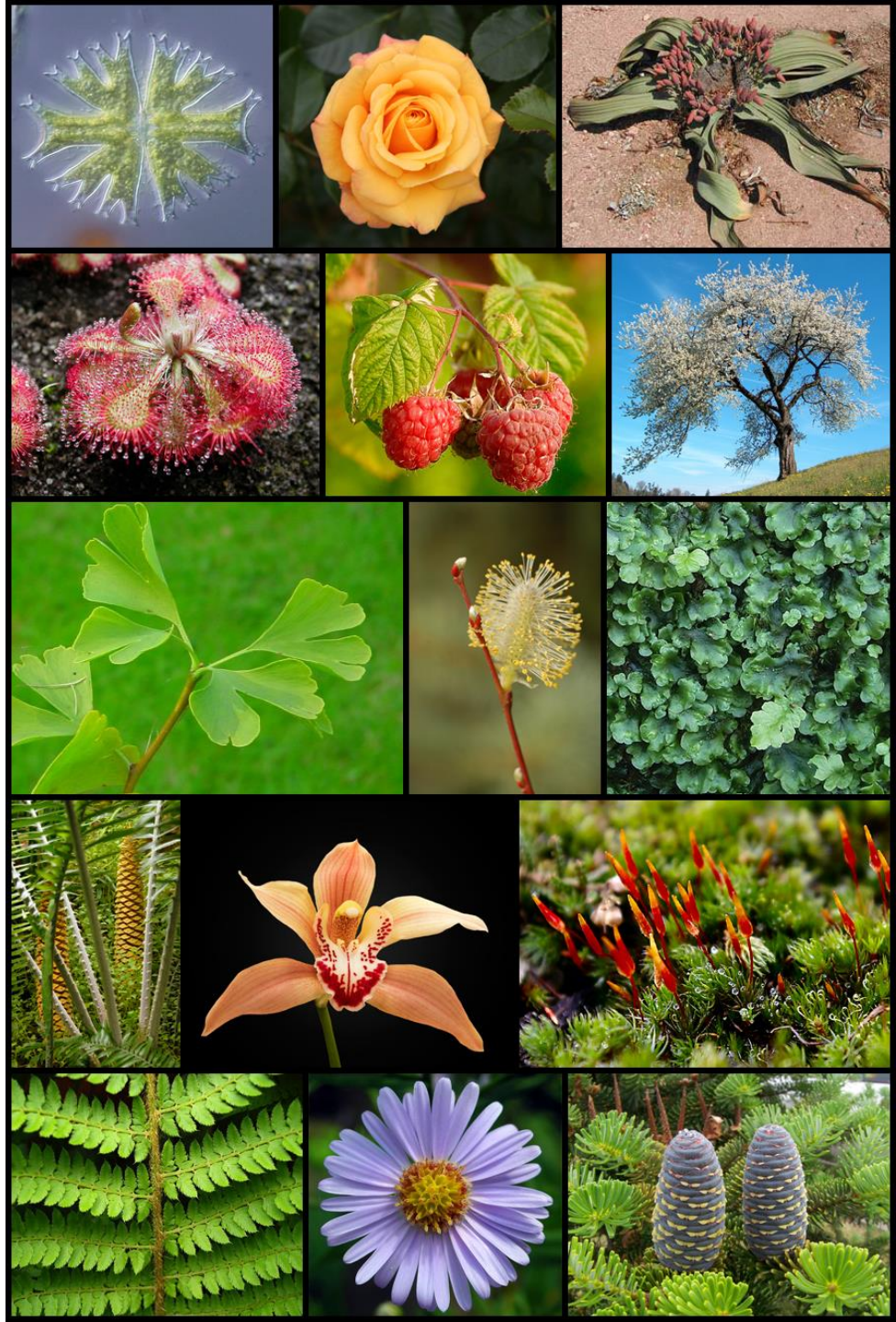
The anatomy of higher plants



Plan

I. Reminder

II. Anatomical study of the plant organs of angiosperms (monocotyledons and dicotyledons) and gymnosperms :

1. Roots

2. Stem

3. Leaves

III. A comparative study of the anatomy of dicotyledonous and monocotyledonous angiosperms





Reminder : Classification of plants

- PLANTS
  - Embryophytes
  - Pteridophytes
  - **SPERMAPHYTES**
    - GYMNOSPERMS (Naked seeds)
    - ANGIOSPERMS (Covered seeds)
      - Monocotyledons (Monocots) (1 cotyledon/seed)
      - Dicotyledons (Dicots) (2 cotyledons/seed)

Reminder : Primary and secondary anatomical structure

1. Primary anatomical structure :

The primary structure of a plant organ (stem, root and leaf) is the arrangement of all the primary tissues originating from the primary root and/or stem meristems.

2. Secondary anatomical structure :

Secondary tissues result from the functioning of the secondary meristems (cambium and phellogen) and give the secondary anatomical structure.

Reminder : Primary and secondary anatomical structures

Primary anatomical structure	Secondary anatomical structure
<u>This structure characterize:</u> - **Young** and **old** organs of monocotyledonous angiosperms; - Some herbaceous dicotyledons; - Young organs of many: Dicotyledonous angiosperms and Gymnosperms.	<u>This structure characterize</u> : - The **older organs** of many: Dicotyledonous Angiosperms and all Gymnosperms.

II. Anatomical study of the plant organs of angiosperms (monocotyledons and dicotyledons) and gymnosperms :

1. ROOTS

1.1. Angiosperms-Monocots

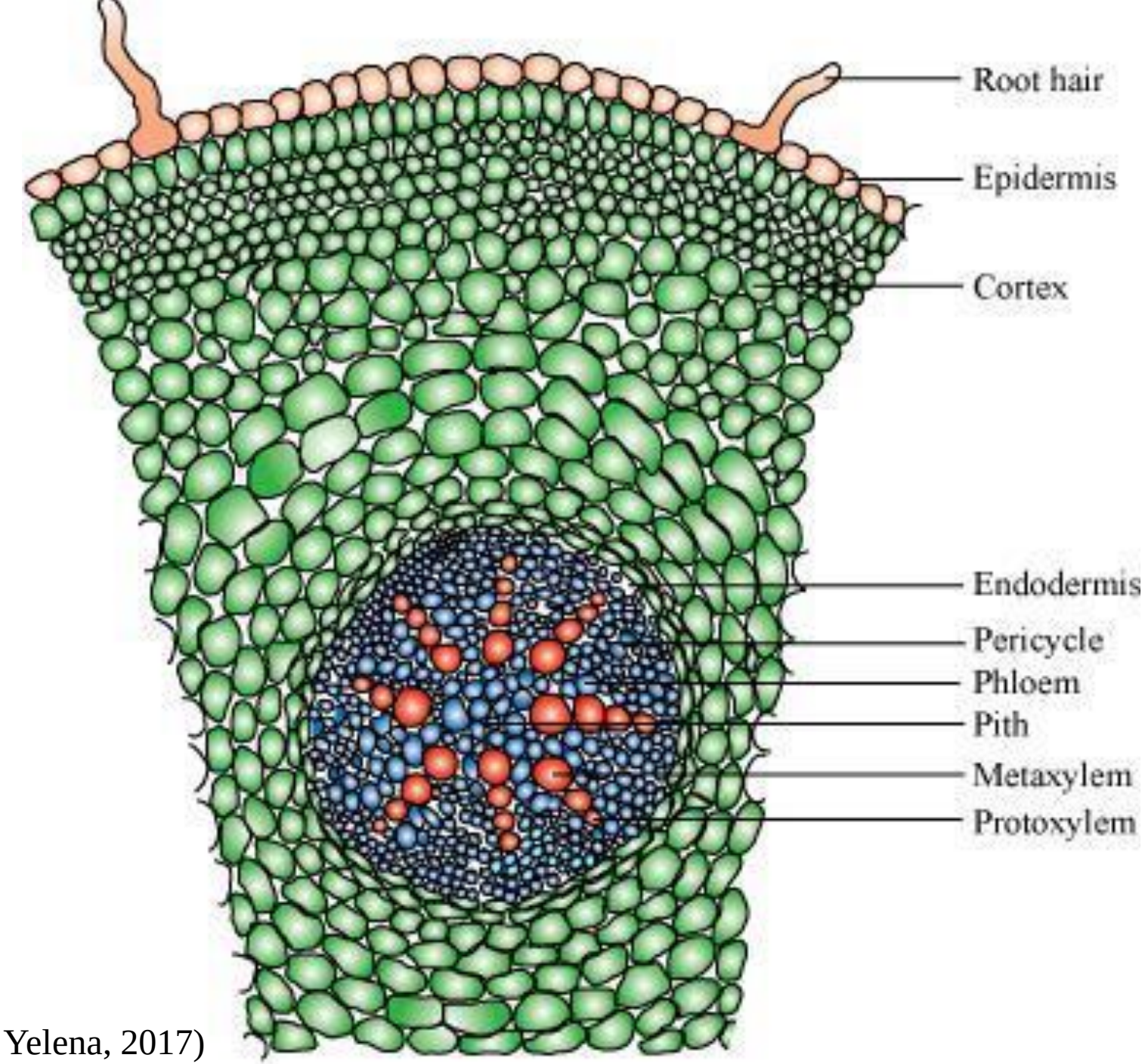
a. Primary anatomical structure

The anatomical study is carried out on a cross section (Fig. 1) of a young or old root.

The roots of monocots include :

a.1. the cortex : This consists of the following tissues: roost hairs base - subereous base (or suberoid) - cortical parenchyma and endodermis.

a.2. Central cylinder (or stele): The tissues observed are: the pericycle - the primary vascular tissues (xylem and phloem) and the pith.



Monocot root *(*Melikyan Yelena, 2017)

b. Anatomical structure secondary

In the **monocotyledonous** plants, there is no secondary formation.

I.2. Angiosperms-Dicotyledons

a. Primary anatomic structure

The anatomical study was carried out on a cross section of a young root (Fig. 2.). The symmetry is axial and the **cortex** is thicker than the **central cylinder**:

a.1. cortex: The tissues observed from the outside to the inside of the cortex are piliferous base - suberous base - cortical parenchyma - endodermis

a.2. Central cylinder: The tissues observed from the outside of the central cylinder inwards are : pericycle - primary conducting tissues - medulla.

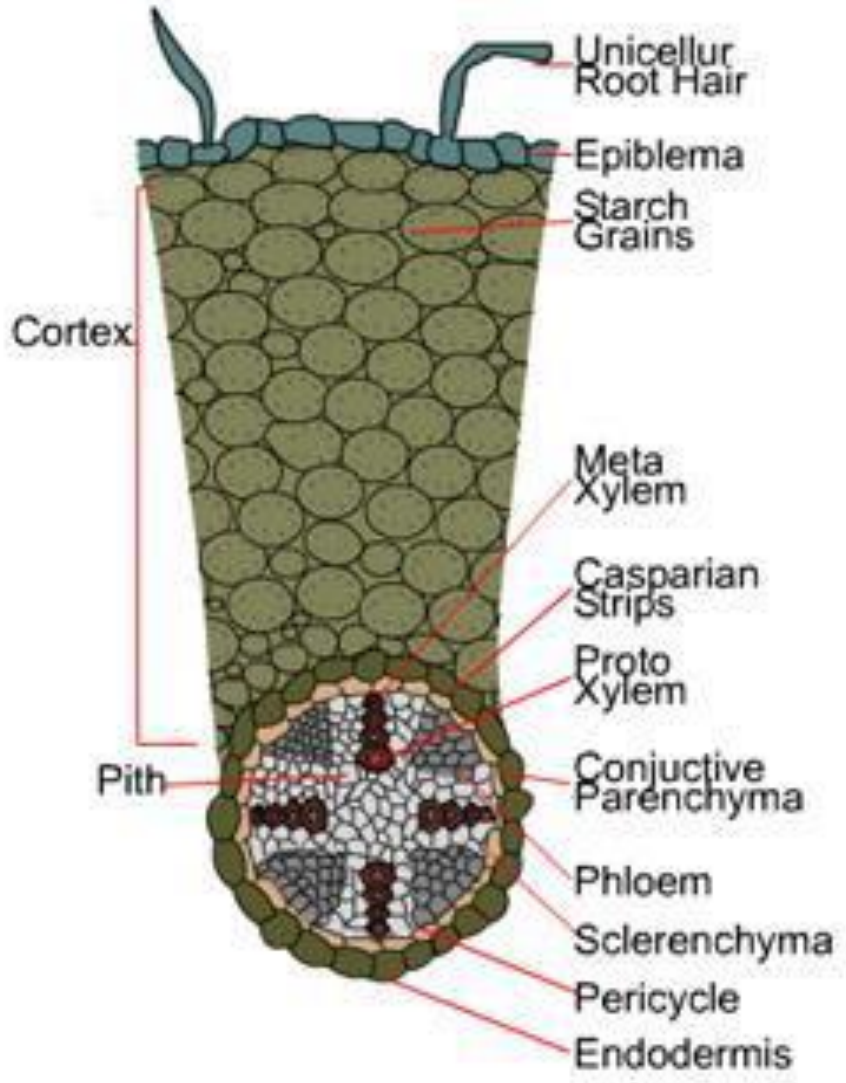


Fig. 2. Cross section of a root of a dicotyledonous angiosperm. Primary structure

b. Secondary anatomic structure

Two types of secondary formation can be seen in an anatomical study of a cross section of an aged root (Fig. 3): pachyte and periderm.

