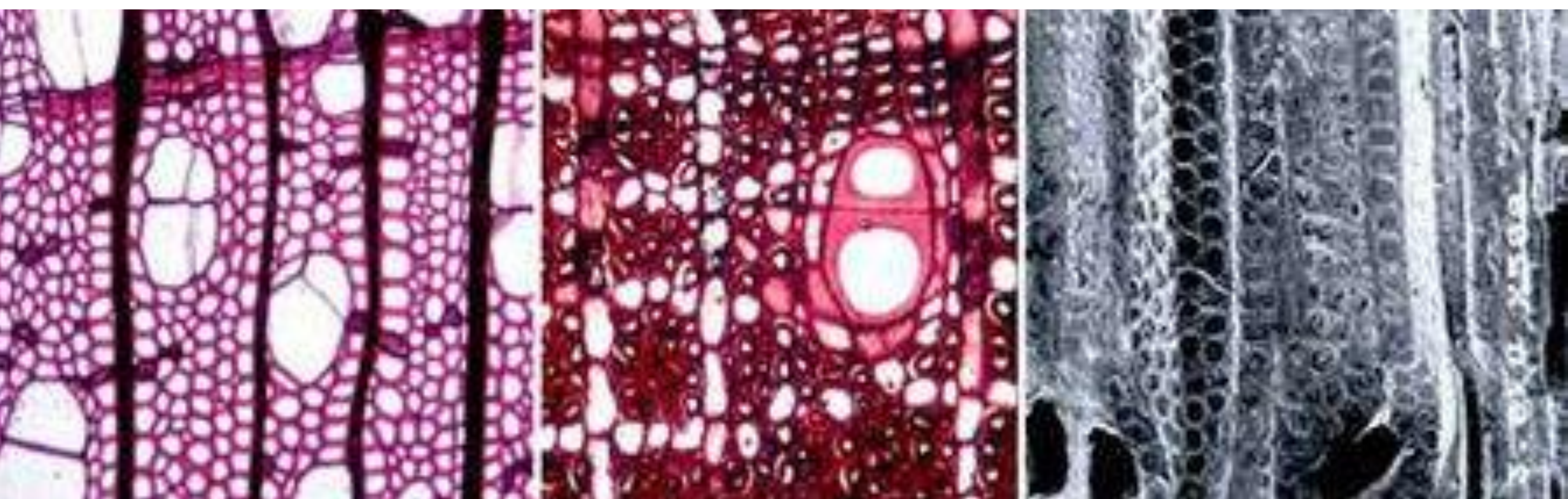
Chap 2-3. Secondary Plant Tissues



1. Secondary meristems

- A **secondary meristem** is a generative zone that appears at plant maturity step. The cells of the secondary meristem allow dense growth around the stem and root of dicotyledonous angiosperms.

- Secondary meristems are formed within primary tissues by dedifferentiation :

Dedifferenciation   Differenciation

Differenciated cells → Cells of secondary meristems → Differenciated cells

(Primaires Tissues)   (Secondary Tissues)

- **Secondary meristems** are composed of two generative layers :

