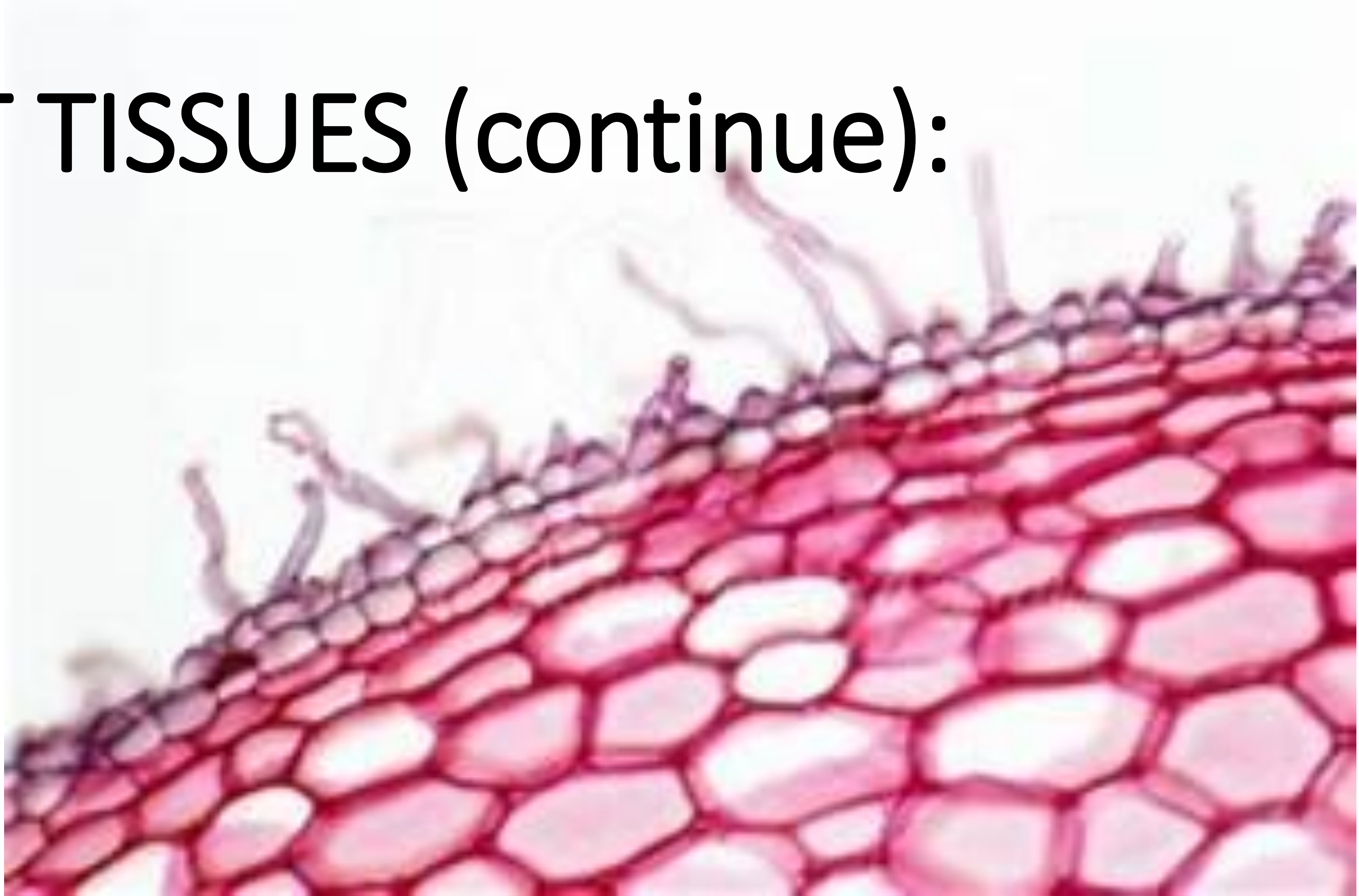
PLANT TISSUES (continue):



2. Tissues produced by meristems :

a. Covering tissues (epidermis)
b. Parenchyma (Filling cells)
c. Supportive tissues : Collenchyma and Sclerenchyma
d. Conducting (vascular) tissues (xylem and phloem)
e. Secretory cells and tissues

a. Covering Tissues

a. Covering tissues

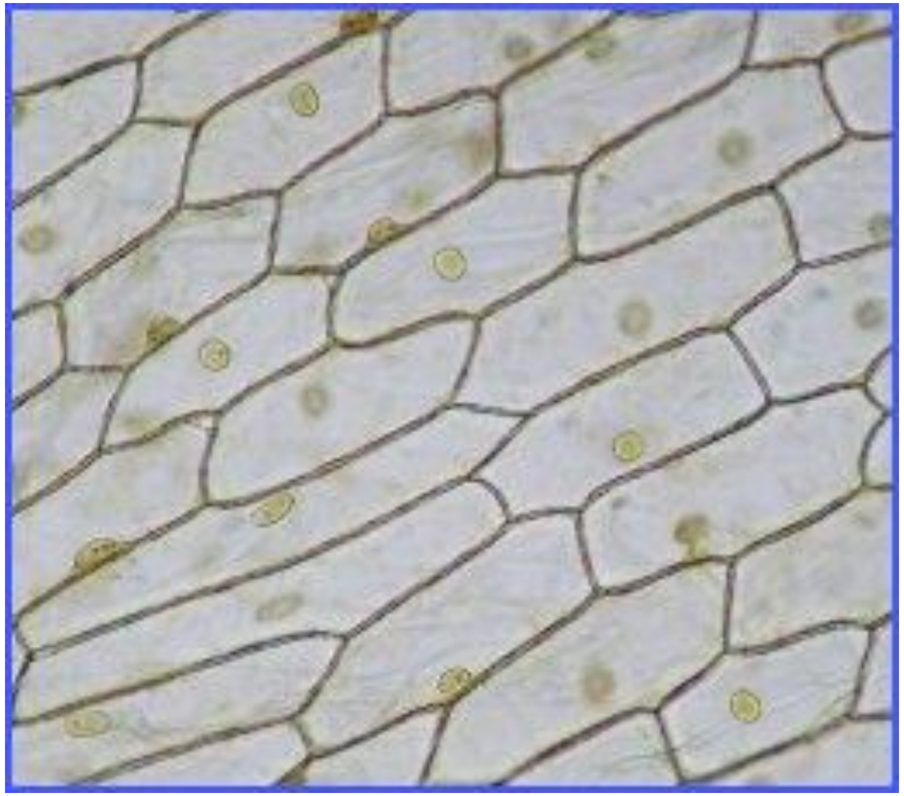
These are the surface tissues and the covering tissues that protect the plant from the external environment.

a.1. Epidermis

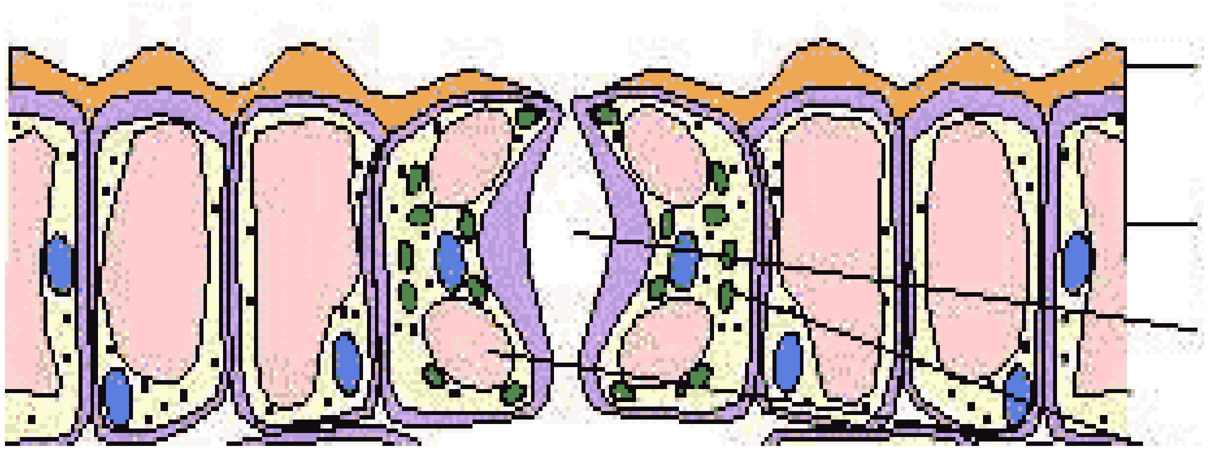
- Compact primary tissue consisting of a single layer of living superficial cells on the surface of the entire plant. It **covers the aerial organs, protecting them from desiccation and external attack**, while regulating gas exchange with the atmosphere. In places, these cells are thickened by the cuticle, which forms a protective film on the surface. The cells of epidermis do not have chloroplasts. The epidermis is interrupted at the level of the stomata in the leaves and sometimes by bristles (or hairs).

Figure 1. Examples of the epidermis of an onion and the leaf of a bulb.

The onion's epidermal cells



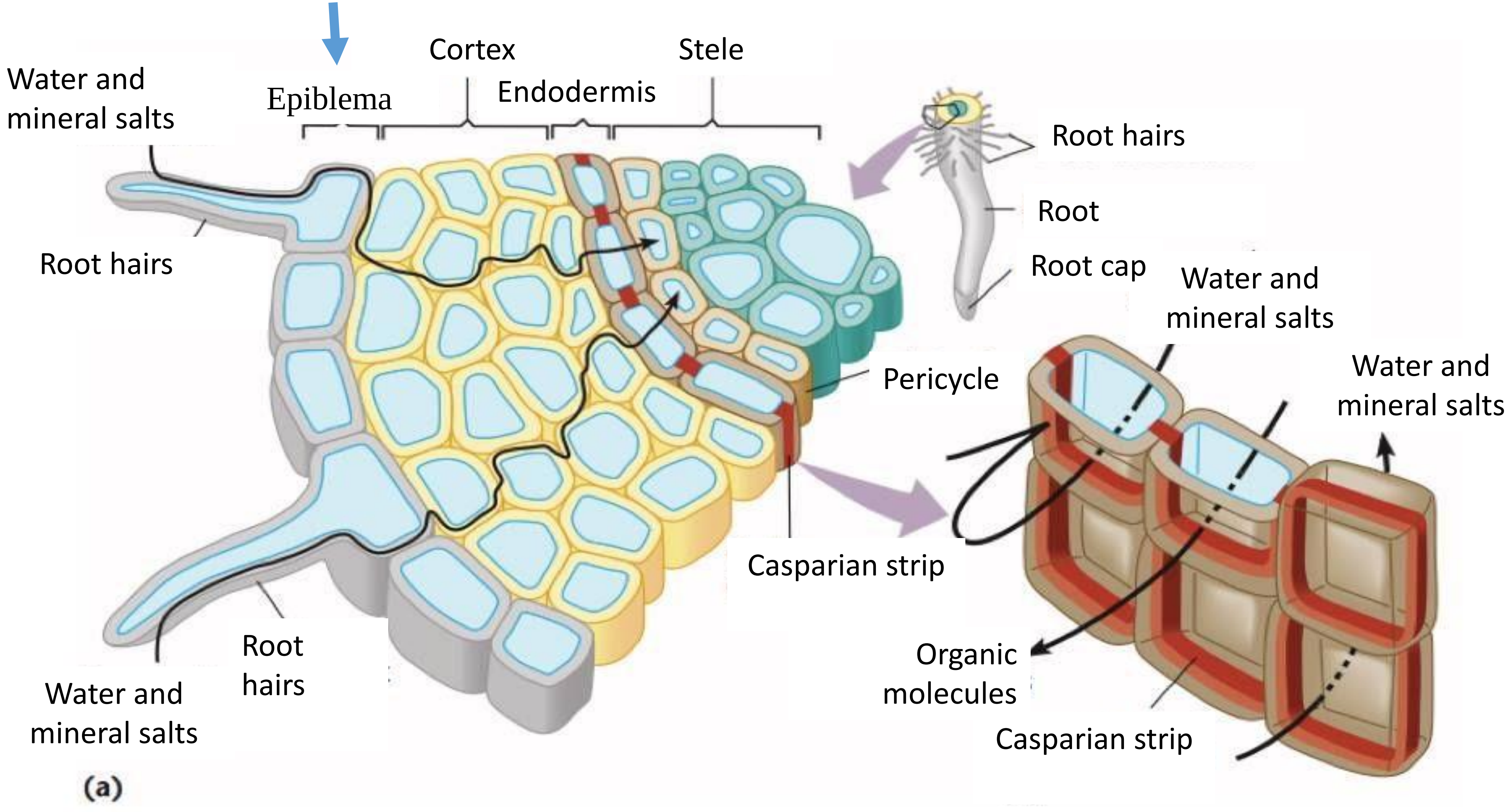
Cells in the epidermis of an onion leaf



b.2. The epiblema or root hairs base

- At the root level, epidermal cells replace the **root hairs base**. It is present in young roots in the absorbing region (Fig. 2-A).
- The **root hairs base (epiblema)** contains highly elongated and highly permeable cells that are essential for the uptake of water and soluble nutrients (salts). Some of these cells are hypertrophied and take on the shape of a hair, known as an absorptive hair (Fig 2-A).

Figure 2-A. Cross section of a root



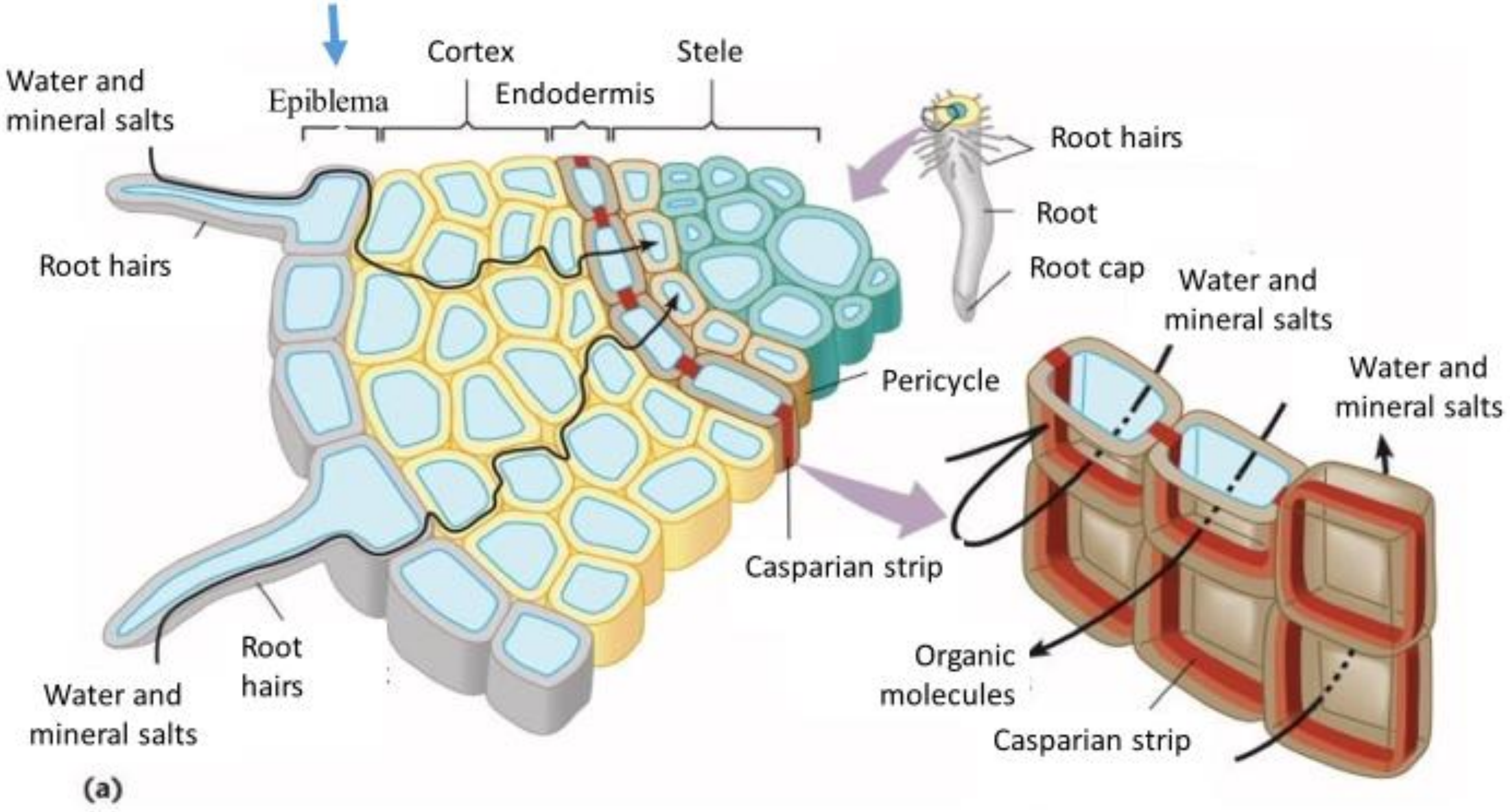
b.3. Endodermis

- The **endodermis** is the deepest part of the bark at root level. It plays a protective role within the plant (by sorting the substances taken up by the plant, some of which migrate to the conductive tissues) (Fig 2-B).

b.3. Endodermis

- The cells of the endodermis undergo lignification and suberification. As the plants get older, the endodermis becomes more lignified (suberous thickening in the form of framing, forming Caspary frames (Fig. 2-B)).