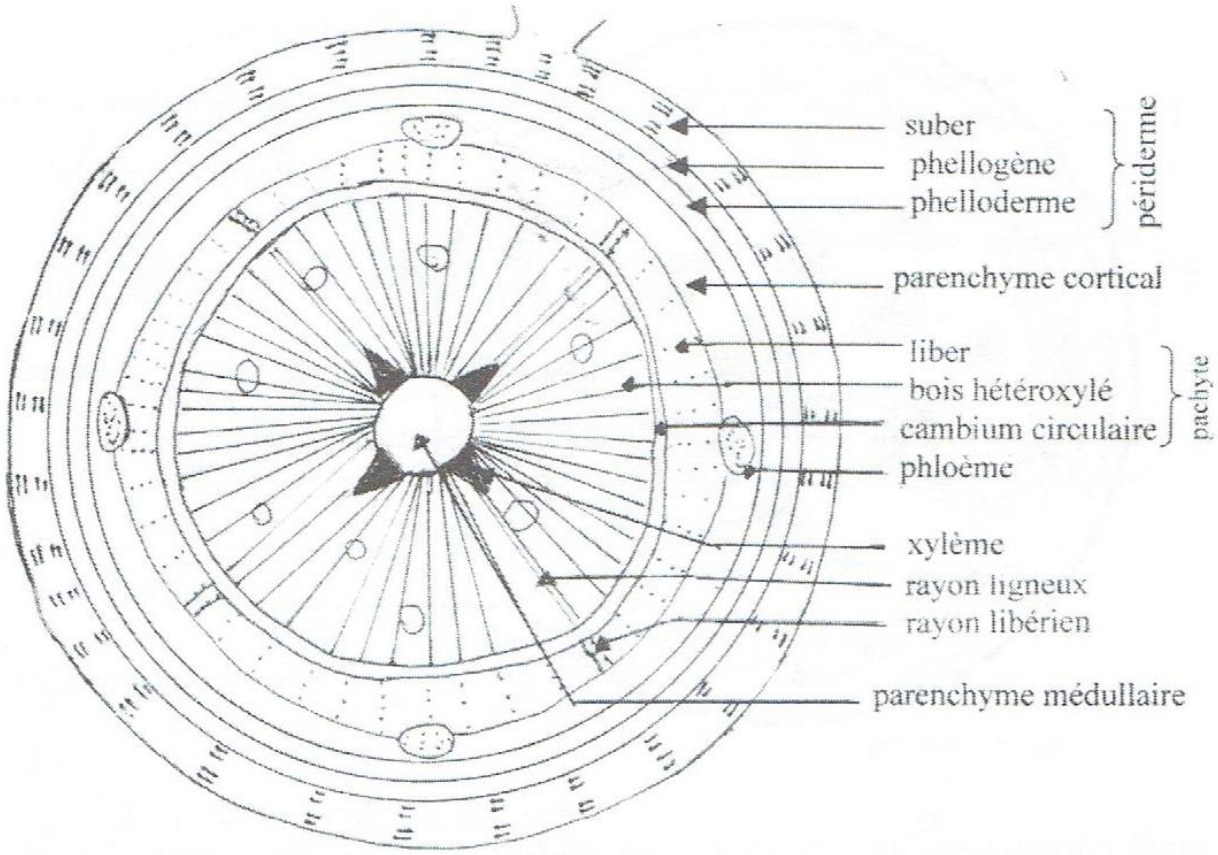


Fig. 3. Cross-section of an aged root of a dicotyledonous angiosperm.

b.1. Pachyte: Located in the central cylinder, it is composed of :

- A **bundle** (xylem and phloem, which alternate);

- A **cambium**, which appears on the inside of the phloem after transformation of the procambium;

- **Wood** and **bast** are derived from the already formed cambium.

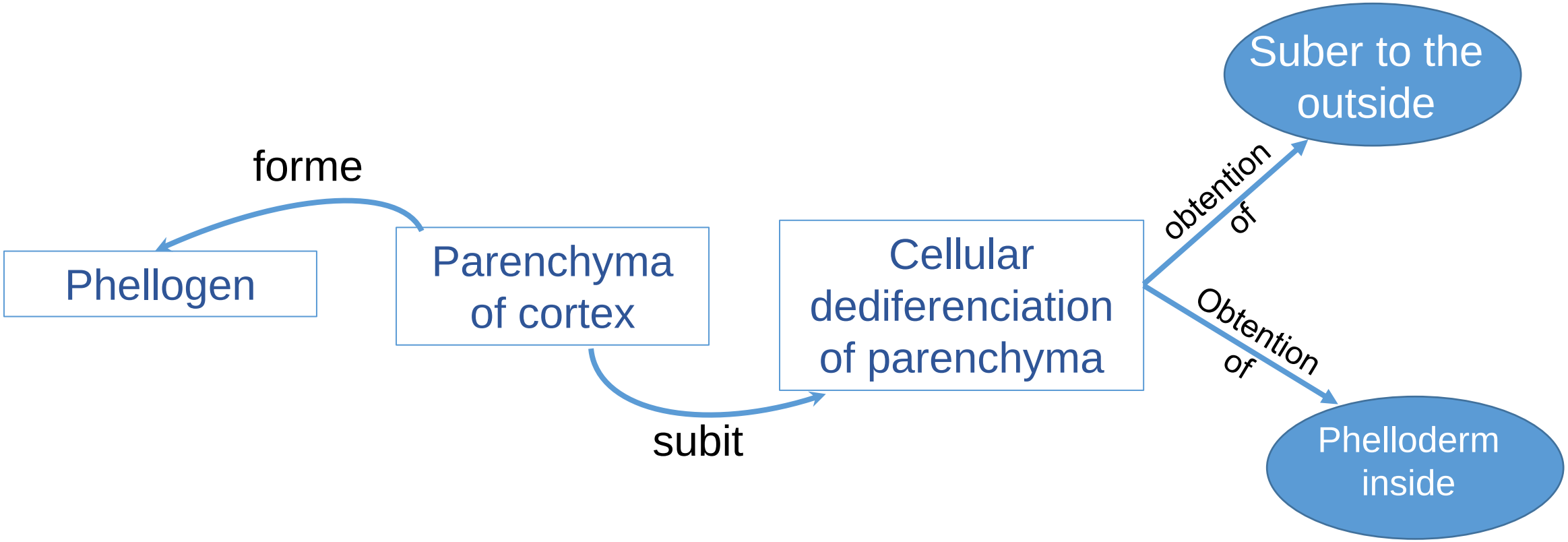
b.2. Periderm: Found in the bark, it is composed of :

-Phellogen (secondary meristem);

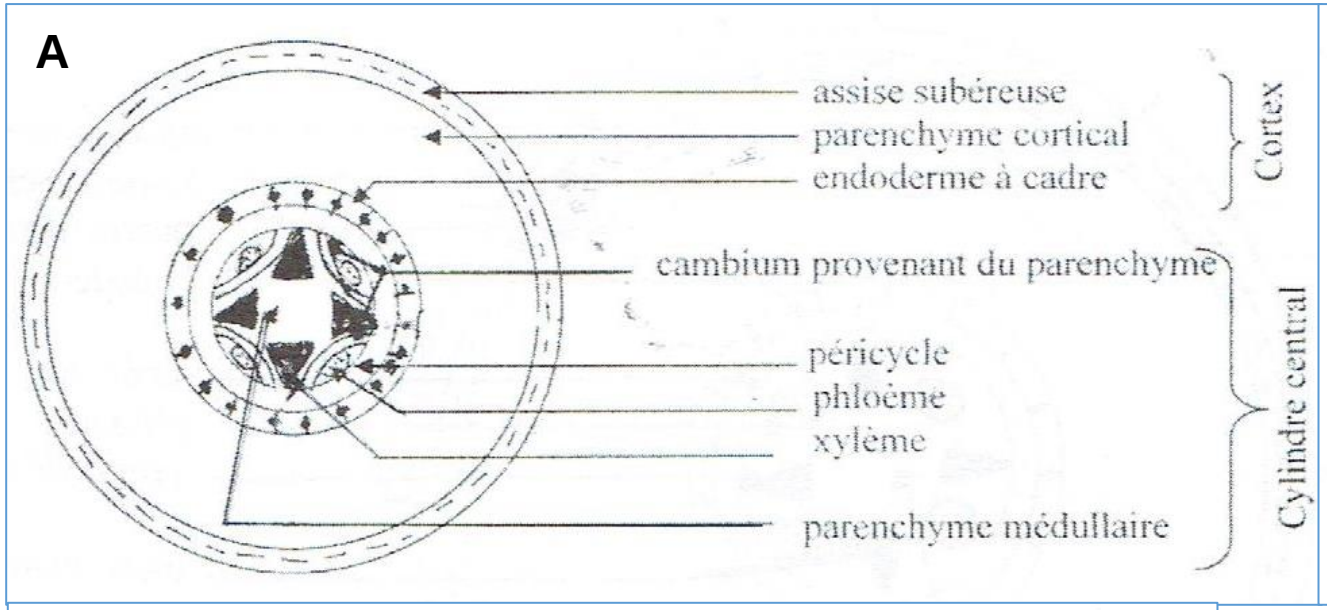
-The suber, which is larger than the phelloderme;

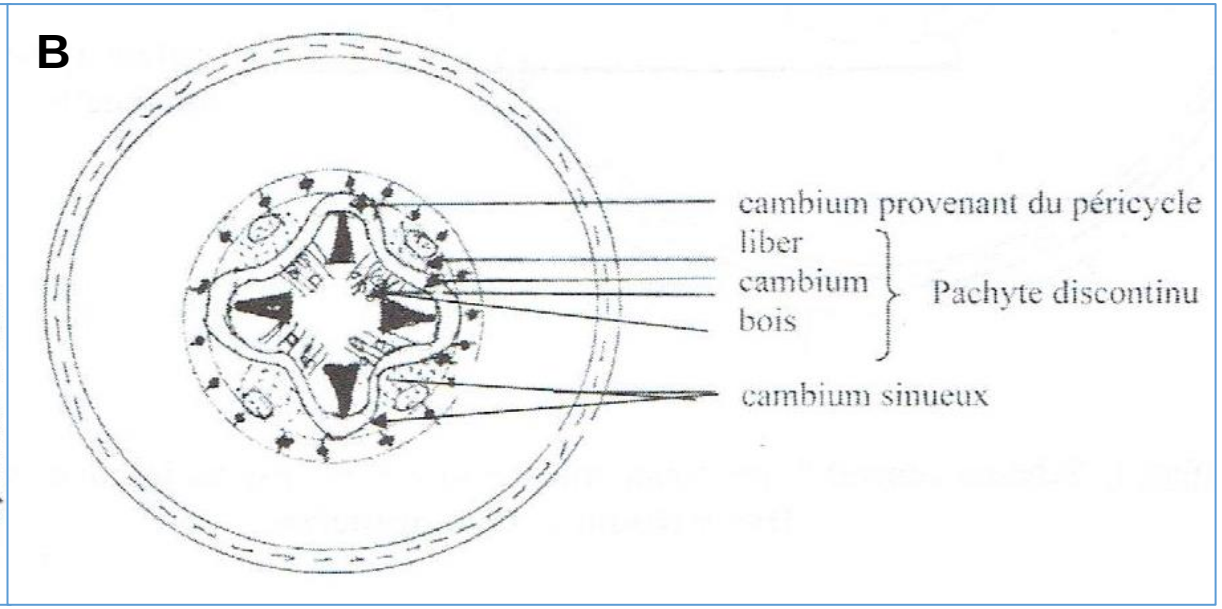
-phelloderme.

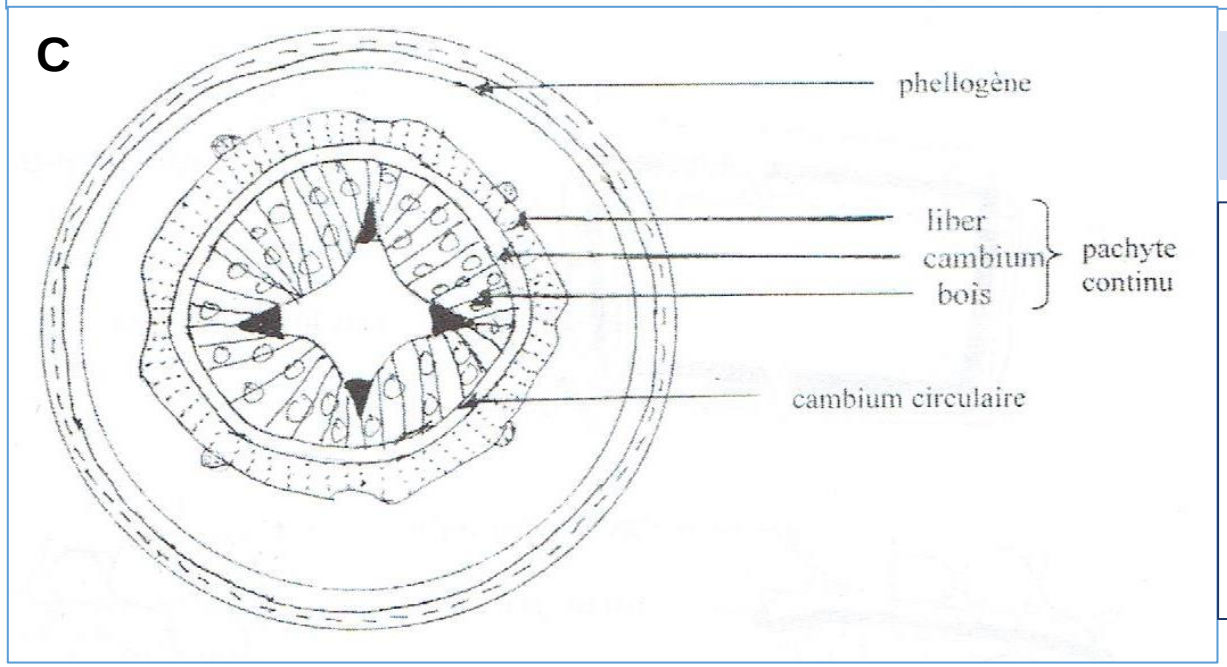
1. ROOTS


Suber to the outside
forme
Phellogen
Parenchyma of cortex
Cellular dediferenciation of parenchyma
obtention of
Obtention of
subit
Phelloderm inside