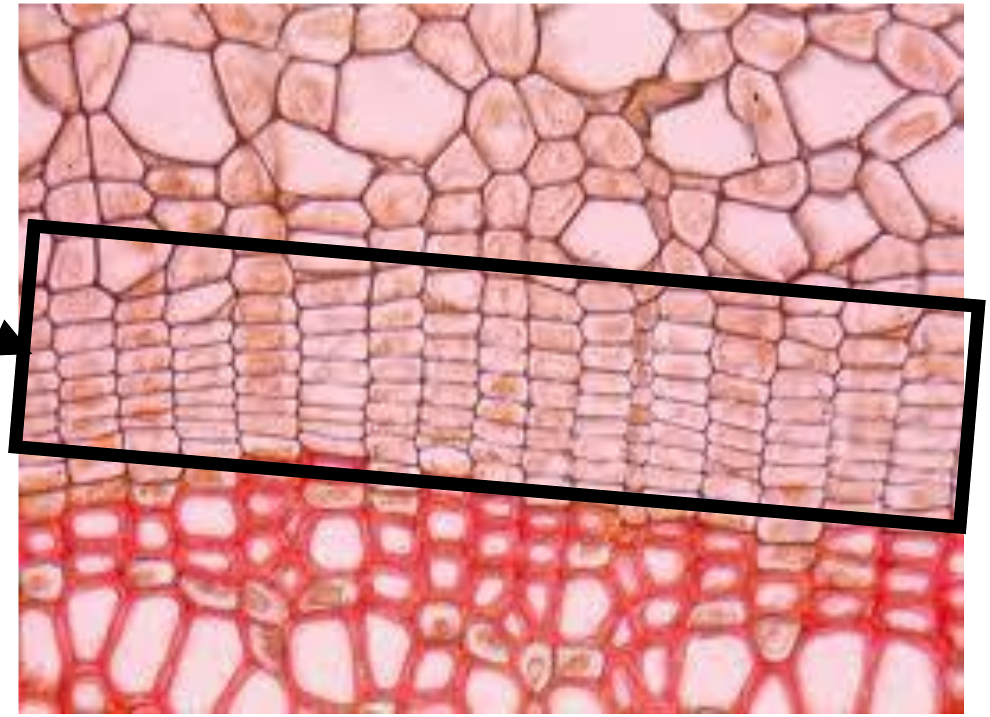
Cambium et **Phellogen**

1. **The cambium:** is a generative liberulinous base;
2. **The phellogen:** is a sub-phellodermal generating base.

a. Histological caracters

- Histologically, tissue of secondary origin can be identified by a correct alignment of the cells.

Tissu secondaire

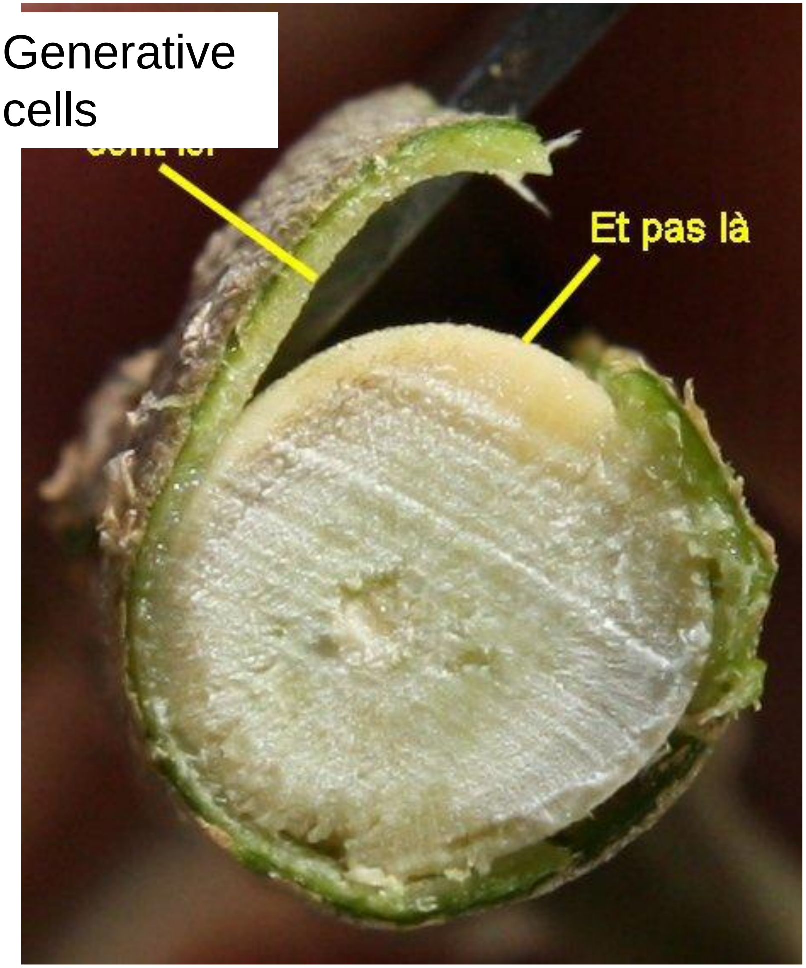


b. Localization of the secondary meristem

- The **cambium** is found in : stems - roots and leaves (gymnosperms and dicotyledonous angiosperms).
- The **phellogen** is found in : stems and roots (gymnosperms and angiosperms).

