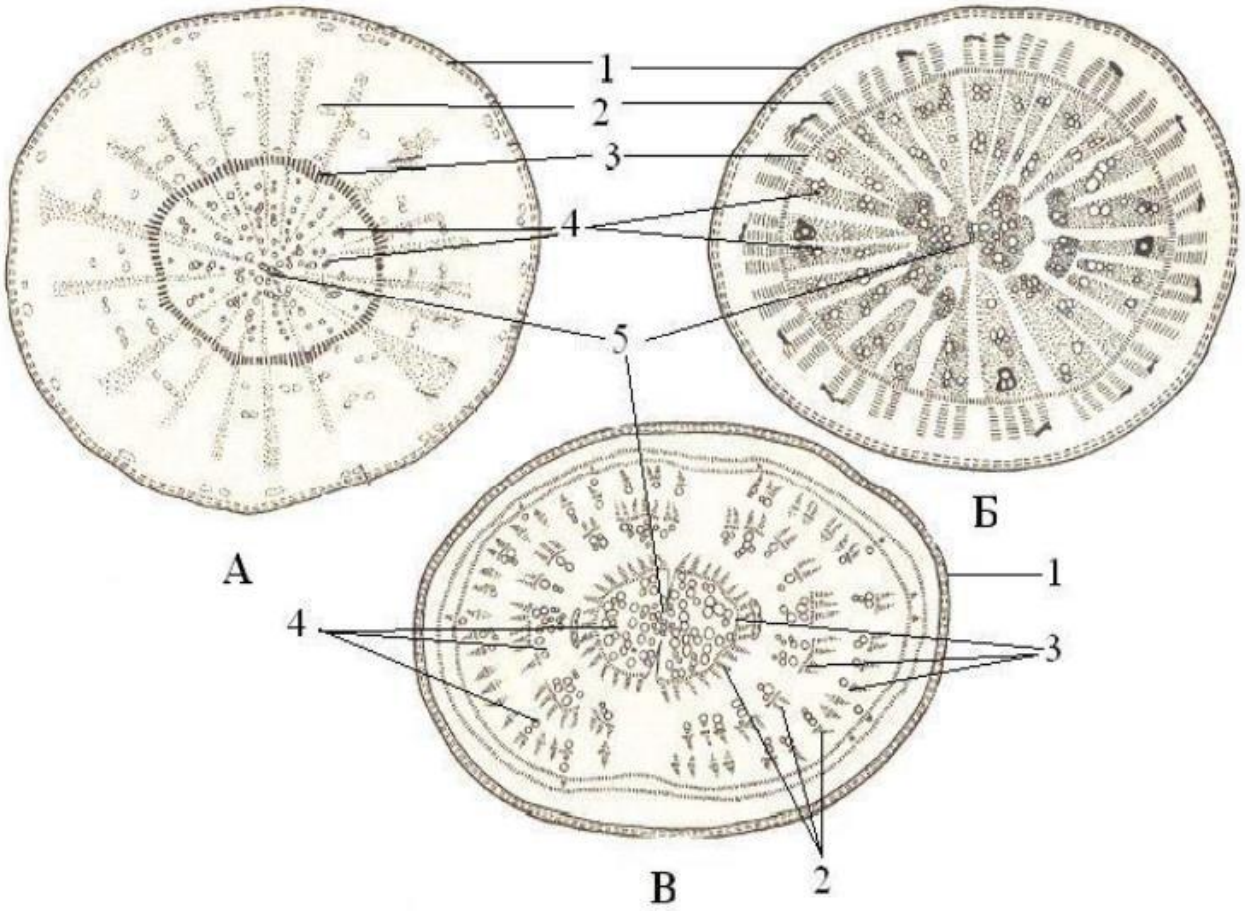
B-root crops

Root crop of carrot (1, 2), turnip (3, 4) and beet (5, 6, 7)



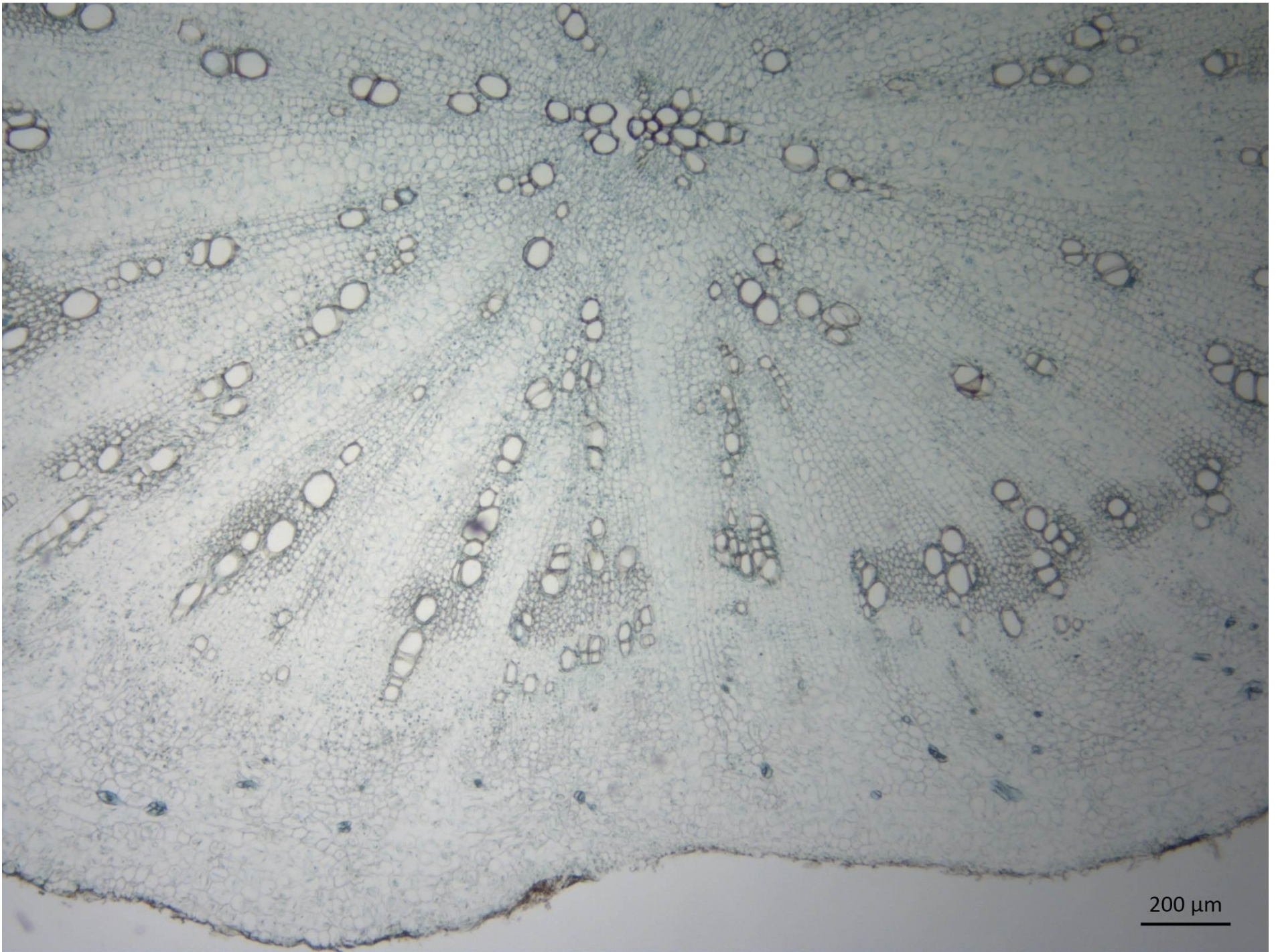
(on the cross cut the xylem marked by black color; horizontal line – a border between stalk and root)

