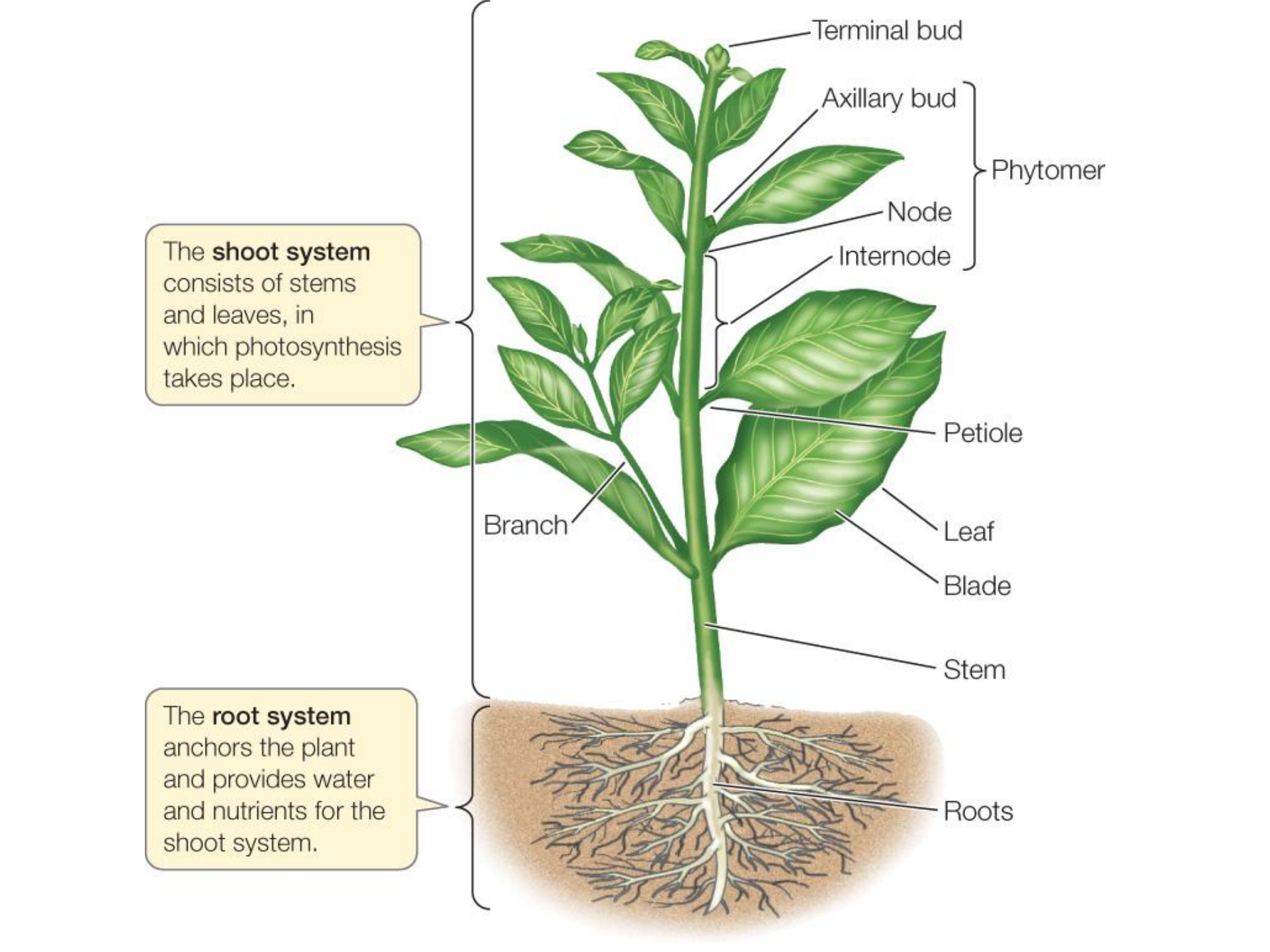
Anatomical structure of the herbaceous and woody stem. Morphology of the stem.

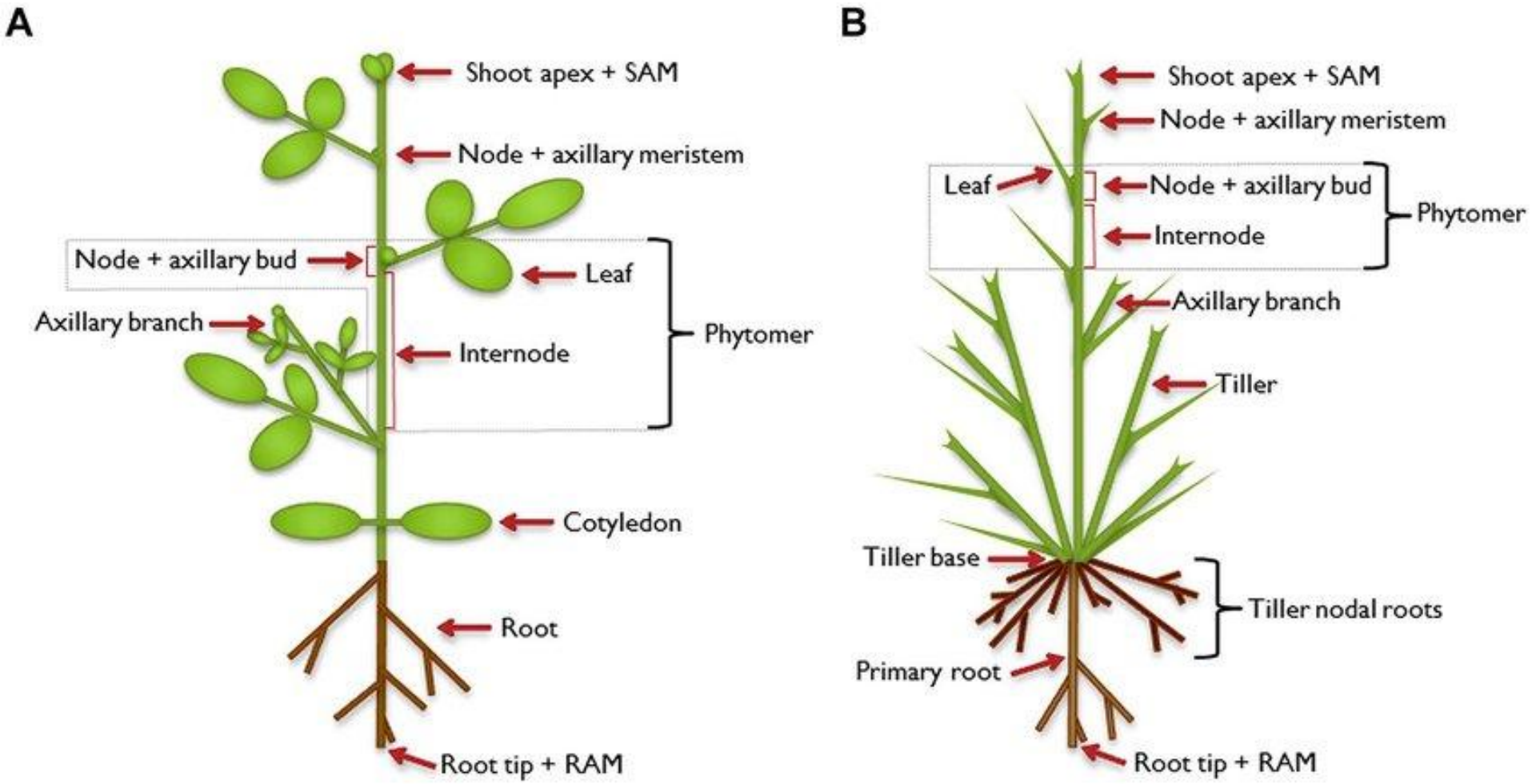
Plan

- **The shoot. The organs of shoot.**
- **The stem is the axial organ of the shoot**
- **The primary structure of the stem.**
- **Differences of herbaceous stems of monocotyledonous and dicotyledonous plants**
- **Formation of the secondary structure of the stem. Types of cambium forming.**
- **Secondary structure of the stem.**
- **Features of the structure of the stem of woody gymnosperms and angiosperms.**
- **The structure of wood**

The shoot

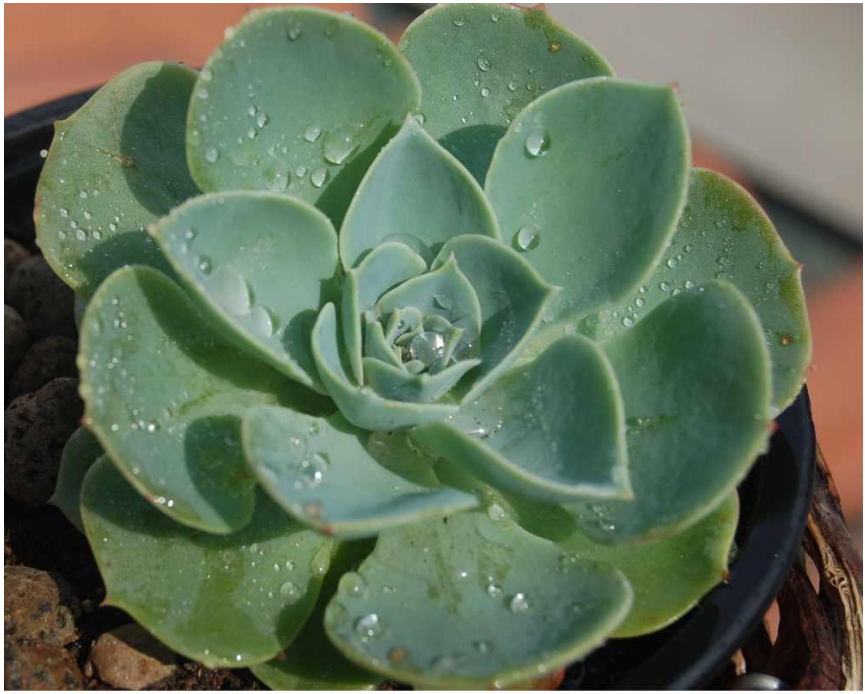
- The shoot - this is an organ that arises from the apical meristem and is differentiated an early stage of morphogenesis into specialized parts: stem, leaves, buds.
- Its main function is photosynthesis. Parts of the shoot can also serve for vegetative reproduction, accumulation of reserves nutritional products, water.


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

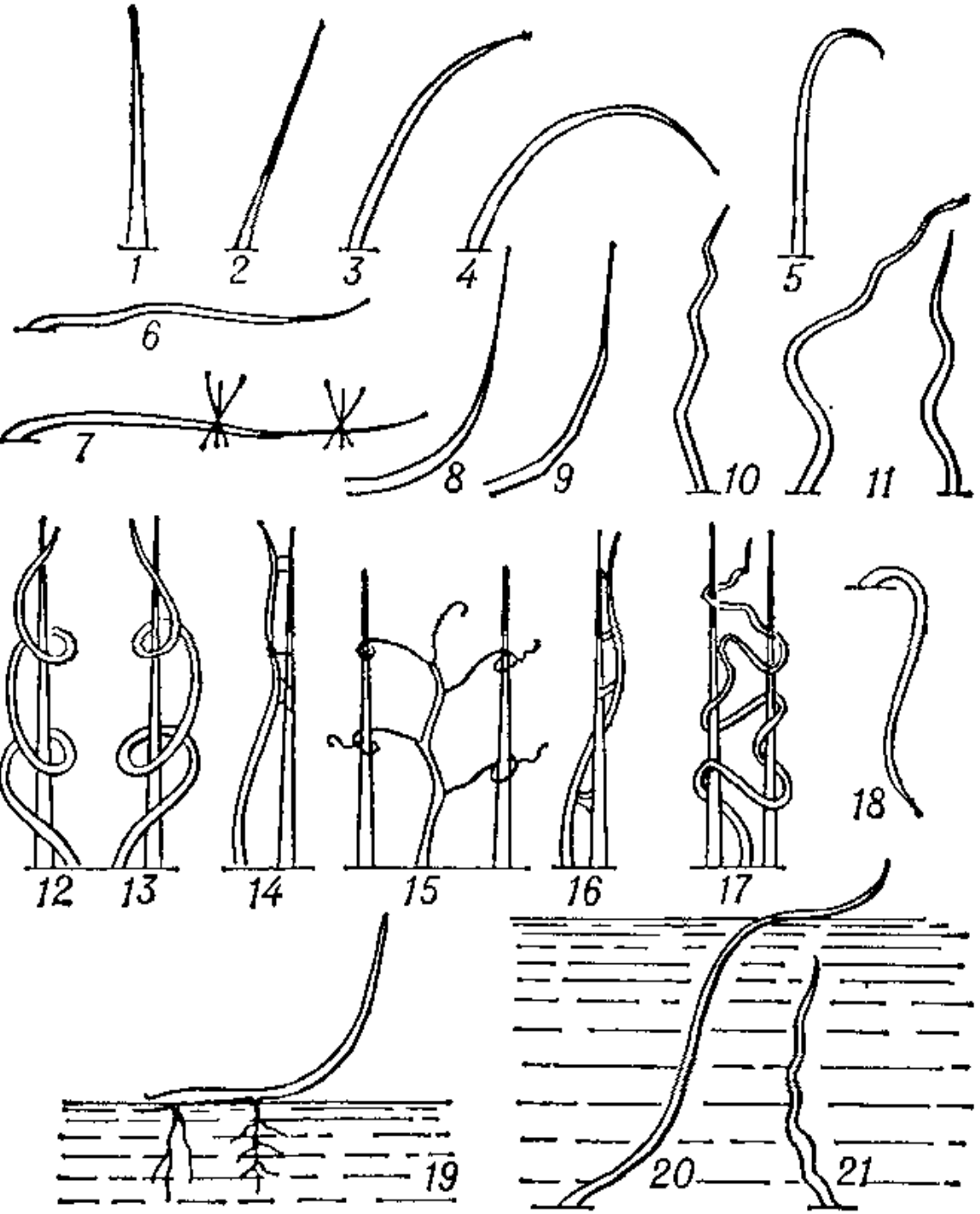


Metamerism. Usually the shoot has several nodes and internodes. Such a repetition of shoot segments having the same organs is called a metamerism. Each metamere (phytomere) of a typical shoot consists of a node with a leaf and an axillary bud and an underlying internode.

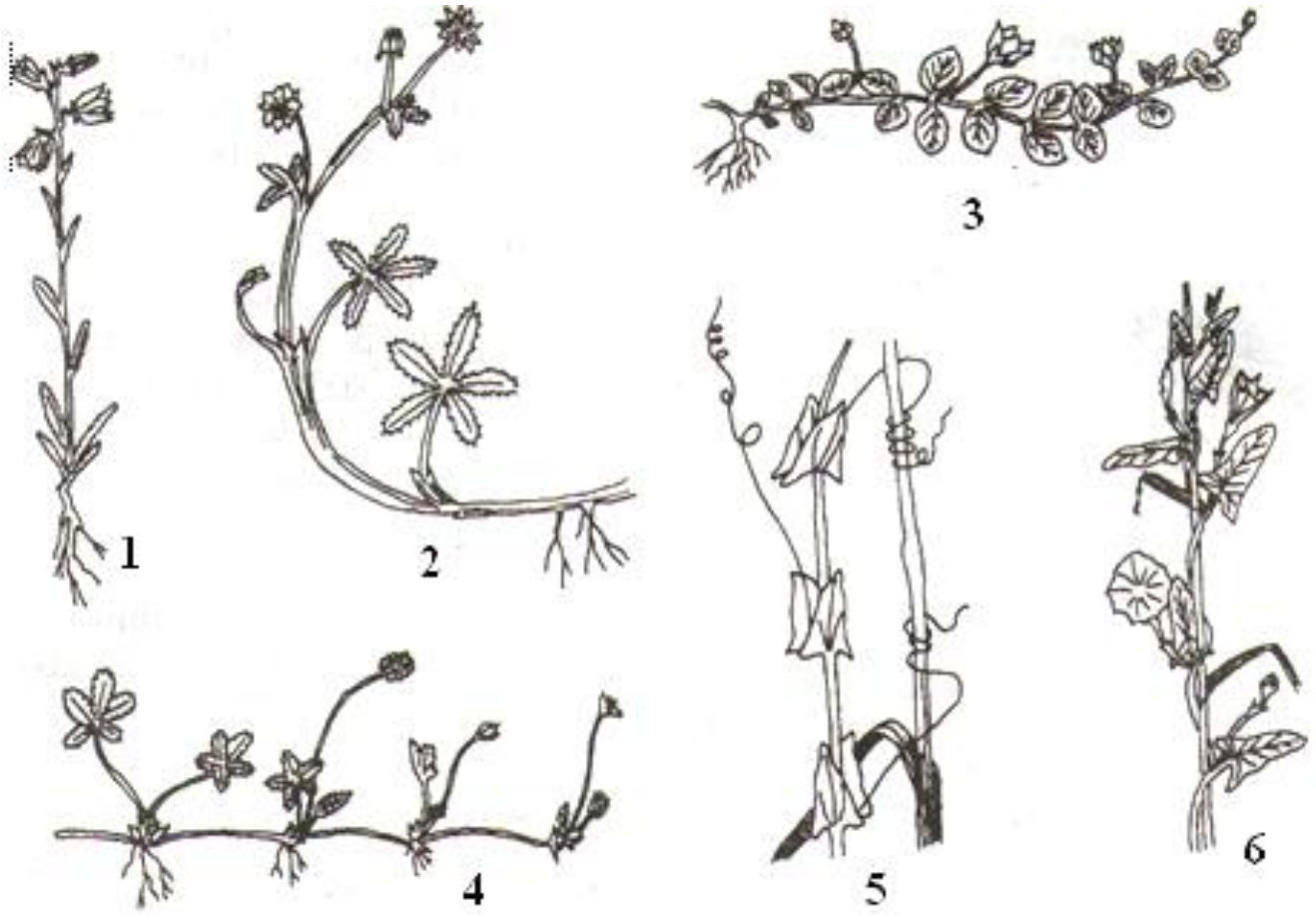
long shoot



short shoot (rosette)



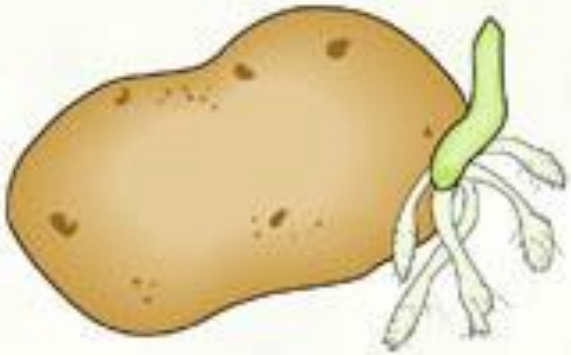
•Types of stems by position in space: 1 — straight, or erect; 2 — inclined; 3 — curved; 4 — arched; 5 — drooping; 6 —prostrate (recumbent); 7 — creeping, rooted in nodes; 8 — ascending; 9 — knee-ascending; 10 — broken; 11 — tortuous; 12 — winding clockwise; 13 — winding counterclockwise; 14 — clinging; 15 — climbing; 16 — climbing; 17 — interwoven; 18 — hanging; 19 — floating; 20 — floating; 21 — submerged in the water column.