Localization

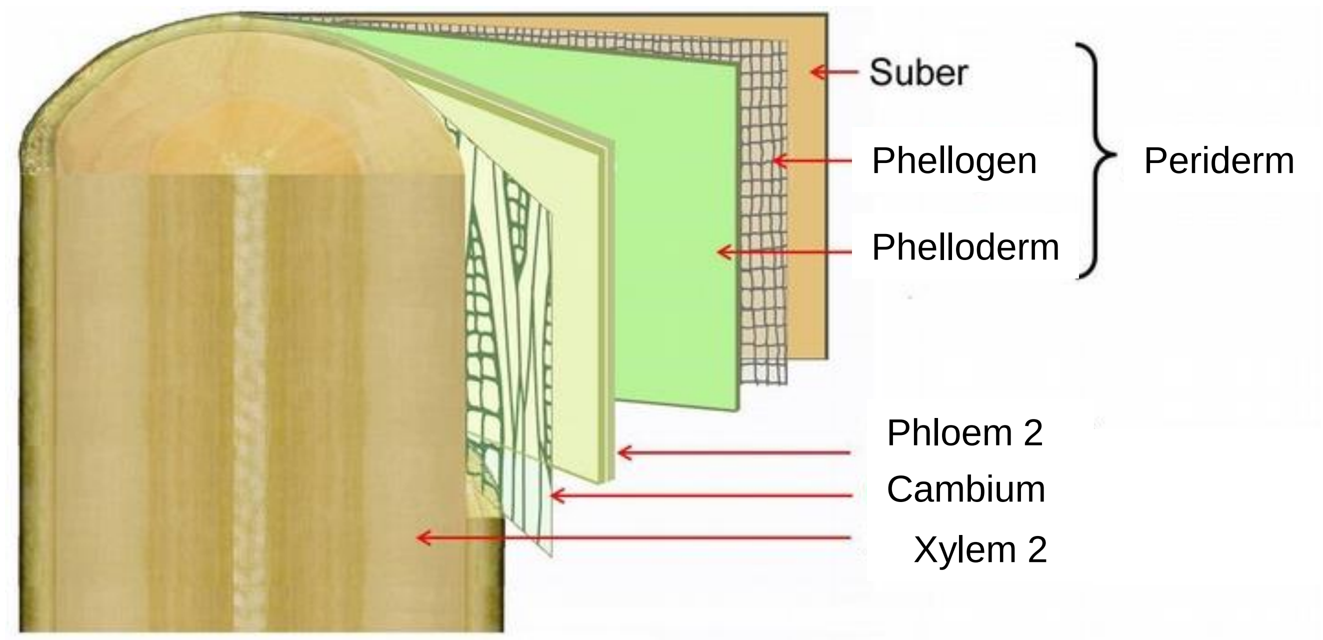
Generative cells



1. The cambium

The **cambium** produces secondary conducting tissues: the liber or secondary phloem (from the outside) and the wood or secondary xylem (from the inside) :

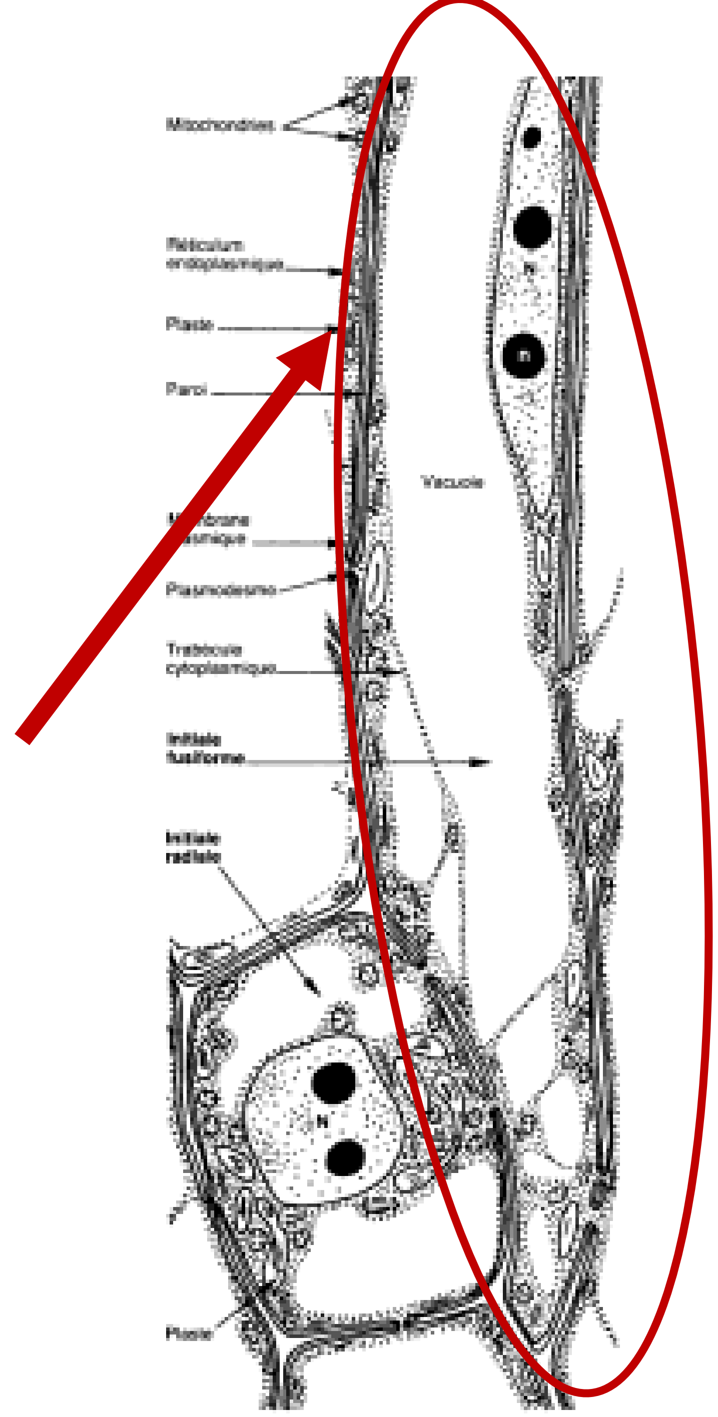
The **cambium** thus allows the central cylinder to expand.