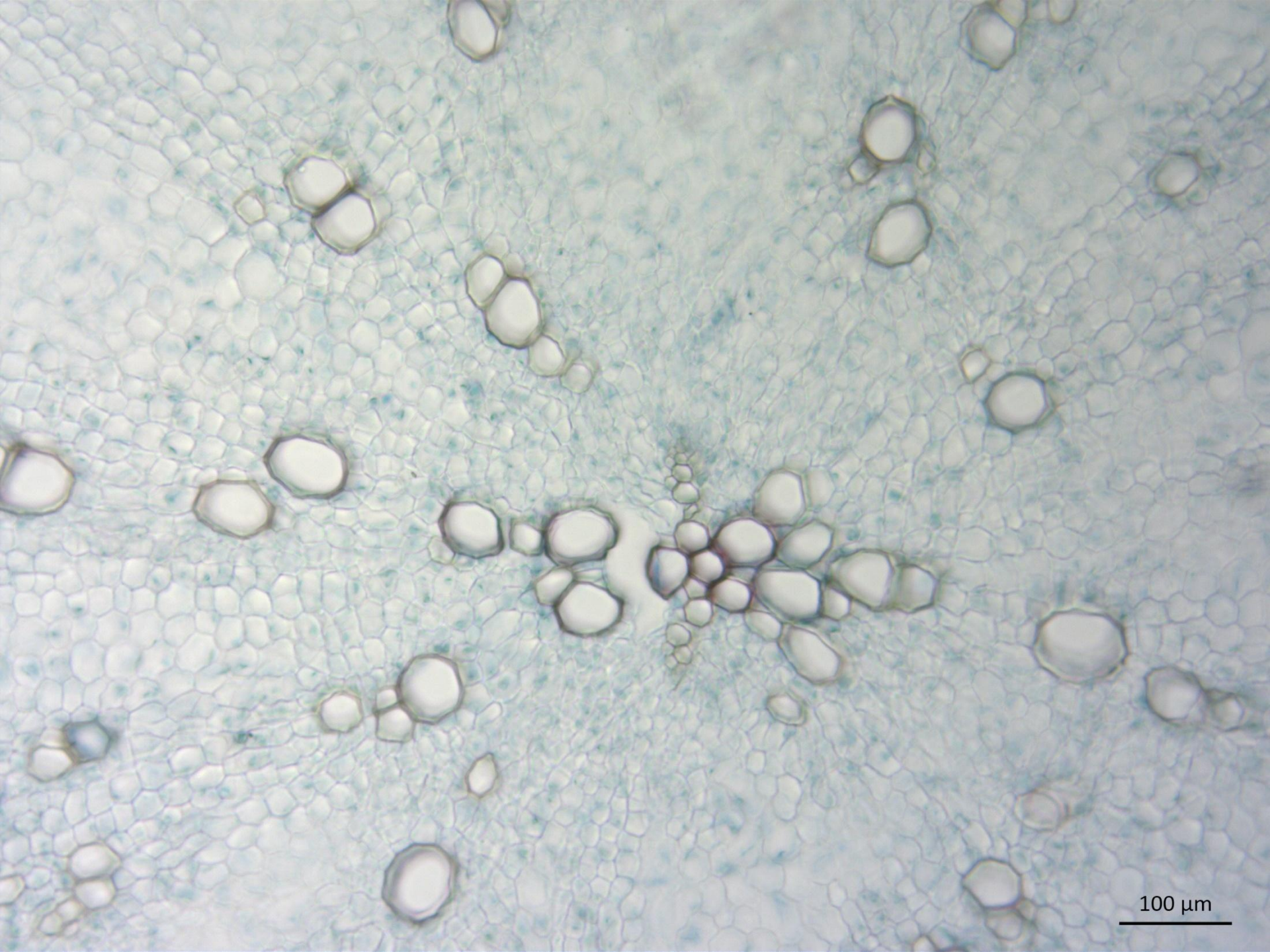
The structure of modified roots (rootlets).