Figure 2-A. Cross section of a root



C. Filling tissues

C. Filling tissues : Parenchymal tissues

- The **parenchyma** is a filling tissue. It consists of few differentiated living cells with a thin, flexible primary wall.
- Parenchymatous tissues are the most voluminous in the plant and are found in the cortical (cortex) and medullary (medulla) regions of stems and roots. In the leaf they are found in the mesophyll and in the flesh of the fruit.

C.1. The chlorophyll parenchyma (or chlorenchyma)

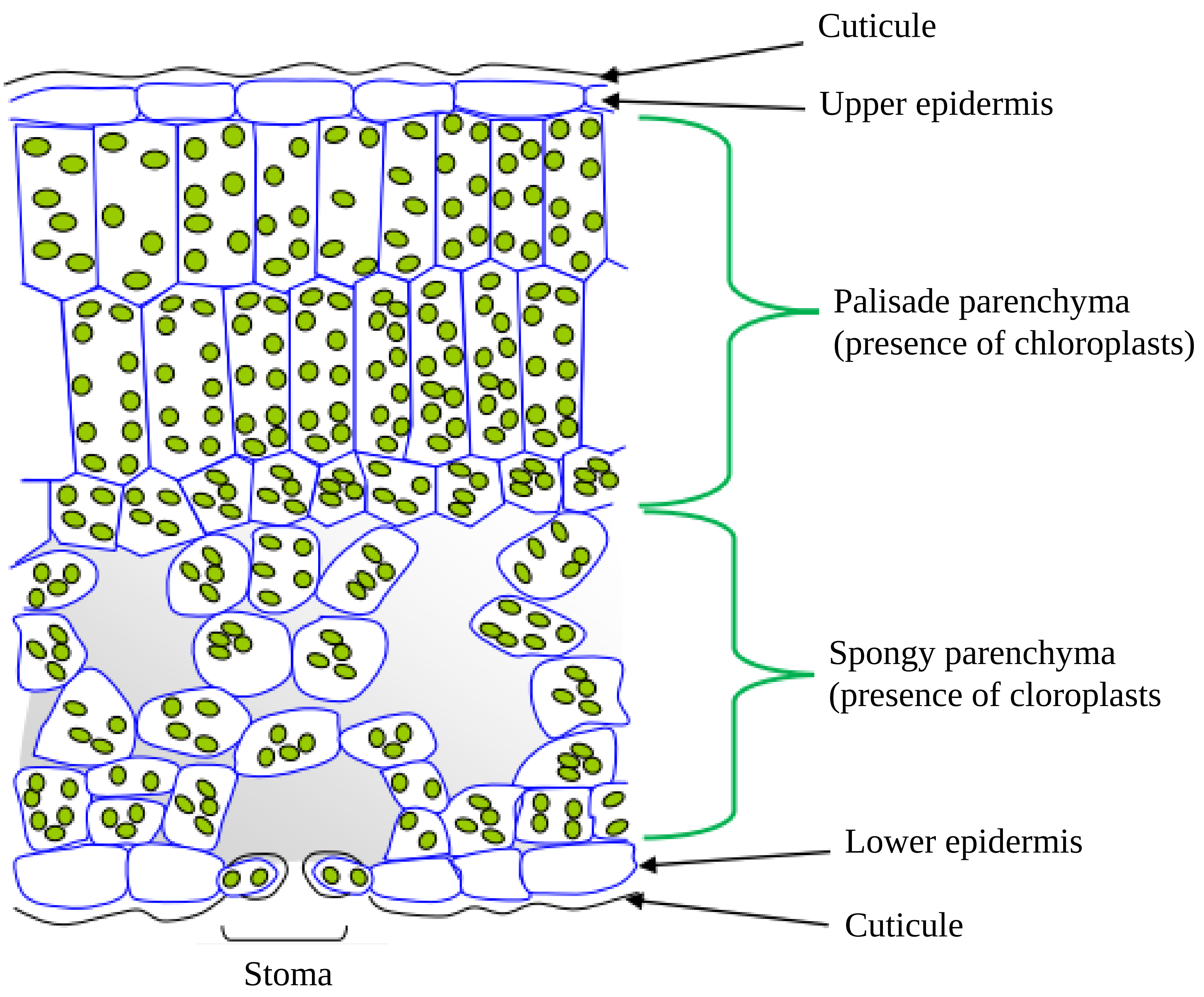
The **leaves** contain mainly :

Chlorophyllous palisade parenchyma, which enables photosynthesis. The cells that compose this parenchyma contain numerous chloroplasts. On the upper surface of the leaf, the palisade parenchyma is surrounded by the epidermis and traversed by the conduction vessels (Fig. 3.).

C.1. The chlorophyll parenchyma (or chlorenchyma)

- The **chlorophyll parenchyma**, which has gaps, is generally found on the lower leaf surface with a reduced number of chloroplasts. This parenchyma is involved in gas exchange through the stomata (Fig. 3).

Figure 3. Longitudinal section of a leaf



C.2. Storage parenchyma

- **Storage parenchyma** may be found in various forms (e.g. **potato starch**) in stems or roots,
- The **Storage parenchyma** is composed of living cells found in roots, underground stems, fruits and seeds. These reserves are used to maintain the tissues of the plant.

C.2. Storage parenchyma

- These storages may come from carbohydrate (sugar beets), starch (potatoes), fat (groundnuts) and protein (cereals).
- The **storage parenchyma** plays a role in the regeneration of tissues and in wound healing.

C.2. Storage parenchyma

The storage parenchyma includes (Fig. 4) :

a. **Vascular parenchyma :** Consists of voluminous cells with a highly developed vacuole. It is abundant in the stems and leaves of succulent plants, where it forms a water reserve.

b. **Air parenchyma :** is a type of lacunar tissue in which the lacunae trap air (e.g. aquatic plants).

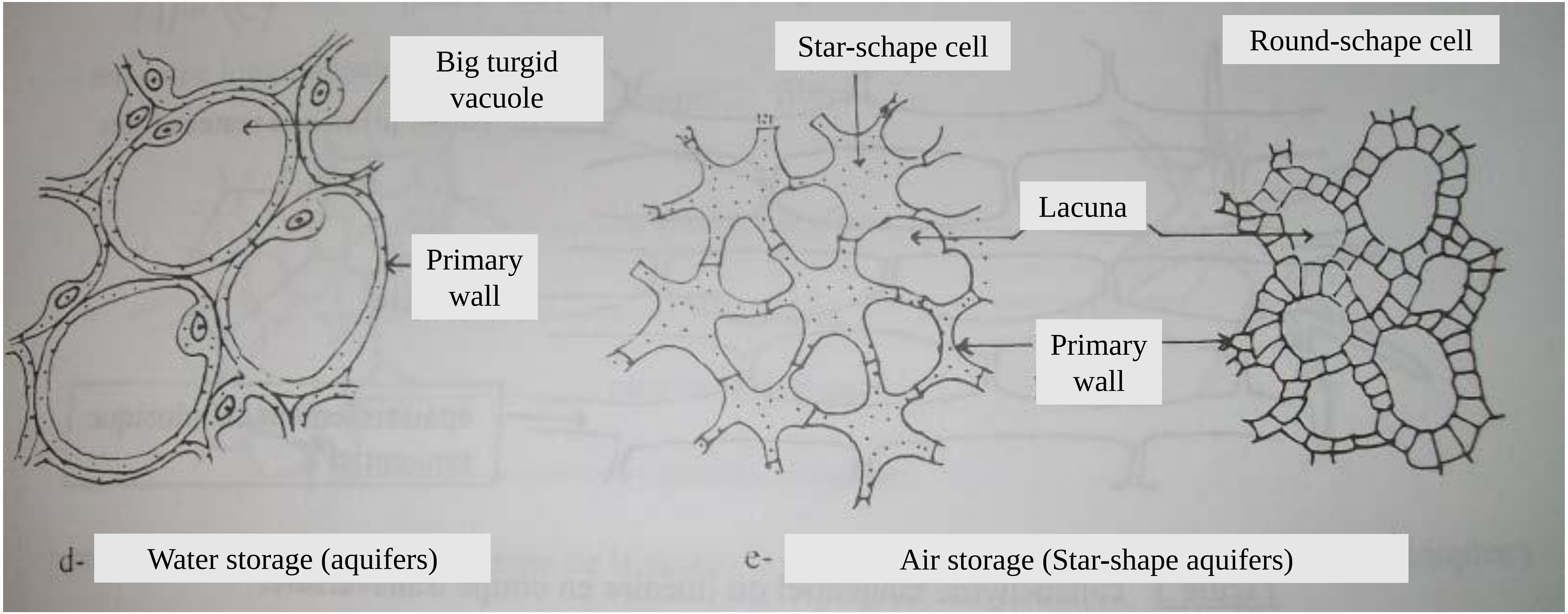
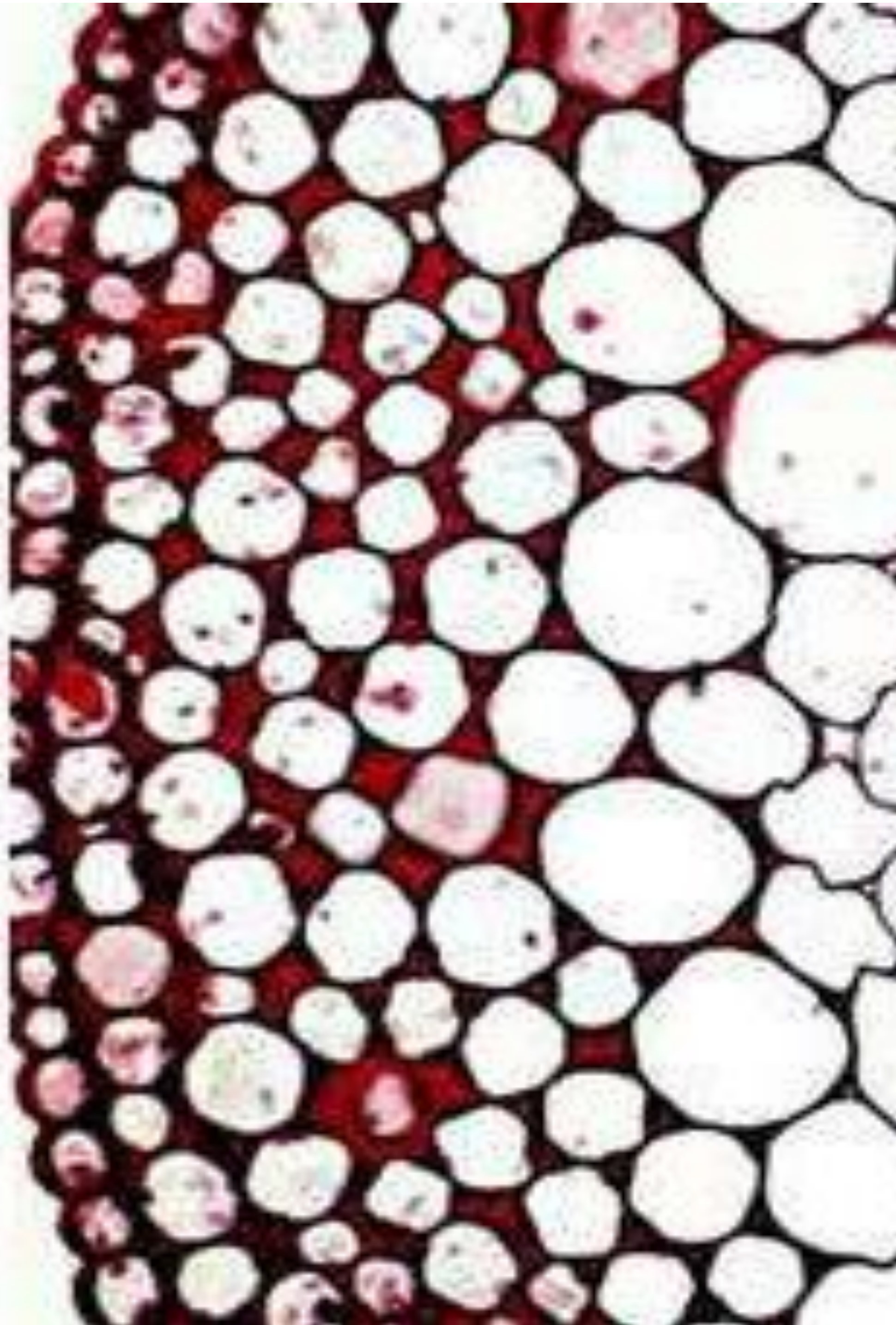


Figure 4. Different types of storage parenchyma

D. Supportive Tissues



D. Supportive Tissues (collenchyma and sclerenchyma)

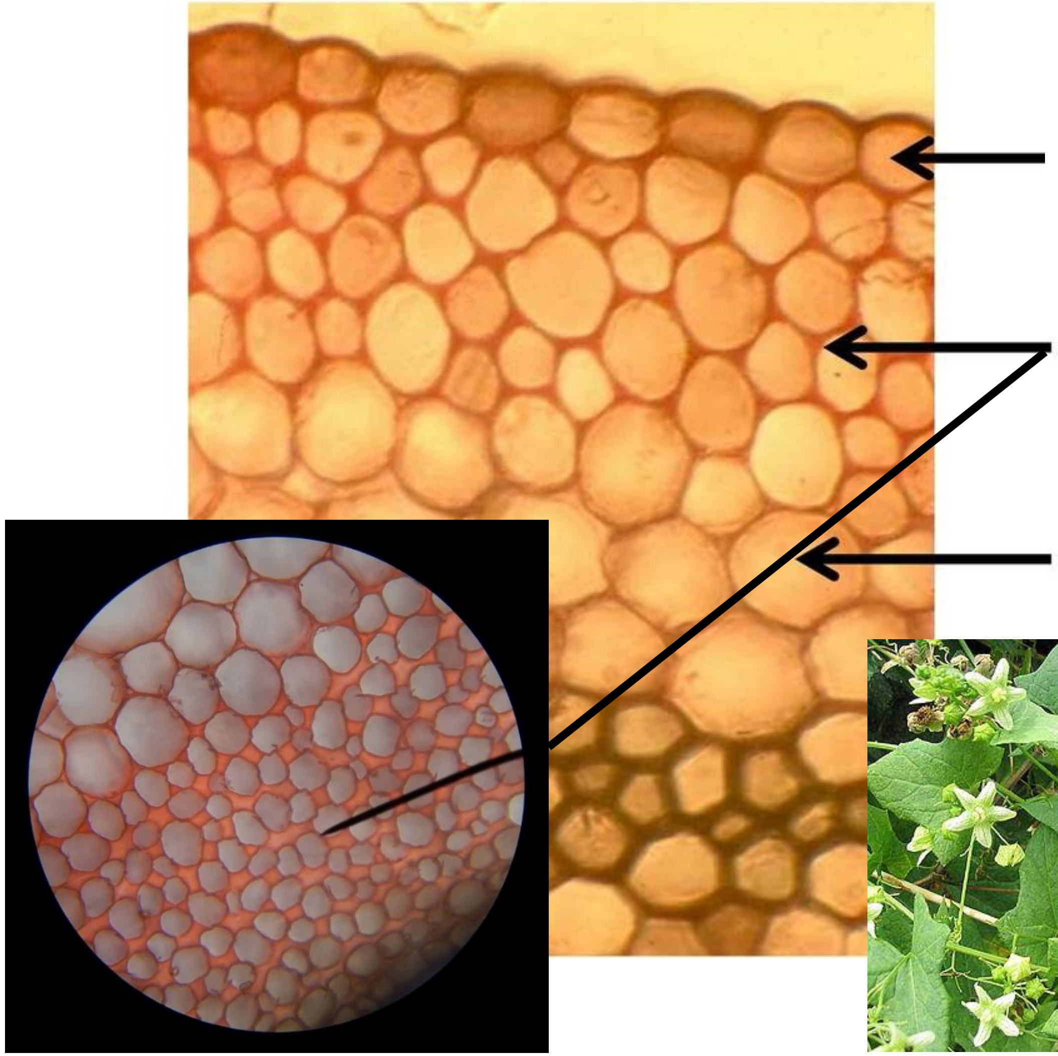
- **Supportive tissues** are composed of cells with thick walls that give them a certain **rigidity**.
- In particular, the supportive tissues of herbaceous plants are the collenchyma and the sclerenchyma.