1. ROOTS





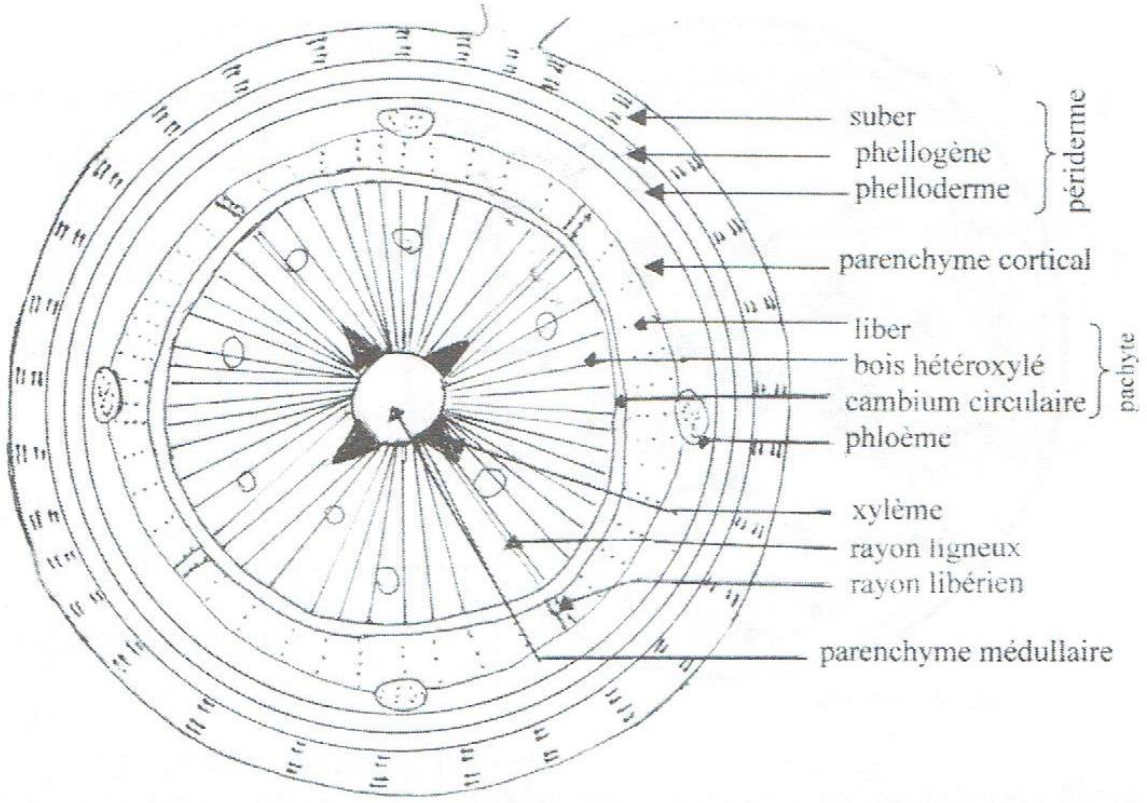


Functioning of secondary meristems in dicotyledonous angiosperms: **A – B – C**

Fig (A-B). The 1st arches of the cambium formed quickly become functional and produce wood towards the inside and bast towards the outside under the phloem.

Fig (C). Phelogen (Fig. C) is derived from the dedifferentiation of cortical parenchyma cells and produces suber towards the outside and phelloderm (Fig. D) towards the inside.

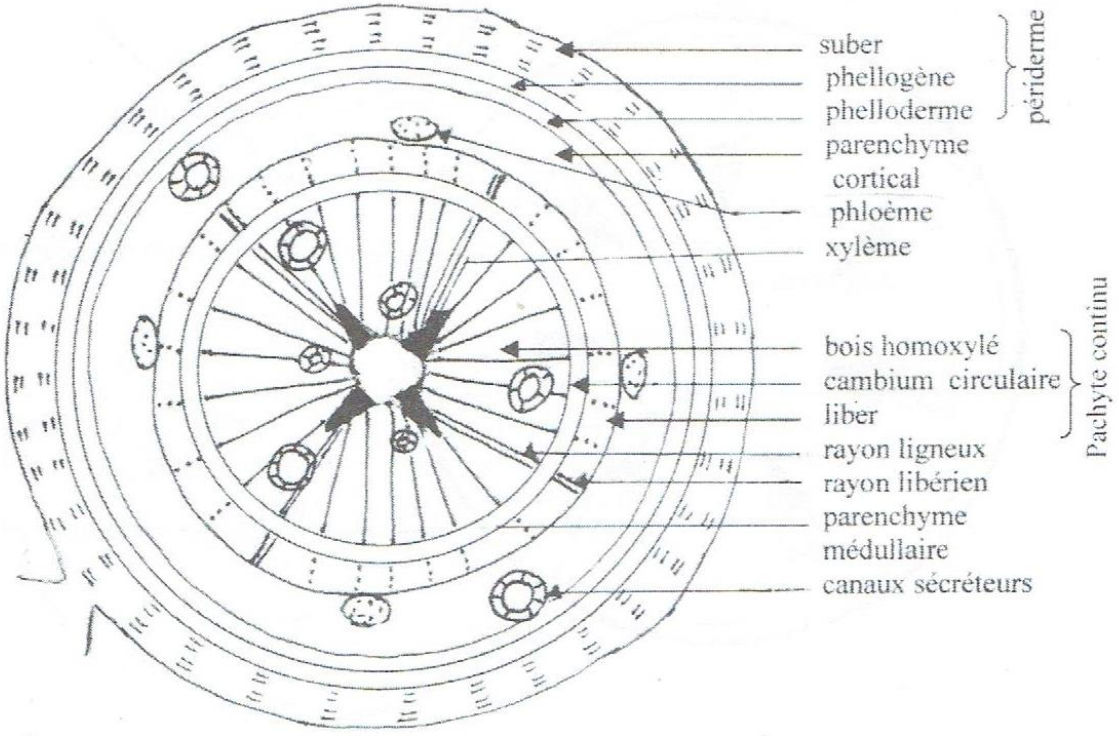
D



Cross-section of an aged root of a dicotyledonous angiosperm.

Functioning of secondary meristems in dicotyledonous angiosperms (D) and gymnosperms (E).

E



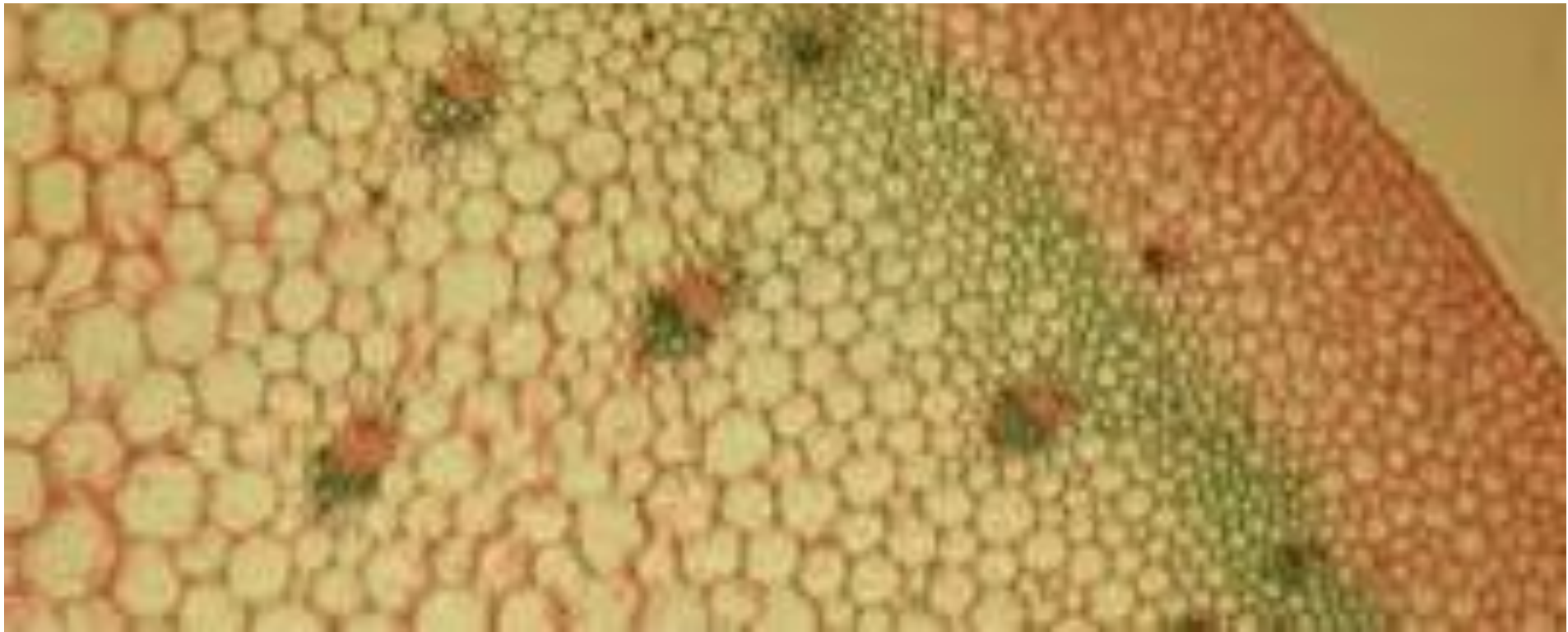
Cross-section of an old gymnosperm root

I. 3. The gymnosperms

In **gymnosperms**, young roots have the same primary anatomical structure as monocotyledonous angiosperms. In the case of older roots, secondary formation (pachyte and periderm) takes place in the same way as in dicotyledonous angiosperms.

II. Anatomical study of the plant organs of angiosperms (monocotyledons and dicotyledons) and gymnosperms:

2. THE STEM



II.1. Angiosperms monocotyledons

a. Primary anatomic structure

The anatomical study is carried out on a cross section of a young or old stem (Fig. 4). Two concentric zones are distinguished :

a.1. Cortex: The tissues observed from the outside to the inside of the cortex are Epidermis (a layer of cells with a pectocellulose wall + a cuticle containing stomata and epidermal tectorial/secretory hairs). Parenchyma

a.2 Central cylinder: The tissues observed from the outside of the central cylinder towards the centre of the trunk are:

- A sclerified pericycle zone delimiting the central cylinder and composed of sclerenchyma cells;

- Primary conducting tissues: centrifugally differentiated xylem and phloem. The xylem and phloem are superimposed to form a cribrovascular bundle (CVB). The outermost bundles are small and located in the sclerified pericycle zone, which are the youngest. The other CVBs, surrounded by a sheath of sclerenchyma, are widespread in older stems.

The medulla is a medullary parenchyma consisting of a large, more or less rounded cells with meat.

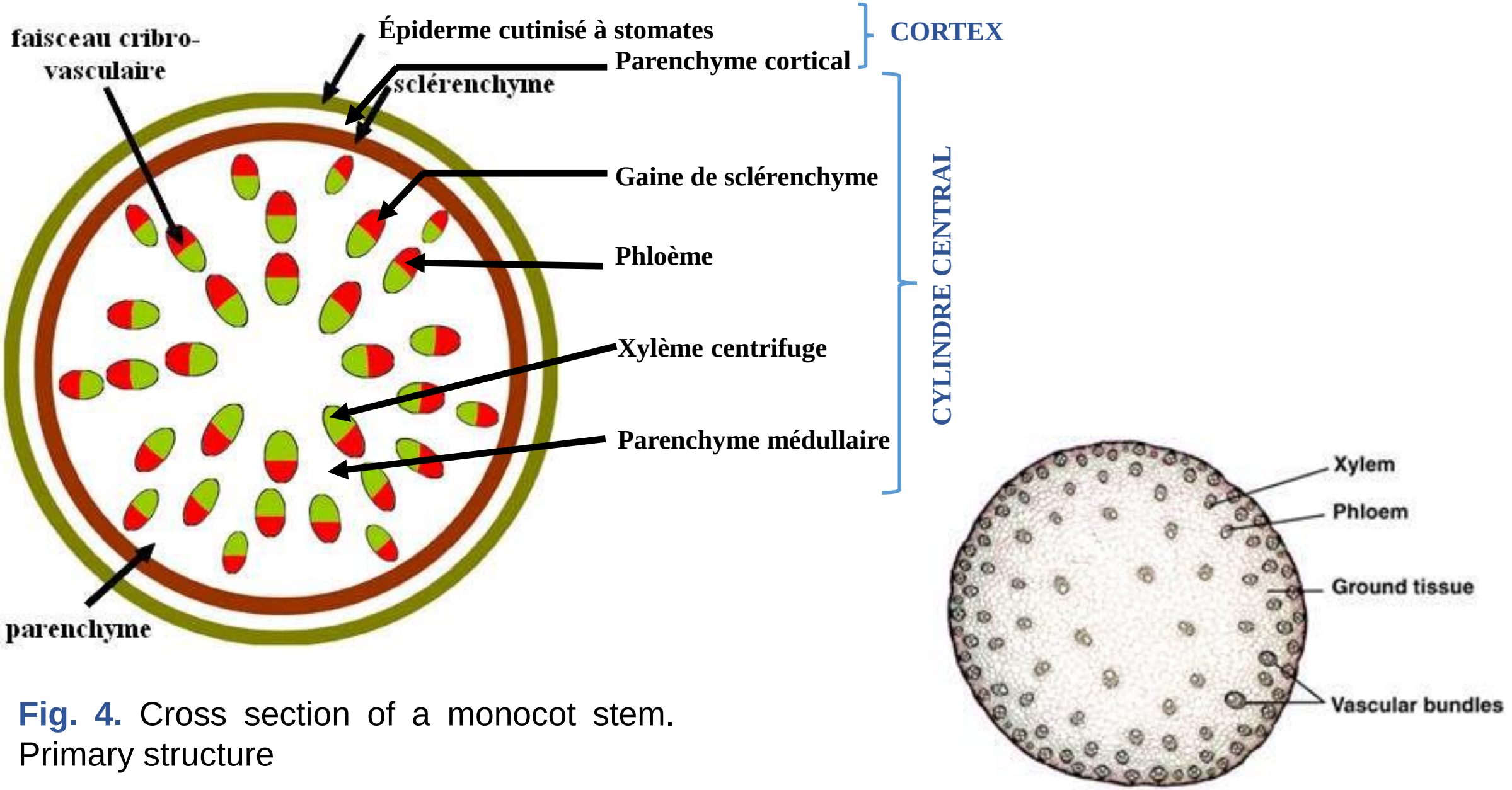


Fig. 4. Cross section of a monocot stem. Primary structure

b. Secondary anatomical structure

Note: Monocotyledonous roots and stems do not have secondary structures, even if they become older. In this case, the ageing of the organs is linked to the presence of a high quantity of sclerenchyma in the stem.