Cross-sections of rootstocks with different types of cambium and storage deposition: A - monocambial phloem (carrot); B - monocambial xylem (radish); C - polycambial (beet). 1 - periderm, 2 - secondary phloem, 3 - cambium, 4 - secondary xylem, 5 - primary xylem.

Cross-section of radish root


200 µm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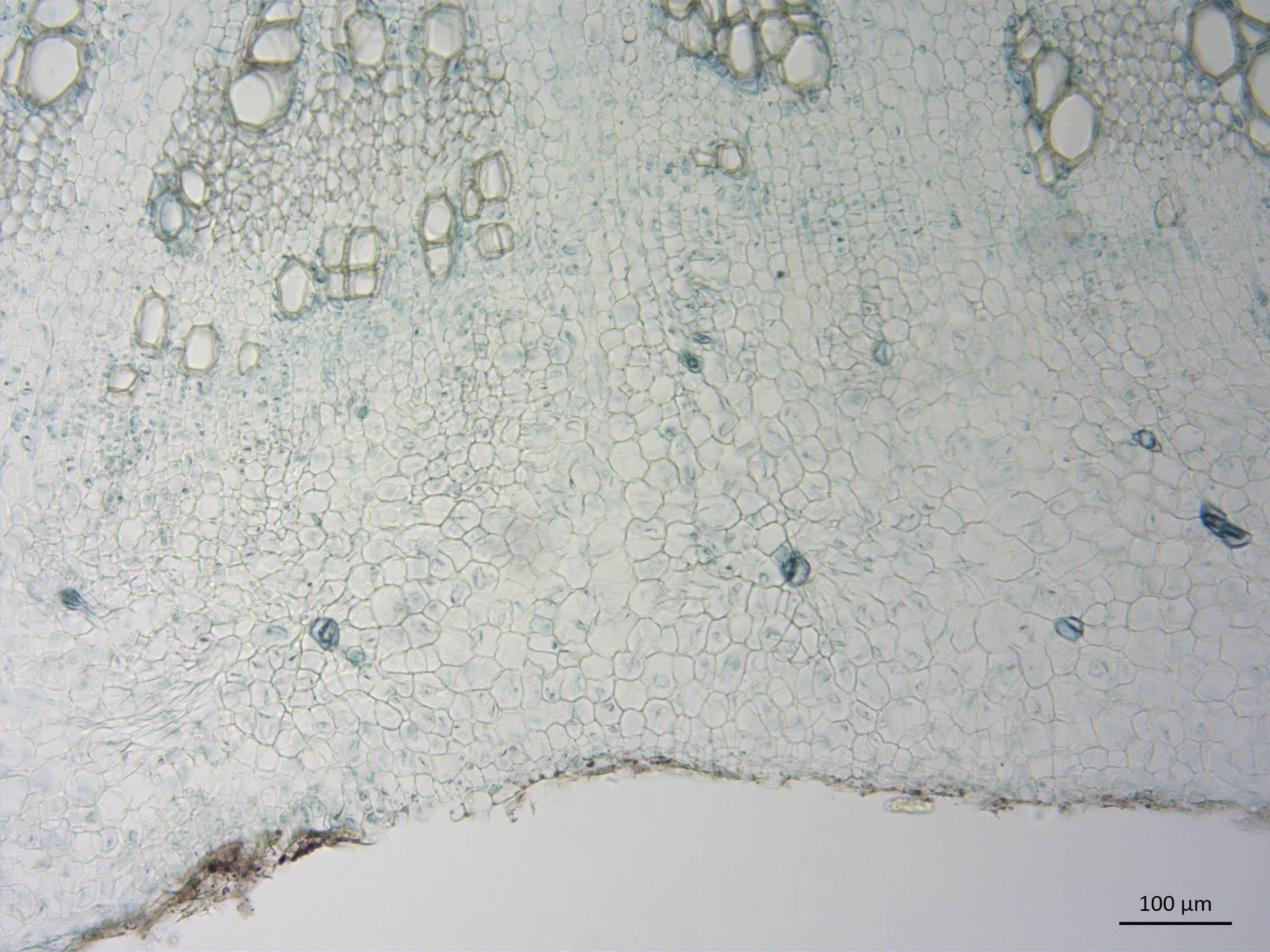
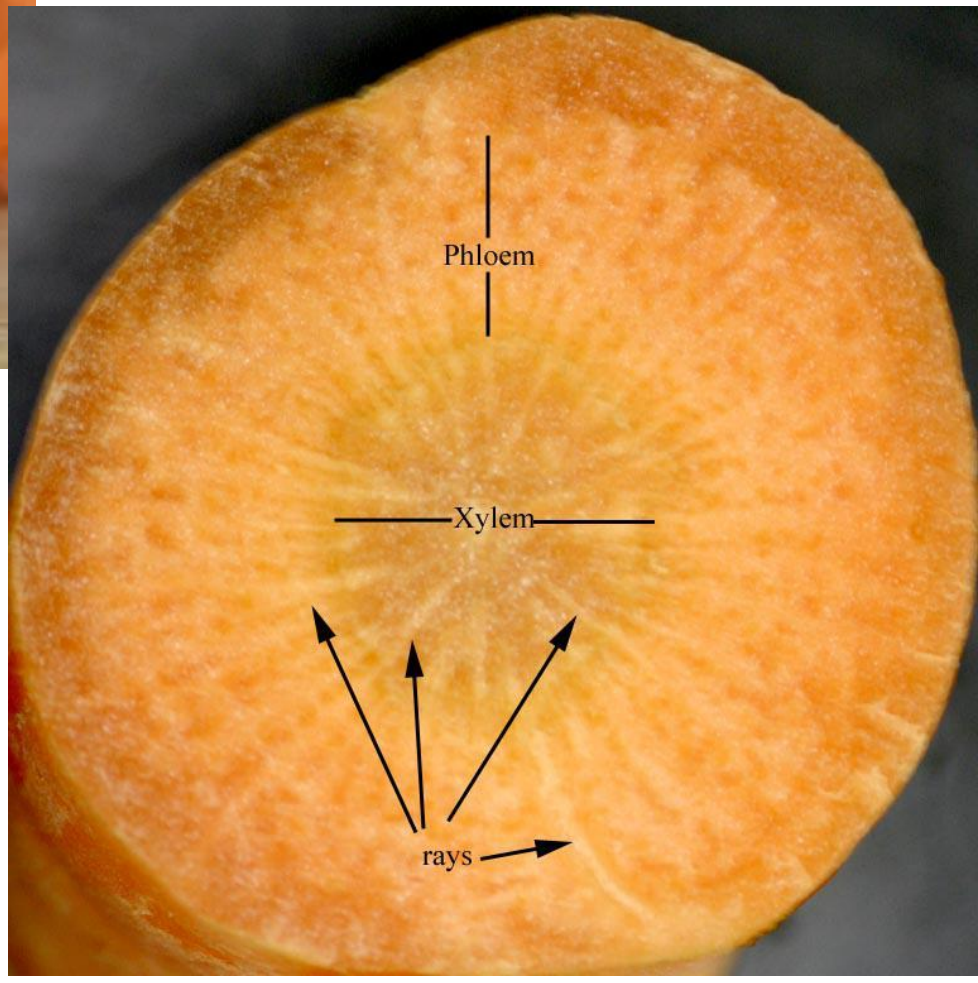
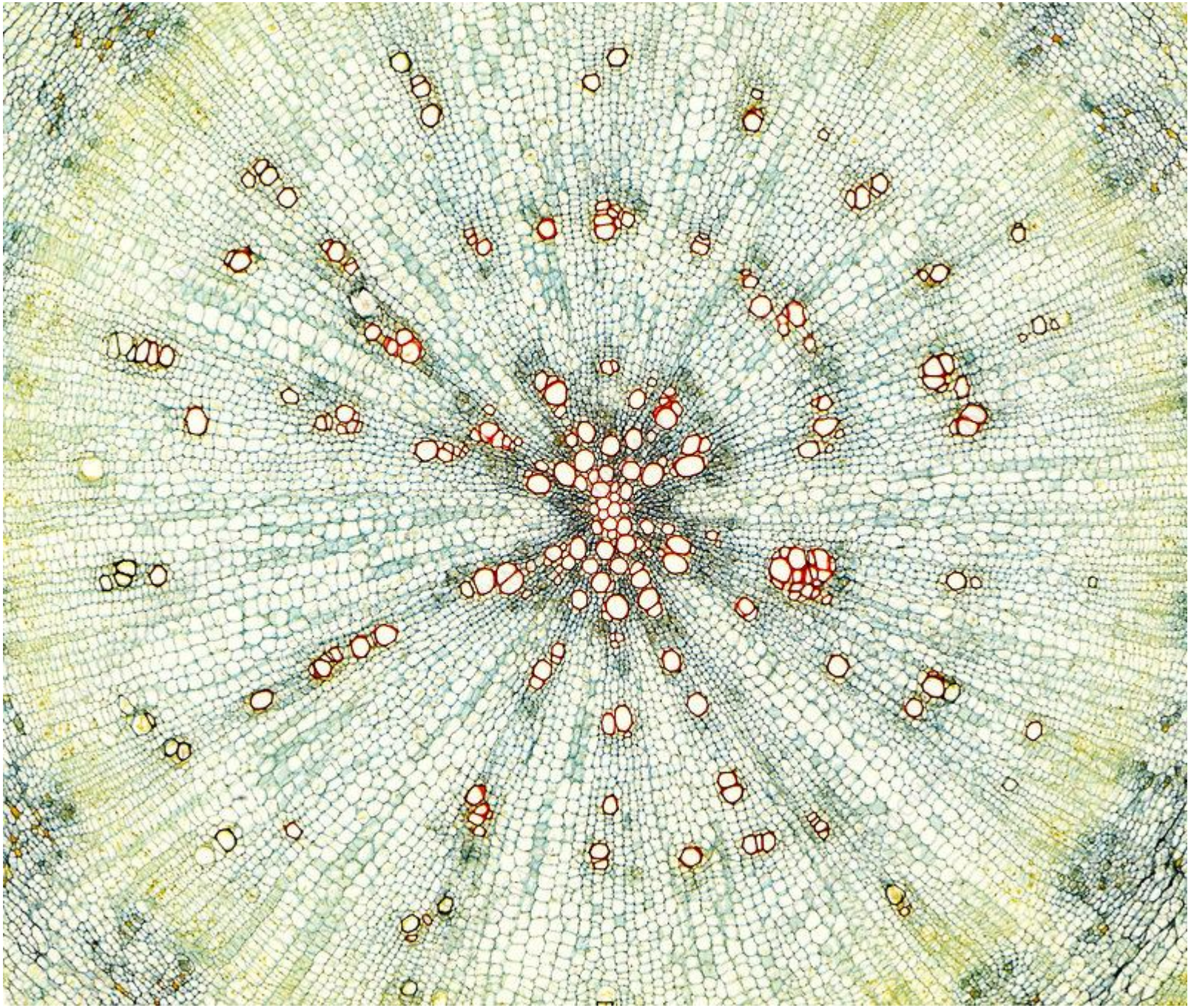
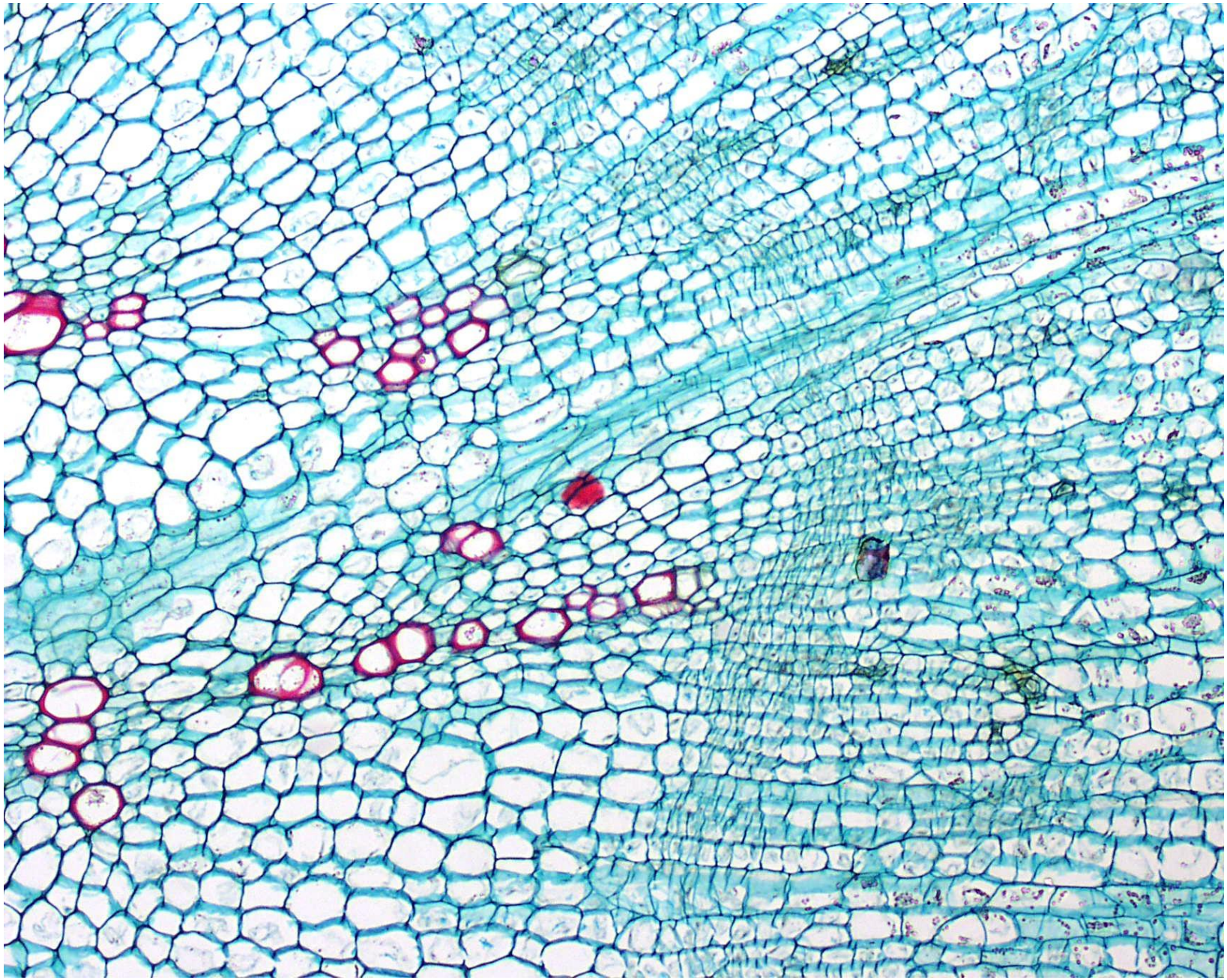