D. Supportive Tissues (collenchyma and sclerenchyma)

D.1. Collenchyma

It is a primary tissue that is located under the epidermis and precisely at the periphery of the aerial parts of the young growing organs (the stem and the petiole).

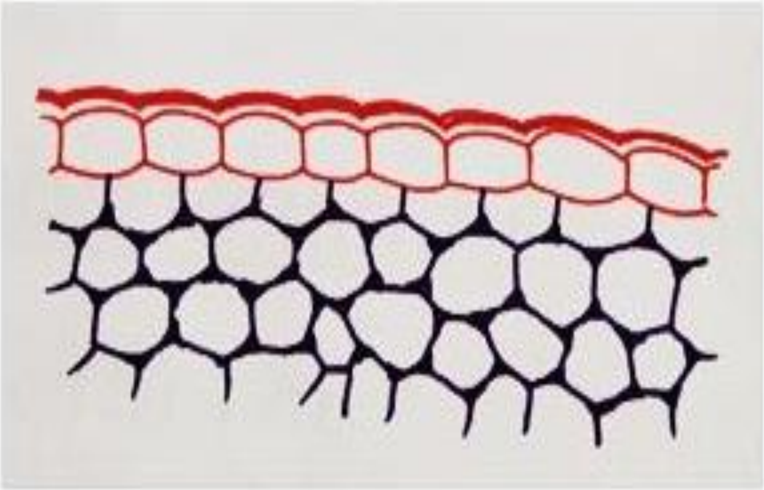
Observation of the cross section of the stem of the bryonia



There are different types of collenchyma depending on wall thickness:

1

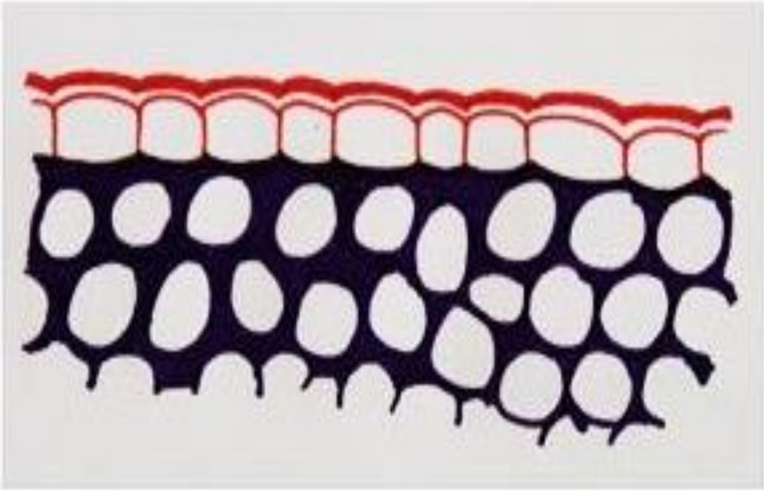
Angular



The thickening of the cellulose is concentrated in the corners of the wall.

2

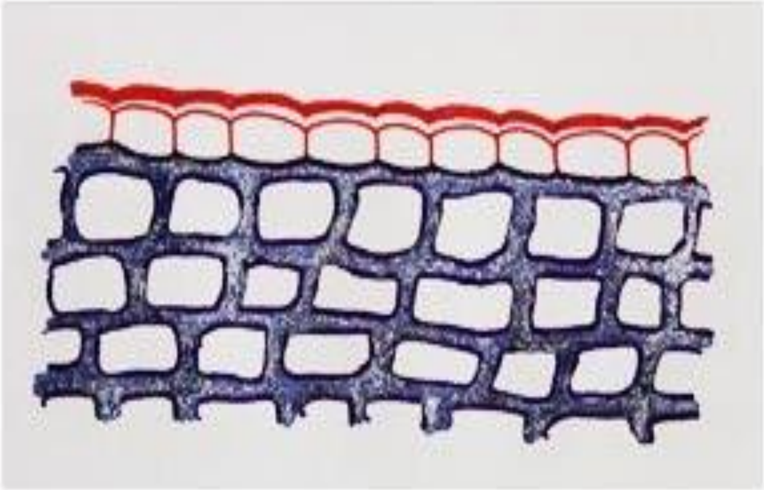
Circular



The cellulose deposit is evenly distributed around the wall.

3

Lamellar

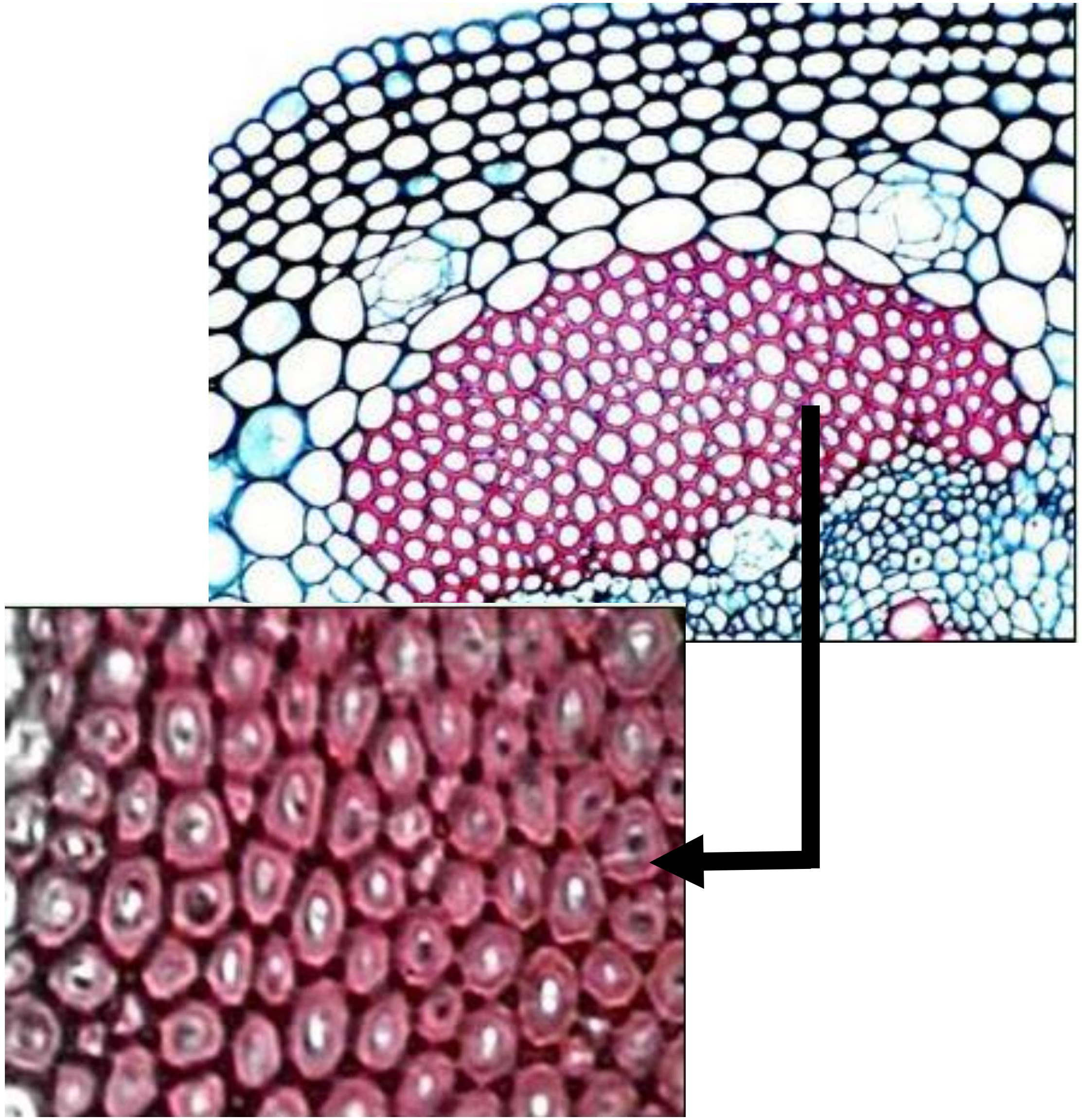


The tangential walls (parallel to the external face) are thicker.

D. Supportive Tissues (collenchyma and sclerenchyma)

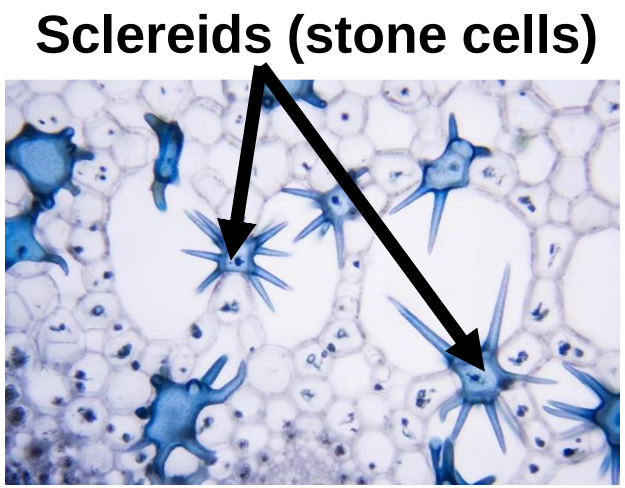
D.2. Sclerenchyma

- The **sclerenchyma** is a primary tissue composed of dead cells whose walls are thickened by a ***deposit of lignin (sclerites)*** that gives the plant **hardness and rigidity**.

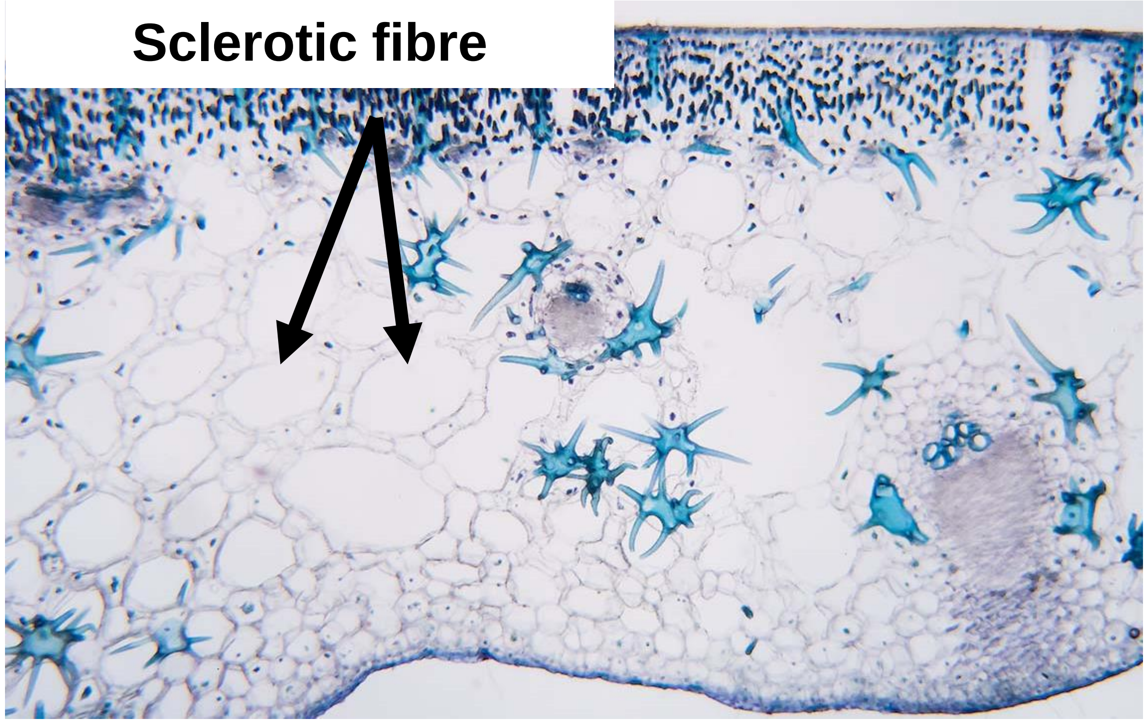


There are 2 types of sclerenchyma cells:

Sclereids : Short cells of variable shape, isolated in the parenchyma, grouped in clusters or in continuous layers. They ensure the rigidity or consolidation of the organs.



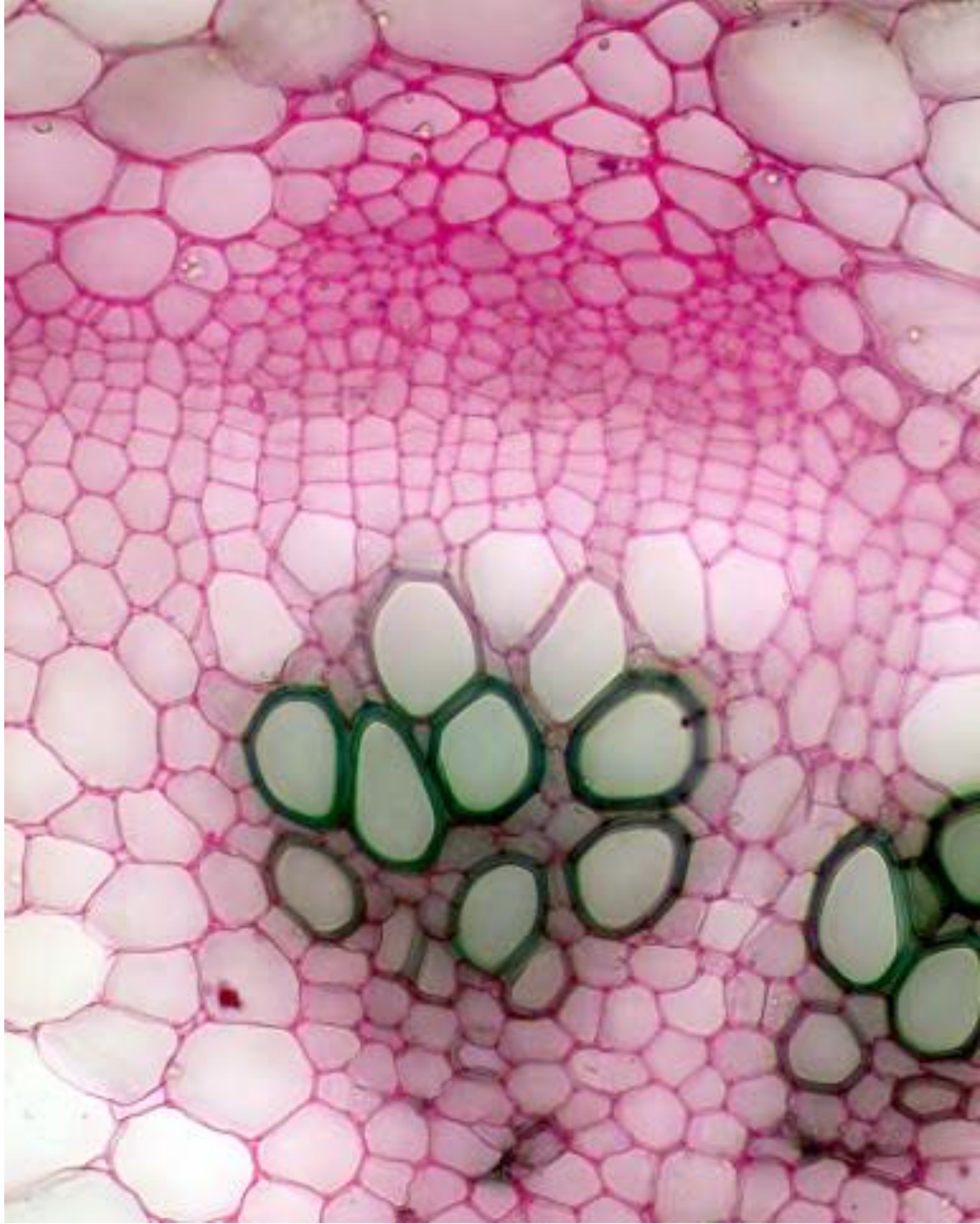
Sclerotic fibres : very elongated, spindle-shaped cells. Circular, elliptical or polygonal in section. In a continuous ring under the epidermis, close to the central cylinder or grouped in islands.