II.2. Angiosperms-Dicotiledons

a. Primary anatomic structure

The study was carried out on a cross-section of a young stem (Fig. 5). It should be noted that the central cylinder is quite as large as the bark:

a.1. The bark: Tissues observed from the outside to the inside of the bark are :

- The epidermis, which is identical to that of the monocotyledonous stem;

- Chlorophyllous cortical parenchyma occupies a relatively narrow zone. It may be associated with supporting tissues, such as the collenchyma (cluster/ring) located beneath the epidermis and the sclerenchyma (often in a ring) which is more internal than the collenchyma.

a.2. The central cylinder: The tissues observed from the outside of the central cylinder towards the center are as follows **:**

The primary conducting tissues are composed of centrifugally differentiated xylem and phloem. The xylem and phloem are superimposed and form cribrovascular bundles arranged in 1 or 2 circles. The phloem is often surmounted by a cluster of sclerenchyma fibres called peri-phloem fibres;

The medulla is a large cellular medullary parenchyma with flesh. The medulla disappears during the formation of the pachyte (secondary structure).

Note: The same primary anatomical structure characterises the young stem of gymnosperms.

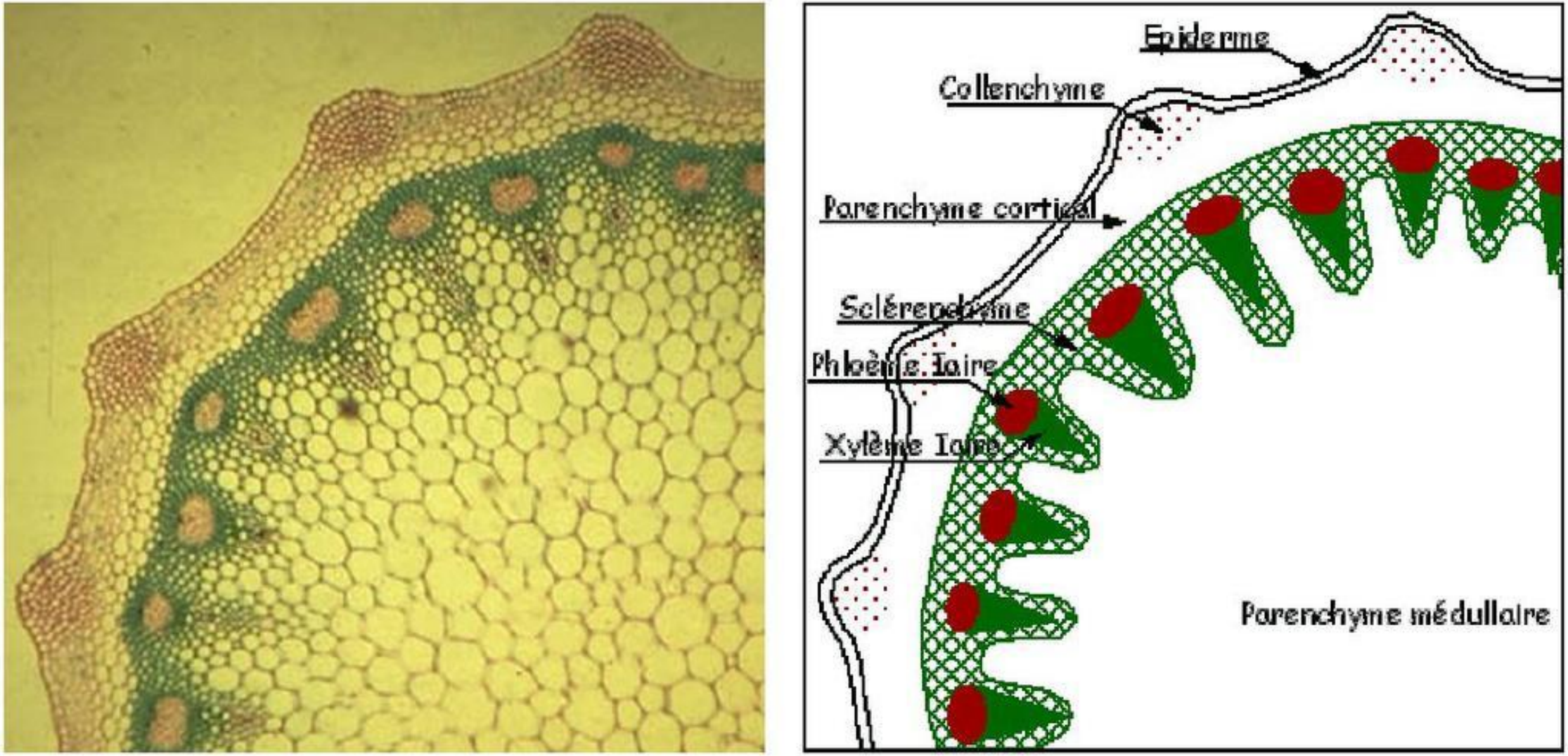


Fig. 5. Cross section of a dicot stem. Primary structure

b. Secondary anatomical structure

An anatomical study carried out on a transverse section of an aged stem (Fig. 6) shows the two types of secondary formation:

b.1. The pachyte in the central cylinder of the stem;

b.2. The periderm in the bark. The phellogen appears after the formation of the cambium.

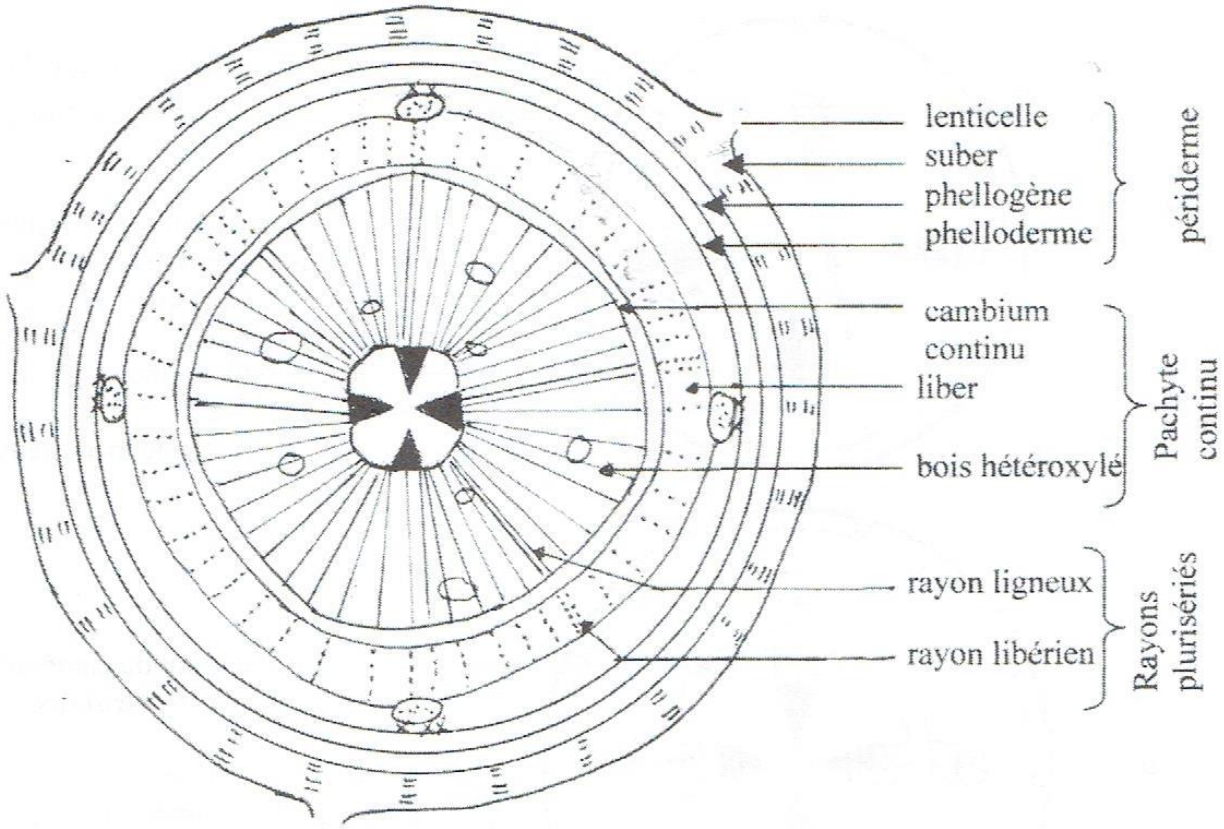


Fig. 6. Cross section of an aged stem of a dicotyledonous angiosperm.

➢ PACHYTE FORMATION:

Stage 1 (Figs. 7 and 8) **:** Formation of the cambium in the cribro-vascular bundle (between xylem and phloem): i.e. the primary meristem (or procambium) is transformed, giving rise to the cambium known as the intrafascicular cambium. This intrafascicular cambium then gives rise to bast by pushing the phloem outwards and to heteroxylated wood by pushing the xylem inwards. This gives rise to the discontinuous pachyte.

Stage 2 (Figs. 7 and 8)**:** Dedifferentiation of the parenchyma to form an interfascicular cambium; This interfascicular cambium joins the intrafascicular cambium to form a continuous circular cambium throughout the central cylinder; The continuous cambium produces a continuous pachyte; The continuous pachyte may be formed under several rings in older stems.