100 µm

Cross-section of carrot root

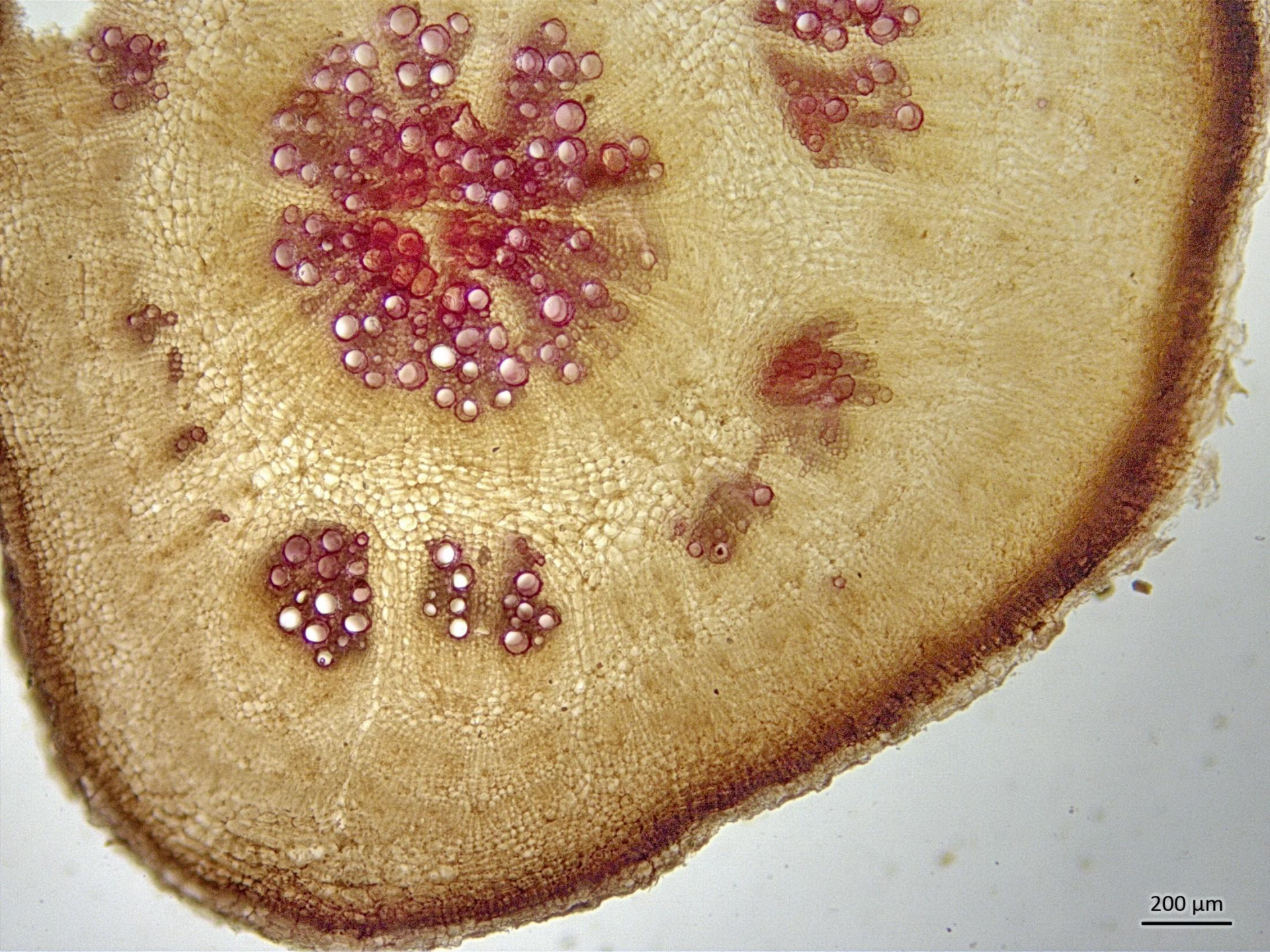




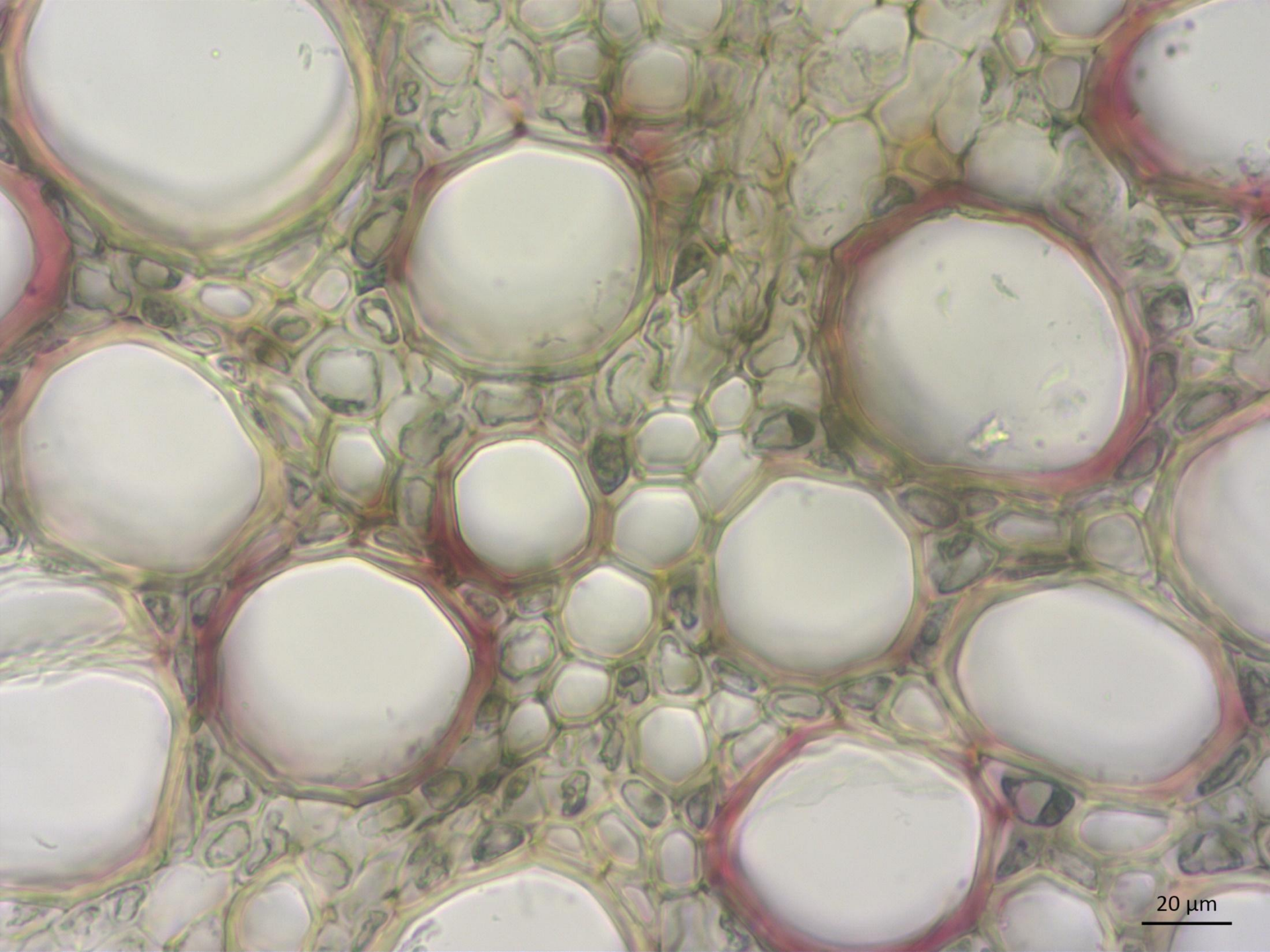


The rings on the cross-section of the beet are formed due to the repeated occurrence of vascular cambium.