Summary of the main characteristics of **supportive tissues**

Collenchyma	Sclerenchyma
- Living tissue; - More or less elongated fusiform cells; - Thickened cellulose walls; - Thinned cytoplasm, nucleus and single large vacuole; - Three types according to the degree of thickening :	- Dead tissues; - Extended cells; - Thick lignified impermeable wall; - Punctuations or gaps; - Two types of cells ;
Types of thickening: Angular - annular and lamellar	Cell type : Sclerotic tissues and sclereids

C. Conducting (vascular) Tissues

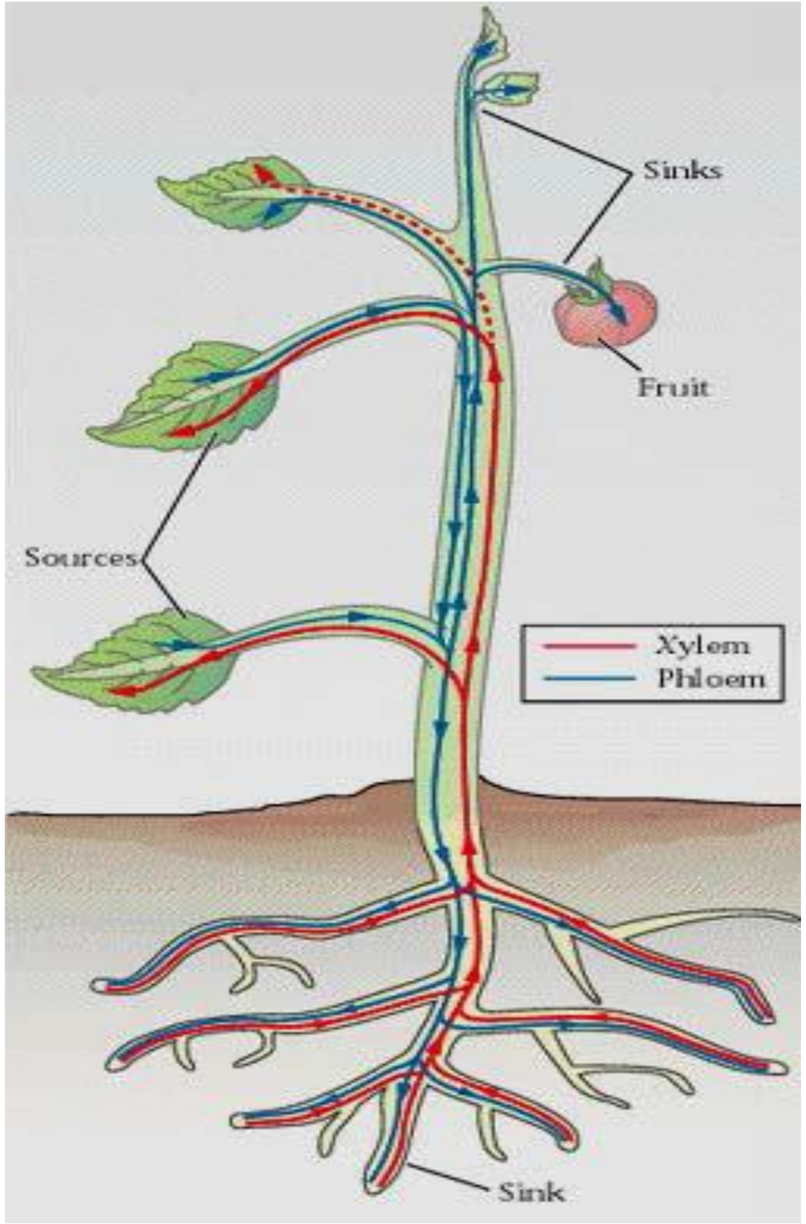


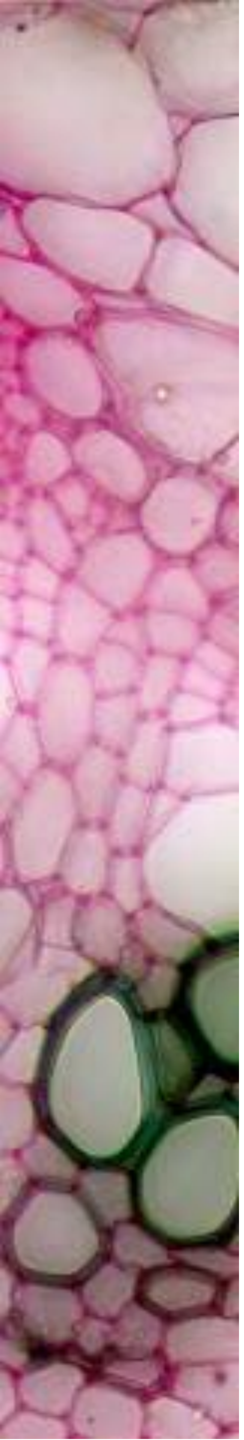
C. Conducting Tissues

Conductive tissues are specialised tissues for transporting sap within the plant. There are two types:

1. **Xylem (or lignified tissue)**: Conducts the **raw sap** (water + mineral salts) absorbed by the roots through the hair roots base.

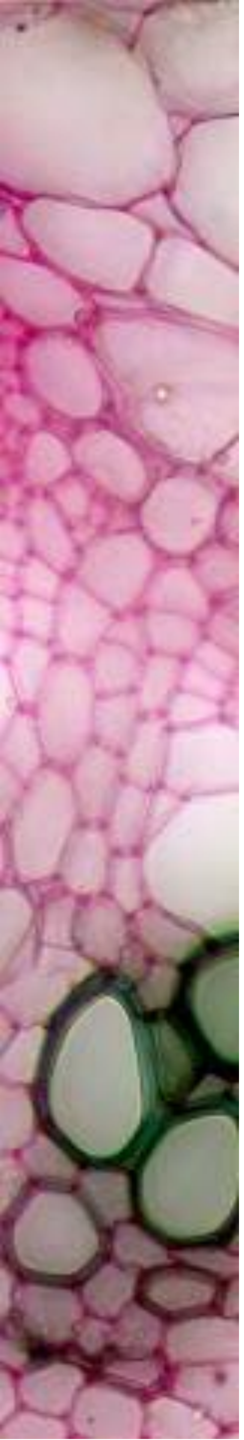
2. **Phloem (or cribled tissue)**: It transports the **sap (organic substances produced by photosynthesis)** to all the organs of the plant.





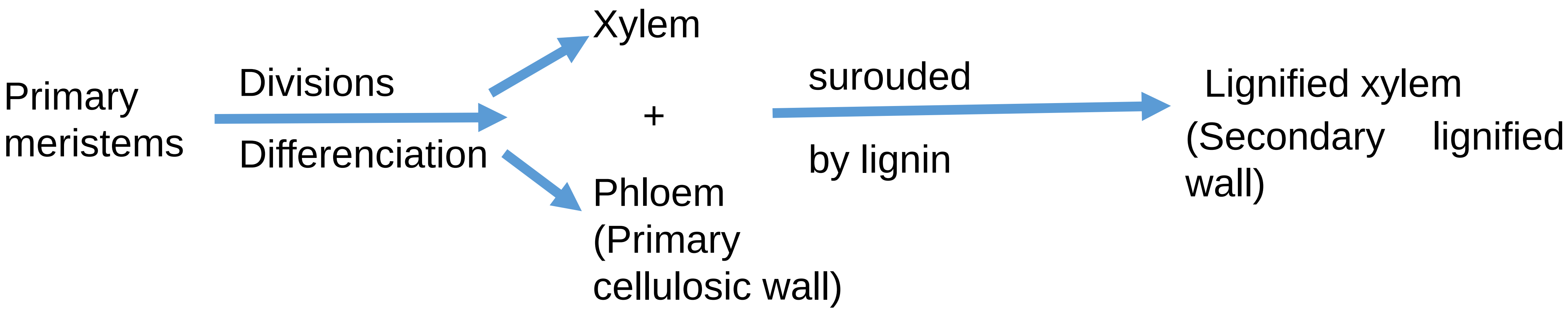
C. The conducting Tissues

- Plants with conducting tissues are called vascular (tracheophytes).
- From the pteridophytes onwards, simplified conducting tissues appear, and the differentiation is accentuated in the gymnosperms and angiosperms.



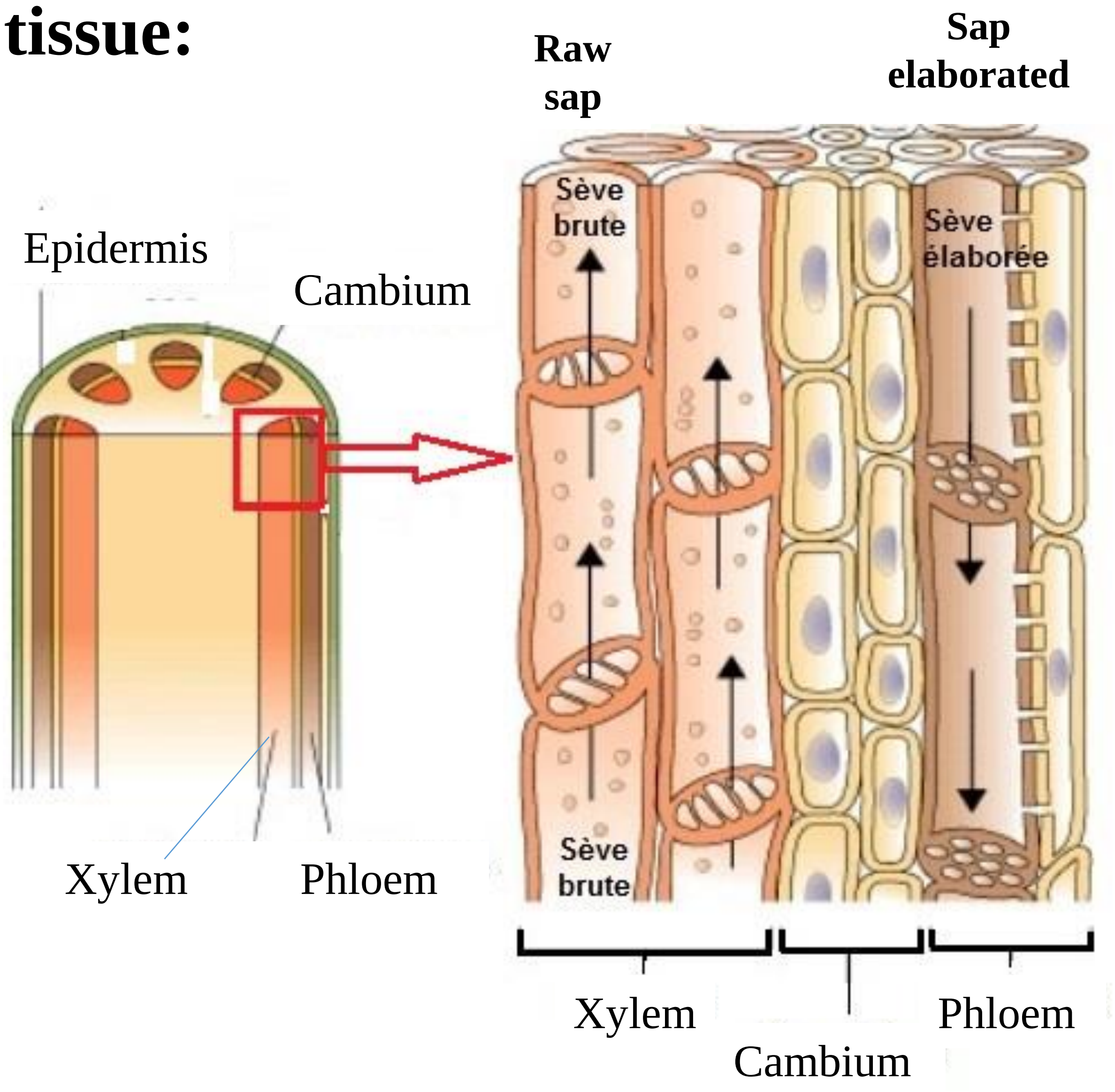
- The origin of conducting tissue :

- Xylem and phloem are conducting tissues of primary origin. They are derived from <u>primary meristems</u>.