Stems with different positions in space: 1 - erect; 2 – rising (decumbent); 3 - prostrate (recumbent) ; 4 - creeping; 5 - clinging; b - curly.

DIFFERENT TYPES OF STEMS

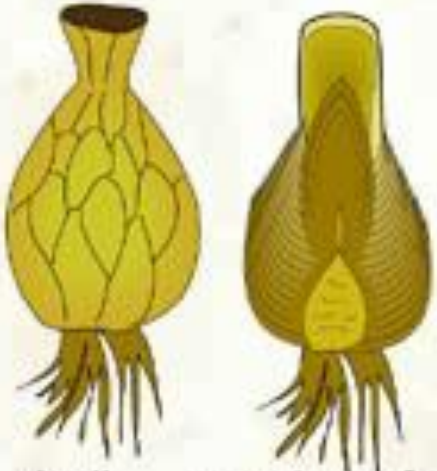
stolon



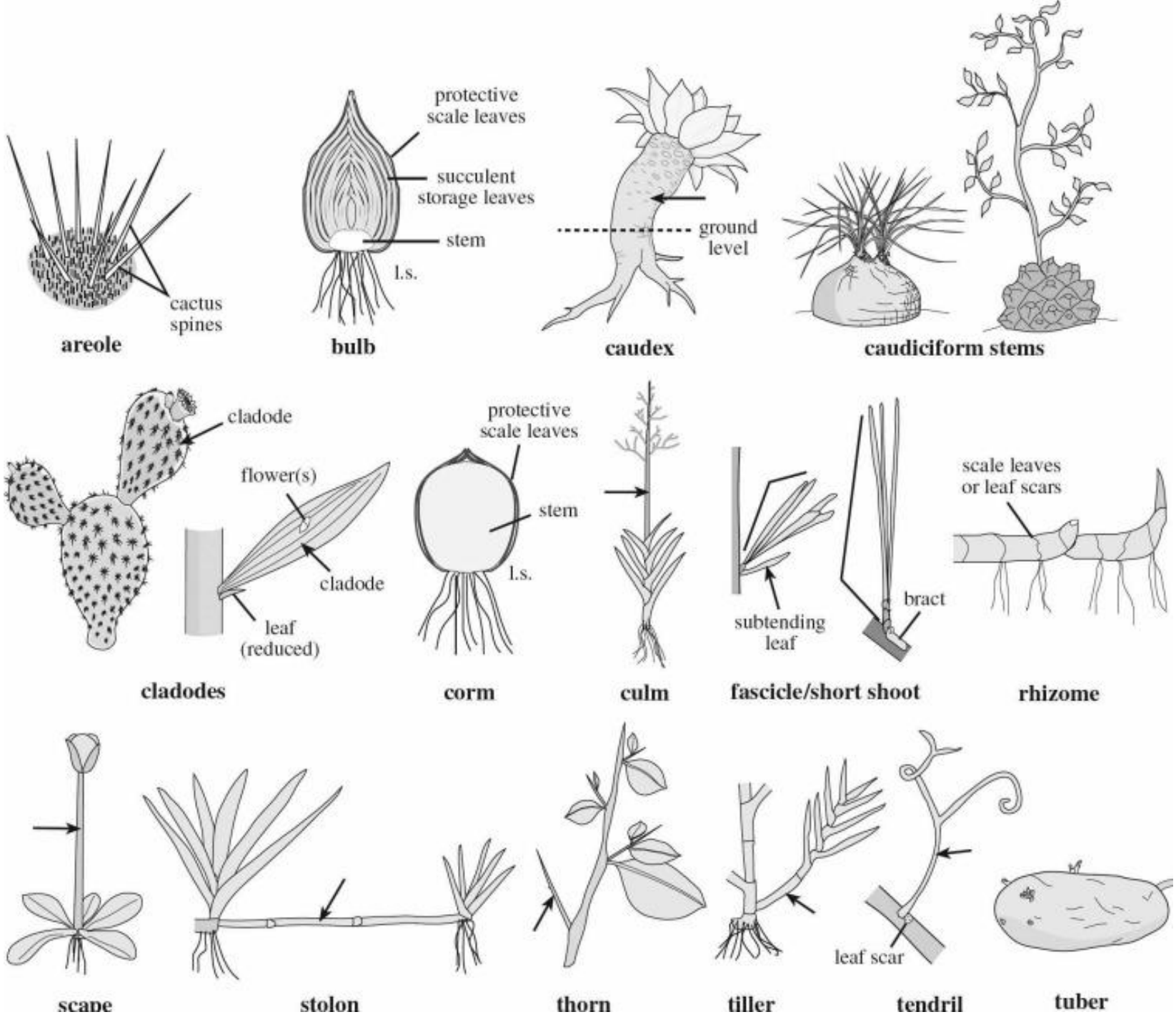
tuber

volubilate twining

rhizome



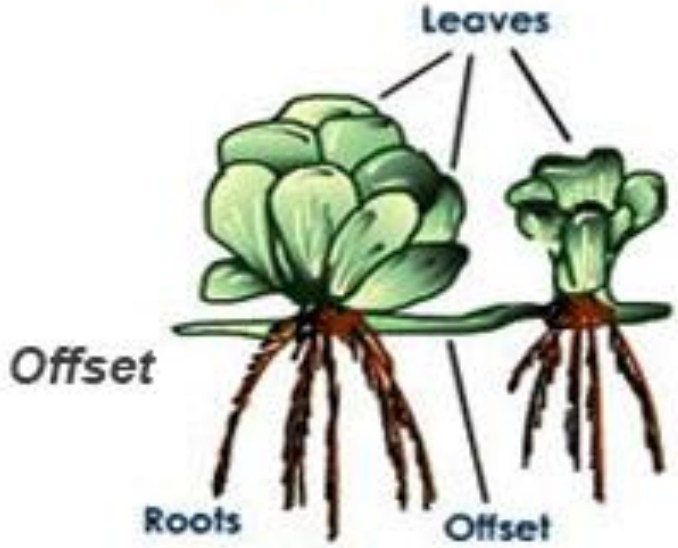
bulb section of a bulb


cactus spines
areole
protective scale leaves
succulent storage leaves
stem
l.s.
bulb
ground level
caudex
caudiciform stems
cladode
flower(s)
cladode
leaf (reduced)
cladodes
protective scale leaves
stem
l.s.
corm
culm
subtending leaf
bract
fascicle/short shoot
scale leaves or leaf scars
rhizome
scape
stolon
thorn
tiller
leaf scar
tendril
tuber

Runner

Stolon

Sucker



Offset

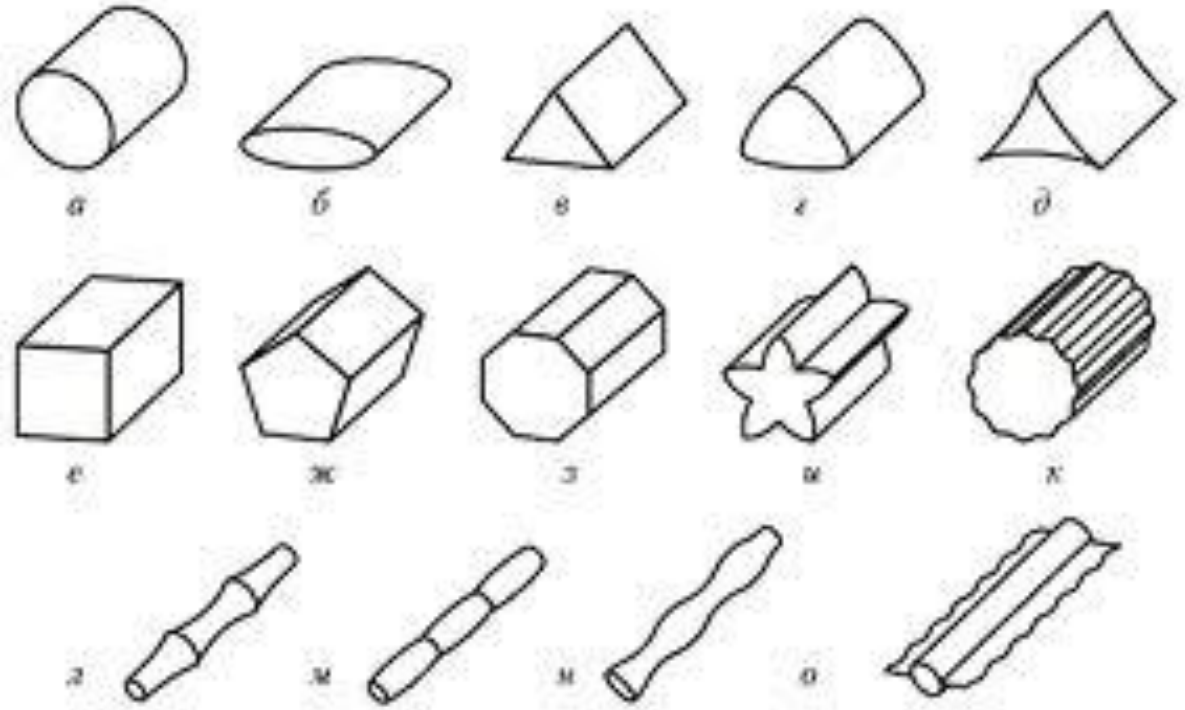
The Stem

- In typical cases, it is an axial shoot organ with radial symmetry, negative geotropism, having unlimited growth in length, having leaves and buds; the increase in length occurs by apex and insertion growth.
- The stem provides a connection between the leaves and the roots, determines the formation of a powerful assimilation surface of the leaves and their best placement in relation to light, serves as a container for spare products. Stems (as well as roots) of woody plants can reach the age of 4-6 thousand years (mammoth and dragon trees). In some herbs, the stem age is limited to only 30-45 days (ephemeral plants). In grasses, stems usually live only 1 year, in trees, the stem has existed for many years.

Functions of stems

1) conductive - ascending (transpirational) and descending (assimilational) currents of substances between the roots and leaves move in the stem;
2) mechanical, or supporting, - the stem ensures the position of the body in space and brings the leaves to the light, withstanding significant mechanical loads (the weight of its own branches, leaves, flowers, fruits, wind action, mechanical damage, etc.);
3) storage - in some storage tissues of the stem, organic substances are deposited in reserve;
4) assimilation — this function is characteristic of young green plant stems, perennial stems of many succulents (cacti, euphorbias), as well as stems of some plant species of arid regions (species of ruscus, etc.).

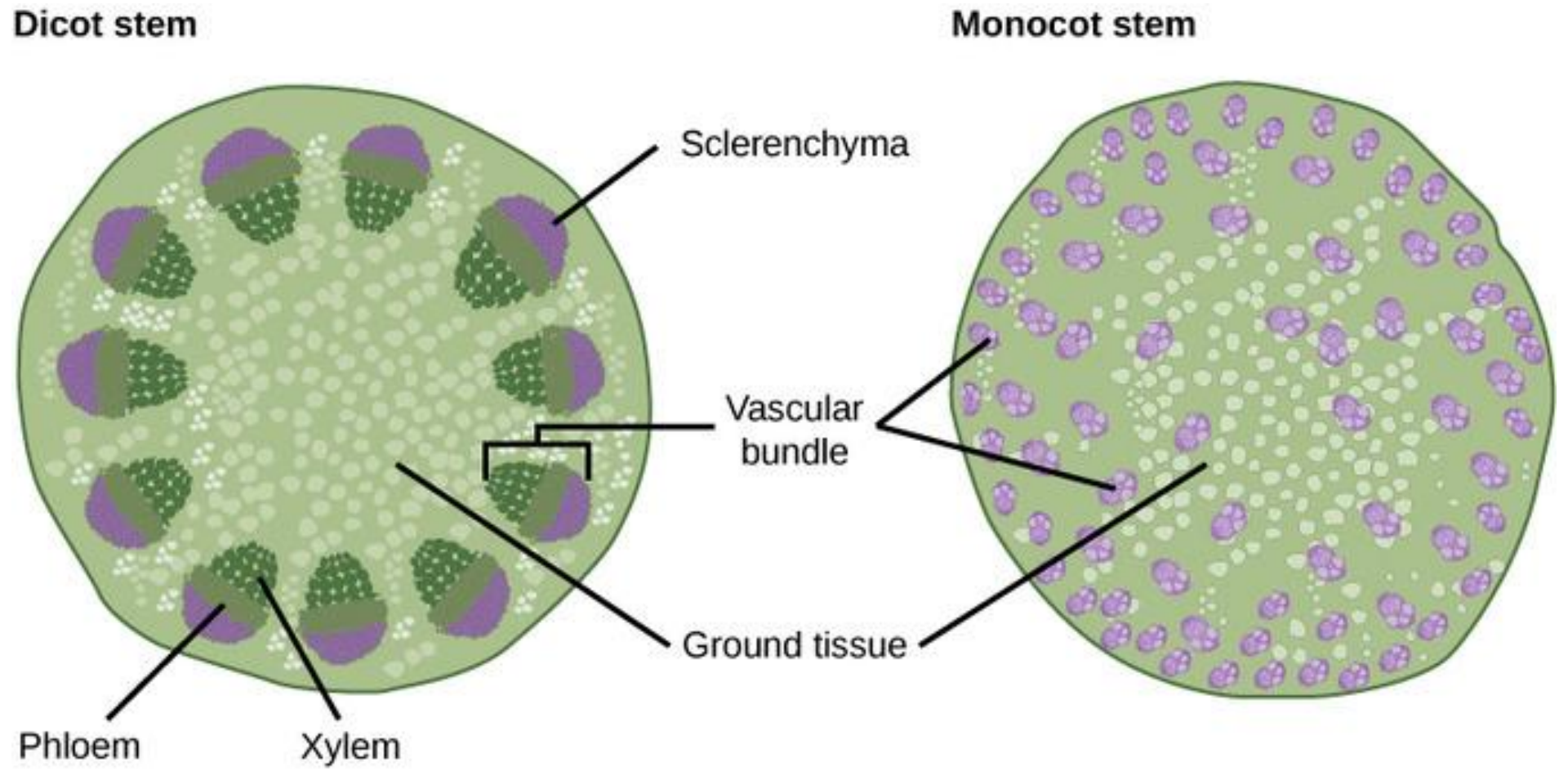
Form of stems on cross sections

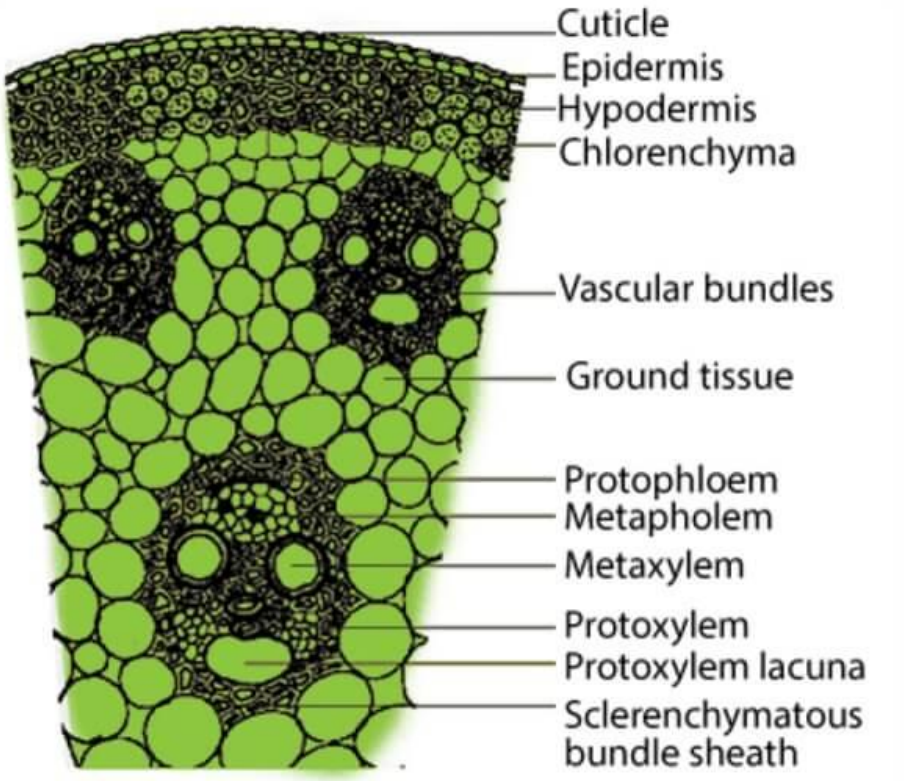


a - cylindrical; b - flattened; c - triangular; d - obtuse-triangular; d - curved-triangular; e - tetrahedral; f - pentahedral; z - octahedral; i - ribbed; k - furrowed; l - knotted; m - jointed; h - beaded; o - winged