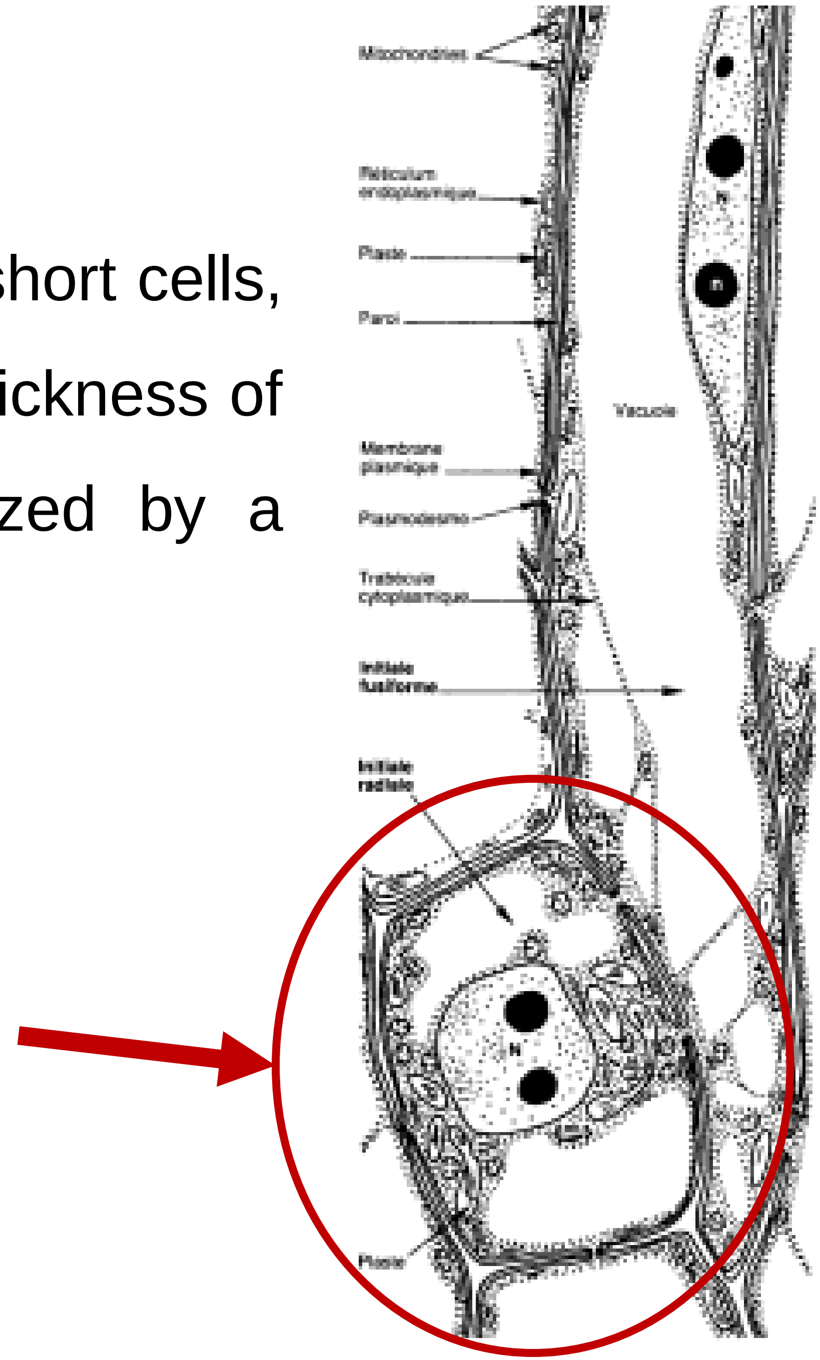
Cytological characteristics of the cambium