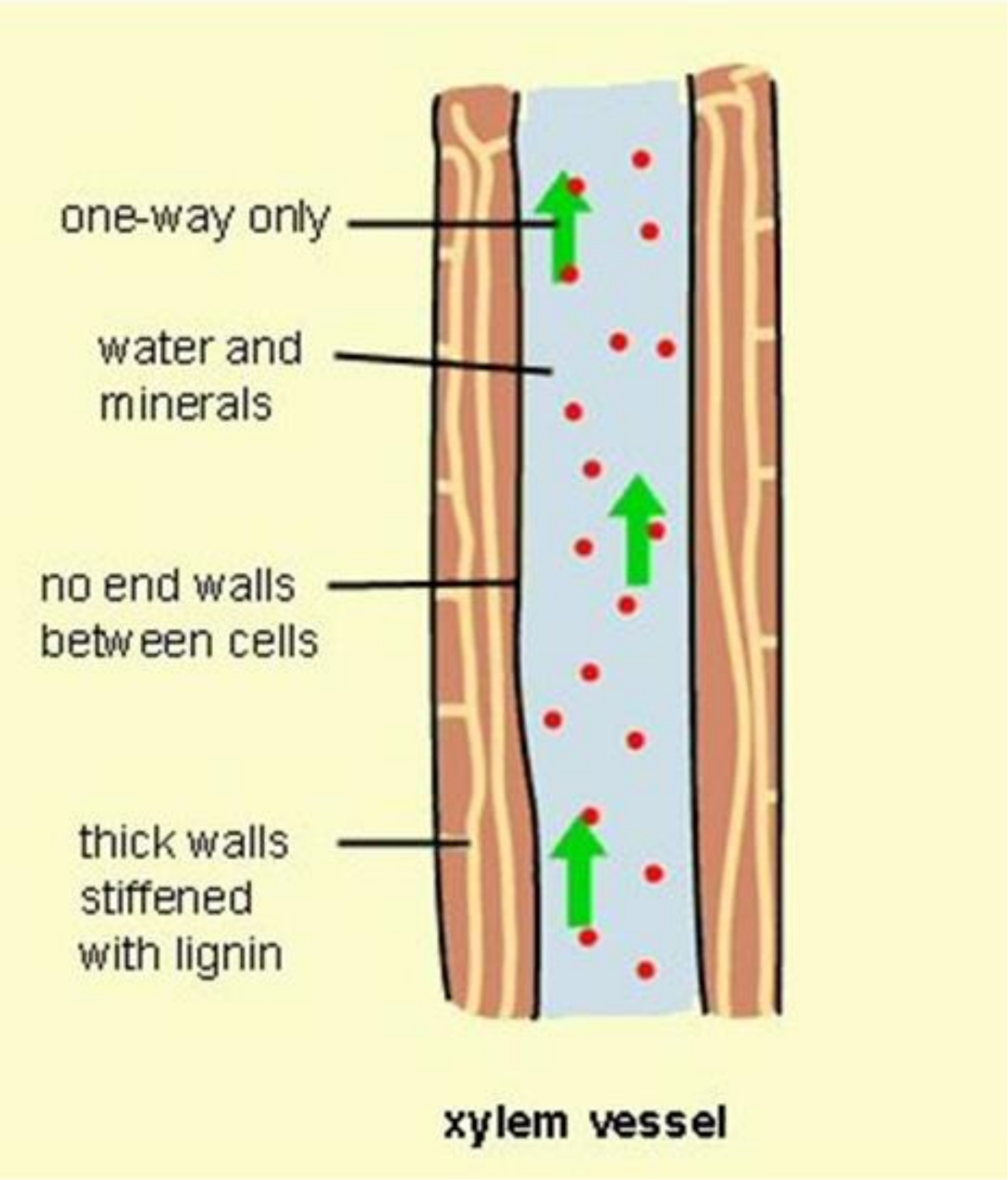
- The location of the conducting tissue:

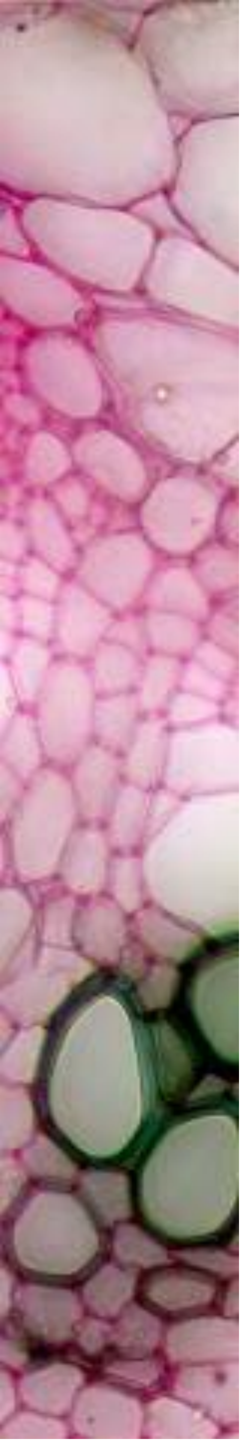
- Xylem and phloem are formed in young organs (stems, leaves and roots).
- They are located deep inside the organs in the central cylinder or pith.



C.1. Xylem

The xylem carries raw sap (water and mineral salts in the soil) from the roots to the photosynthetic organs. The xylem is composed of very extended dead cells with walls thickened by lignin deposits, interrupted in places to allow the raw sap to pass through.





- Organisation of the xylem:

The xylem is composed of conductive elements associated with non-conductive accessory elements.

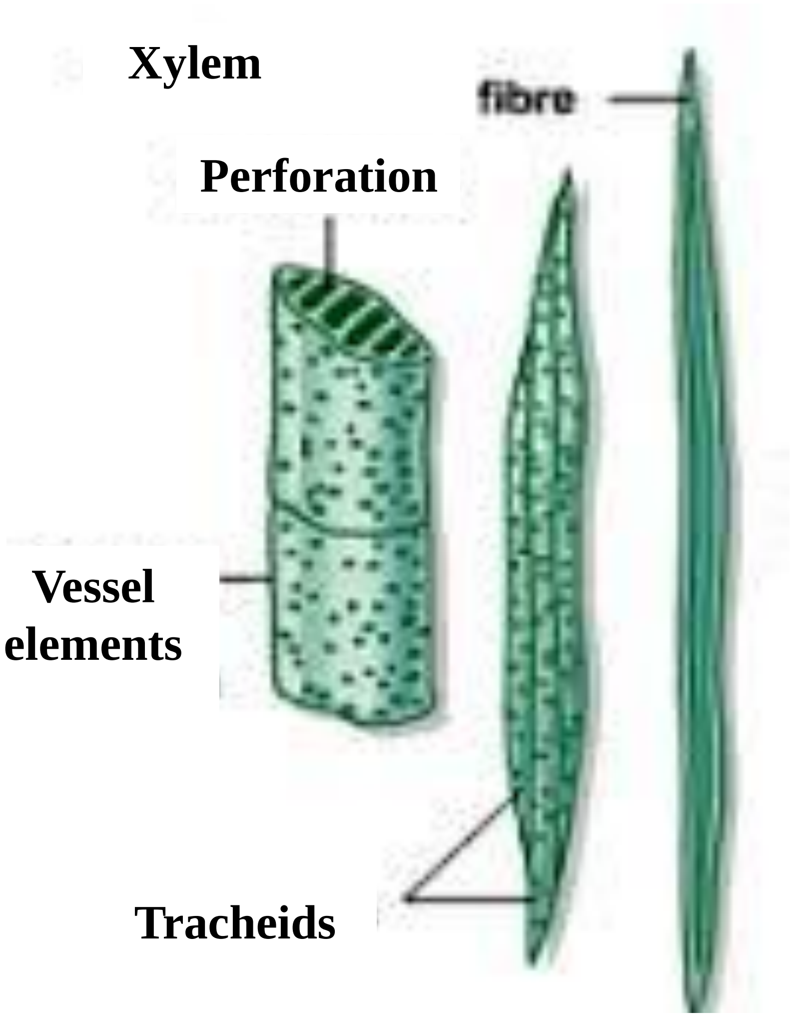
a. Conductive elements :

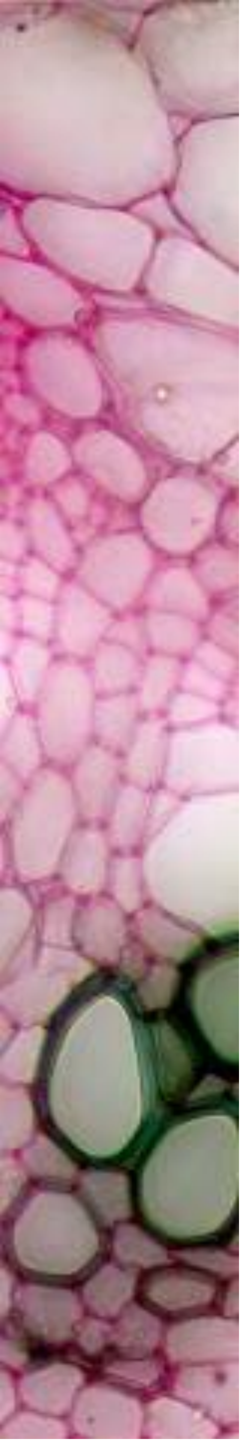
The characteristic elements are tracheids and vessels. These are dead, lignified cells that become functional after degeneration of the cytoplasm.

a. Conductive elements

a.1. Tracheids (Gymnosperms and Angiosperms)

- These are elongated, spindle-shaped cells with a thick, lignified secondary wall and no cytoplasm at the time of differentiation;
- These are dead cells. They communicate with each other (sap circulation) and with the parenchymal cells via punctata.





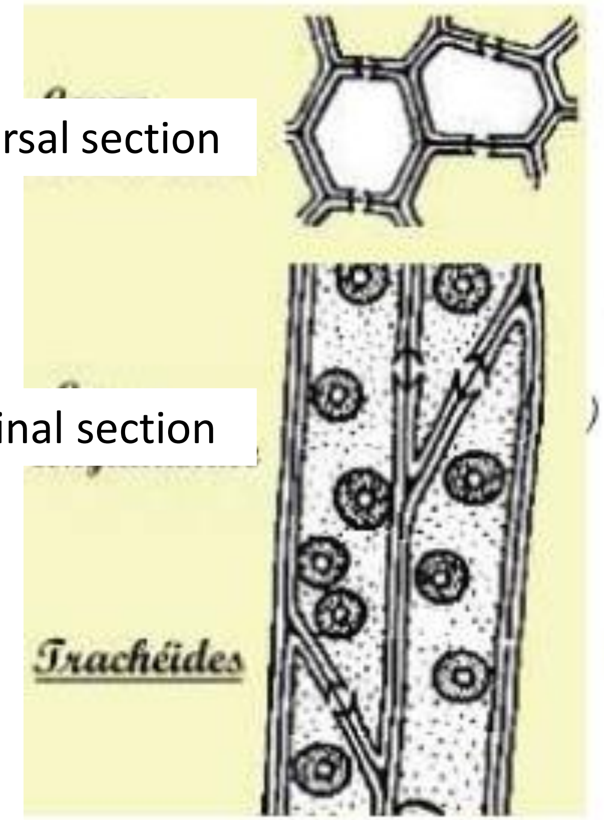
Depending on how the **lignin** is organized or shaped, a distinction is made (Fig. 5.):

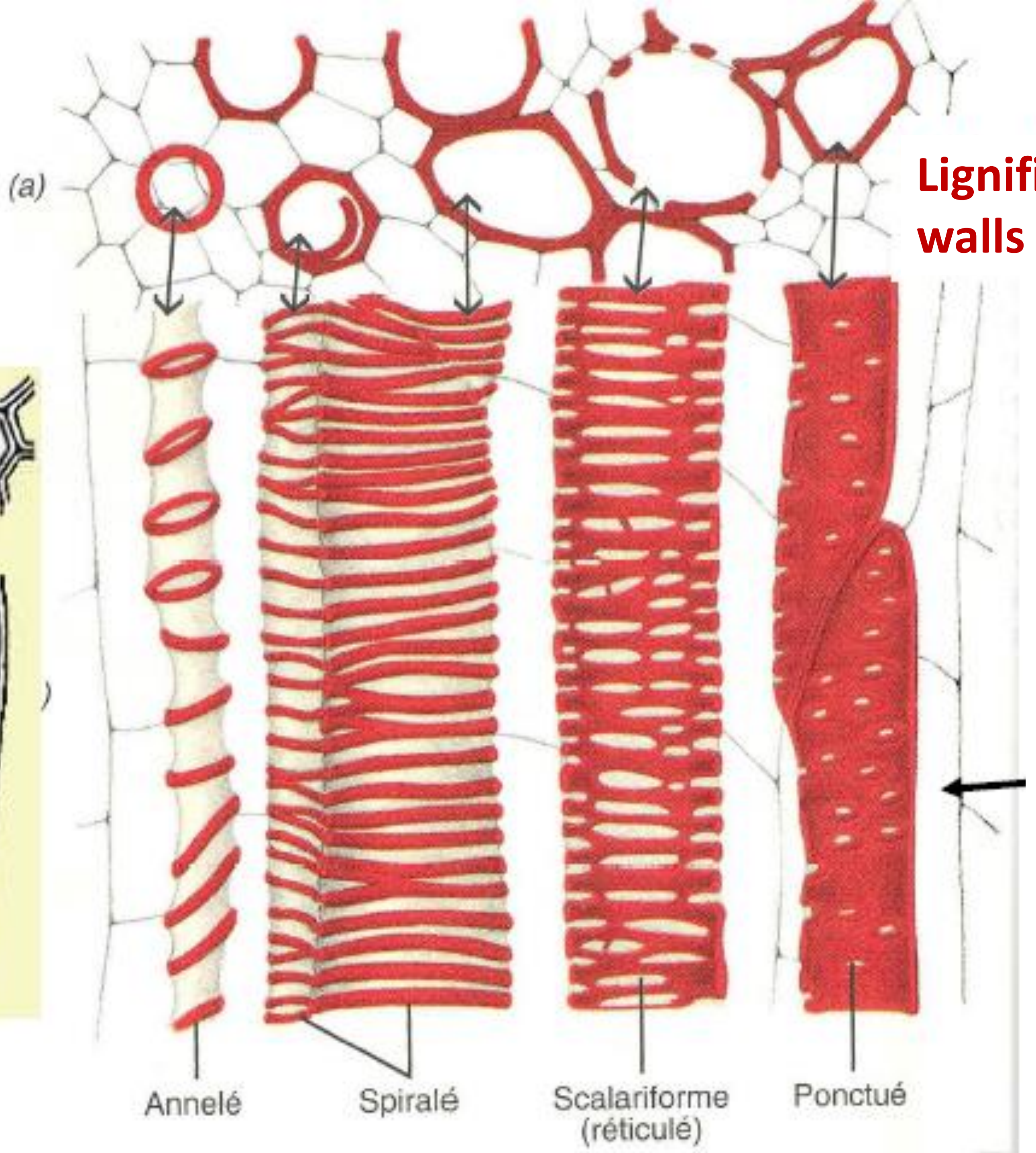
Circular and spiral tracheids: (Pteridophytes - Gymnosperms and primitive Angiosperms), these are small-calibrated elements which appear first in all young organs.

Areolated tracheids: (Gymnosperms) with areolated punctations and an entirely lignified secondary wall.

Figure 5. Longitudinal section

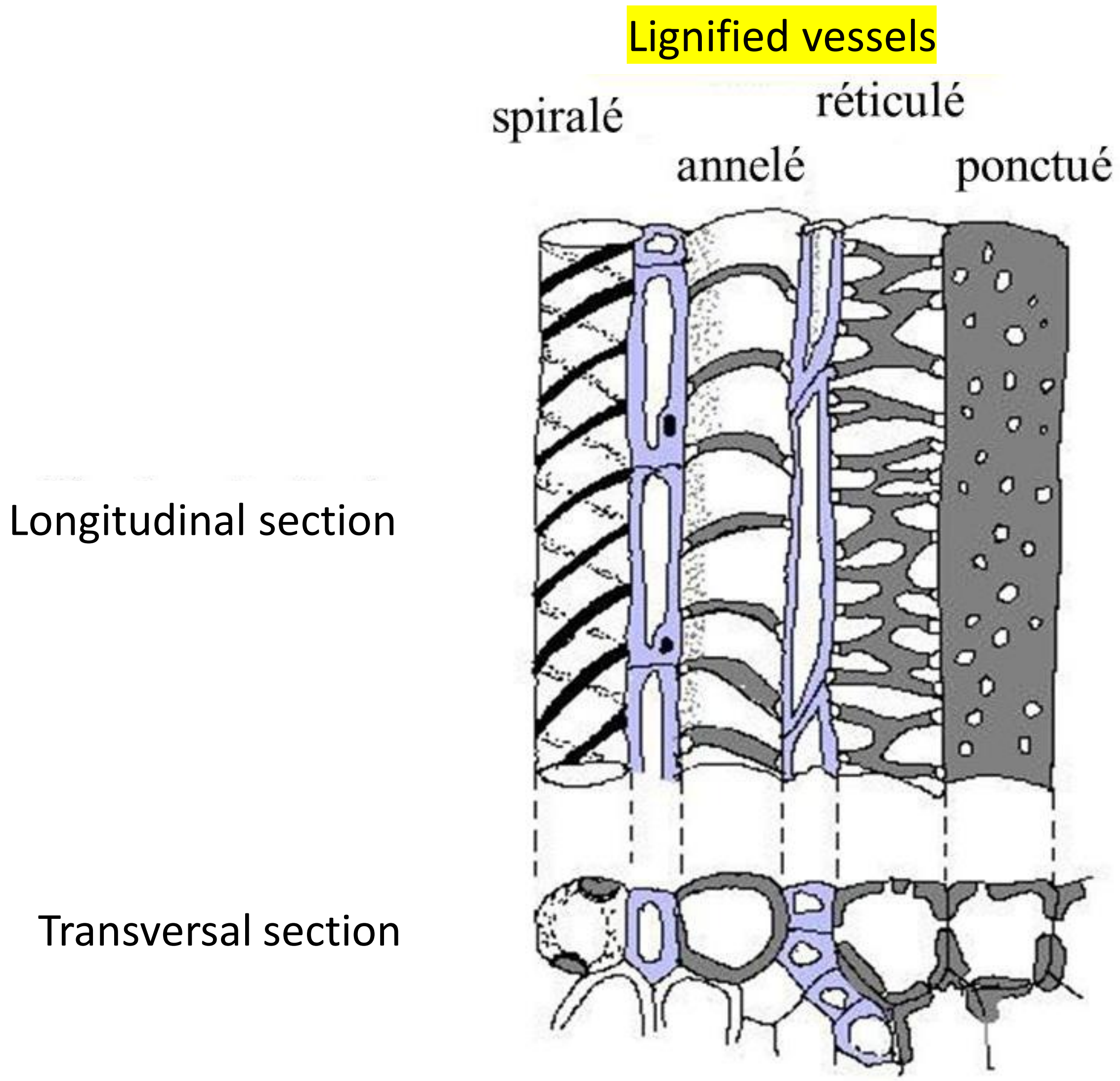
Tracheids





a.2. **Vessels** (angiosperms)

These are long tubes that start at the root tip and extend into the stems and leaves. The thick secondary wall is lignified in various ways: Circular vessels - spiral vessels - striped vessels (transverse) - reticulated vessels - punctate vessels.



b. Non conducting elements :

b.1. Parenchyma

These are living cells with a cellulose wall. These cells accompany the conducting elements of the xylem (Fig. 6.) and play a reserve and pH control role.

b.2. Fibres

These are elongated, spindle-shaped, thick-walled, lignified and therefore dead cells, which play a supporting role. They can be isolated or in clusters (Fig. 6).