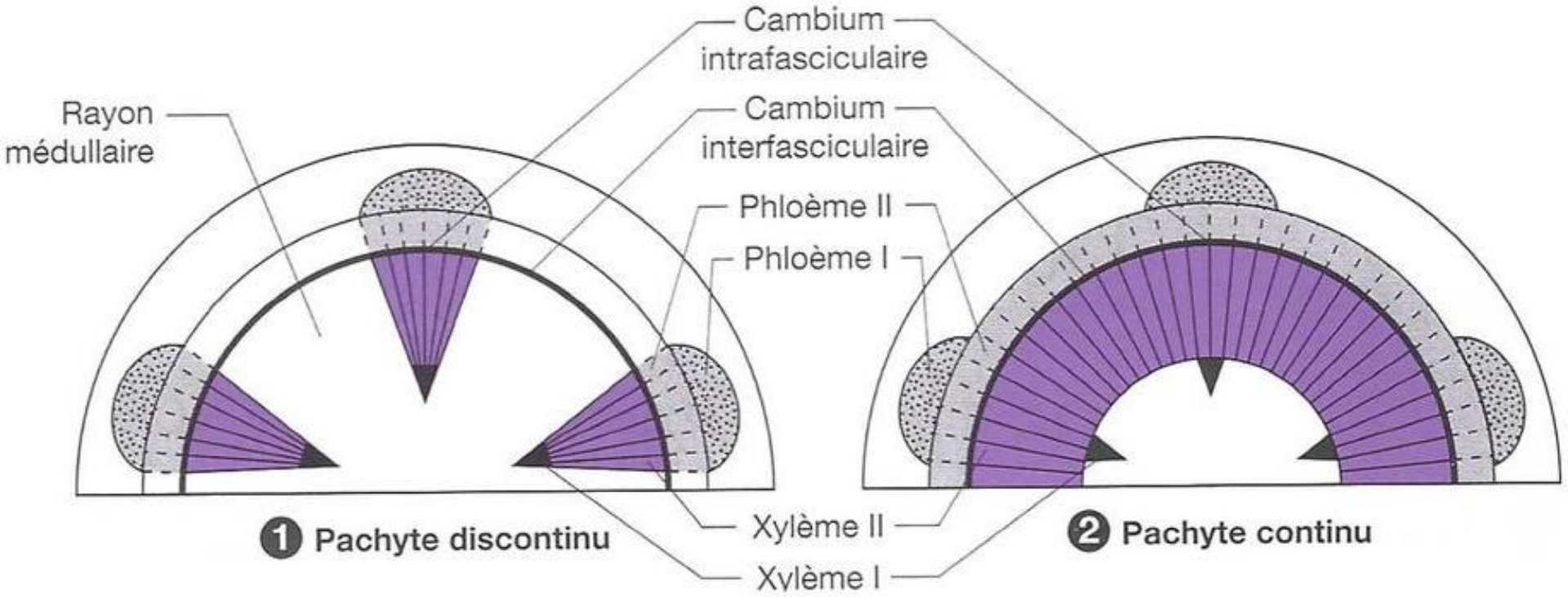
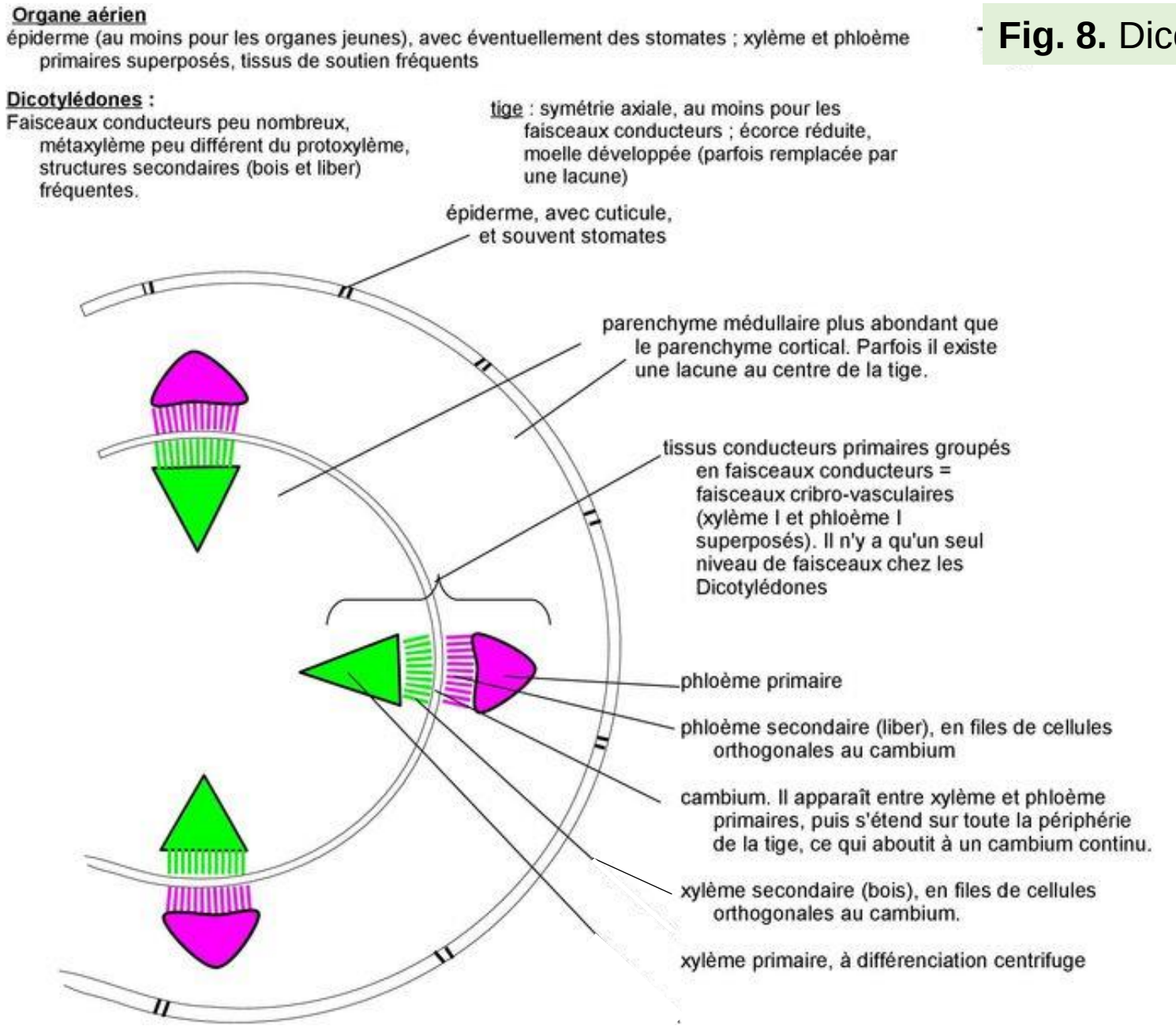
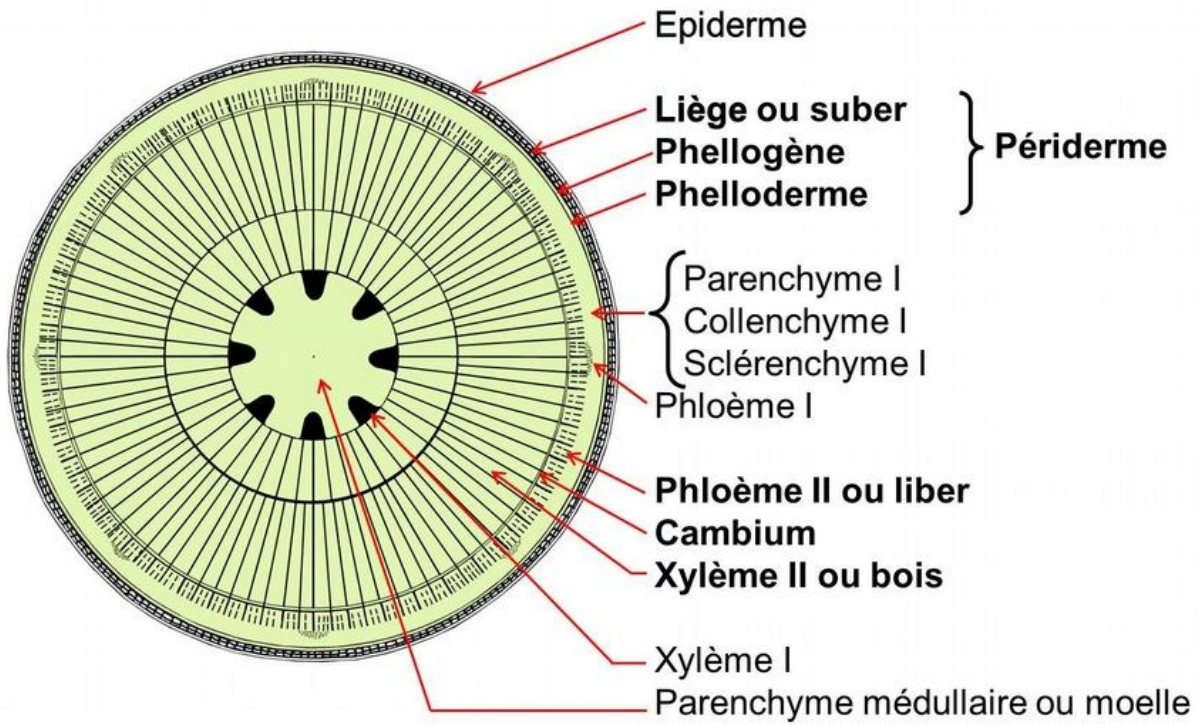


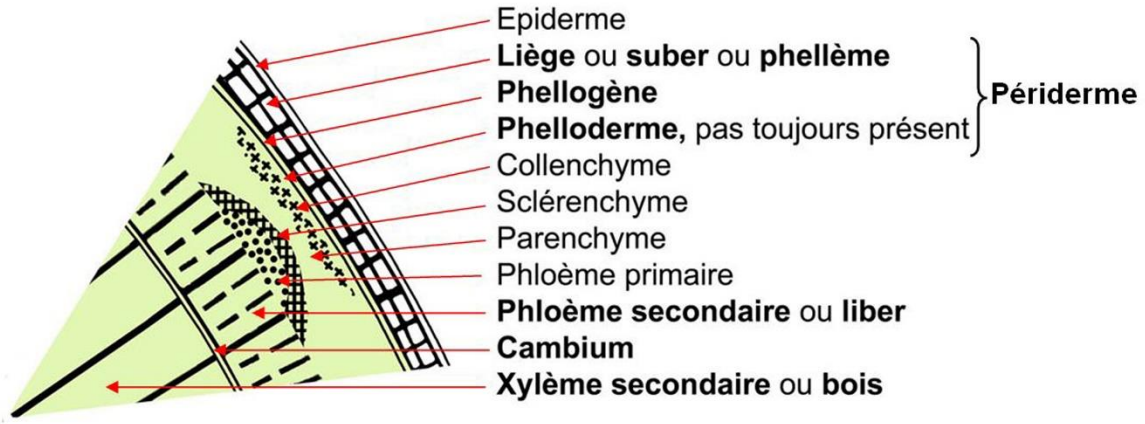
Fig. 7. *Formation des tissus secondaires conducteurs à partir du cambium*

Fig. 8. Dicotyledons stem



- **THE FORMATION OF THE PERIDERMIS:** The stages of phellogen formation are: Differentiation of cortical parenchyma and/or collenchyma. Sometimes, the phellogen appears from epidermal cells and gives rise to the suber and phelloderm.



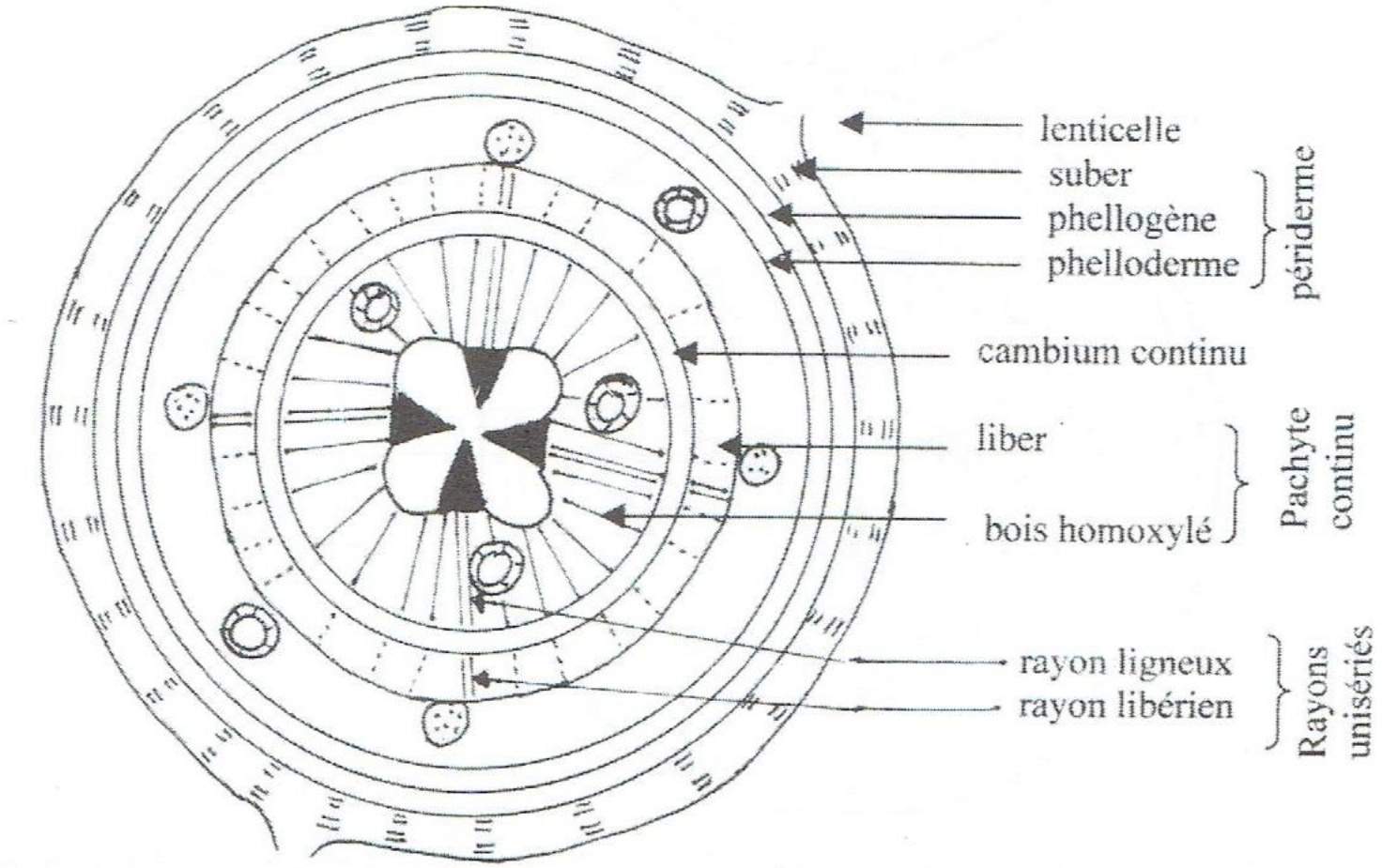


II. 3. The gymnosperms

- **Pachyte :** In gymnosperms, the pachyte is formed in the same way as in dicotyledonous angiosperms. However, in the case of gymnosperms, the wood is homoxylated and contains resin-secreting ducts.

- **Periderms :** In the aged stem of gymnosperms, the periderm forms in the same way as in angiosperms.