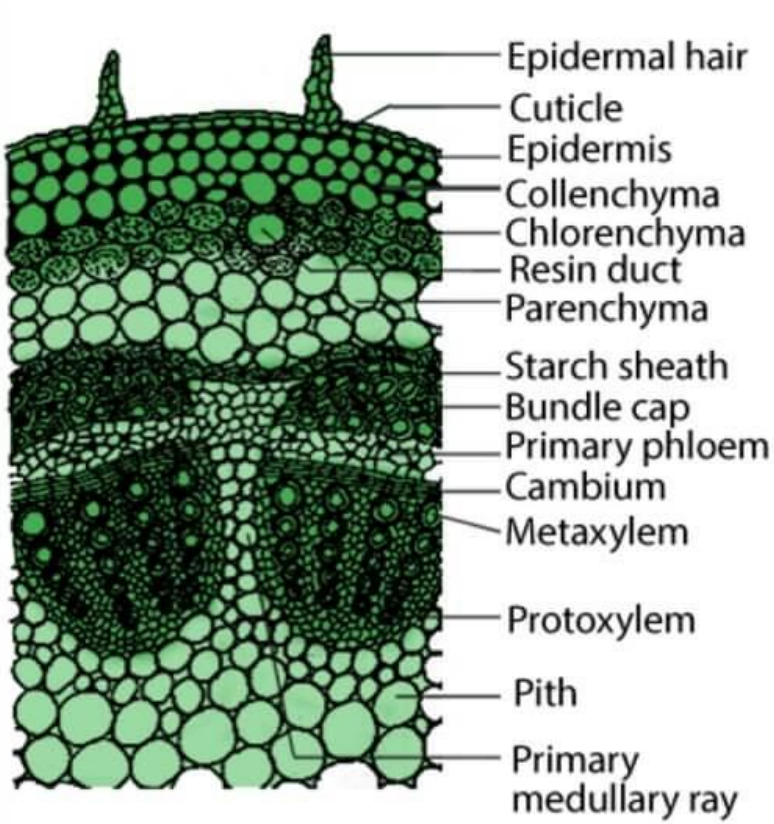
The primary structure of the stem

- There are three main parts in the anatomical structure of the stem of herbaceous plants:
- **1. The dermal tissue.**
- **2. Primary cortex.**
- **3. Central axial cylinder.**


Dicot stem
Monocot stem
Sclerenchyma
Vascular bundle
Ground tissue
Phloem
Xylem

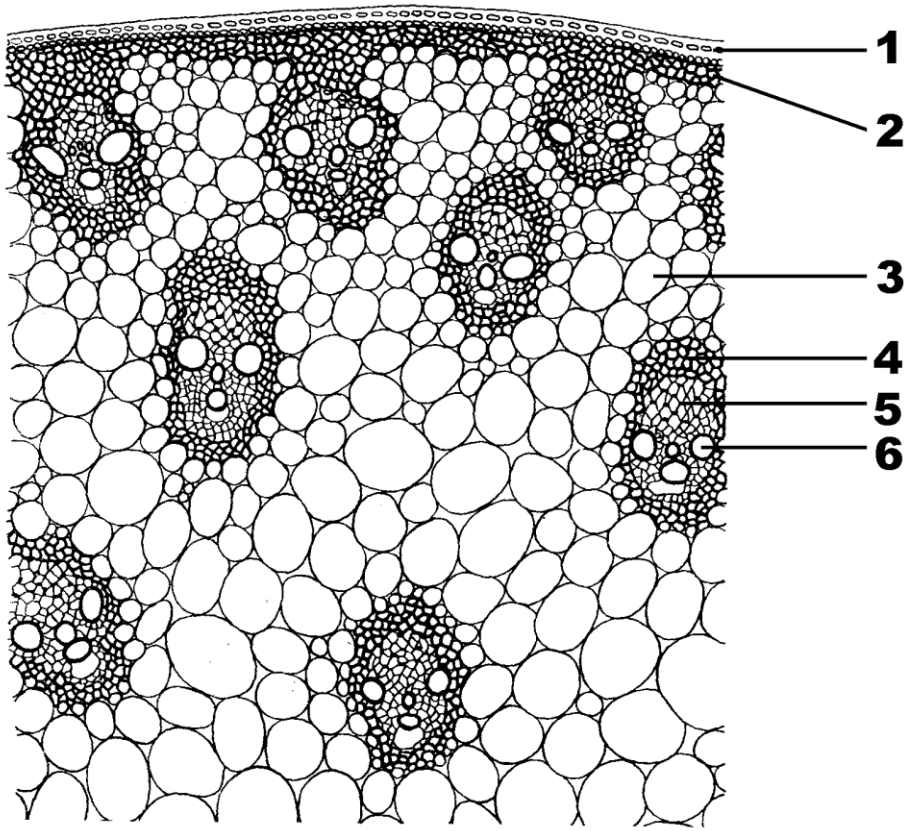


T.S. of Monocot Stem

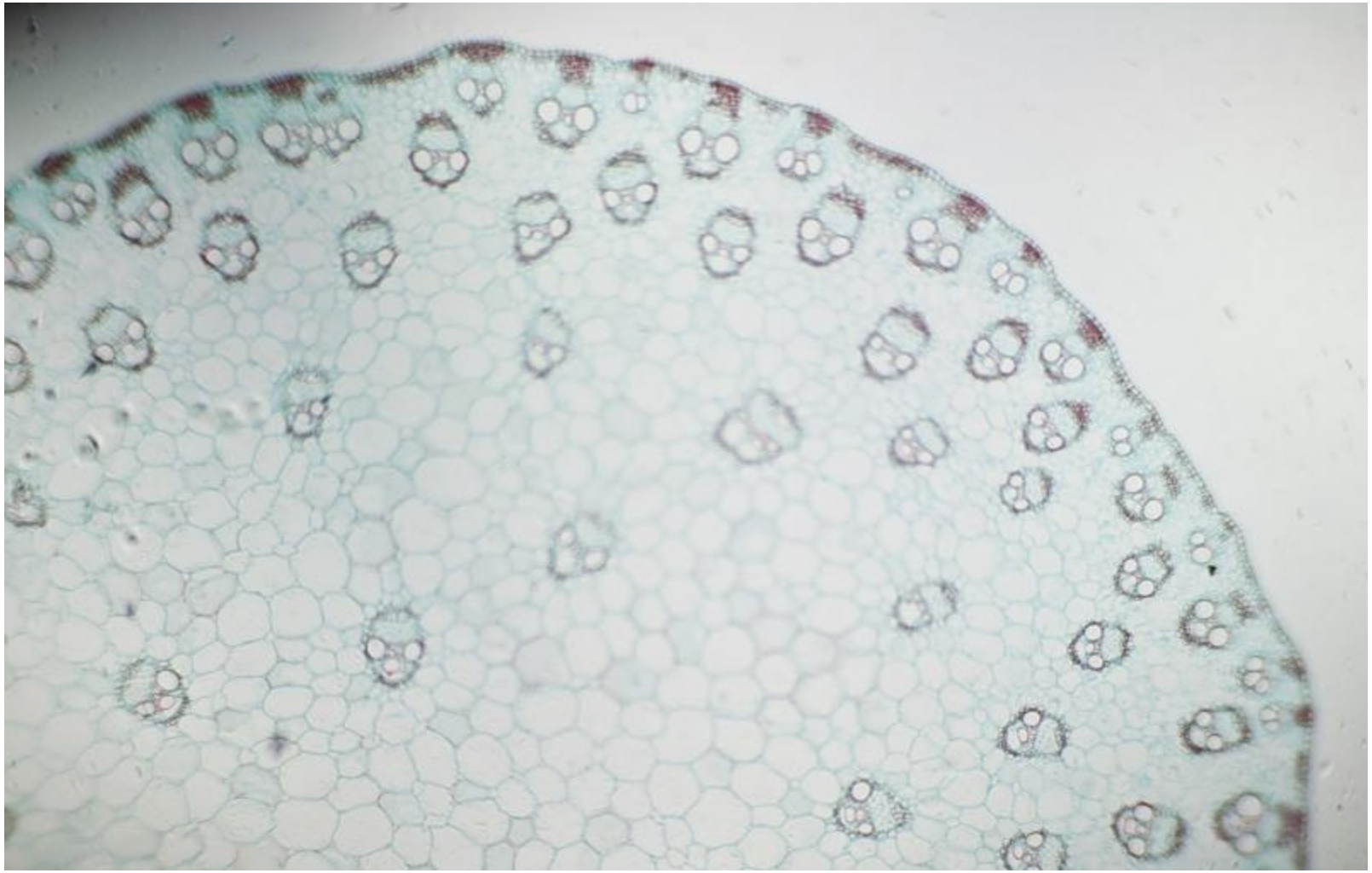


T.S. of Dicot Stem

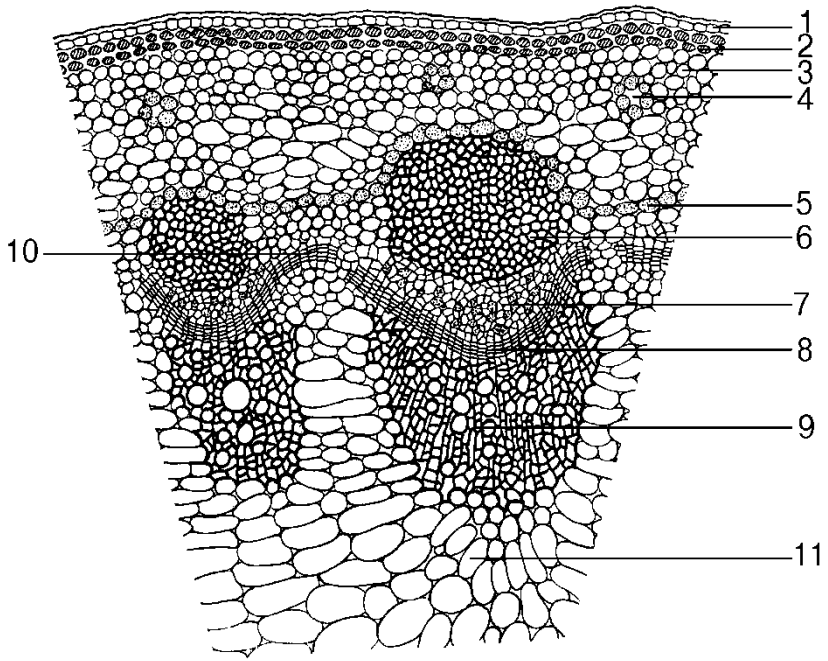
The primary structure of the stem of monocotyledons



The structure of a corn stem on a cross section: 1 - epidermis, 2 - pericyclic sclerenchyma, 3 - pith parenchyma of the central axial cylinder, 4 - 5 closed collateral vascular bundle: 4 - sclerenchymal sheath of the bundle, 5 - phloem, 6 - xylem



The primary structure of the stem of dicotyledons



The structure of the sunflower stem on a cross section.

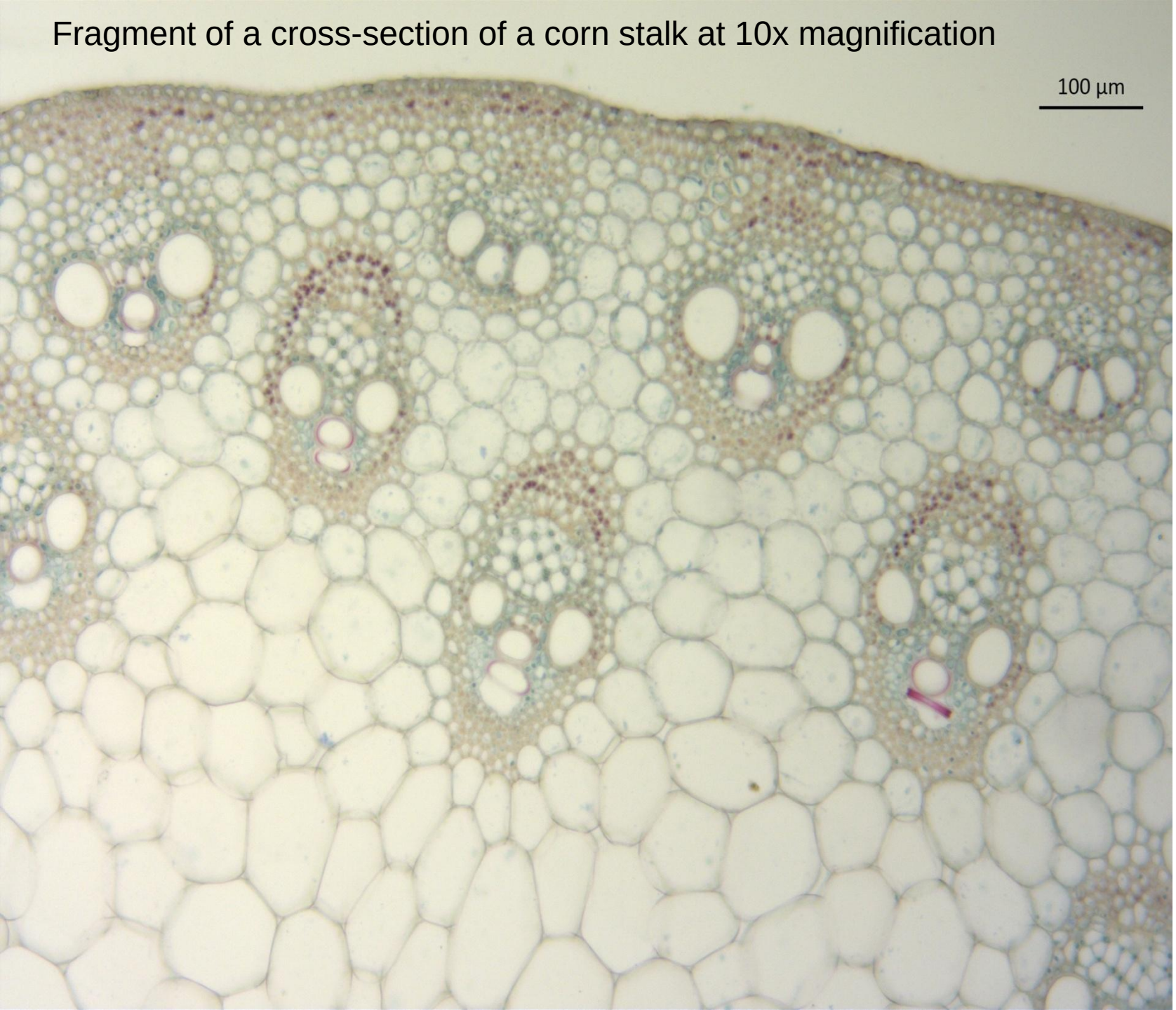
1 - epidermis, 2 - lamellar collenchyma, 3 - assimilating parenchyma, 4 - resin duct, 5 - endoderm, 6 - 9 - open collateral vascular bundle: 6 - pericyclic sclerenchyma, 7 - phloem, 8 - fascicular cambium, 9 - xylem, 10 - interfascicular cambium, 11 - pith parenchyma of the central axial cylinder.