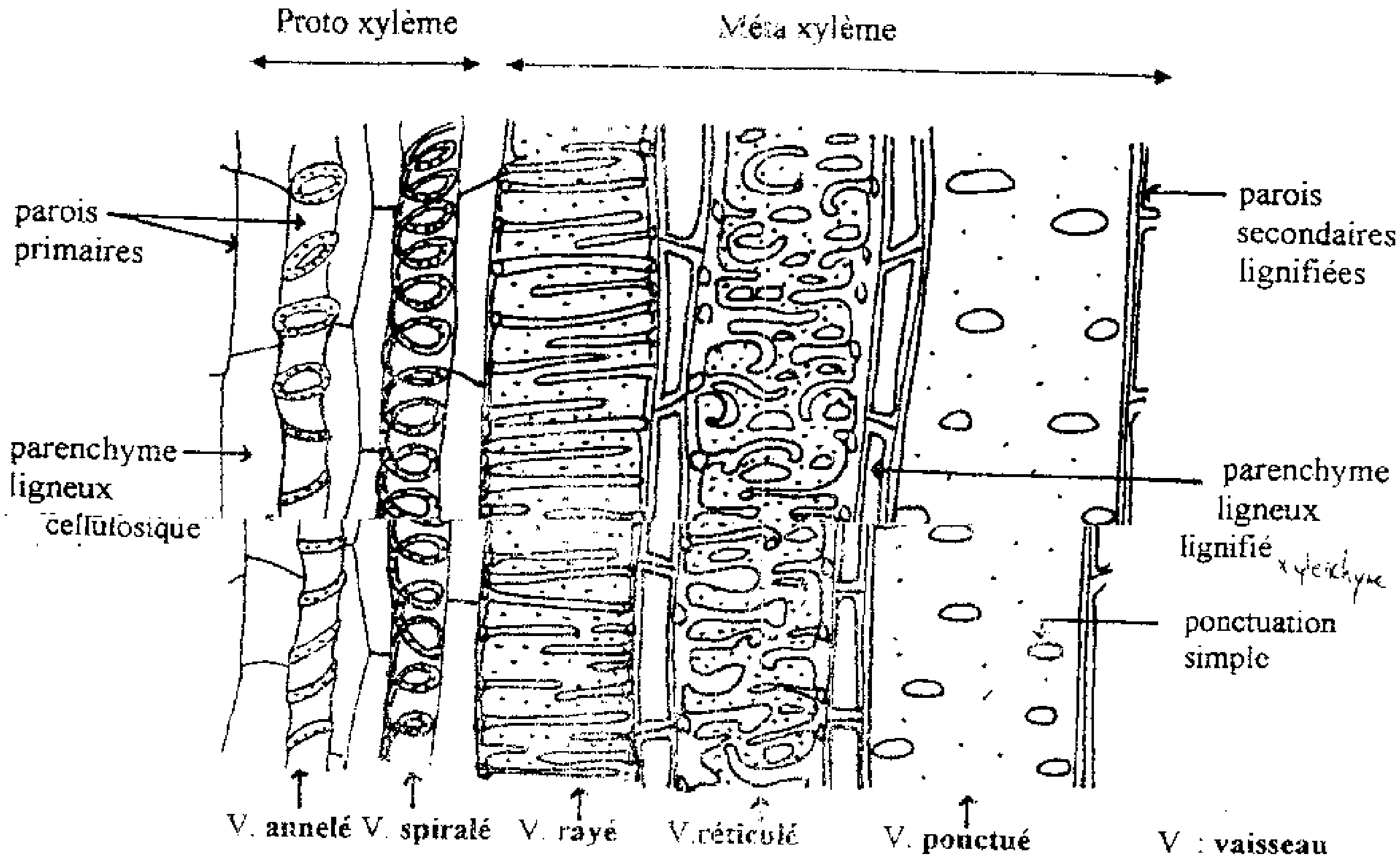


Figure 6-1. Longitudinal section of a vascular bundle in an angiosperm.

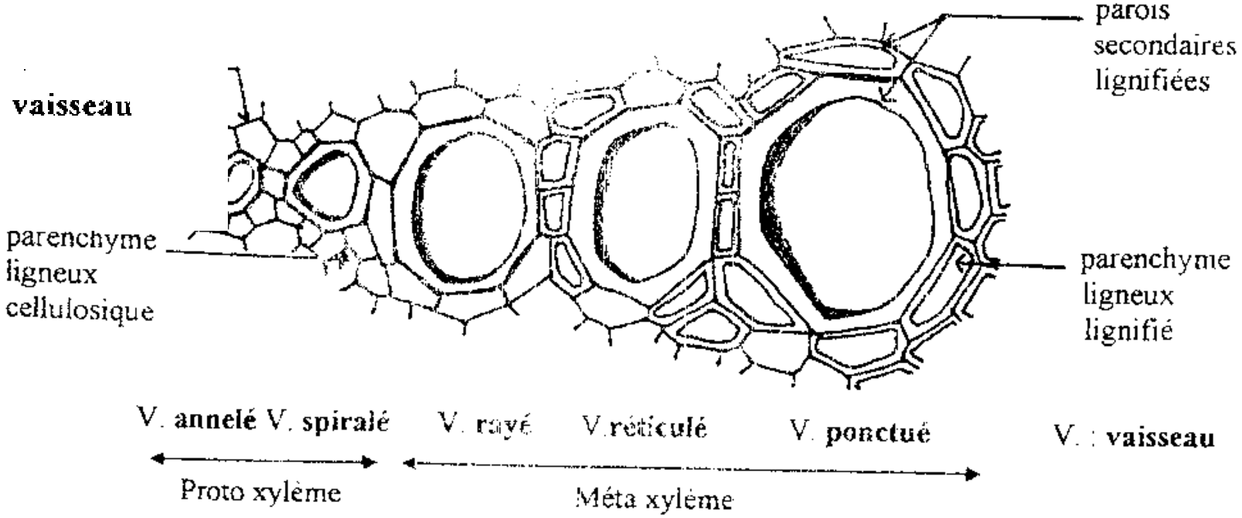
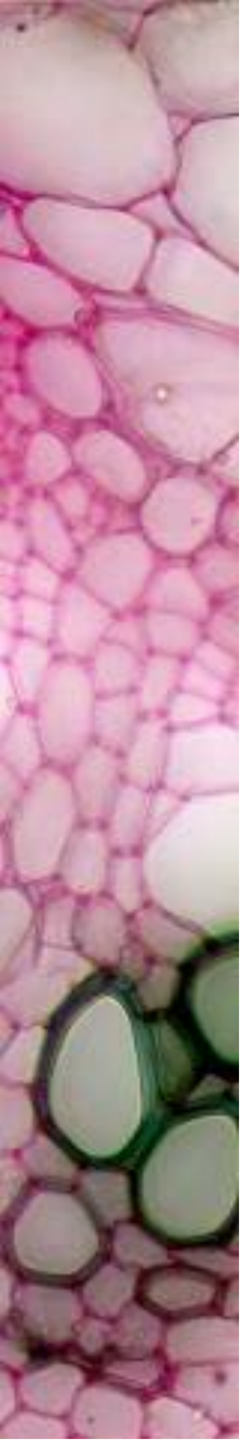
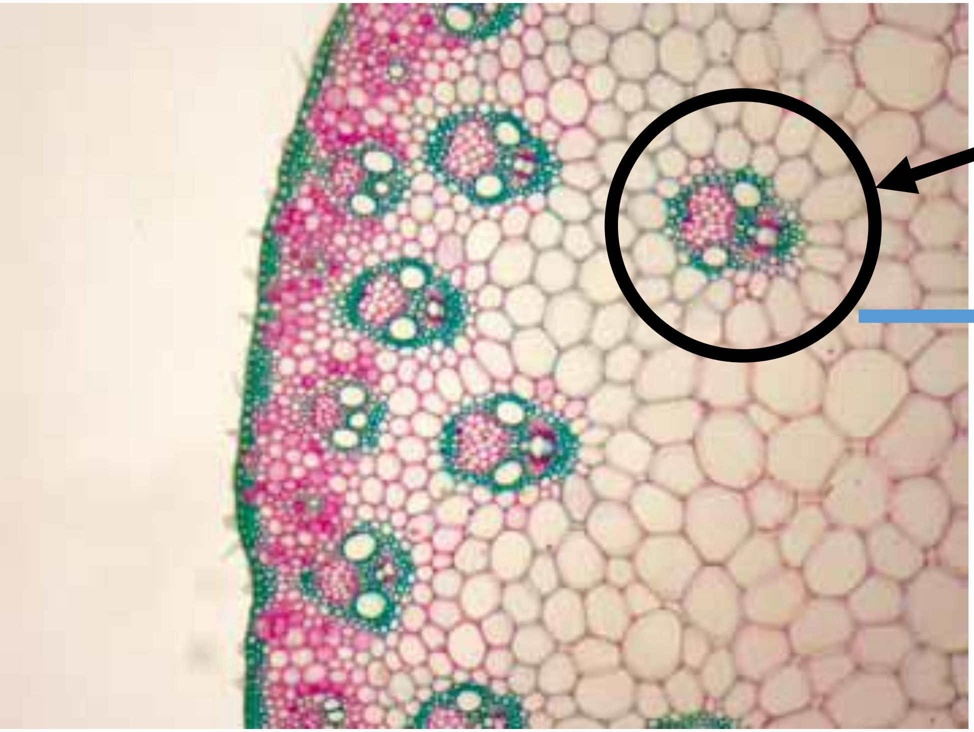


Figure 6-2. Transversal section of a vascular bundle



C.1.1. Structure of the xylem:

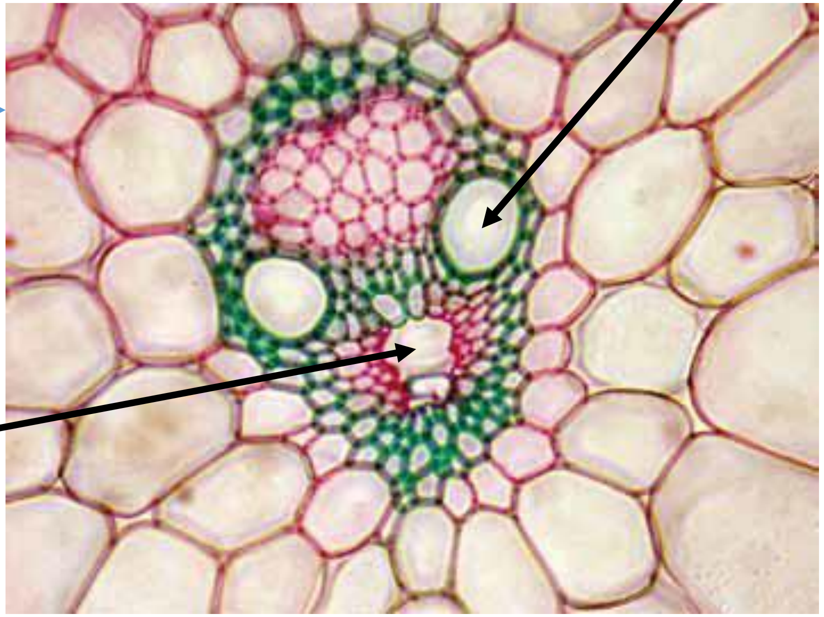
- There are two categories of conducting elements arranged in xylem bundles or vascular bundles (Fig. 7):
- **Protoxylem**: elements that first appear in young organs. These vascular elements extended as the organ grows (Fig 7-1 and 2).
- **Metaxylem**: differentiated in mature organs (Fig 7-1 and 2).



The cribro-vascular bundle

Cross-section of a Maize stem (monocot)