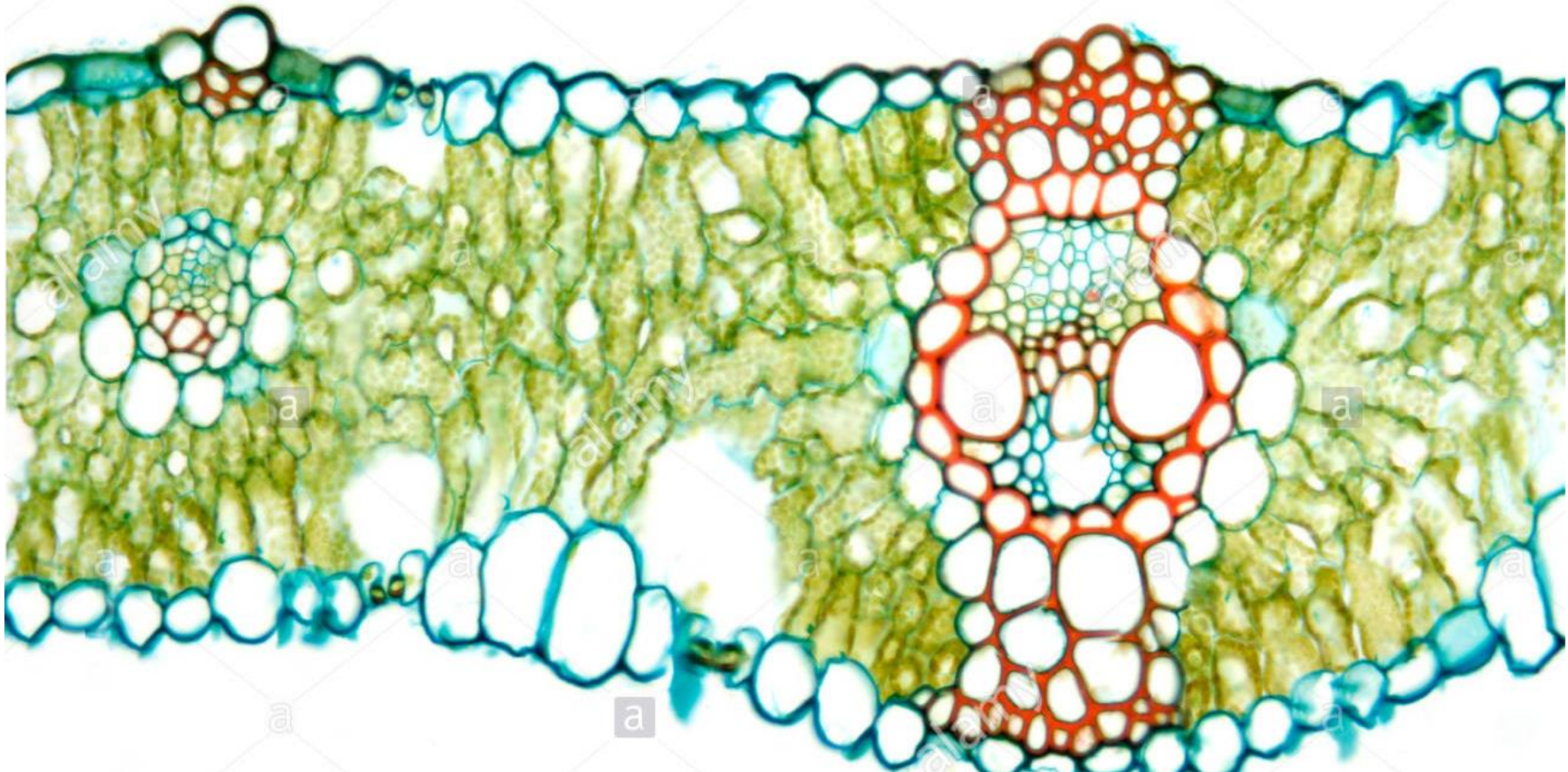
2. STEM



Coupe transversale de tige âgée de gymnospermes

II. Anatomical study of the plant organs of angiosperms (monocotyledons and dicotyledons) and gymnosperms :

3. THE LEAVES



III.1. Angiosperms-Monocotyledons

a. Primary anatomical structure

The study is carried out on a transverse section of the leaf blade. In a leaf, 2 faces are distinguished: An upper (or ventral) side exposed to light and a lower (or dorsal) side not exposed to light. The leaf blade is bilaterally symmetrical. The tissues observed are (Fig. 9) :

- **Upper epidermis:** Covers the upper surface of the leaf, composed of cells with pectocellulosic walls. This epidermis is cutinised (protected by a cuticle). There are very few stomata.

- **Lower epidermis:** Covers the underside, with a much less cutinised outer wall. The stomata are more widely distributed than in the upper epidermis.

- Sclerenchyma : This is a support tissue often found in clusters against the 2 epidermis and/or sometimes forming a sheath around the cribrovascular bundles (CVB).

Homogeneous mesophyll : This is the basic parenchyma which occupies most of the leaf blade. This parenchyma is of the homogeneous chlorophyllous lacunouse or meatus (orifice) type (see chapter 3: parenchyma).

Primary conductive tissues: Several cribrovascular bundles form the veins. These CVBs have approximately the same size. The central vascular bundle may be larger. Each vascular bundle has a xylem on the upper side and a phloem on the lower side.

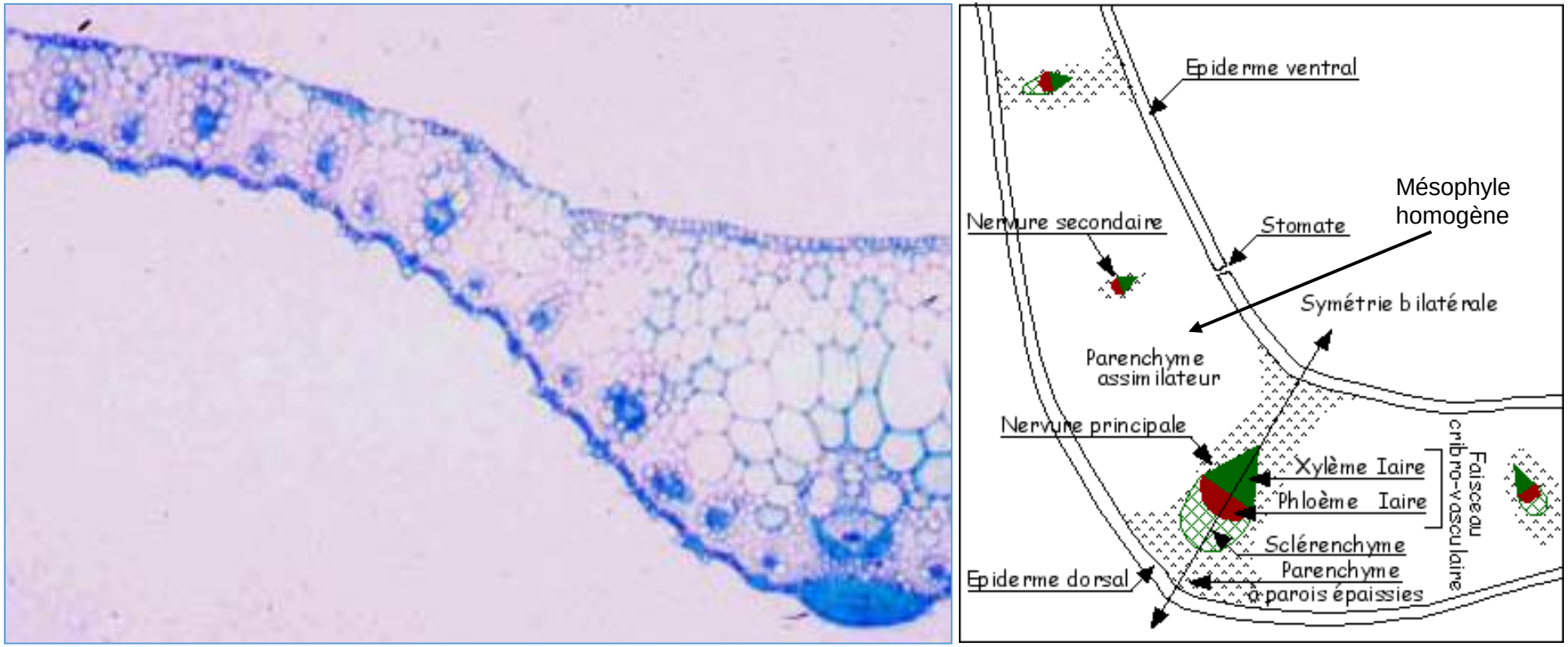


Fig. 9. Cross-section of a monocotyledonous angiosperm leaf

b. Secondary anatomical structure

Absence of secondary structure in monocotyledonous angiosperms.

III.2. Angiosperms-Dicotyledons

a. Primary anatomical structure

The study was carried out on a cross section of the leaf blade of a young leaf. The leaf blade is bilaterally symmetrical and the tissues are observed in Fig. (10):

- **Upper epidermis:** this is an epidermis with a strongly cutinised wall. The number of stomata is very small or almost non-existent.

- **Lower epidermis:** composed of an outer wall with little cutaneous tissue. This epidermis has a very high number of stomata compared to the upper epidermis.

- **Heterogeneous mesophyll:** composed of two types of chlorophyll parenchyma; palisade towards the upper surface and lacunar towards the lower surface (see chapter 3, parenchyma).

3. LEAVES

- **Primary conductive tissues:** These represent the criobrovascular bundles corresponding to the veins, which vary in size. There is one major main vein and other finer secondary vessels found in deciduous and evergreen (young) leaves.
- **Support tissues:** collenchyma and sclerenchyma are present in the main vessel.

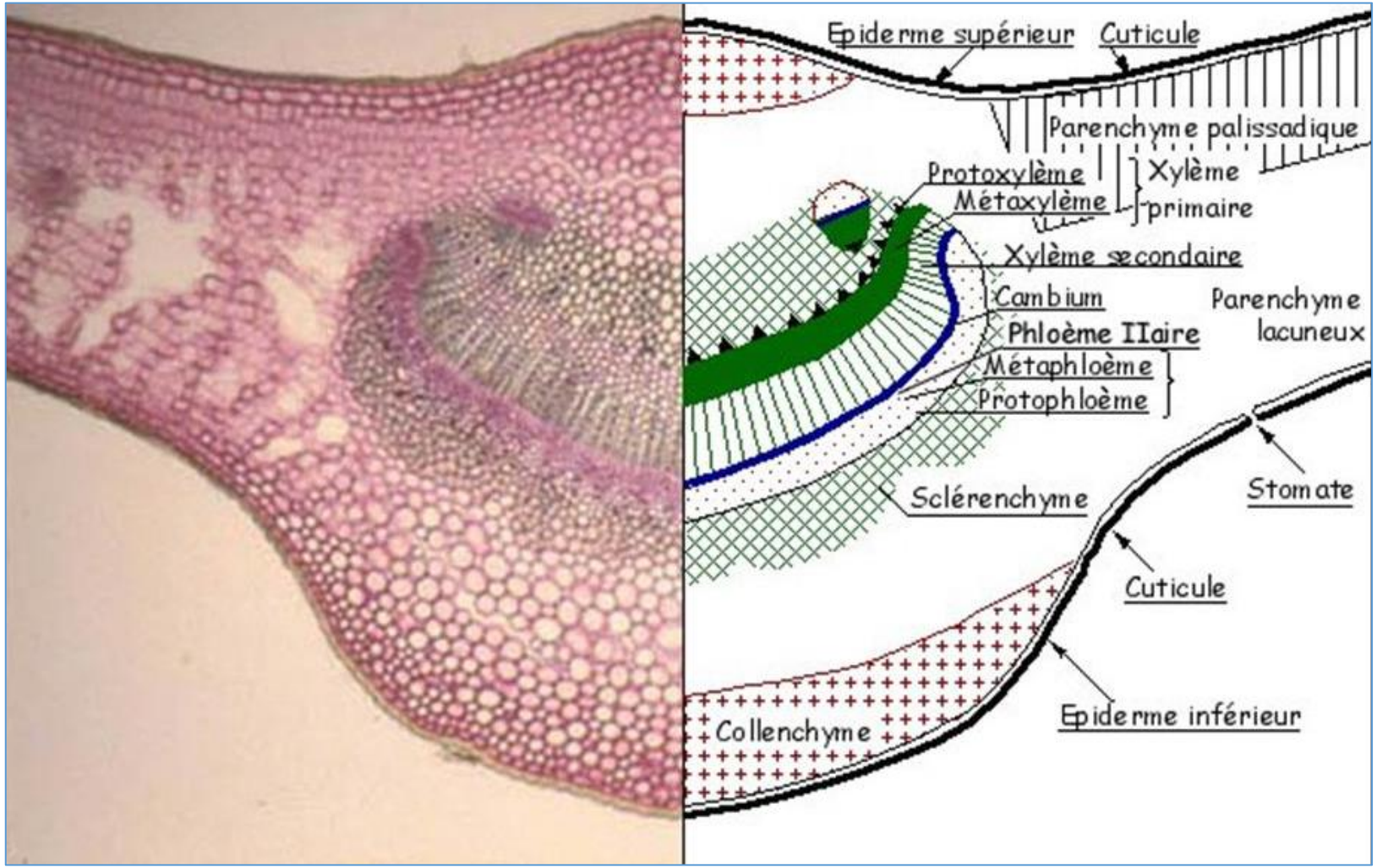
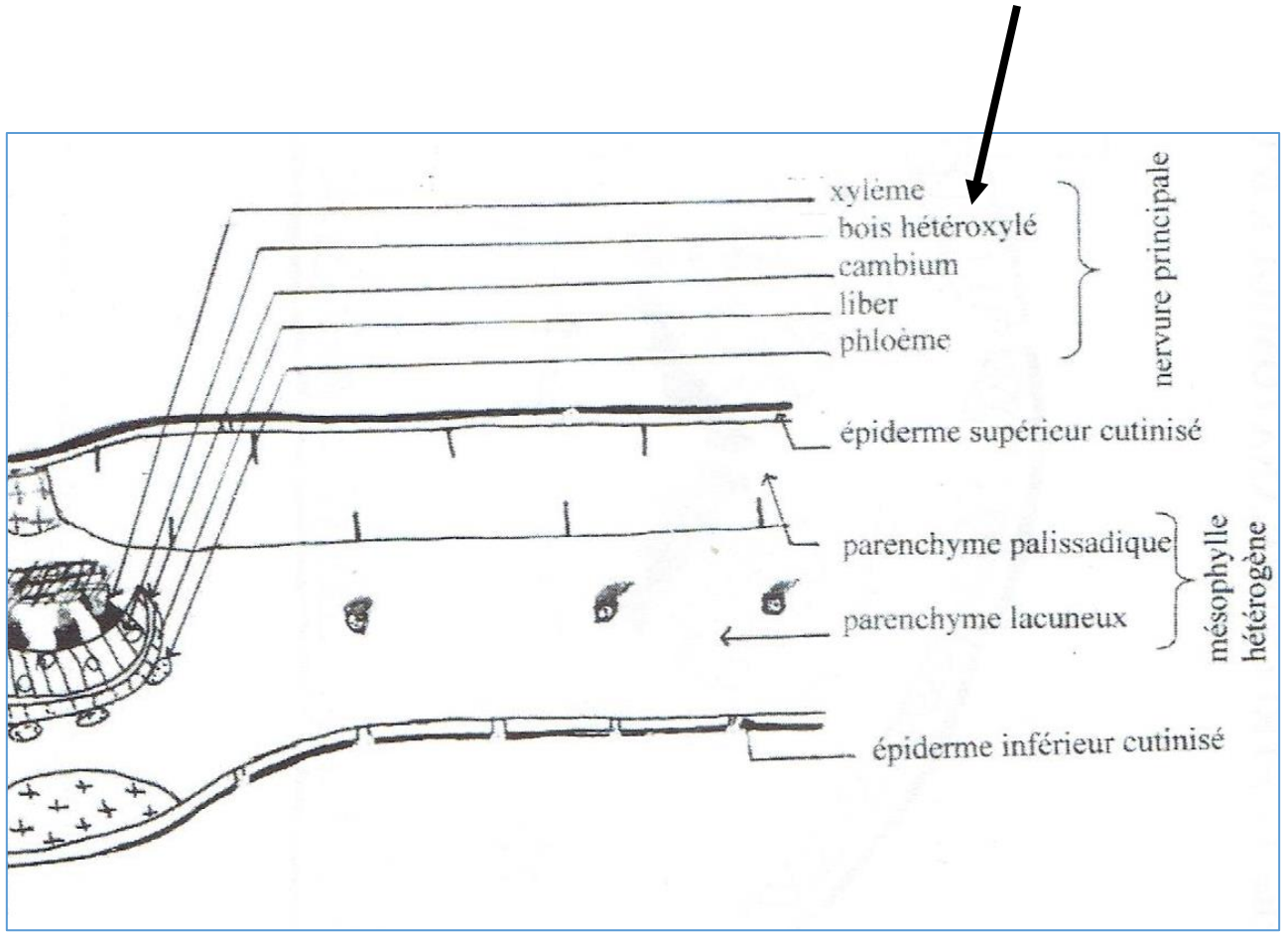