Cross section of beet root


200 µm


100 µm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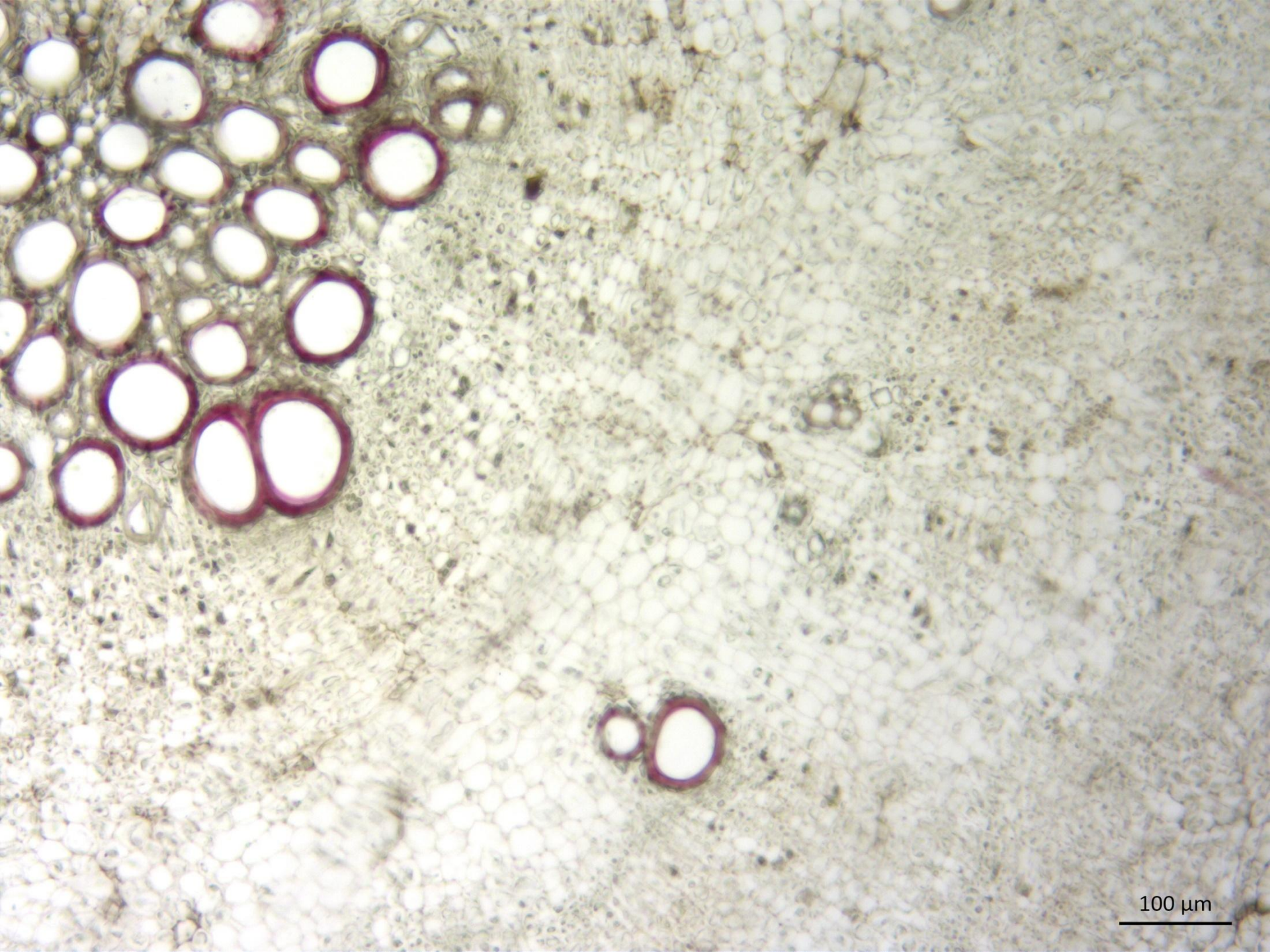