Metaxylem vessel



Lacuna of **protoxylem**

Figure 7-1. Enlargement of the cribro-vascular bundle

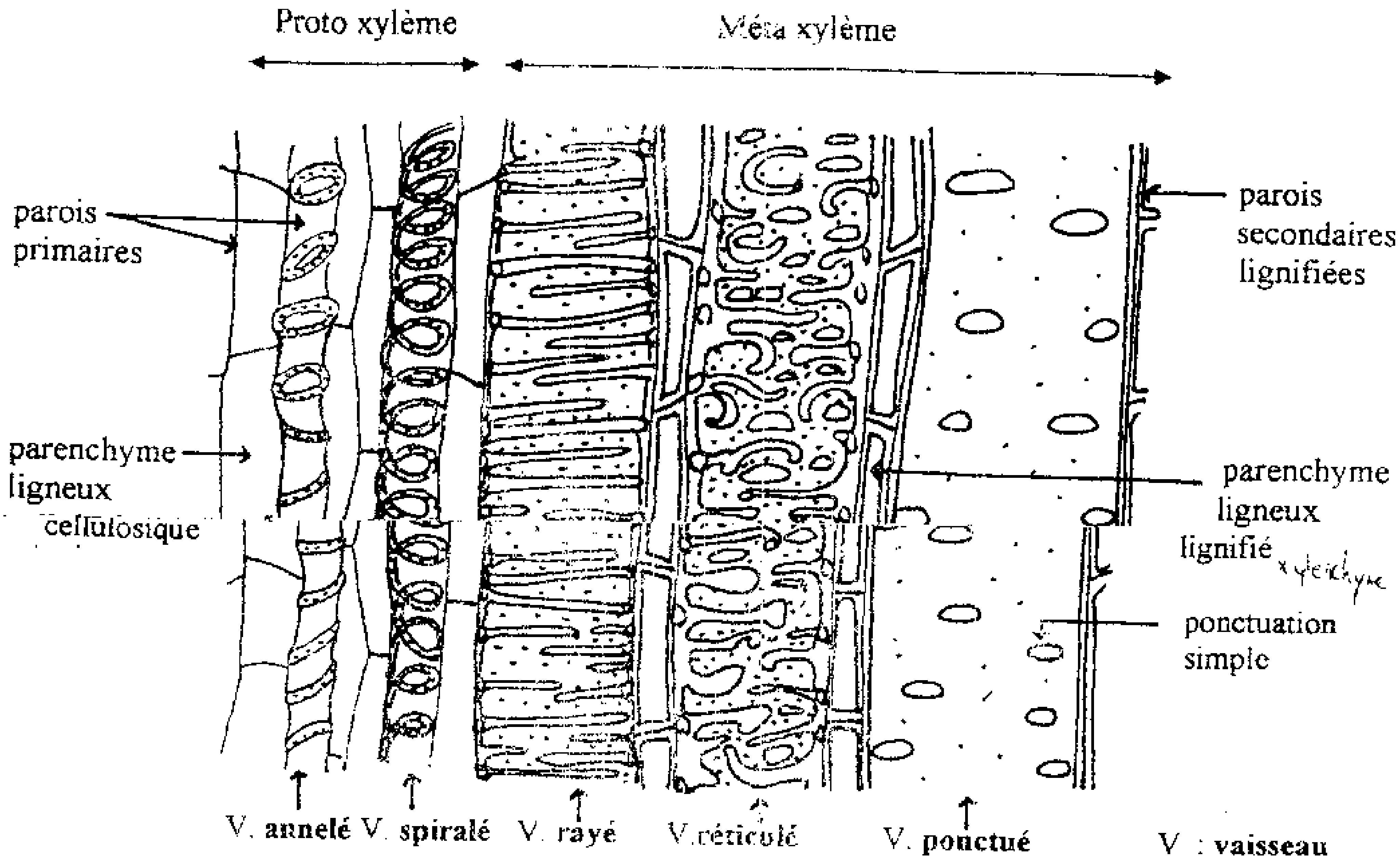


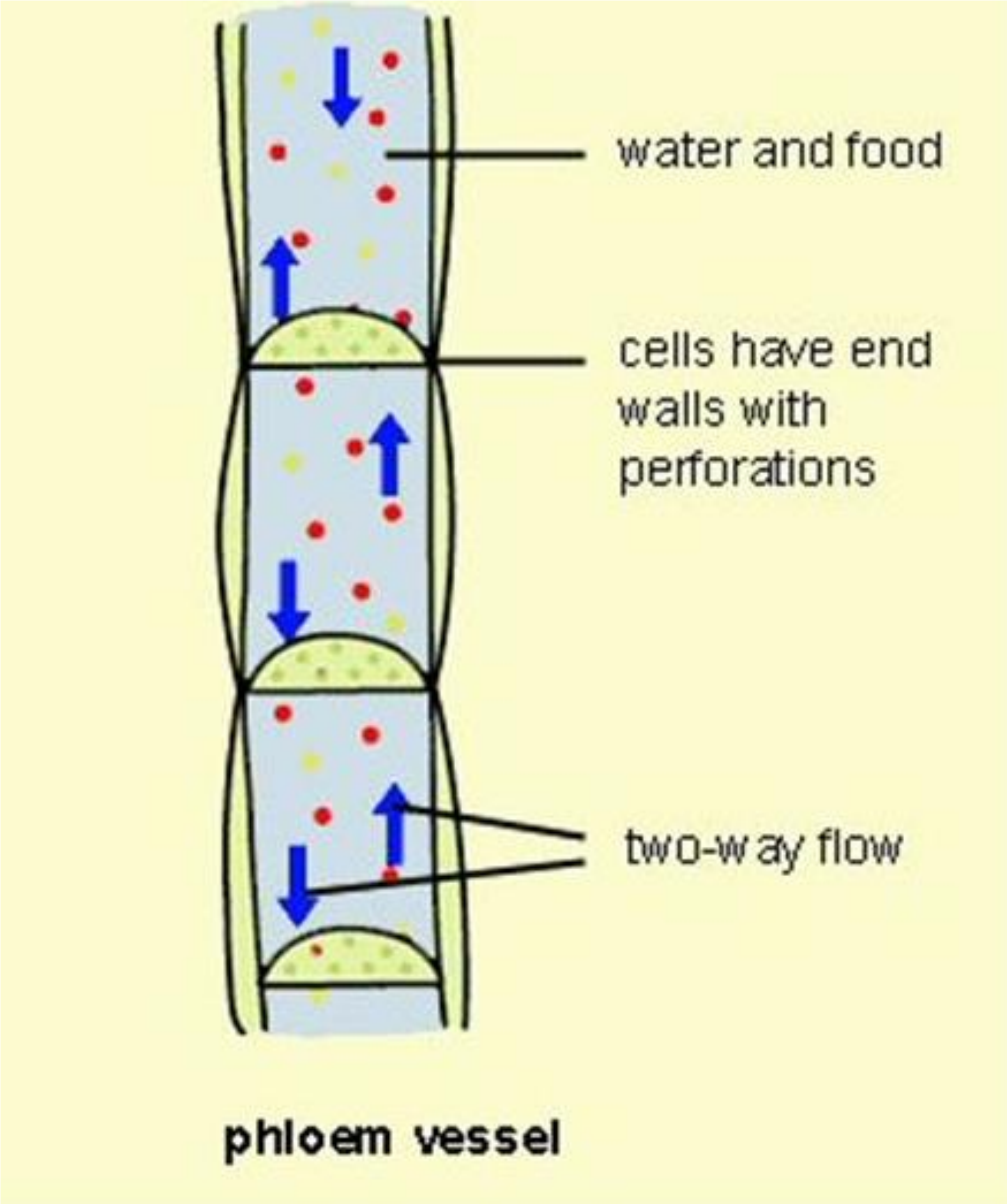
Figure 7-2. Coupe longitudinale d'un **faisceau vasculaire** d'une angiosperme

C.2. The phloem

It allows the circulation of **processed sap** (sap enriched with substances resulting from photosynthesis). This tissue is composed of sieve tubes and companion cells:

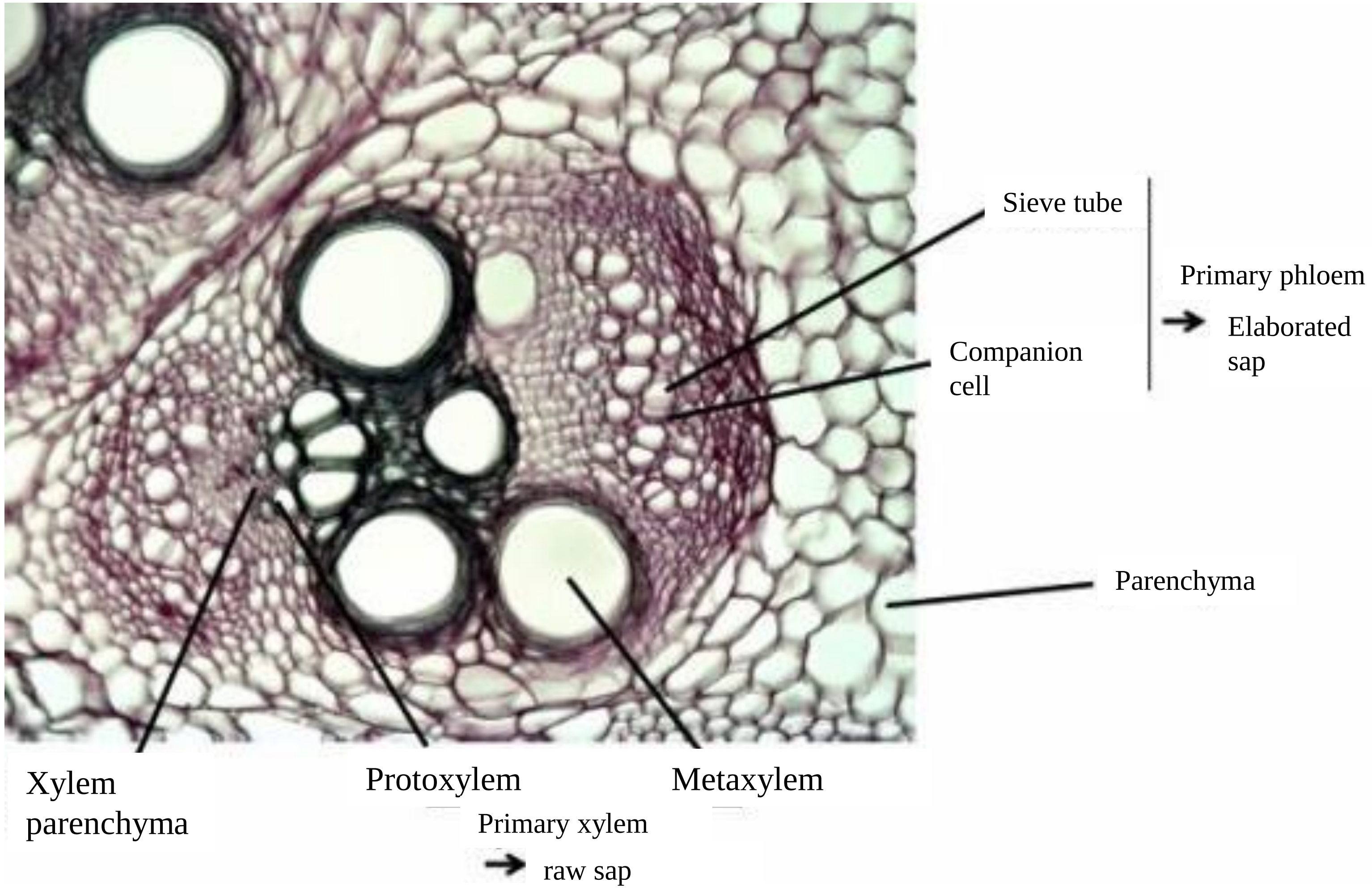
1. **The sieve tubes:** Living cells without nuclei, elongated in the longitudinal direction, arranged end to end, with thick pectocellulose walls. The transverse walls are riddled with pores, called sieves, which allow the sap to pass through.

2. **Companion cells:** Living cells with a nucleus, elongated along the sieve tube, with unscreened cellulose walls that control the circulation of sap in the sieve tubes.



C.2.1. Organisation of phloem

The phloem is composed of the conductive elements of the sap and the non-conductive elements of the sap.



a. Conductive elements :

A group of cells with a ± thick cellulose wall, arranged end to end in a longitudinal row, form a sieve tube in angiosperms (Fig. 8). The walls contain perforations or pores where the middle lamella and the wall are interrupted (plasmodesmata).

These partitions are called sieves. Next to each sieve cell is a narrow, elongated cell with a thin cellulose wall (companion cell) with a large, poorly differentiated nucleus.

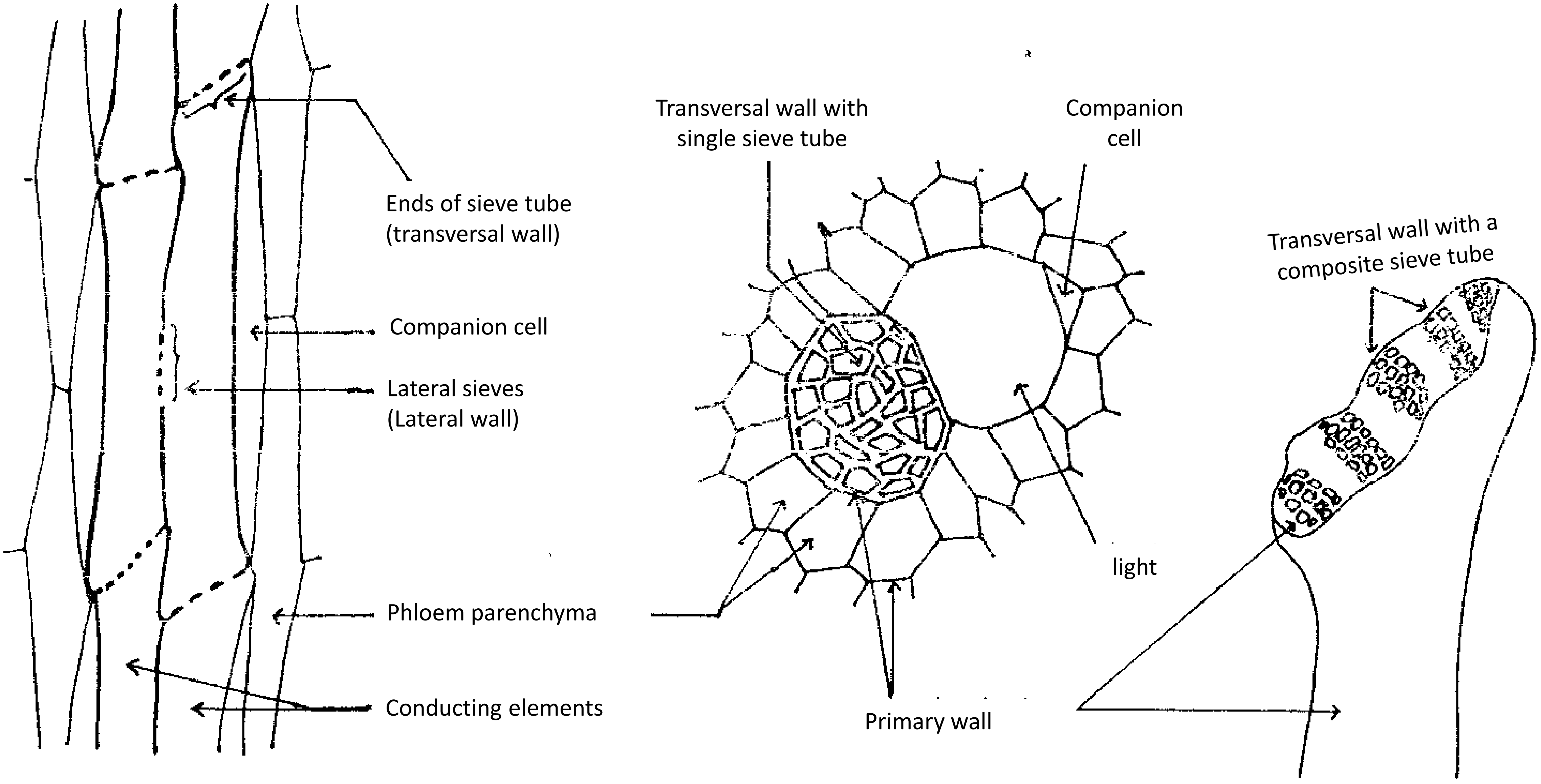
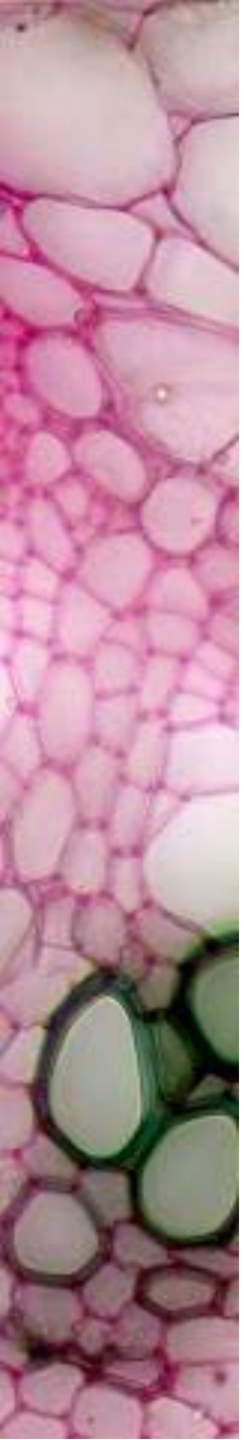


Figure 8: Phloem (sieve tube tissu) of an angiosperm



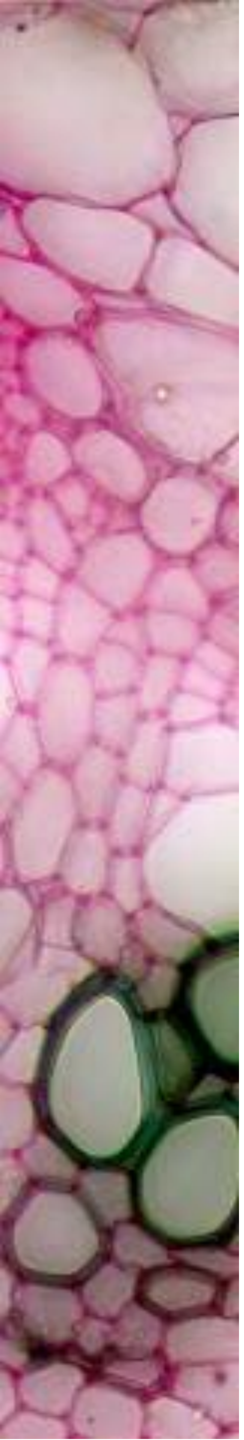
b. Non conductive elements :

1. Cellulose phloem parenchyma

Reserve function, cells with a thin cellulose wall.