Fig. 10. Cross-section of a dicotyledonous angiosperm leaf

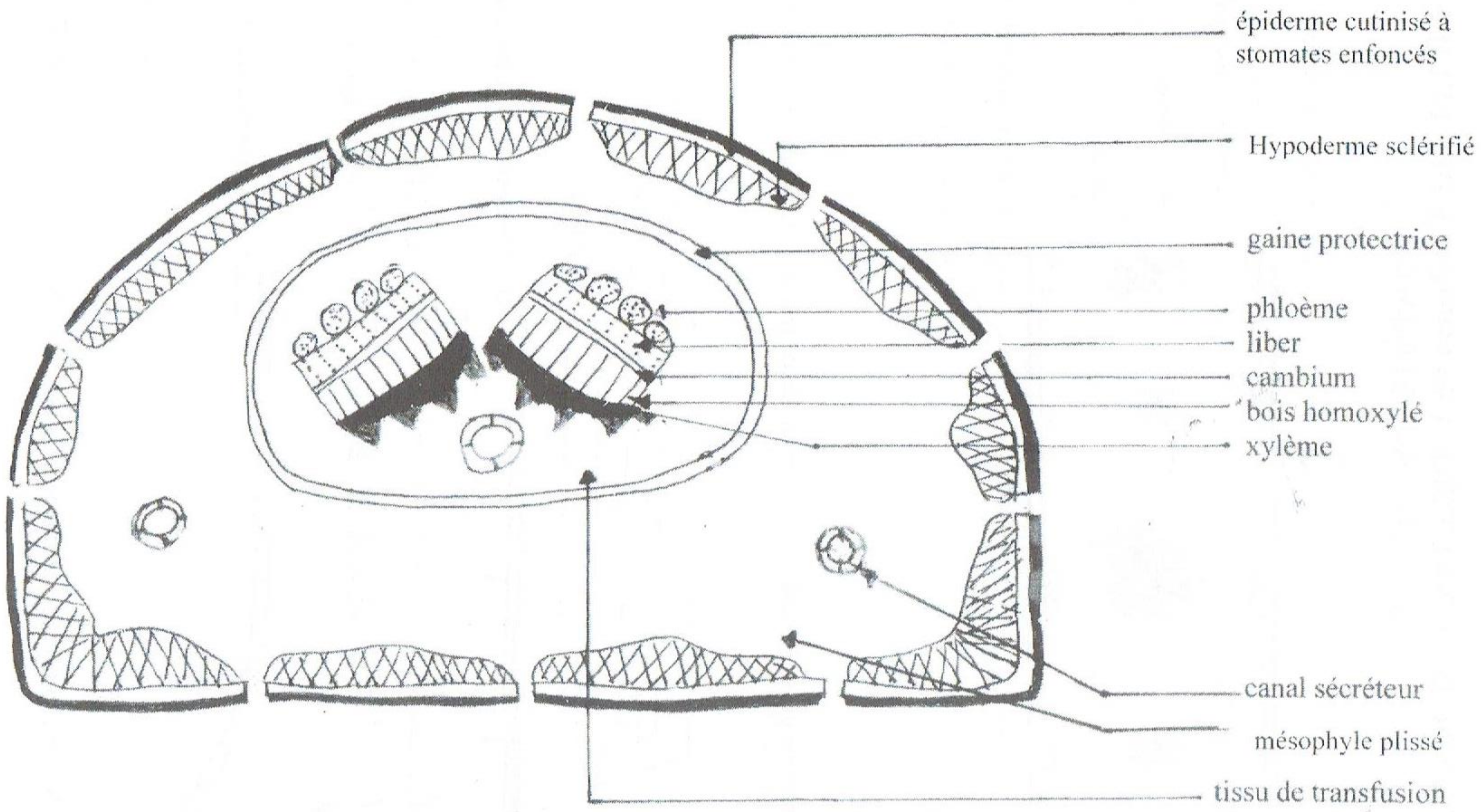
b. Secondary anatomical structure

In evergreen leaves, an intrafascicular cambium forms in the vascular bundles of the main vessels, producing heteroxylated wood in contact with the xylem and bast wood in contact with the phloem.



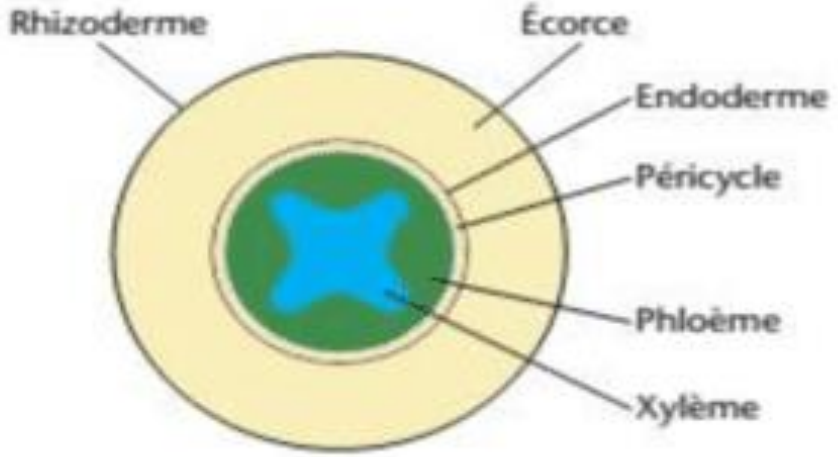
III.3. Gymnosperms

In older gymnosperm needles, an intrafascicular cambium forms between the xylem and phloem of the two vessels, producing homoxylated wood and bast (see chapter: primary anatomical structure).

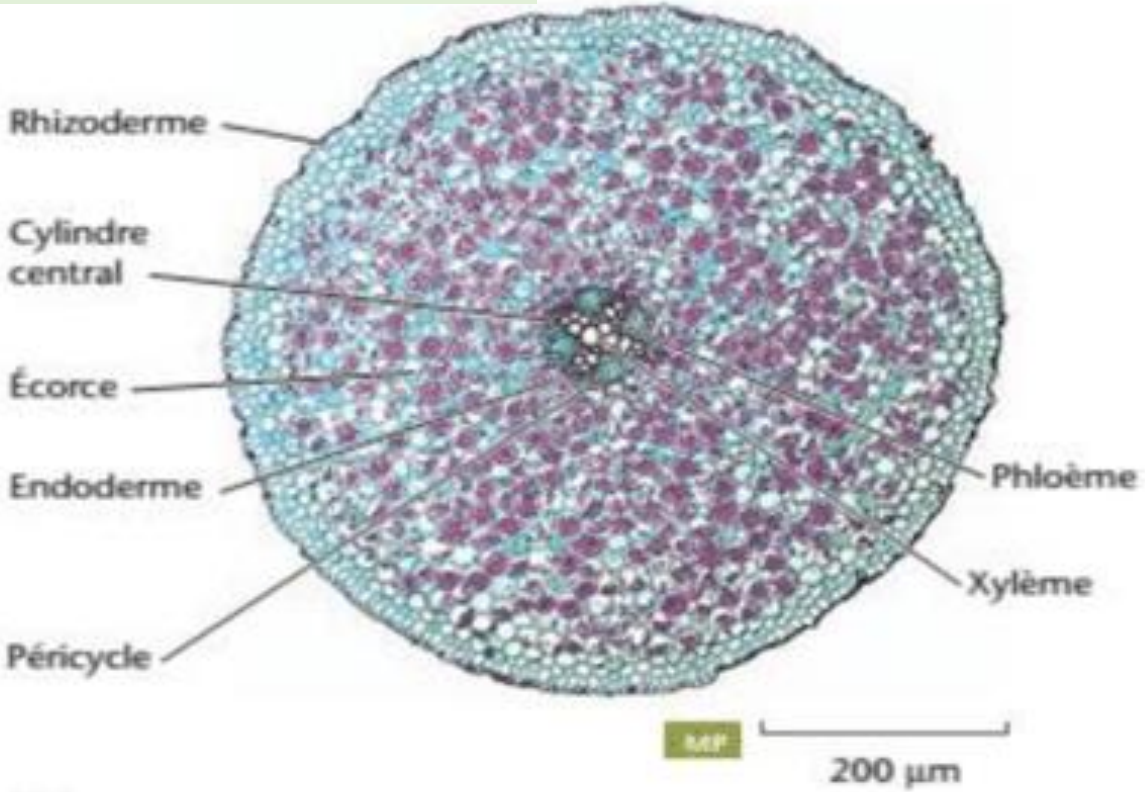


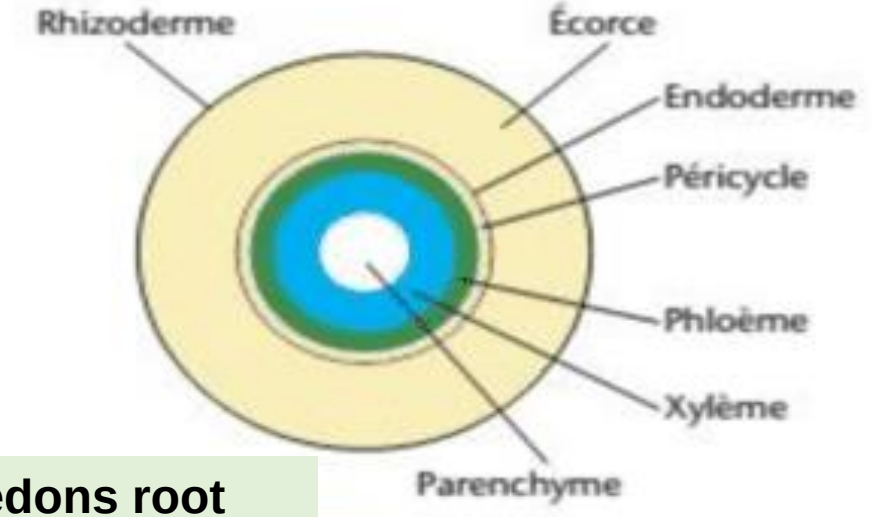
III. Comparative anatomy of dicotyledonous and monocotyledonous angiosperms