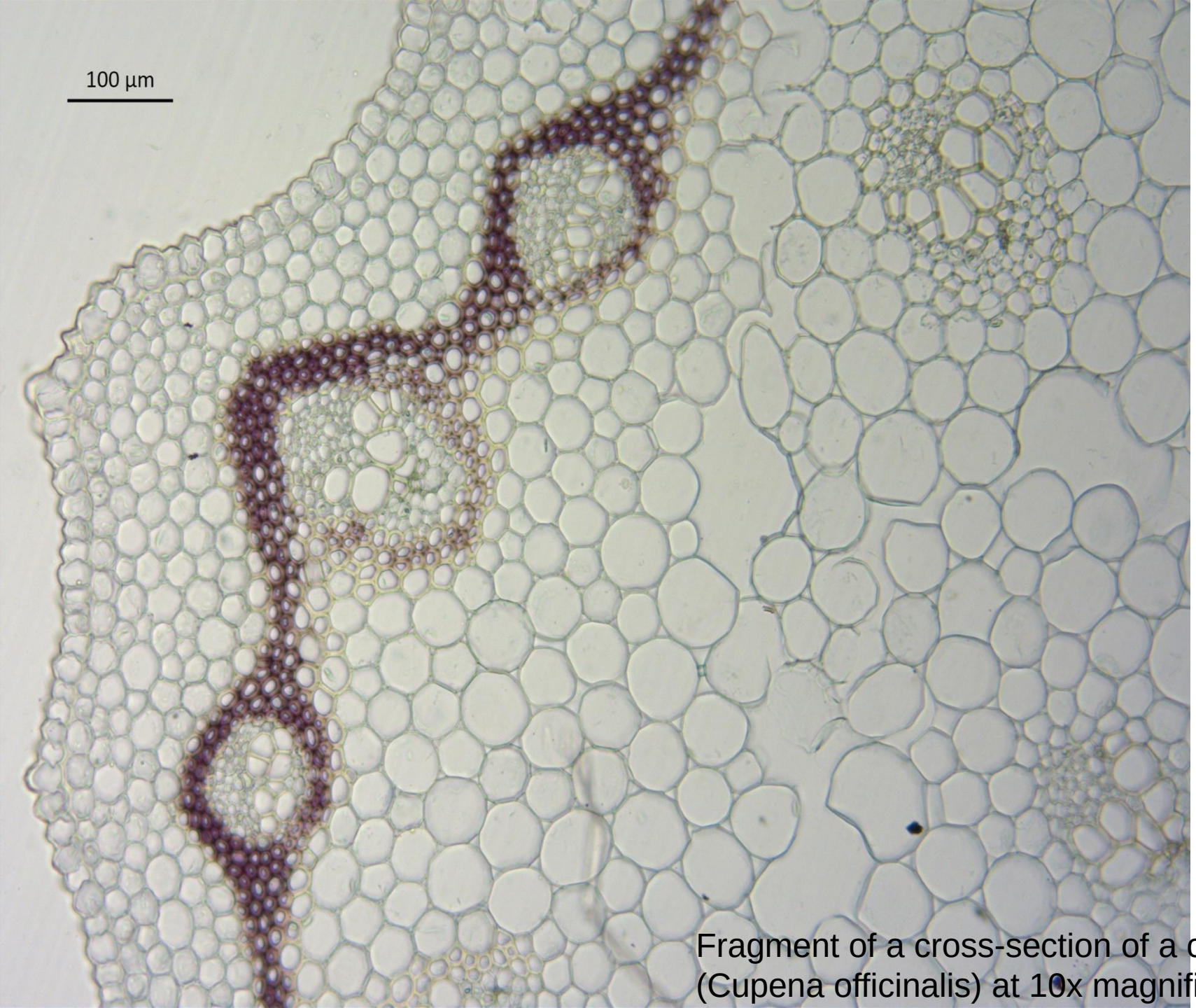
Difference Between Monocot and Dicot Stem

Dicot	Monocot
The dicot stem is solid in most of the cases.	The monocot stem is usually hollow at the centre.
Primary cortex always well developed.	Primary cortex is poorly developed or not developed at all.
The internal tissues are arranged in concentric layers.	There is no concentric arrangement of tissues.
The ground tissue is differentiated as endodermis, cortex, pericycle, medullary rays, pith, etc.	The ground tissue is the same and is composed of a mass of similar cells.
The vascular bundles are formed as broken rings.	The vascular bundles are scattered irregularly around the ground tissue.
Phloem parenchyma is present.	Phloem parenchyma is absent.
Pith is well-developed.	Pith is not as well-developed in monocots (usually absent in most)
Epidermal hair may or may not exist.	Presence of epidermal hair.
Vascular bundles are less in number and are of uniform size.	There are numerous vascular bundles of different sizes.
The dicot stem does not have a bundle sheath on the outside of a vascular bundle.	The monocot stem has a sclerenchymatous bundle sheath on the outside of a vascular bundle.
The dicot stems have trichomes.	The monocot stems do not have trichomes.
The vascular bundles always remain open, due to the presence of cambium within phloem and xylem.	The vascular bundles are closed.
Dicot stem can feature secondary growth as a result of secondary vascular tissues and periderm formation.	No secondary growth is witnessed in case of monocots.
Vessels are of a polygonal shape and are arranged in rows or chains.	Vessels are rounded or oval and are arranged in a Y-shaped formation.
Usually, vascular tissues stop functioning when they get old. New vascular tissues replace the old ones.	Vascular tissues remain the same throughout the plant’s life cycle.

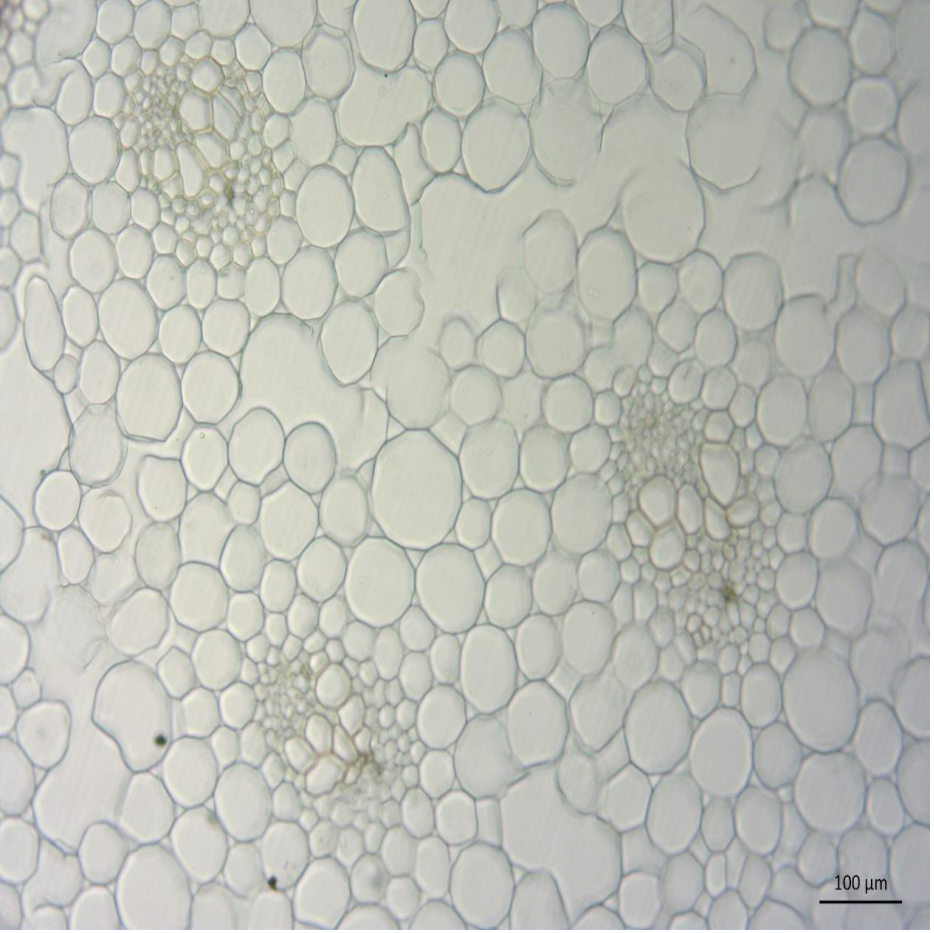
Fragment of a cross-section of a corn stems at 4x magnification

Fragment of a cross-section of a corn stalk at 10x magnification

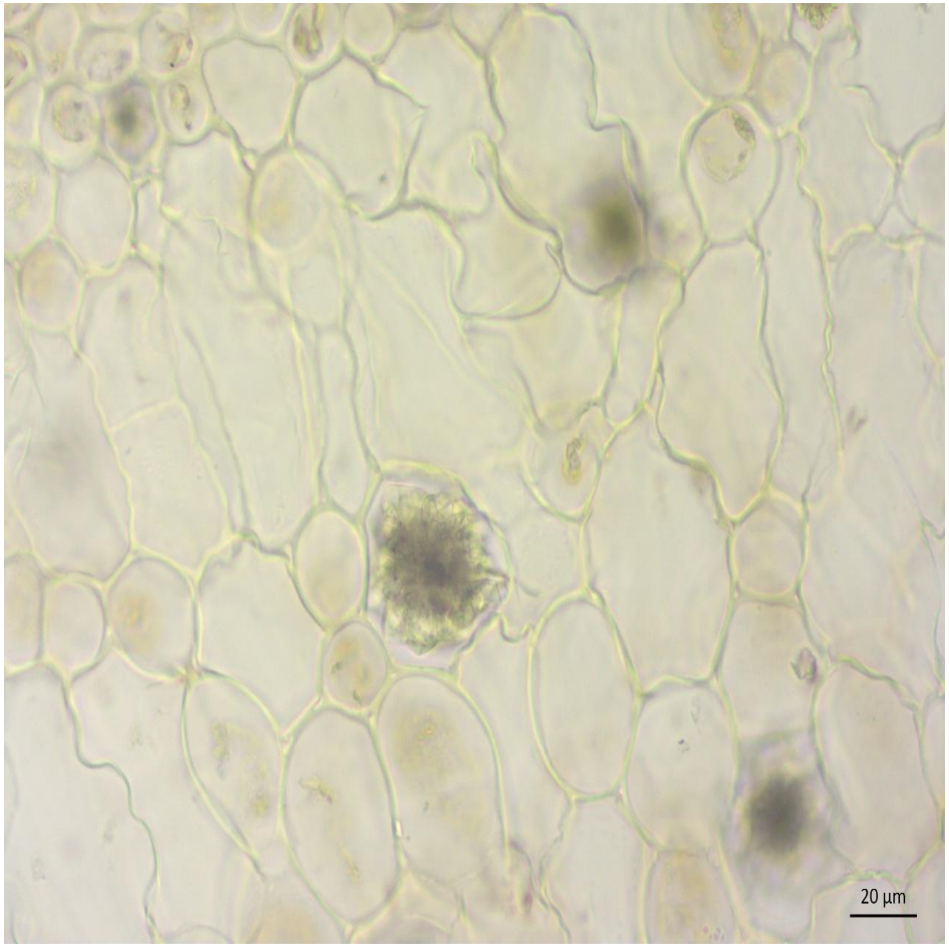




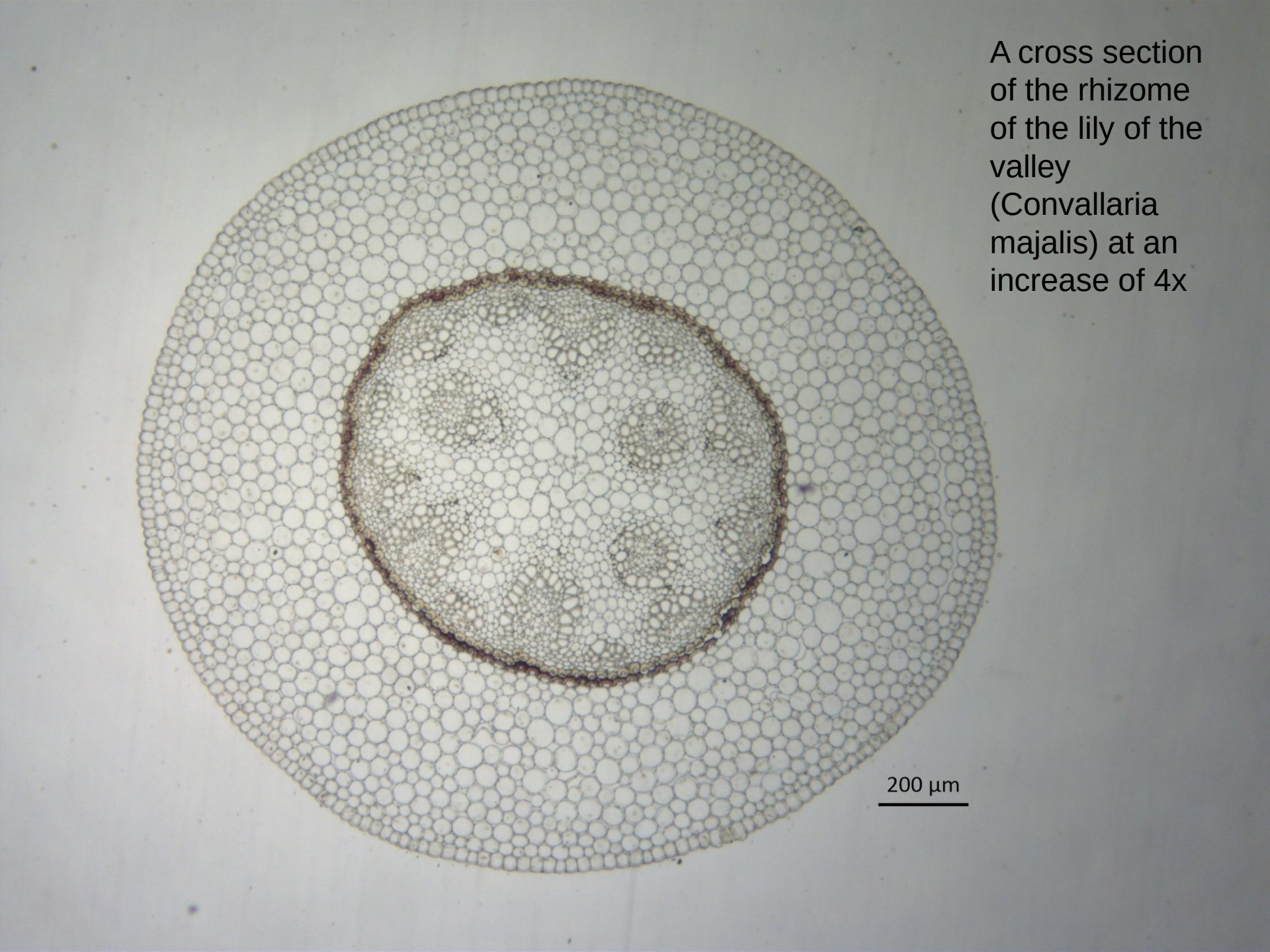
Fragment of a cross-section of a cupua (Cupena officinalis) at 10x magnification



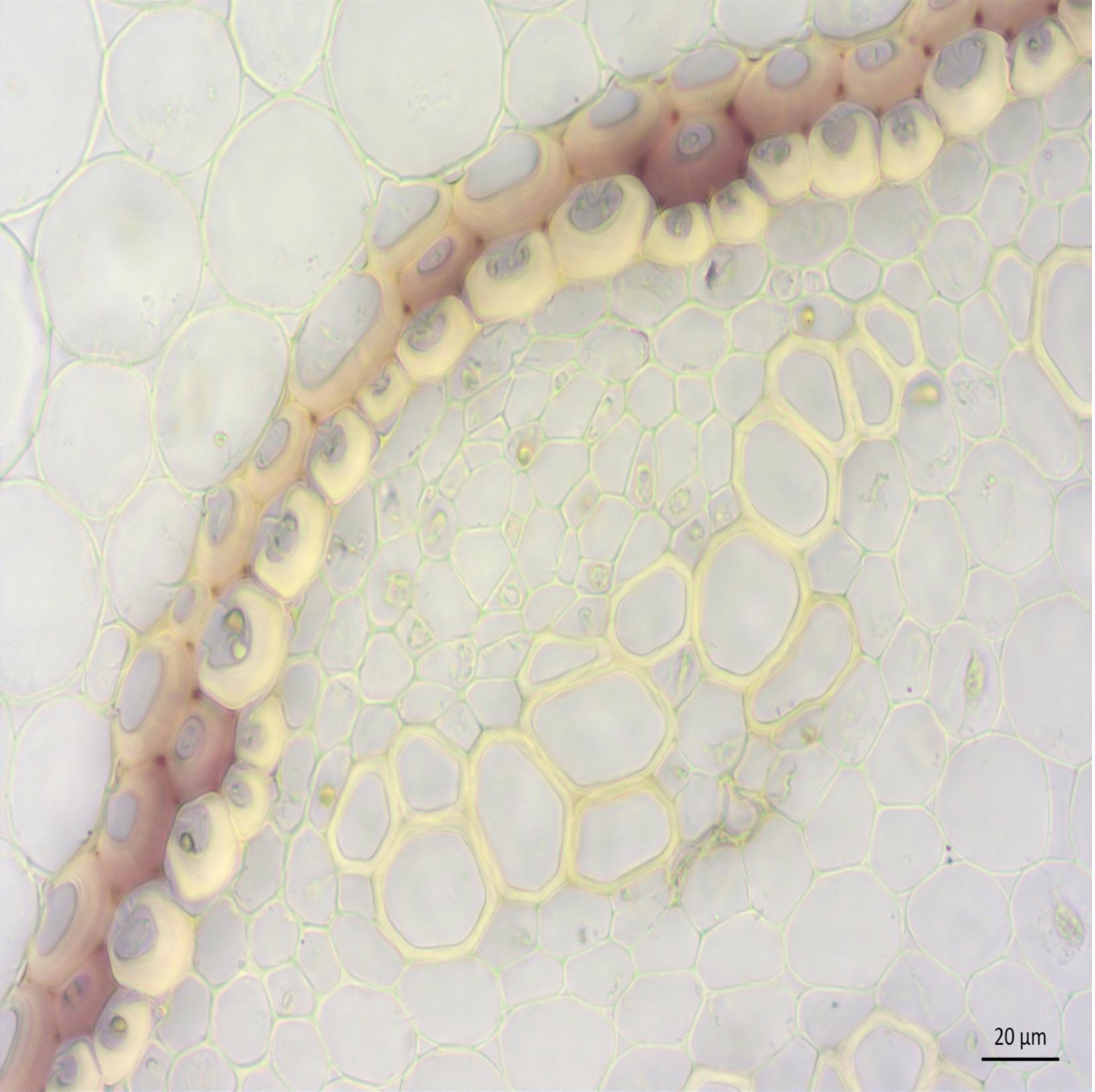
Fragment of a cross-section of a cupua stem under 10x magnification
vascular bundles



Fragment of a cross-section of a cupon stem at 40x magnification. Core parenchyma with intercellular and idioblasts