The **cambium** contains two types of cells:

1. Fusiform initials (90%): Are elongated, spindle-shaped cells arranged in a radial file in the direction of the organ axis, with a primary wall rich in plasmodesmata. These cells have a lenticular nucleus, a well-developed vacuole, proplasts, dividing mitochondria, cytomembranes and ribosomes.



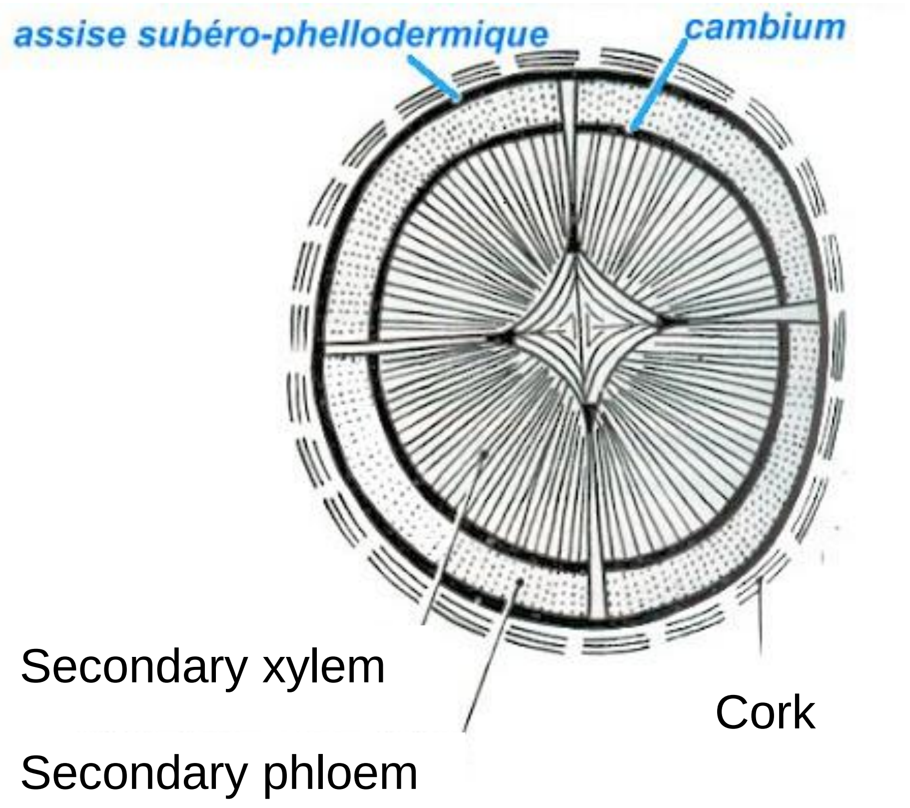
2. Radial initials (at 10%) : Are short cells, arranged in the direction of the thickness of the organ. They are characterized by a rounded central nucleus.



In the **cambial zone**, there are 3 types of division :