Comparison between a monocotyledonous and a dicotyledonous root		
Caracters	**Roots (mono)**	**Roots (dico)**
Stele	important	reduced
Endodermis	Shape of U	Casparian strips
Number of bundles of xyleme and phloem	Important (12 to 20)	Reduced (2 to 5)
Medulla	Abundant	Absent (or replaced by xylem)
Secondary structures	Absents	Presents

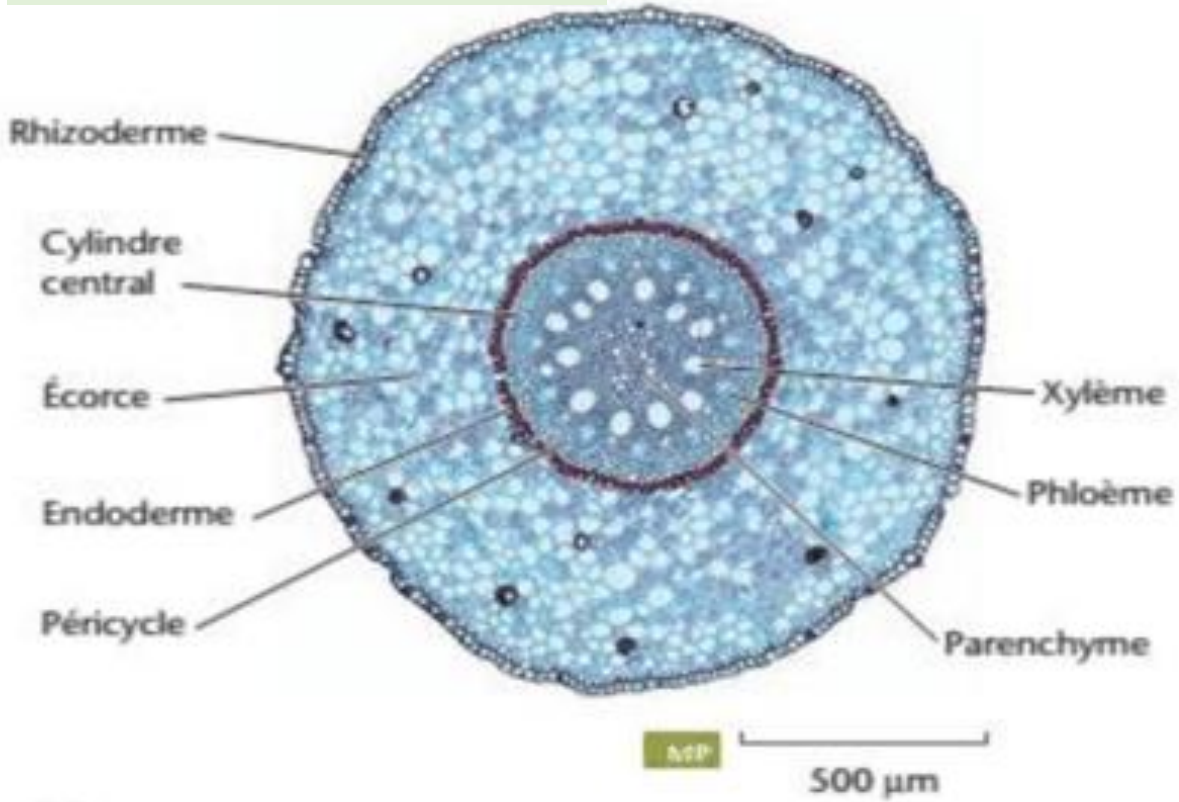


Dicotyledons root



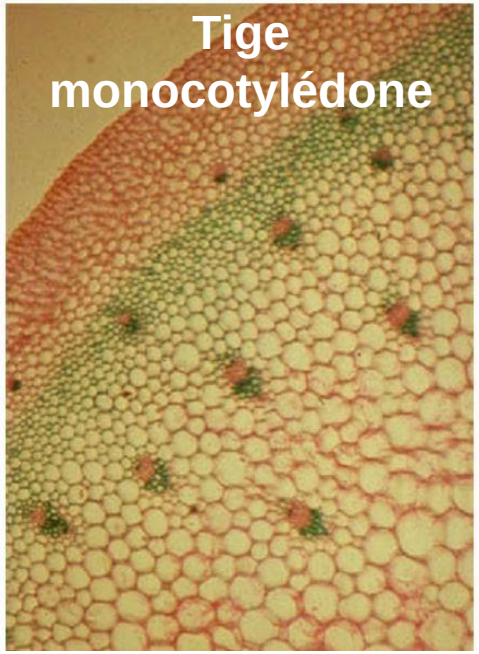


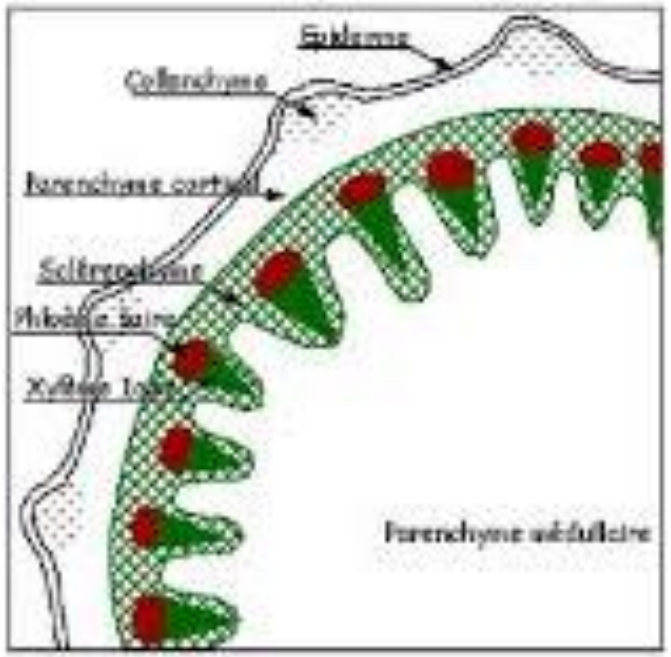
Monocotyledons root

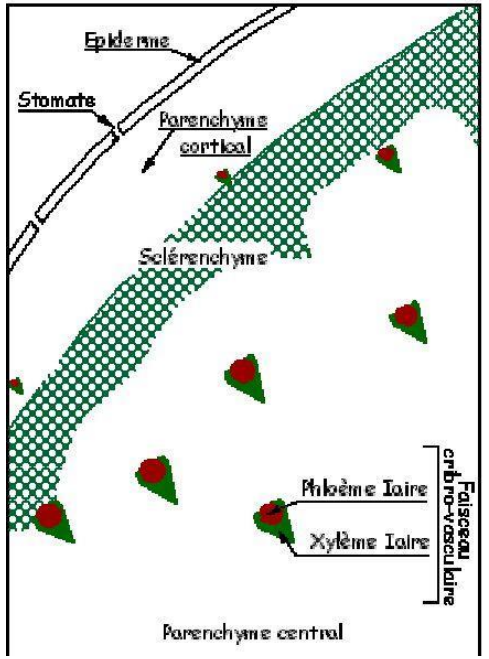


Comparison between a monocotyledonous and a dicotyledonous stem		
Caracters	**Stem (mono)**	**Stem (dico)**
Libero-ligneous bundles (Cribrovascular bundles)	Numerous and arranged in several concentric circles	Few in number (usually 2 concentric circles)
Primary wood	Shaped as V with the primary liber	In a triangle with the primary liber at the base of the triangle
Secondary obtention	Absents	- Suber replace the epidermis - Secondary Liber - Secondary heteroxylated wood


Tige dicotylédone


Tige
monocotylédone

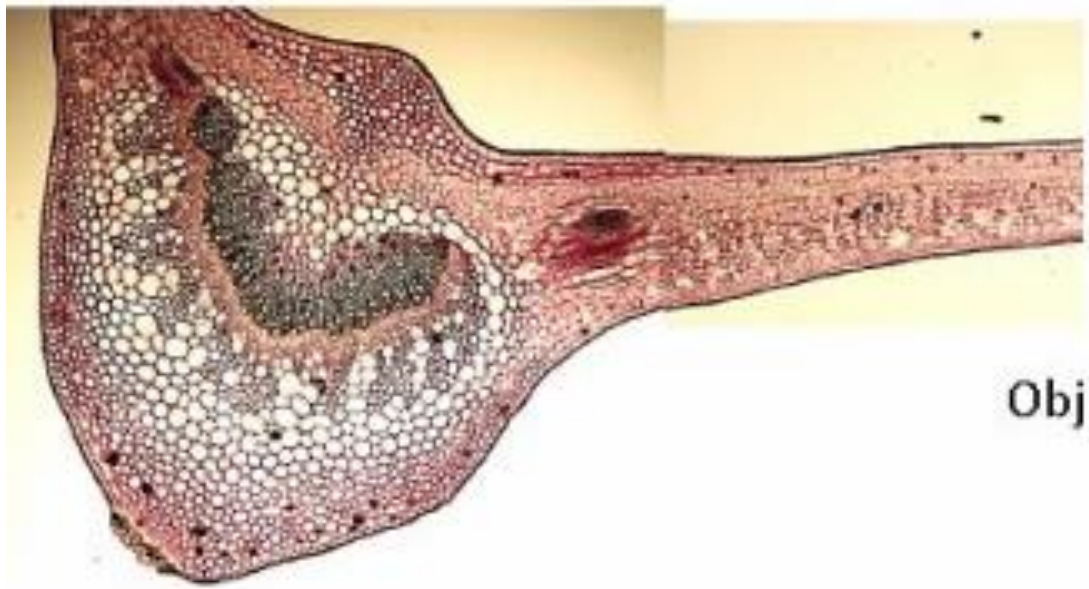

Collenchyme
Parenchyme cortical
Parenchyme médullaire


Epiderme
Stomate
Parenchyme cortical
Sclérenchyme
Phloème Iaire
Xylème Iaire
Faisceau cribro-vasculaire
Parenchyme central

III. Comparative anatomy : Leaves

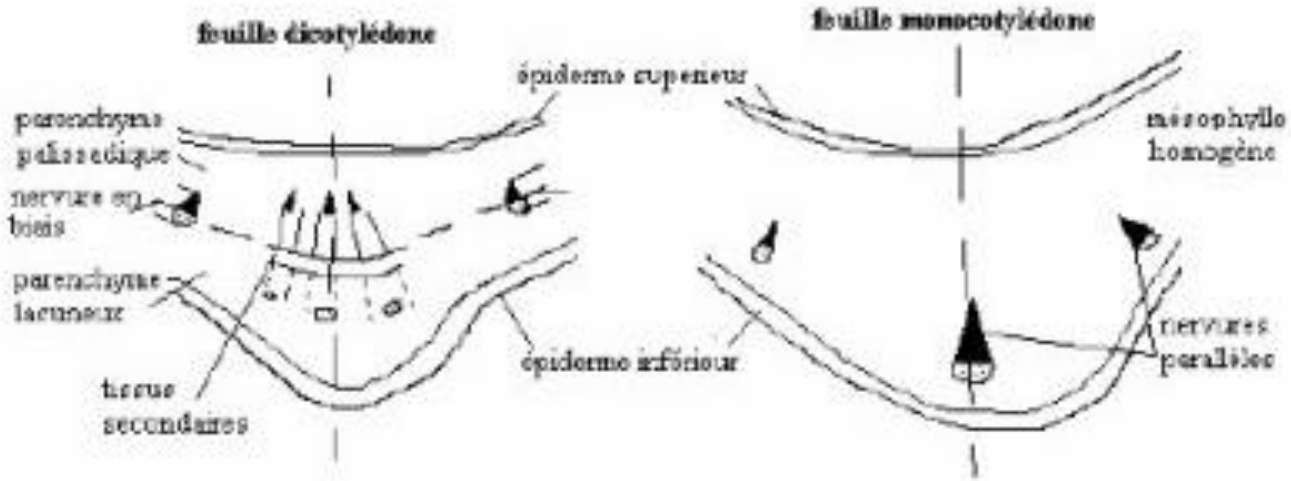
Comparative table between the monocotyledon and dicotyledons leaves		
Caracters	**Leaves (mono)**	**Leaves (dico)**
Mesophyll	Homogenous: parenchyma with meathus	Heterogenous: -Palisade parenchyma : upper surface -Parenchyma lacuneous internal surface
Libero-ligneous bundles (Cribrovascular bundles)	Numerous, substantially the same -> parallel veins	Usually on the main vein.Sometimes in the leaf blade at the level of the secondary veins.
Secondary formations	Absents	Generally poorly developed at the level of the main vein. Secondary wood Heterocycled secondary wood

CT de feuille de laurier cerise, *Prunus lauro-cerasus*, Amygdalacées, dicotylédones



Obj 10x

CT de feuille de maïs, *Zea mays*, Poacées, monocotylédones



III. Comparative anatomy : ROOT – STEM - LEAVES

Caracters	Roots	Stem	Leaves
Symetry	Axial	Axial	Bilateral
bark/centre cylinder	-Developed bark-Reduced central cylinder-E > C	Reduced barkDeveloped central cylinder - E < C	-
Covering tissues	-Piliferous base -Subereal or suberoid seat	Epidermis	Epidermis
Supporting Tissues	Rare	Frequent	Frequent
Delimitation of bark/central cylinder	the endoderm still present	More or less	-
Particulars tissues	Pericycle	-	Mesophyll
Conducting tissues	-xylem I and phloem I (alternated) Xylem I centripet. -xylem II with centrifuge differenciation	-xylem I and liber I overlapping -xylem I a centrifuge differenciation	-xylem I and phloem I overlapping -xylem I oriented to the upper face

Conventional signs for the presentation of plant tissue

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