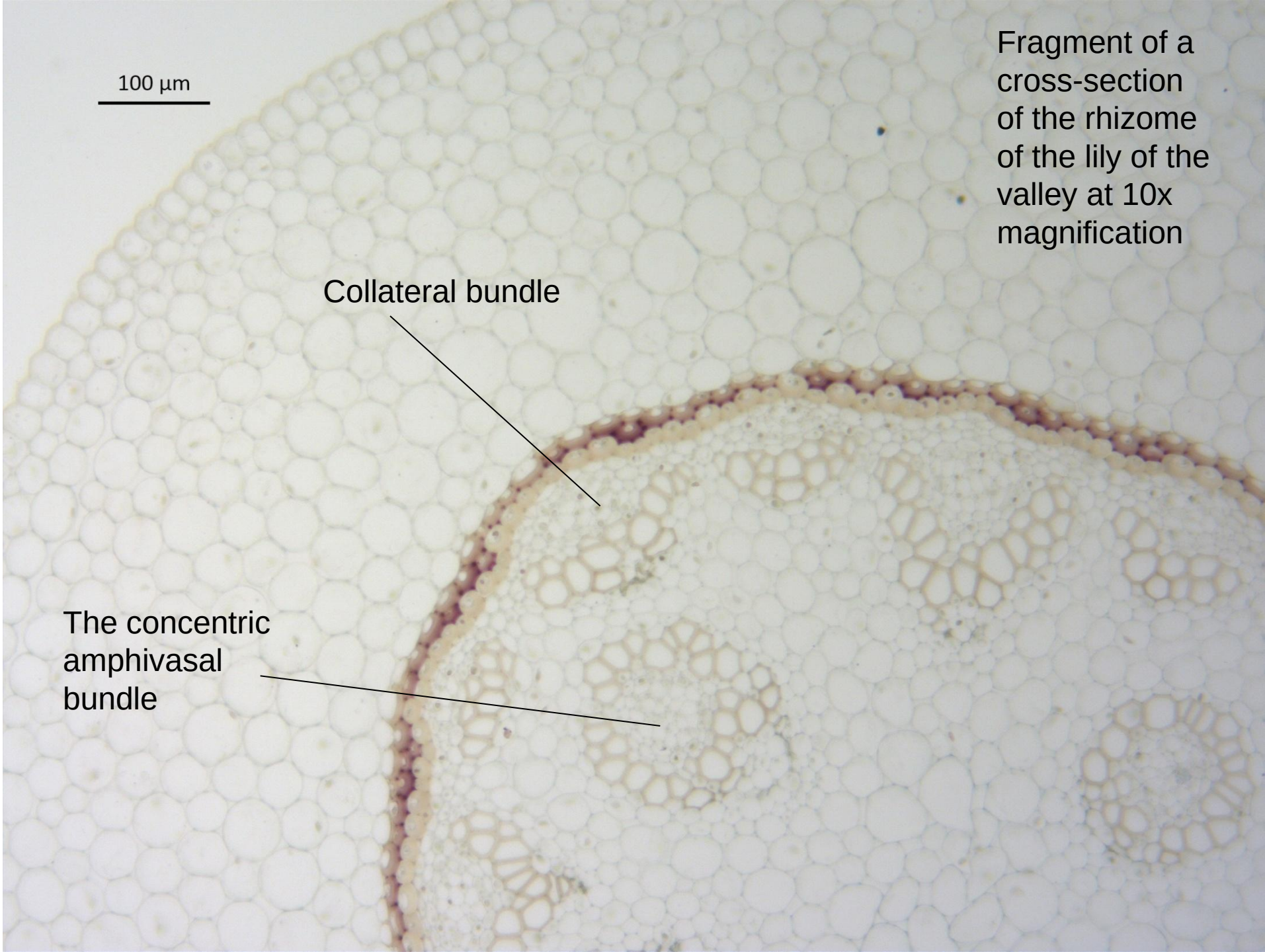


A cross section of the rhizome of the lily of the valley (Convallaria majalis) at an increase of 4x

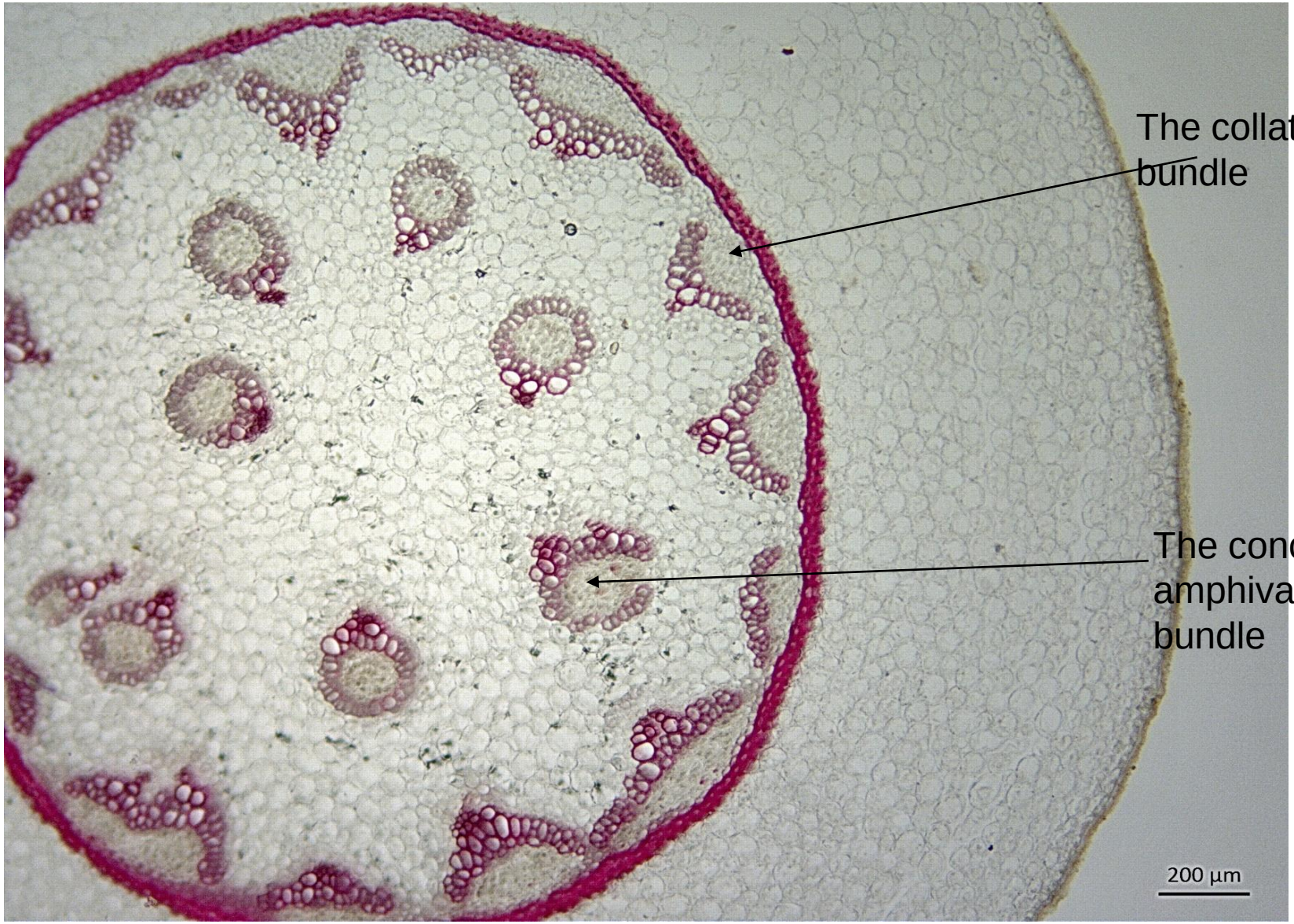


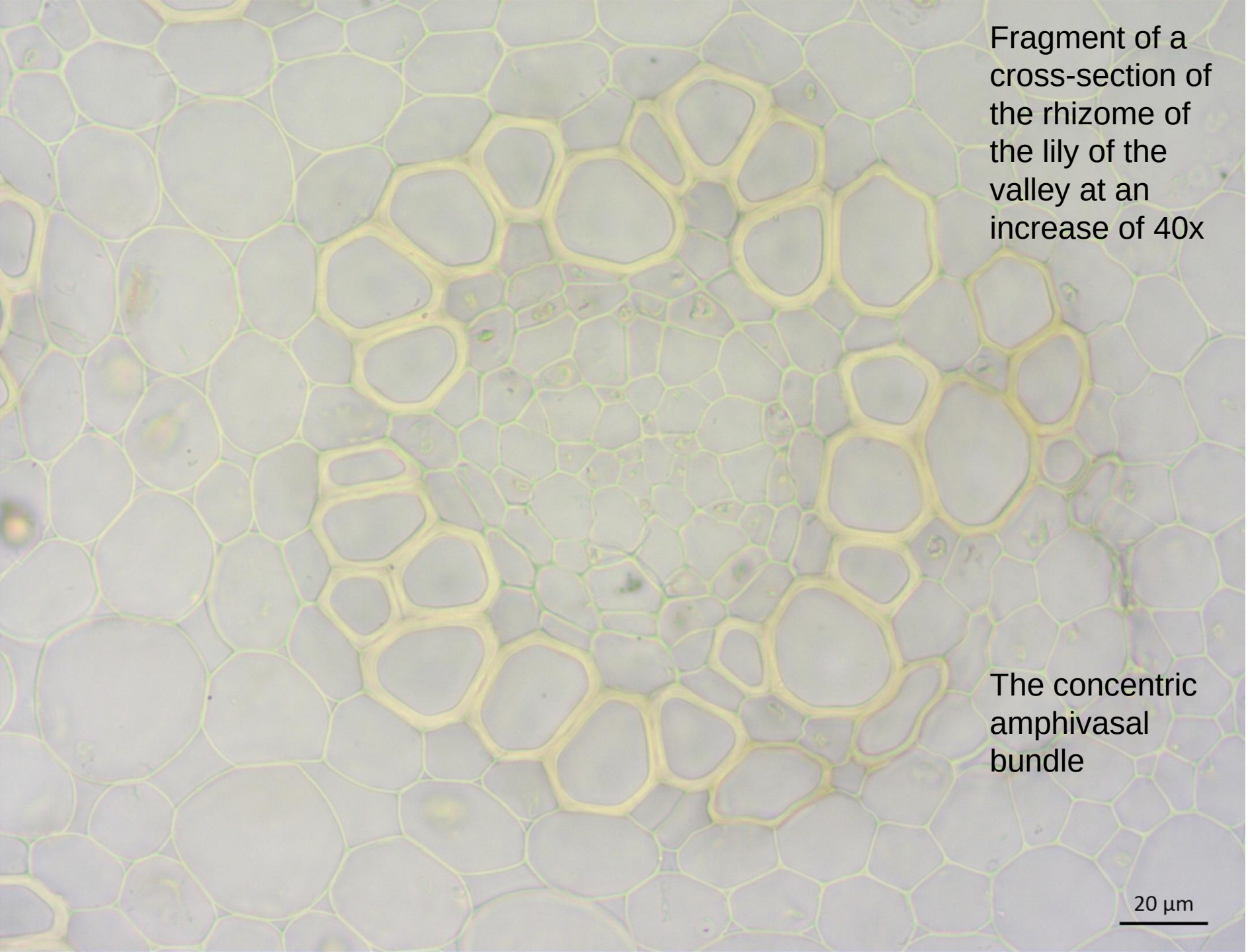
Fragment of a cross-section of the rhizome of the lily of the valley at an increase of 40x

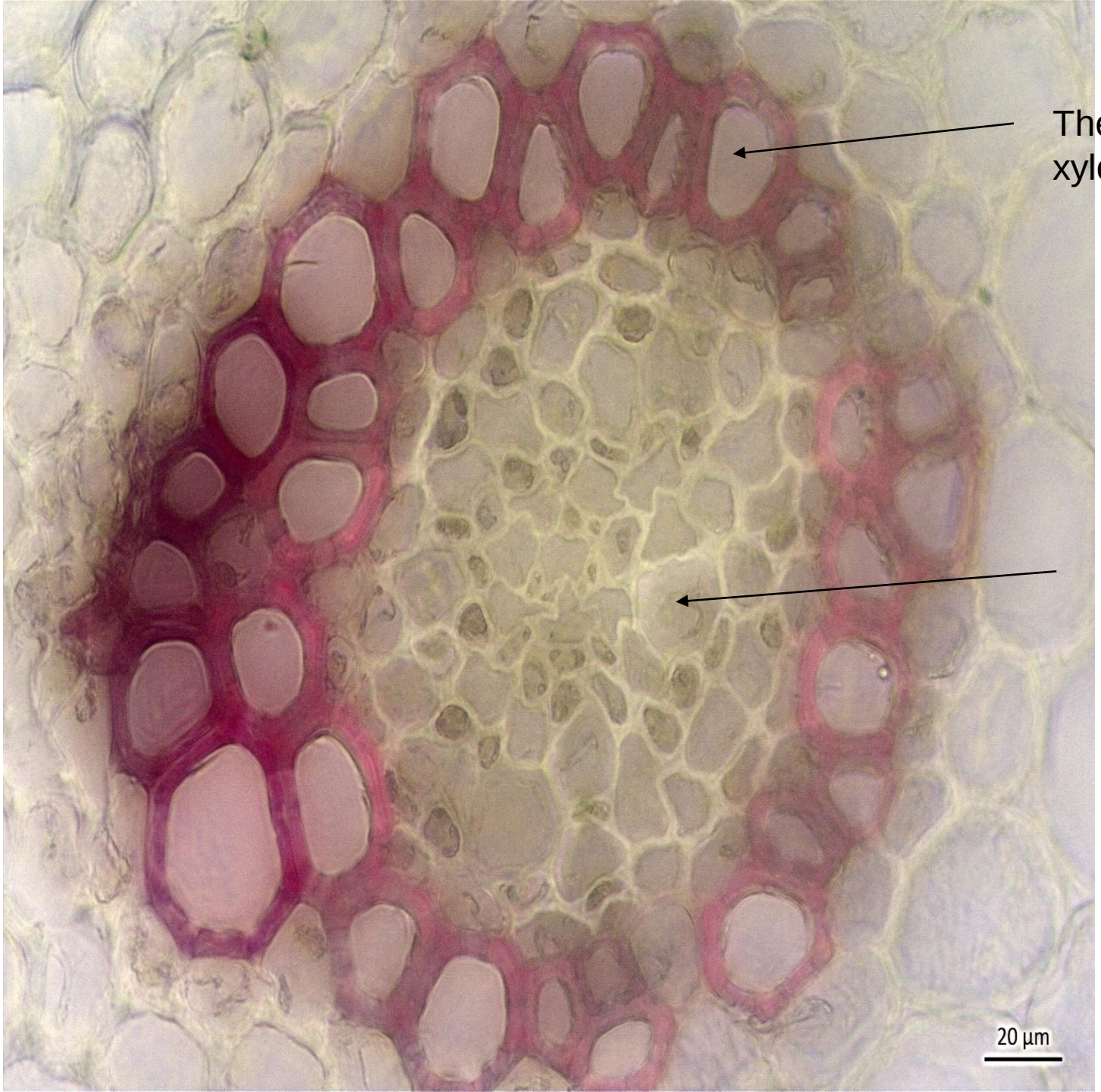
Endoderm, pericycle and collateral vascular bundle

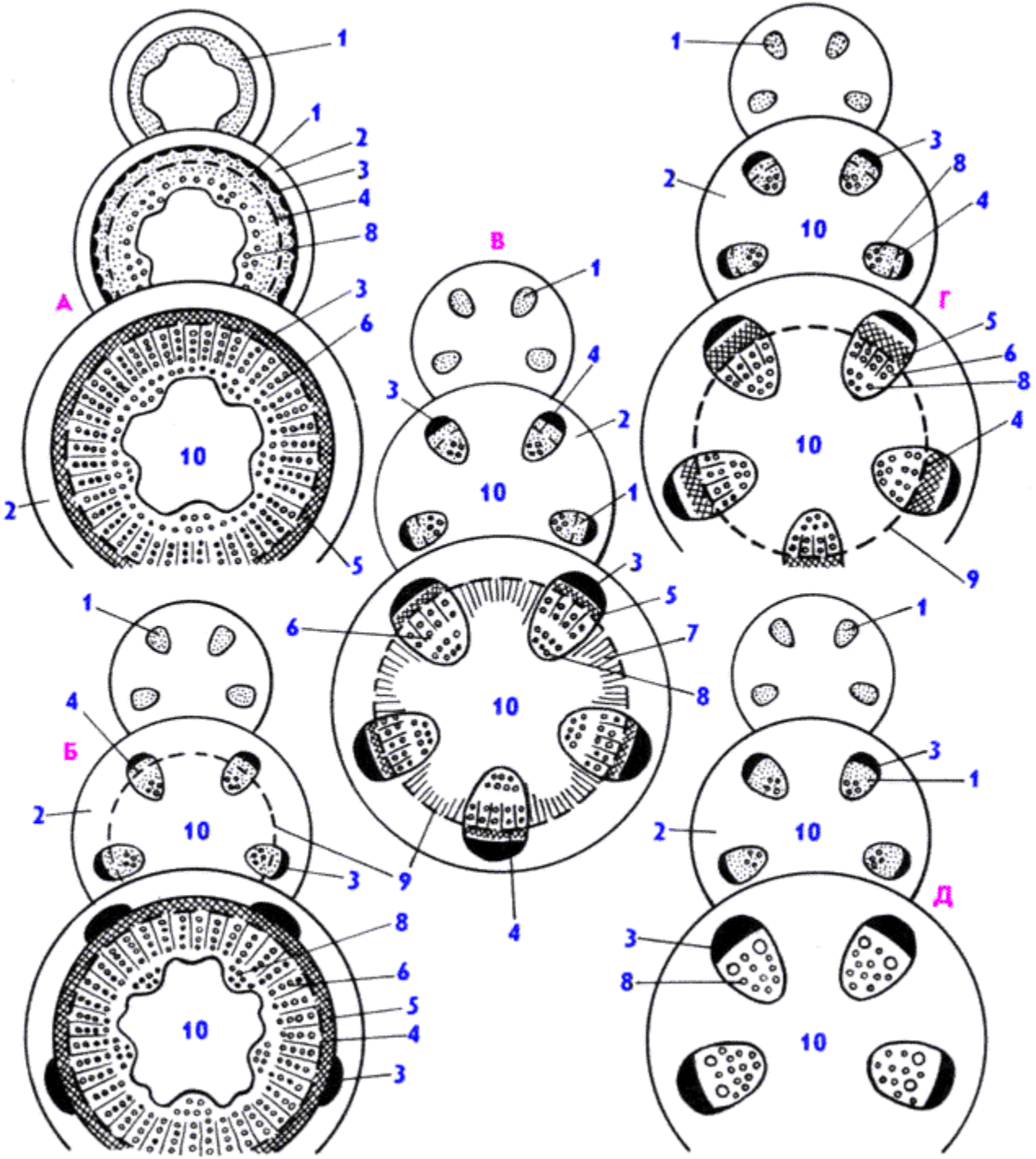

100 µm
Fragment of a cross-section of the rhizome of the lily of the valley at 10x magnification
Collateral bundle
The concentric amphivasal bundle

Conducting bundles in the rhizome of lily of the valley (Convallaria majalis L.).