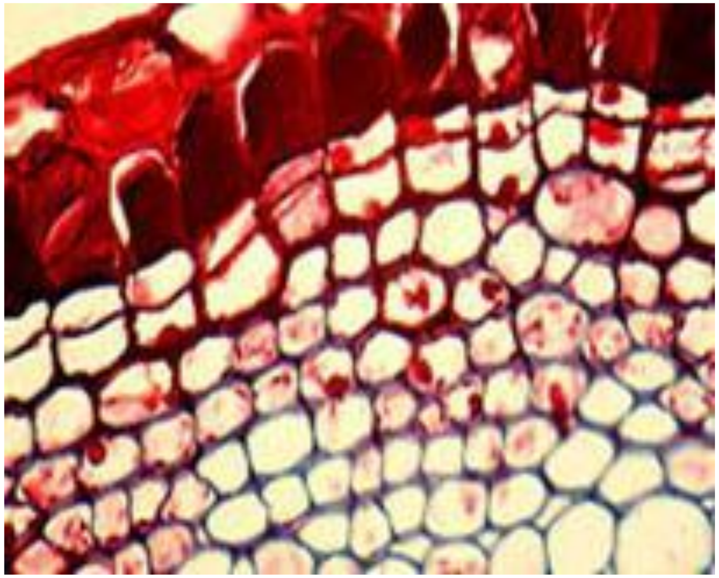
- **Periclinal (or tangential) divisions:** Represent 90% of cambial mitoses giving rise to wood and bast. They concern the spindle-shaped initials.
- **Anticlinal (or radial) divisions:** These increase the cambial circumference by producing wood and bast. They concern radial initials.
- **Transverse divisions:** These allow new rays to form the horizontal parenchyma. Found in both types of initials.

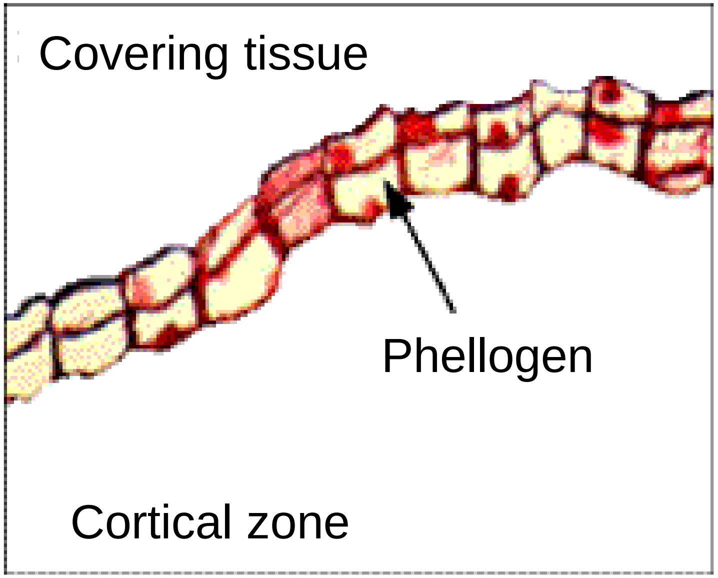
The **cambium** appears within the primary vascular elements of the central cylinder. It produces, often in abundance, new conducting elements: secondary xylem and phloem.



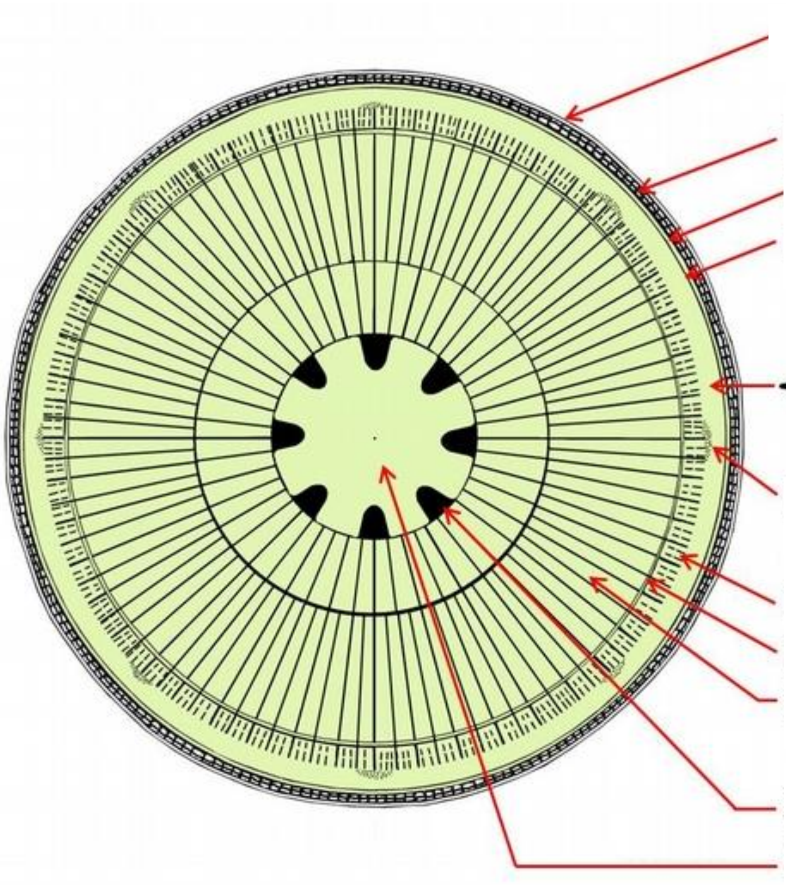
b. The phellogen

- This is a **generative base of phelloderm containing suber** matter, it is present in the cortex of older parts of stems and roots (in angiosperms and Gymnosperms).