2. Fibres

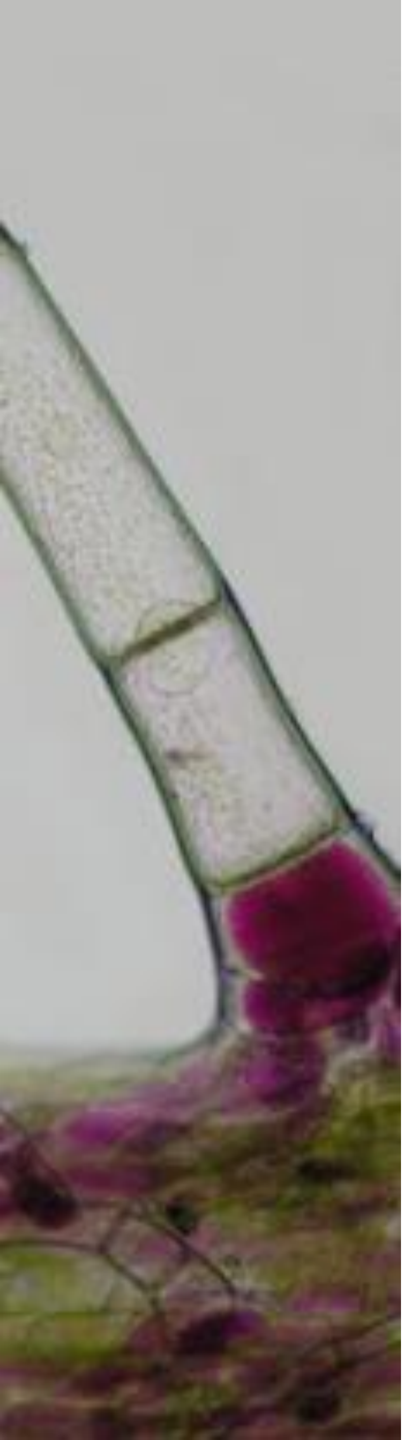
Less common, sometimes absent. Supportive role.



C.2.2. Phloem structure: The conductive elements of the phloem appear in the following order:

- **Protophloema** : First seen in young organs.
- **Metaphloema** : During organ growth or when growth is complete.

C. Secretory Tissues



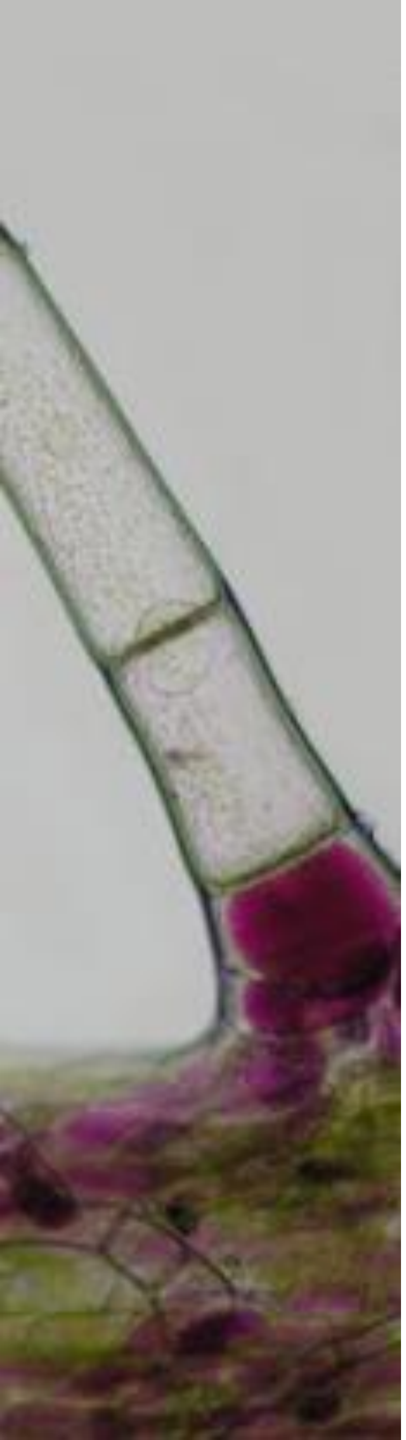
C. Secretory Tissues

These are tissues specialized in the synthesis and secretion of certain substances (petrol, latex, etc.). These substances can be excreted in the cavities of the organs, i.e. excretion of the secreted products.

Il There are two categories of secretory tissues:

1. Internal secretory tissues (e.g. secretory sacs and ducts)

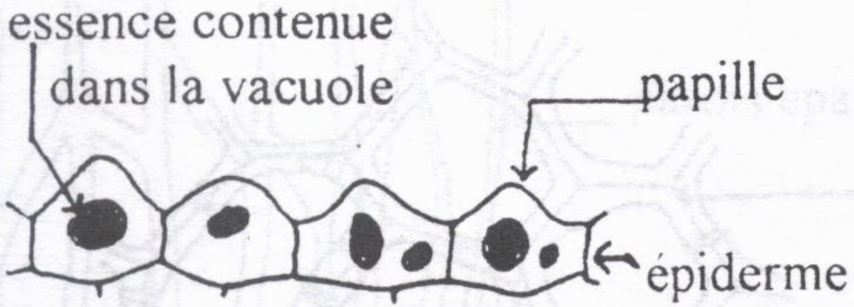
2. External secretory tissues (e.g. epidermis and secretory hairs)



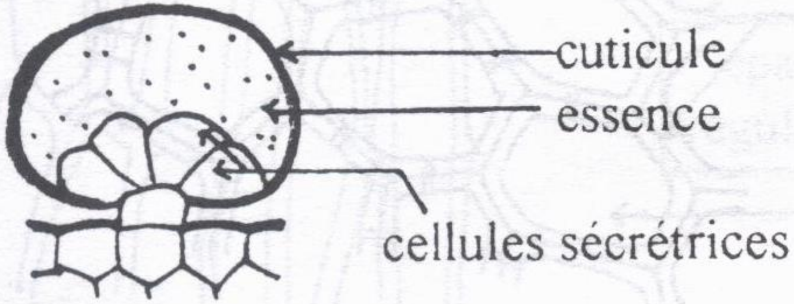
1. **External secretory tissues**

- **Epidermal cells:** produce and accumulate volatile essences, which vaporize through the cuticle and produce fragrances that may or may not be pleasant (Fig. a).

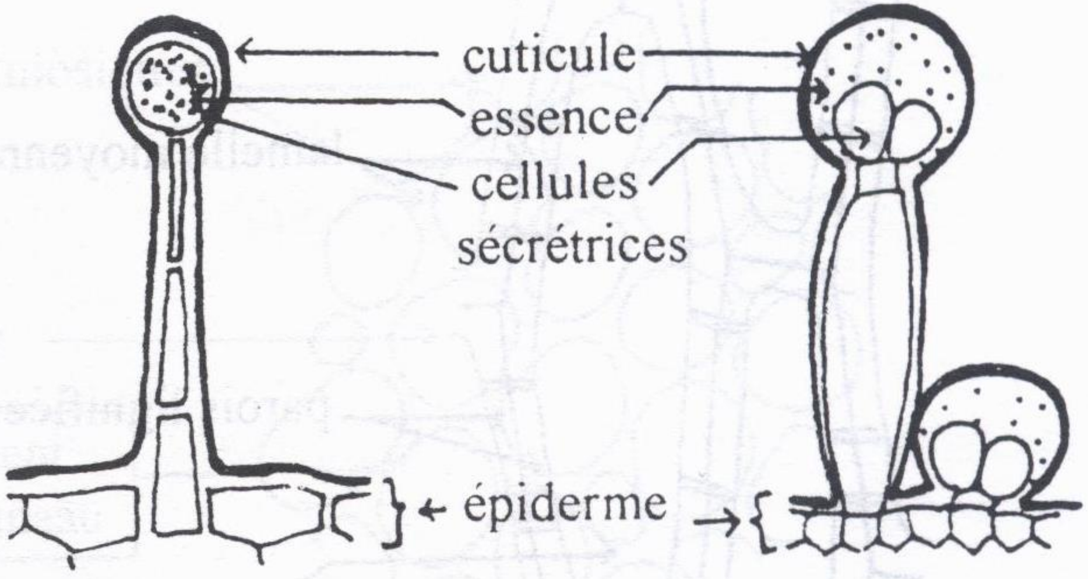
- **Epidermal hairs:** are glandular hairs (Fig. b) or secretory hairs (Fig. c): The terminal cells accumulate volatile essences between the cell wall and the cuticle. Once the cuticle is torn, the essence is released and volatilizes.



a - les **papilles** (pétale de rose)

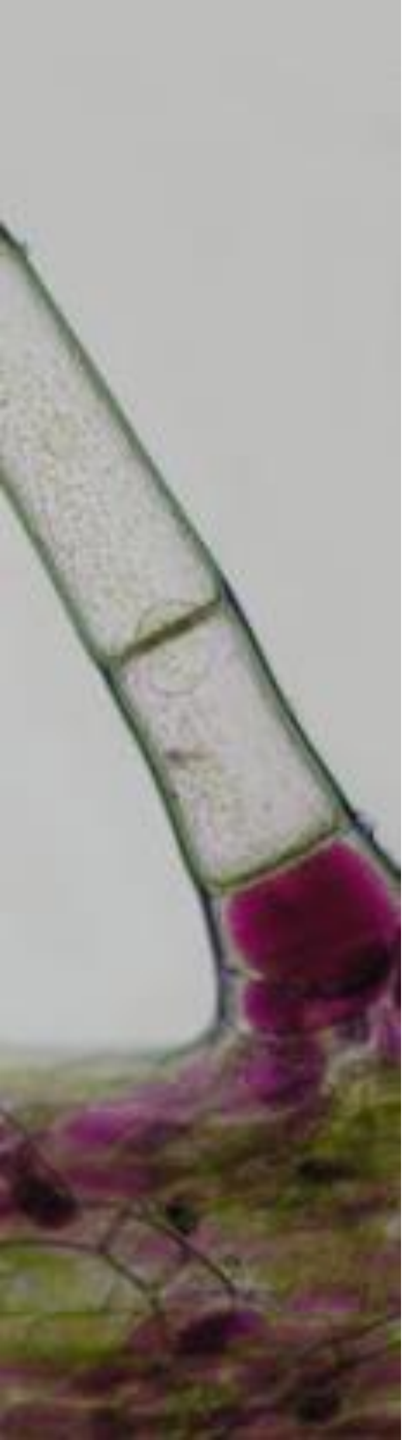


b - **poil glandulaire** (feuille de lavande)



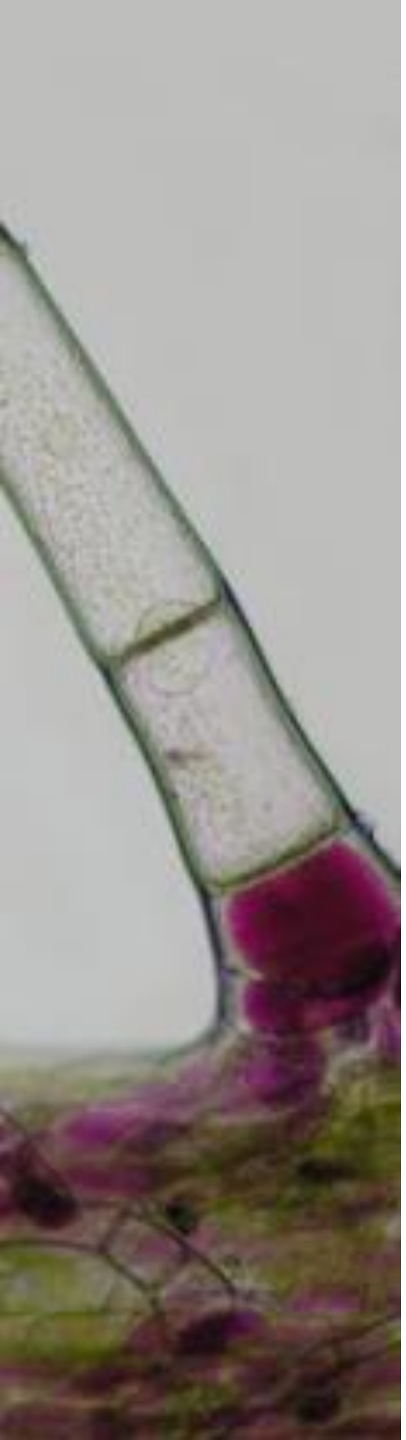
c - **poils épidermiques sécréteurs** (feuille de géranium et feuille de ballote)

Figure 1: éléments sécréteurs de l'épiderme en coupe transversale.



2. Internal secretory tissues

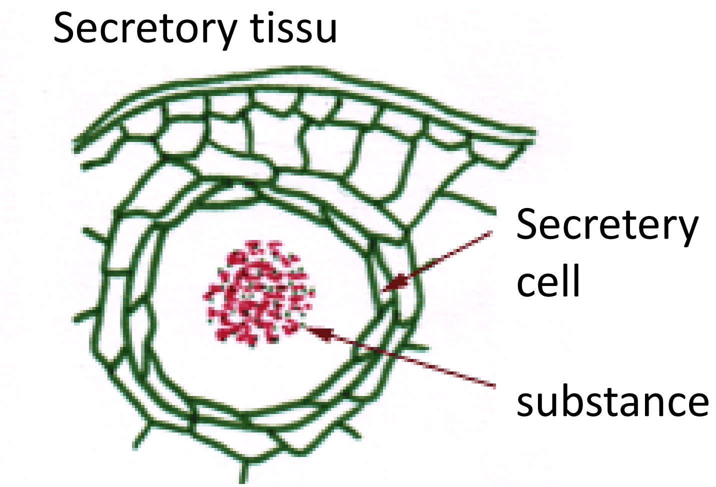
- **Isolated secretory cells:** Cells isolated within the parenchyma that accumulate the synthesized products (in the vacuole). Ex: tannin cells
- **Secretory ducts:** Elongated tubes delimiting a duct bounded by two layers of cells.



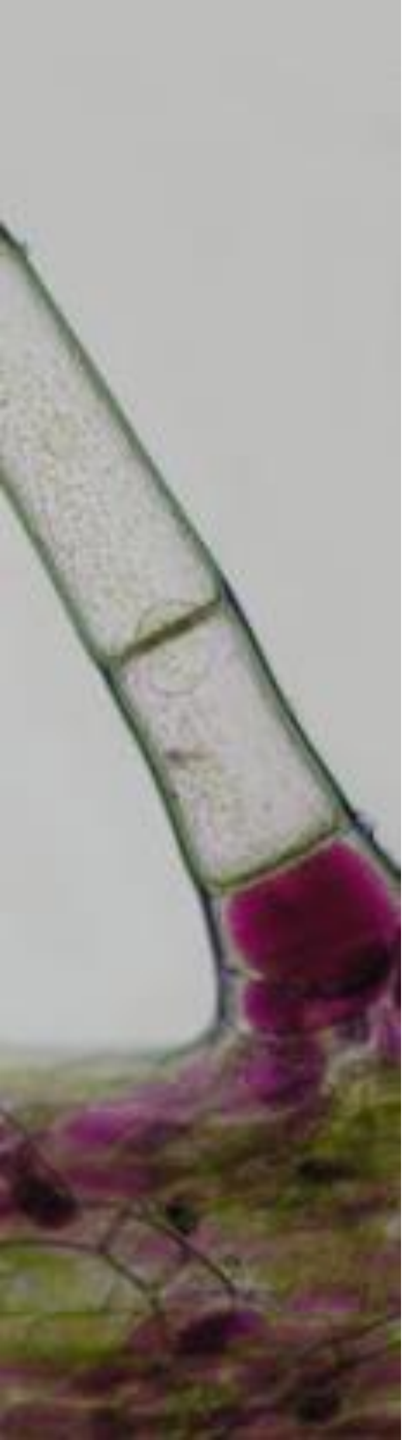
- Secretory pockets:

Pockets lined with cells that secrete their products.

Ex: Citrus pericarp and pine leaf and stem resins.



Secretory tissu in citrus (fruit)



- Laticifers :

These are elongated elements, branched or not, containing a liquid that is generally white, like milk = latex. Latex is a viscous liquid, sometimes coloured. It contains water, glucose, organic acids, mineral salts, alkaloids, tannins, mucilage, enzymes, terpenes and starch. Example: rubber (terpenes). Depending on how they are formed, there are two categories of laticifers: true laticifers and articulated laticifers.