Fragment of a cross-section of the rhizome of the lily of the valley at an increase of 40x
The concentric amphivasal bundle
20 µm

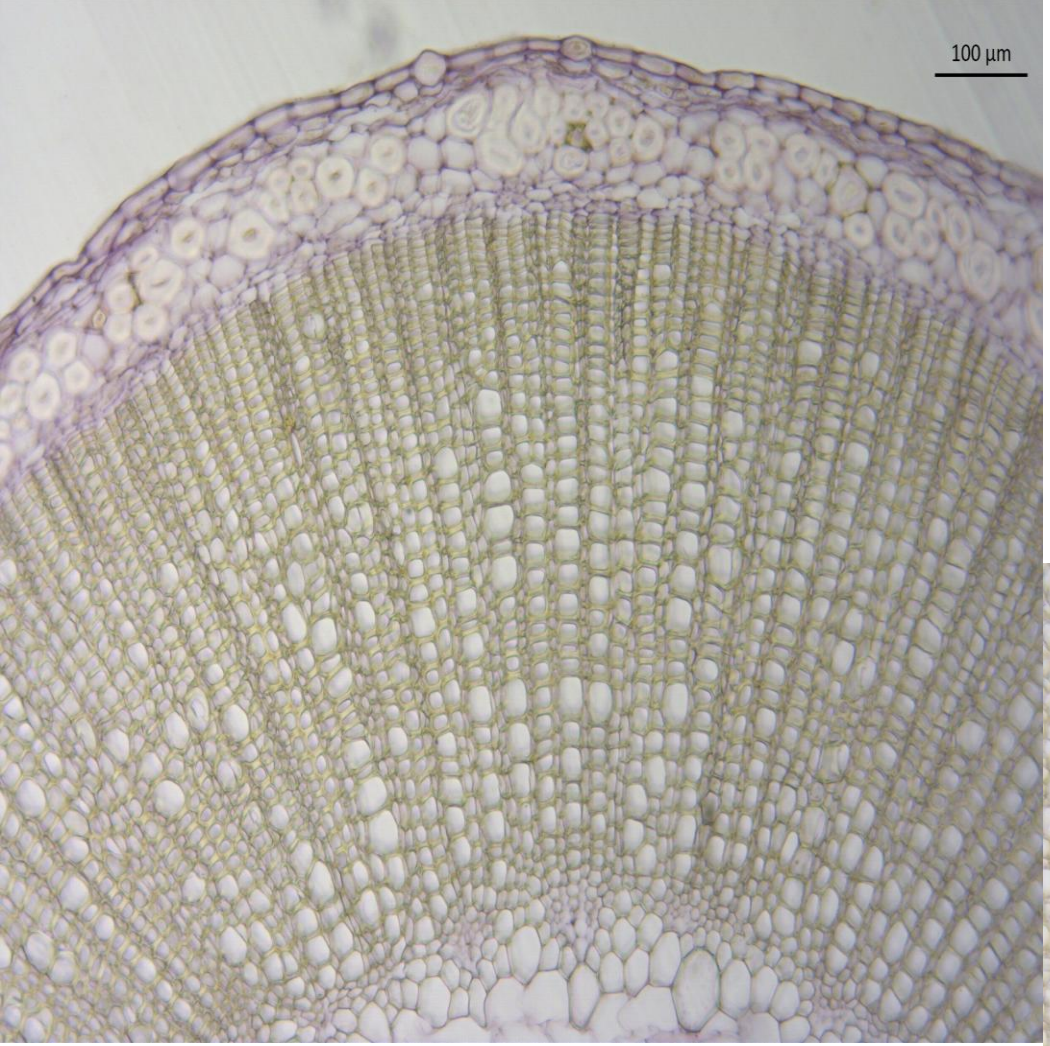

The xylem
The phloem
20 µm



Types of forming of the cambium in stem

1 - procambium , 2 - primary cortex, 3 - primary phloem , 4 - cambium, 5 - secondary phloem, 6 - secondary xylem, 7 - sclerenchyma, 8 - primary xylem, 9 - interfascicular cambium, 10 - pith.

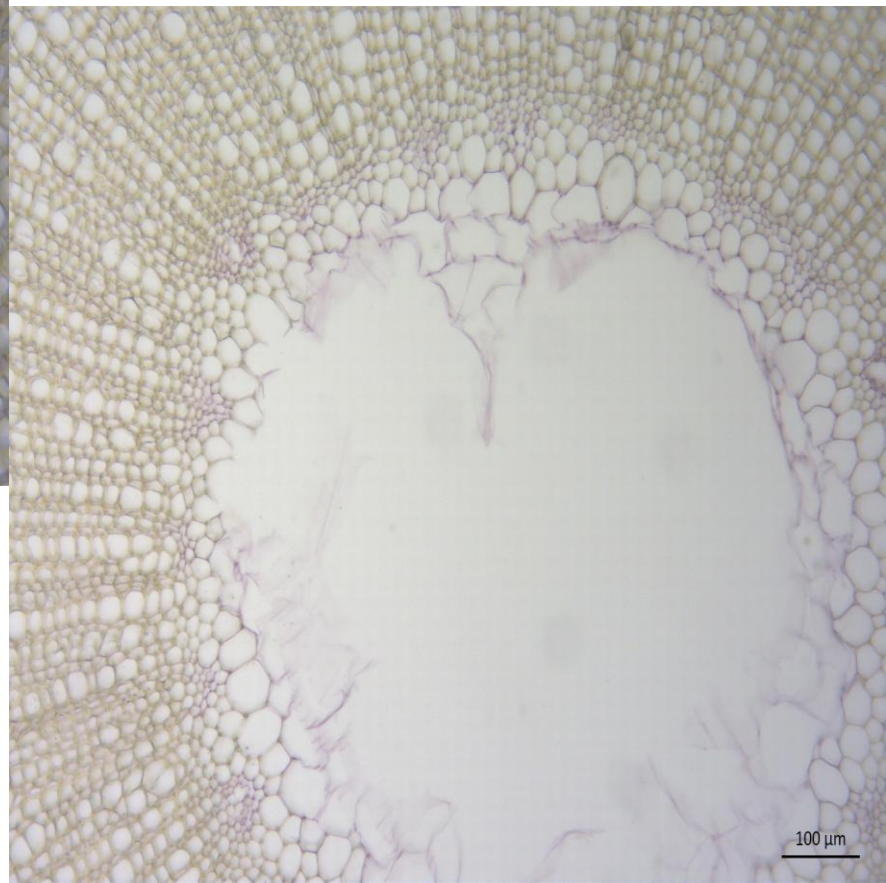

Cross-section of flax stem at 4x magnification
200 µm



Peripheral part

Fragments of a cross-section of a flax stem at 10x magnification. He has a non-ductile (annular structure)

The middle part



A fragment of a cross-section of a flax stem at 40x magnification

Epidermis

Assimilation parenchyma

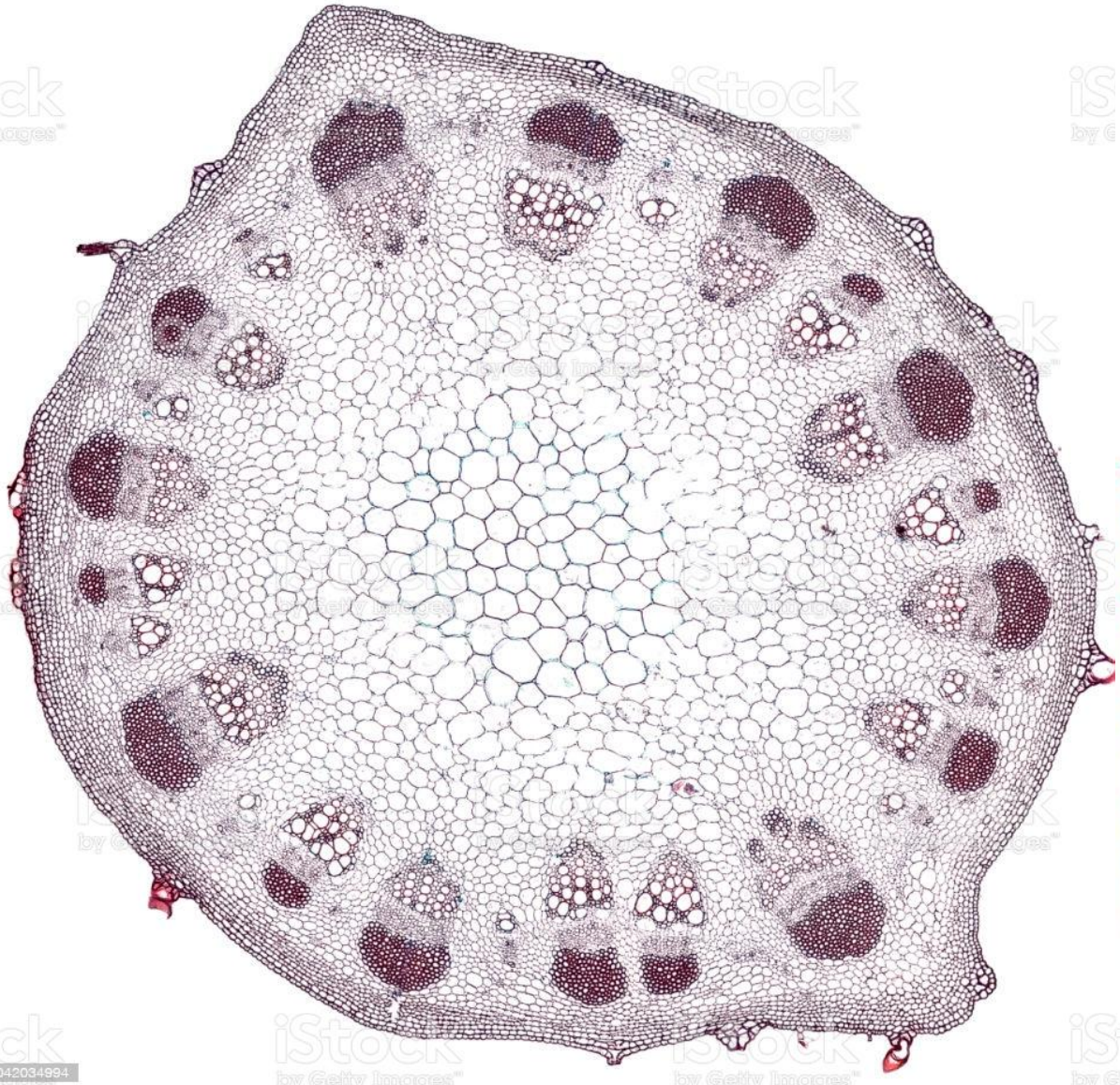
Endoderm

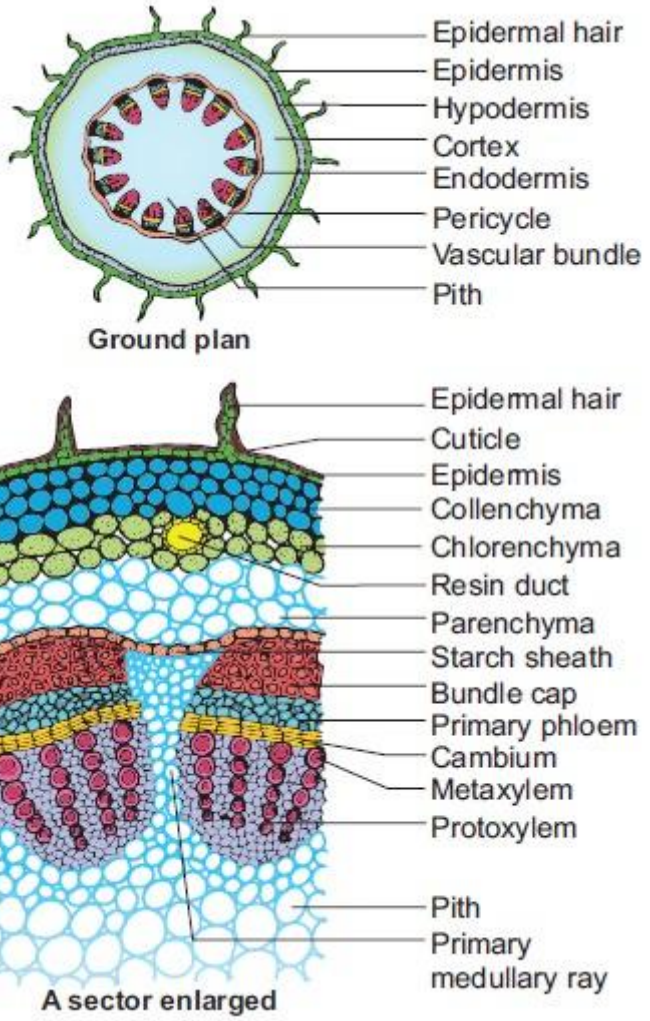
Bast sclerenchyma

Sieve tube

Cambium

Cross section of sunflower stem at 4x magnification





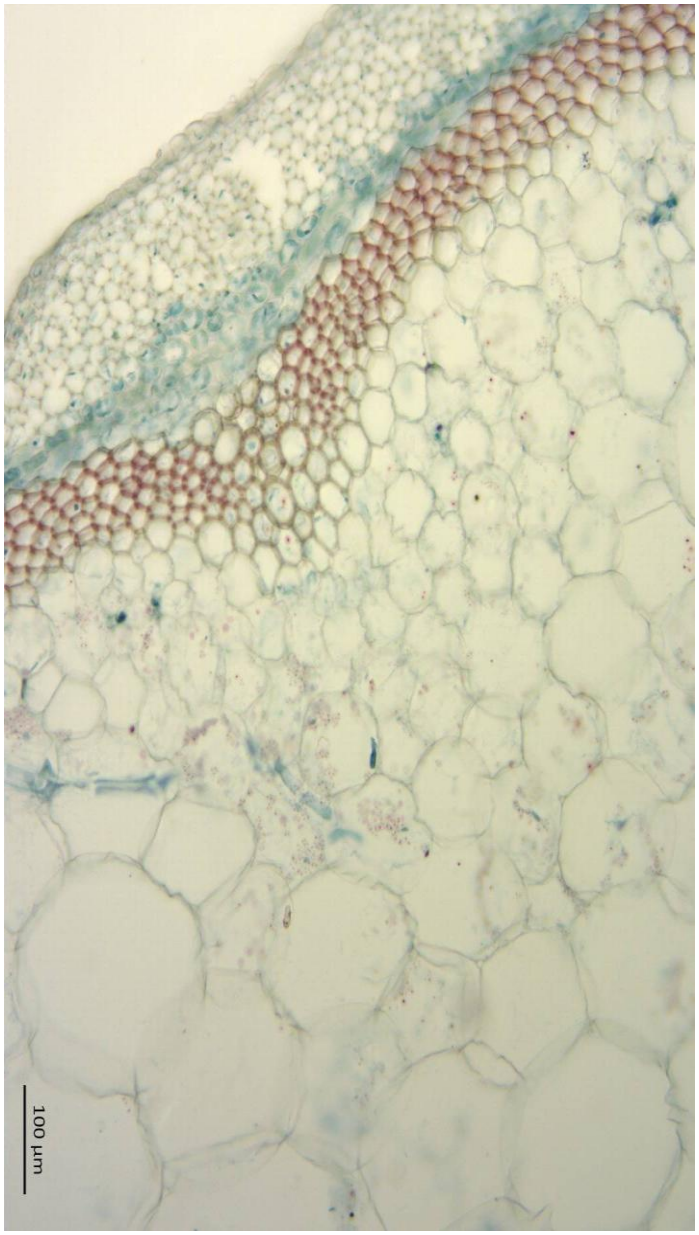
Cross section of sunflower stem at 10x magnification

On this slide we see that over time the bundles grow and interlock into continuous layers of phloem, cambium and xylem

Fragment of a cross-section of a pickaxe (Aristolochia clematitis) stem at 4x magnification