On the outside, the phellogen produces a secondary covering tissue called **suber (or cork)**, and on the inside, a small amount of secondary parenchyma which is the phelloderm with a reserve accumulation function.



2. Secondary Conductive Tissues

a. Introduction

- These tissues conduct the plant's sap;
- They originate from the secondary meristems (or cambium);
- These tissues are present in the older organs of gymnosperms and dicotyledonous angiosperms (stem, leaves and roots).
- These tissues are highly developed in the woody stems of Gymnosperms and Dicotyledonous Angiosperms forming "wood".

- The cambium gives rise to two secondary conductive tissues : *Wood and Liber*
- The cambium functions asymmetrically in the stem and root:

- **Wood** differentiates centripetally (towards the center of the plant organ: stem, root or leaf)

- The **bast (liber)** differentiates centrifugally (towards the periphery of the plant organ: stem, root or leaf);

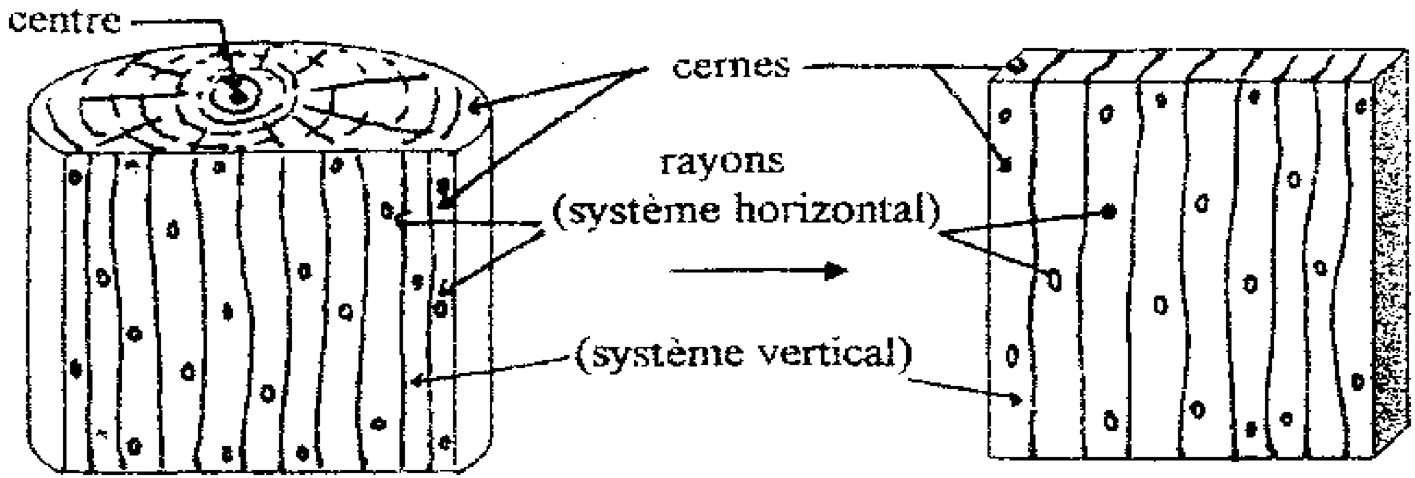
Note: The wood occupies a larger part of the plant than the bast.