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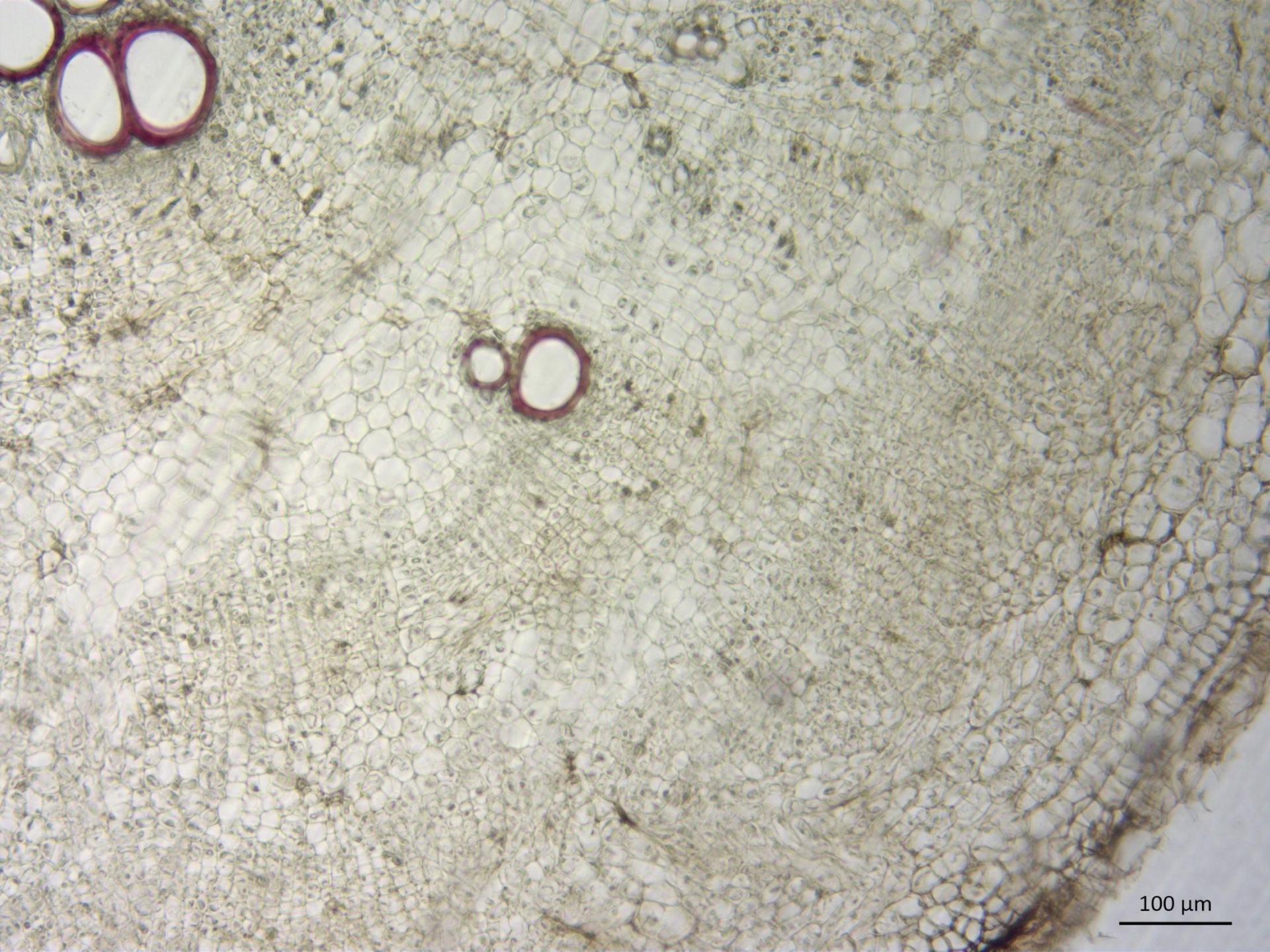
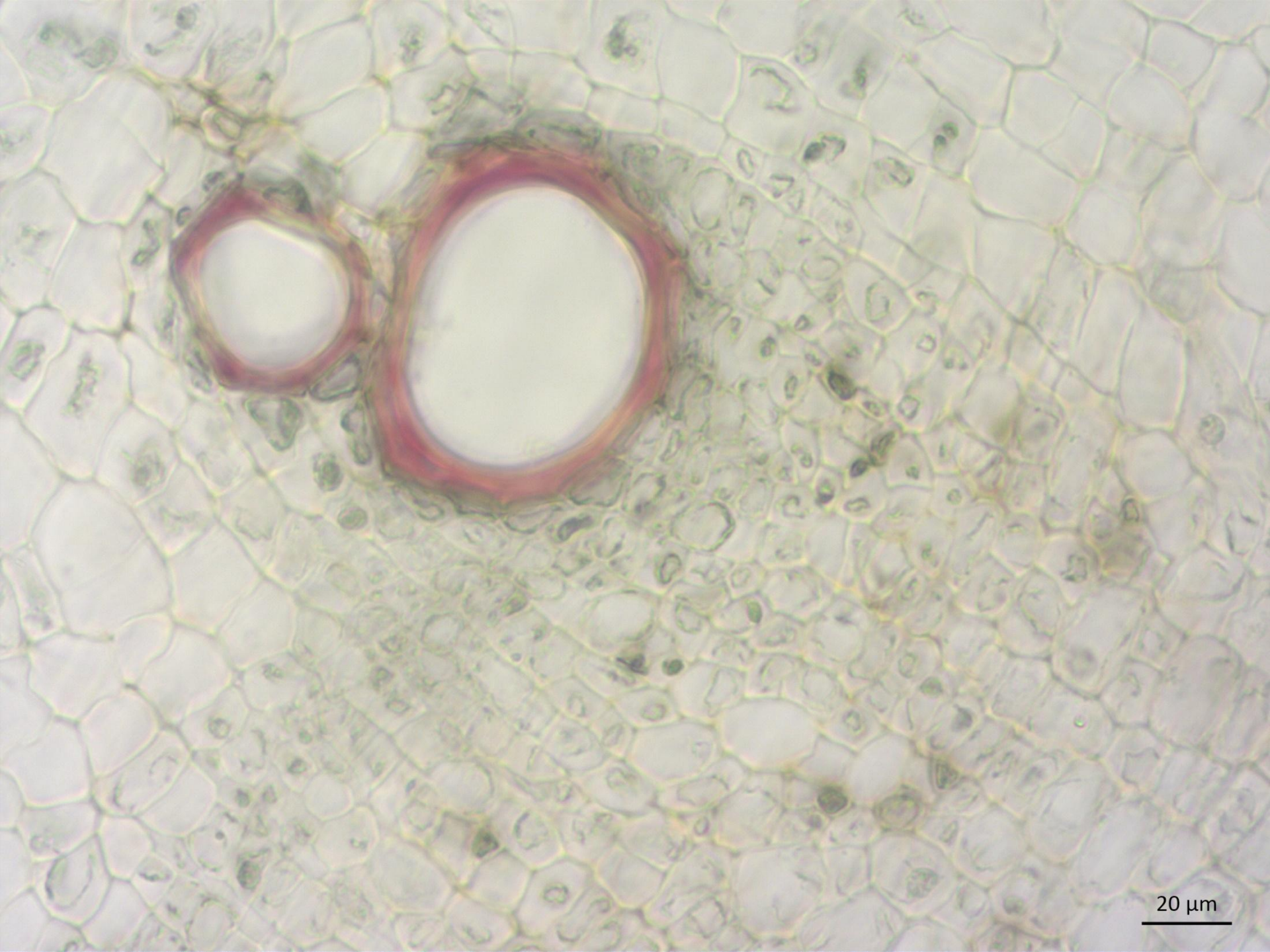

100 µm


20 µm