Fragment of a cross-section of a pumpkin stem under 4x magnification

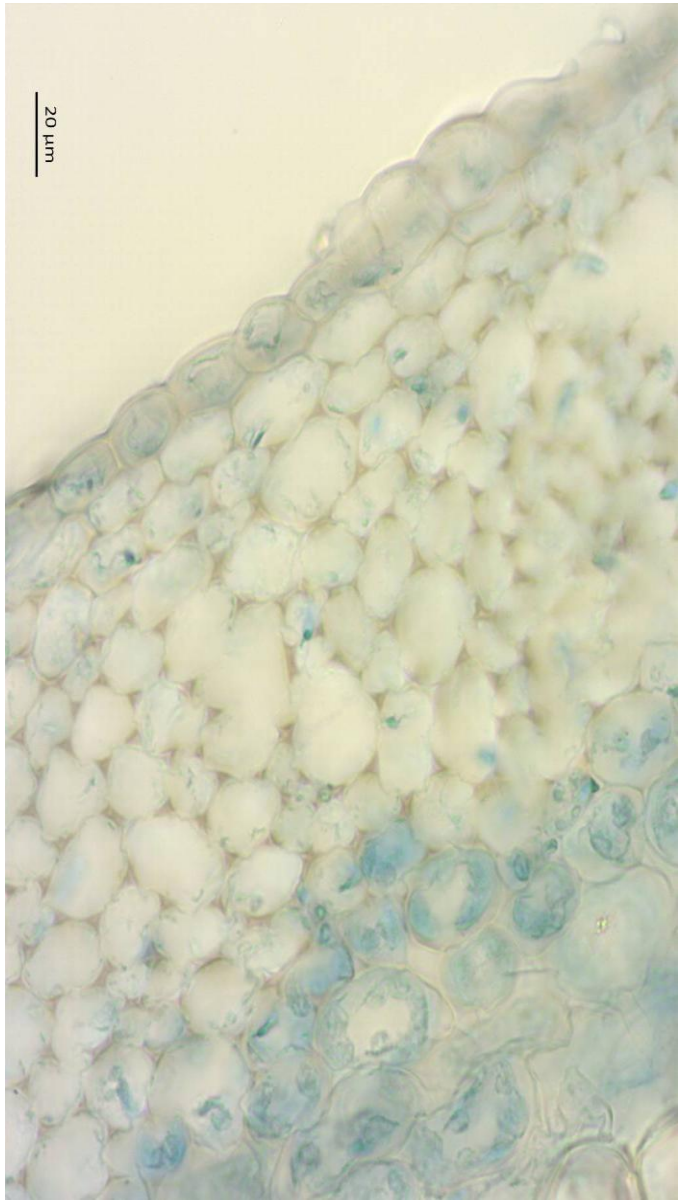
Fragments of a cross-section of a pumpkin stem under 10x magnification



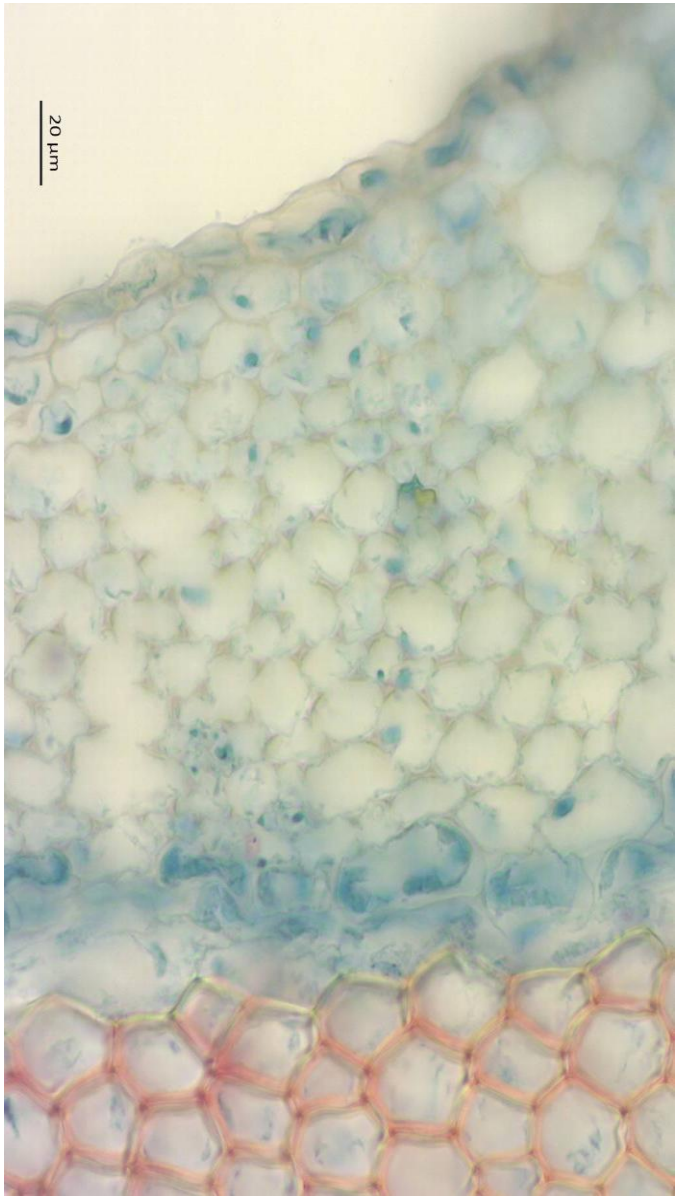
Peripheral part

Bicollateral vascular bundle

Fragments of a cross-section of the pumpkin stem at the periphery under 40x magnification



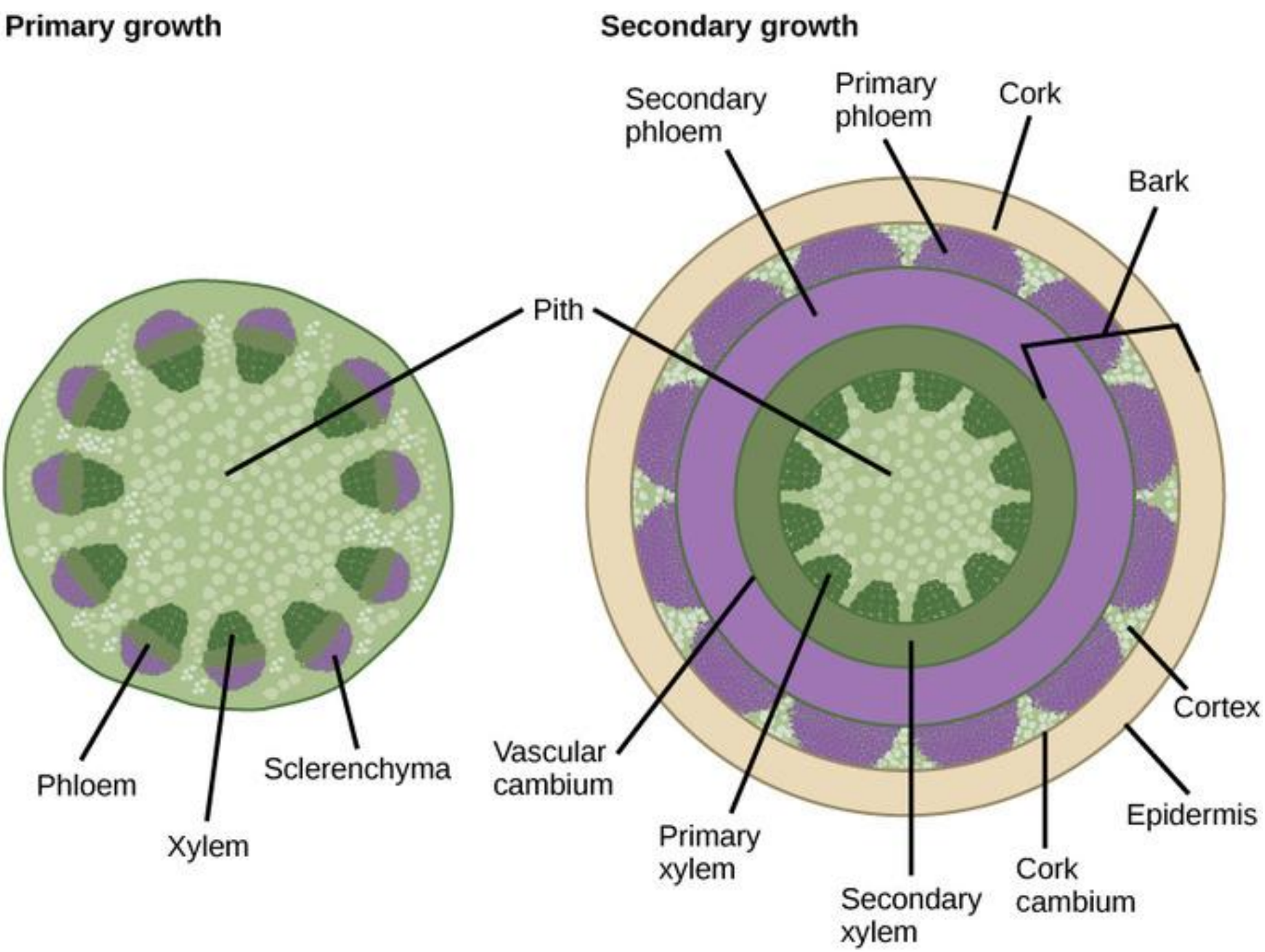
Between the bundles (collenchyma and assimilating parenchyma)

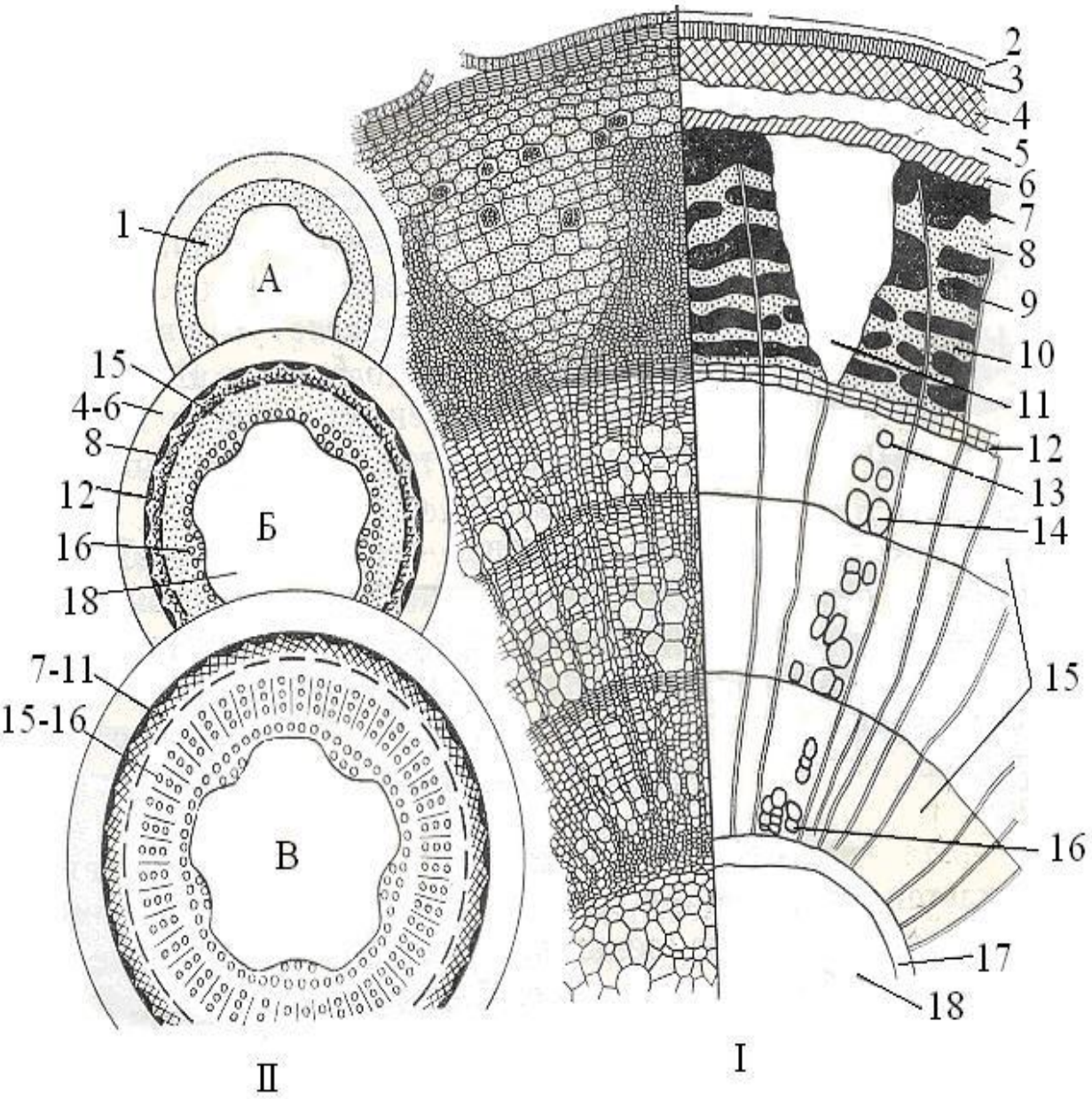


Above the bundle (collenchyma, assimilating parenchyma , endoderm and sclerenchyma of pericyclic origin)

The structure of the stem of woody plants.

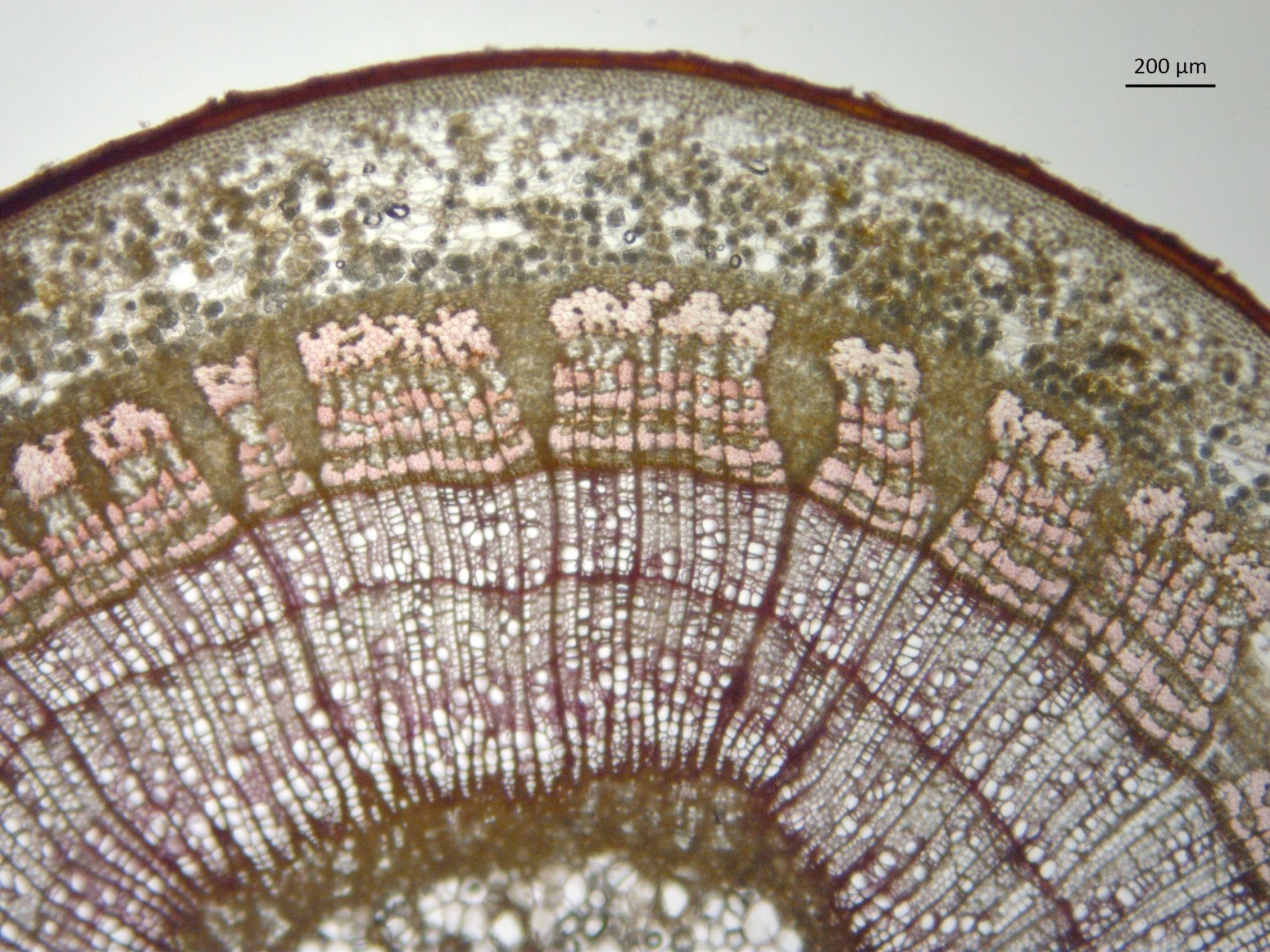
- In the stems of woody dicotyledonous plants, there are:
- **1. Dermal tissue,**
- **2. Secondary cortex**
- **3. Cambium,**
- **4. The wood,**
- **5. The pith.**


Primary growth
Secondary growth
Secondary phloem
Primary phloem
Cork
Bark
Pith
Phloem
Xylem
Sclerenchyma
Vascular cambium
Primary xylem
Secondary xylem
Cork cambium
Cortex
Epidermis

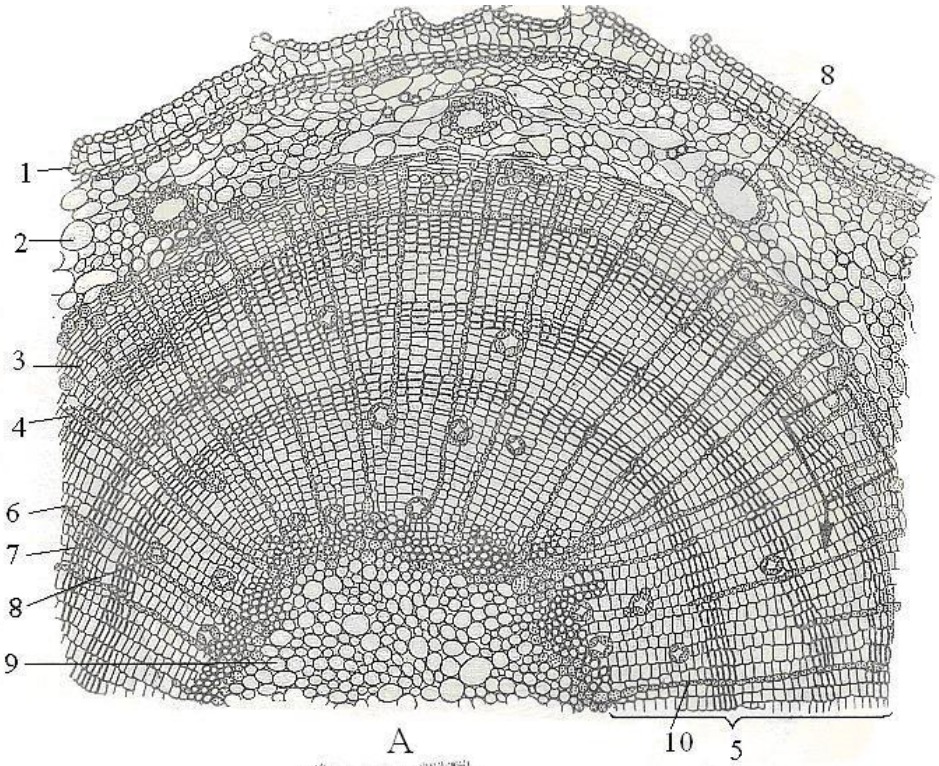


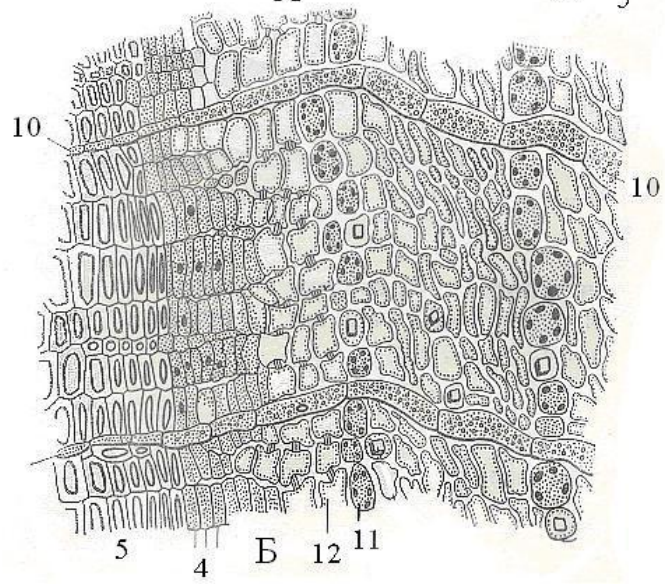
The linden stem structure in cross section (I) and the scheme of stem structure at different levels (II):A - section at the level of procambium occurrence; B - at the level of cambium appearance; C - at the level of the formed structure.

1 - procambium, 2 - remains of the epidermis, 3 - periderm, 4 - collenchyma, 5 - parenchyma of the cortex, 6 - endoderm (4-6 - primary bark), 7 - pericyclic zone, 8 - primary phloem, 9 - hard bast, 10 - soft bast (secondary phloem), 11 - pith ray (7-11 - secondary cortex), 12 - cambium, 13 - late wood, 14 - early wood (13-14 - annual ring wood), 15 - secondary wood, 16 - primary wood (15-16 - wood), 17 - perimedullary zone, 18 - pith parenchyma (17-18 - pith, 7-18 - central cylinder).


200 µm

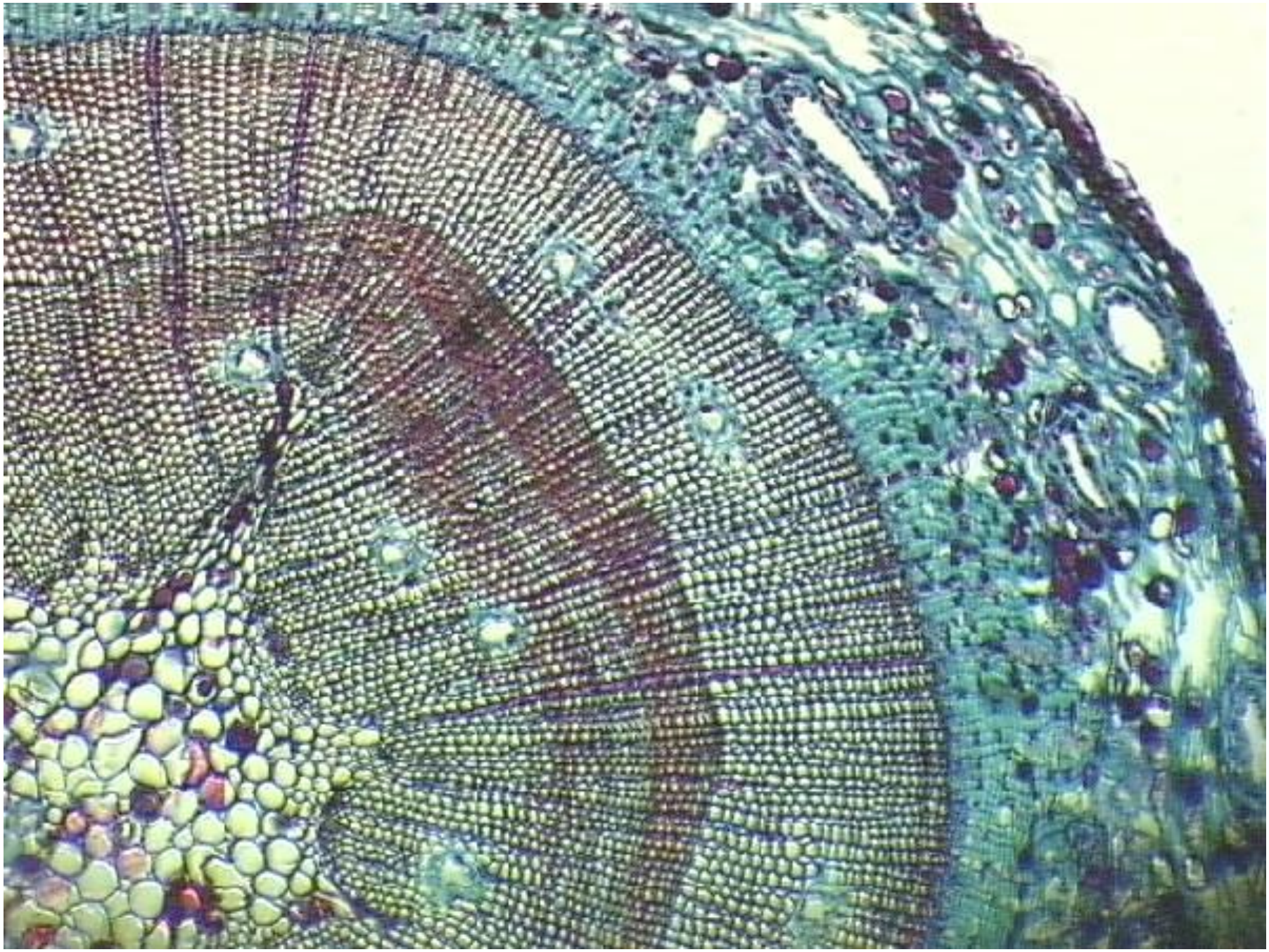
Perennial stem of pine

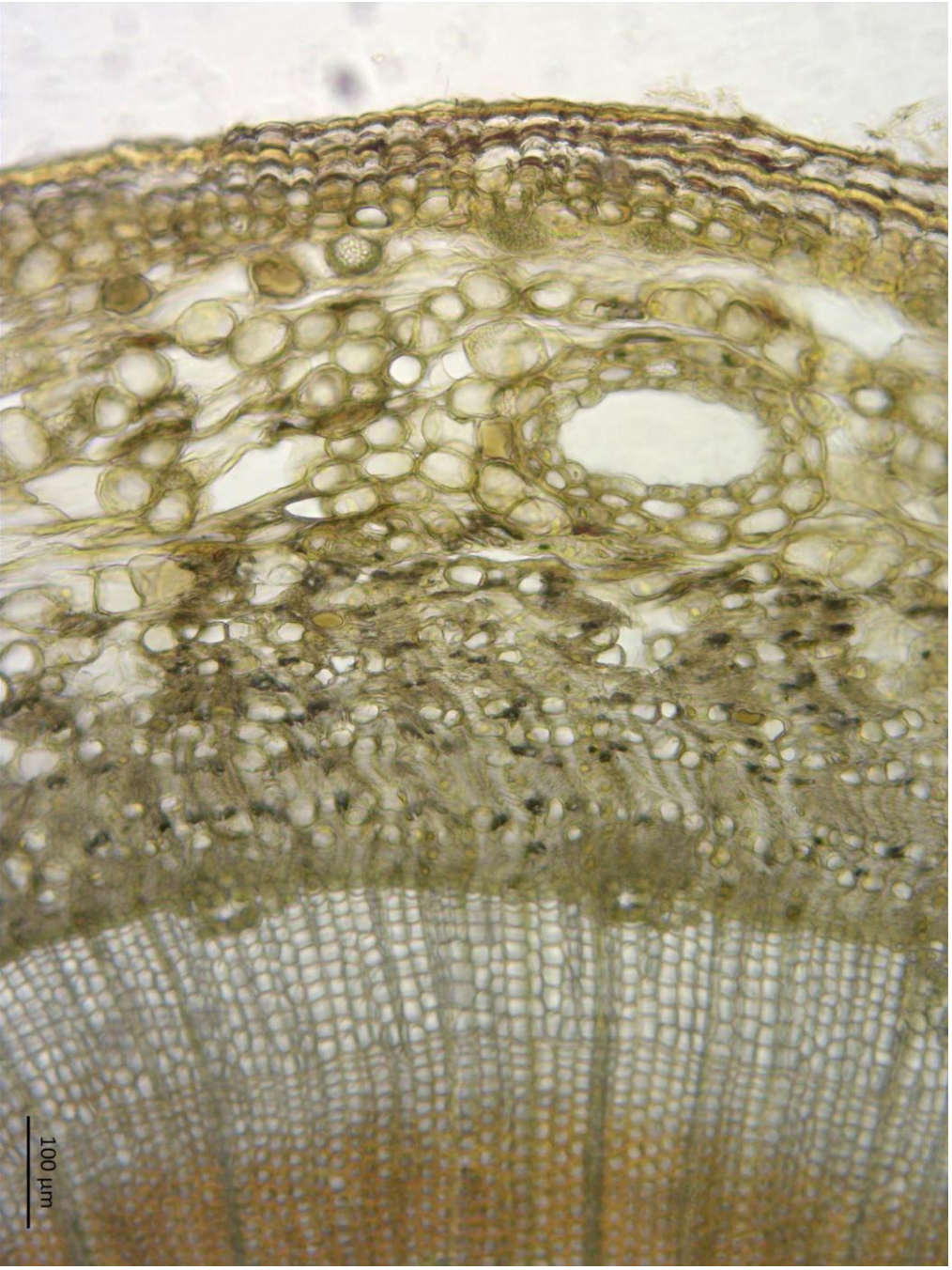




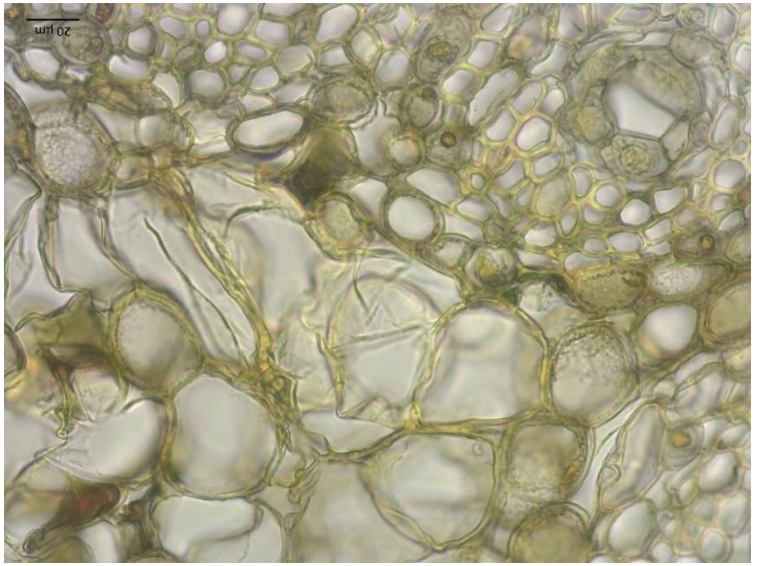
A - part of the cross section; B - phloem and cambium, with adjacent xylem tracheids.

1 - periderm, 2 - parenchyma of the primary cortex, 3 - phloem, 4 - cambium, 5 - xylem, 6 - early tracheids, 7 - late tracheids, 8 -resin duct, 9 - pith, 10 - pith ray, 11 - bast parenchyma, 12 - sieve cells.



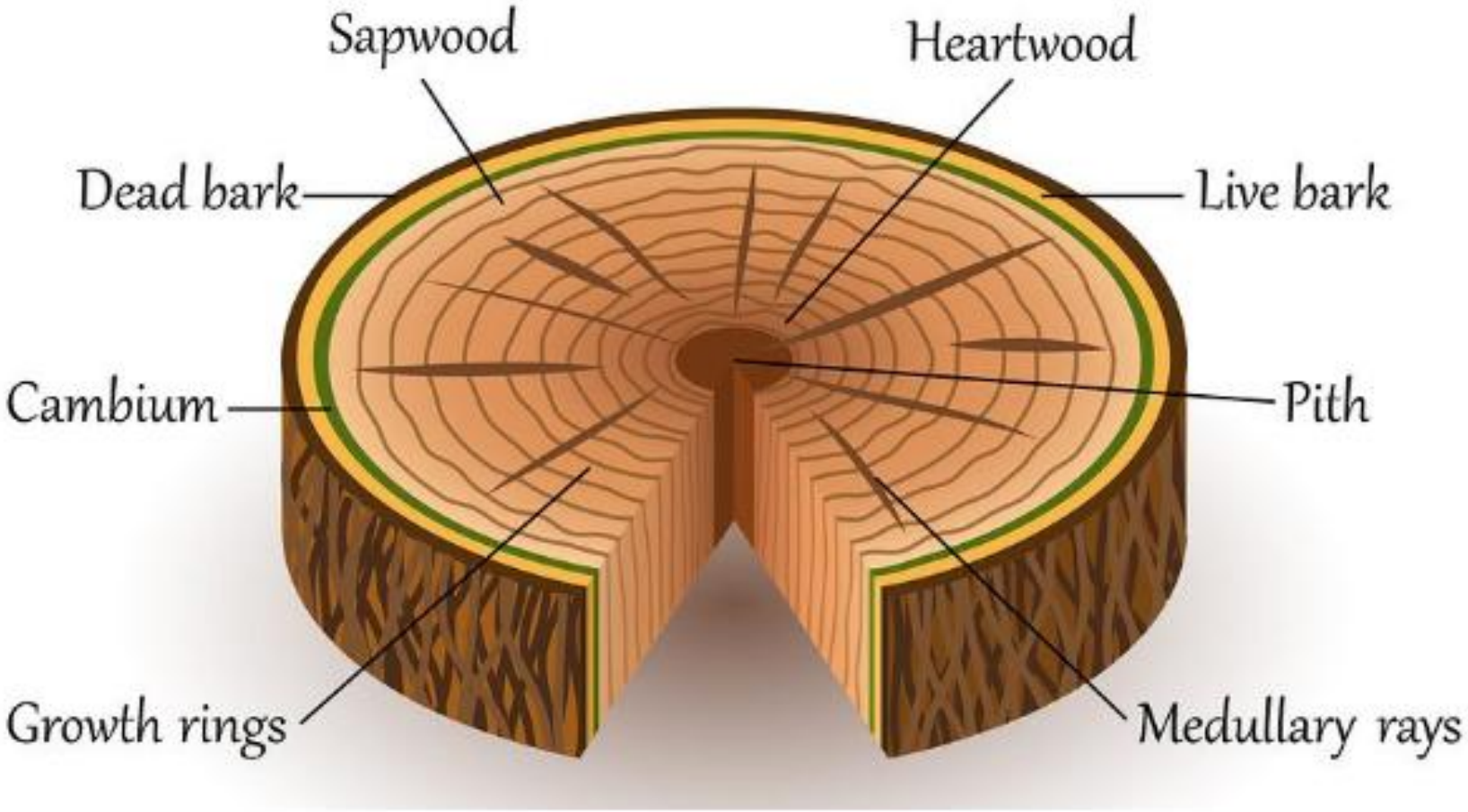

100 µm


20 µm


20 µm

Differences in the anatomical structure of woody stems of Gymnosperms and Dicotyledonous Angiosperms

Anatomical structures and tissues	Gymnosperms Dicotyledonous Angiosperms	Dicotyledonous Angiosperms
Primary cortex	It is represented by a homogeneous assimilating parenchyma, often with resin ducts.	It is represented by assimilating parenchyma, collenchyma and endoderm.
Mechanical tissue	As a rule, they are not developed. The supporting function is performed by tracheids.	Well expresed.
а) collenchyma	Absent.	There is, in woody stems, more often lamellar.
б) sklerenchyma	Absent.	Have. Fibers and sclereids. Fibers can be in phloem (bast), xylem (woody), pericycle (perivascular).
Vascular tissue	Do not contain mechanical elements.	They must contain mechanical elements.
а) phloem	Vascular elements are represented by sieve cells	Conducting elements are represented by sieve-shaped tubes with companion cells.
б) xylem	Vascular elements are represented by tracheids	Conducting elements are represented by vessels and tracheids.
Secretory cavities (their type and location in the stem)	There are resin ducts that are located in the cortex and in the wood.	Of various types, they are located in parenchymal tissues (cortex and pith), but not in wood.


Sapwood
Heartwood
Dead bark
Live bark
Cambium
Pith
Growth rings
Medullary rays


Sapwood
Heartwood