The secondary conductive tissues of stems and roots can be studied from 3 cross-sectional planes:

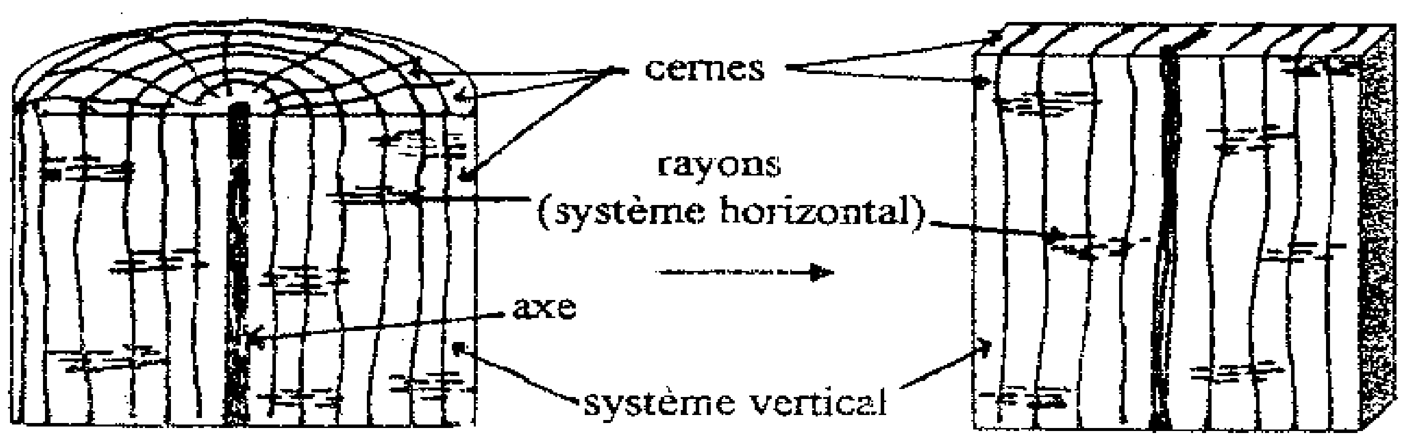
1. Tangential plan

2. Radial plan

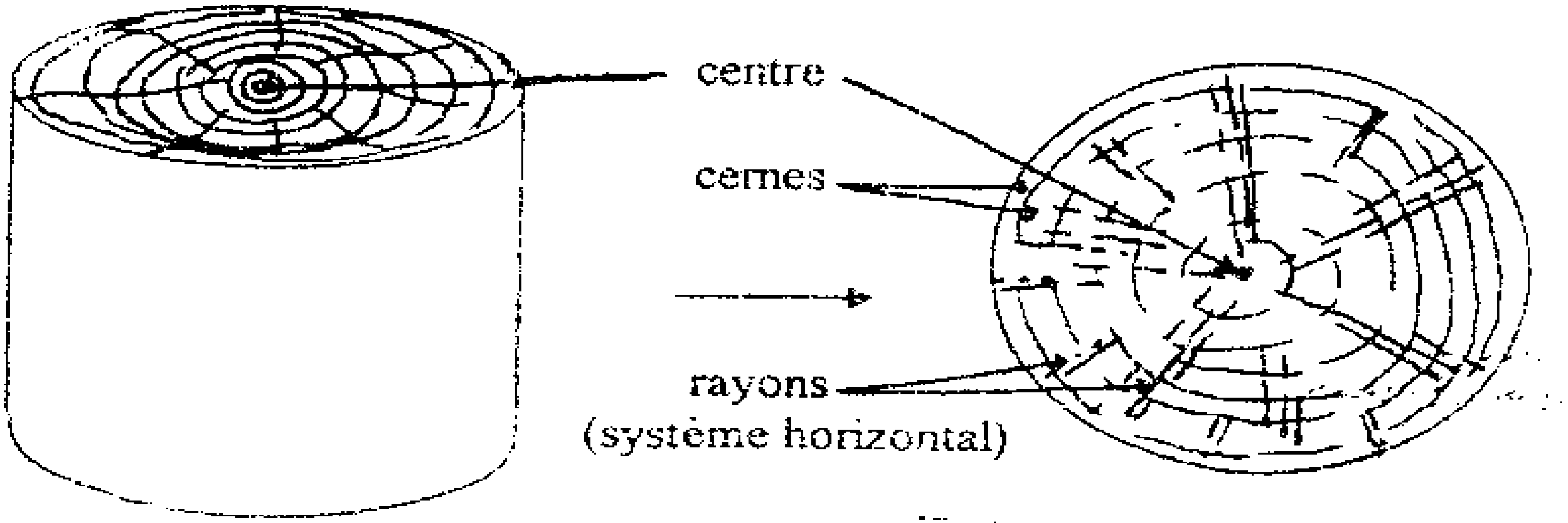
3. Transverse plan



1. Tangential plan and longitudinal tangential sections



2. Radial plan and longitudinal radial sections



3. Transversal plan and transverse section

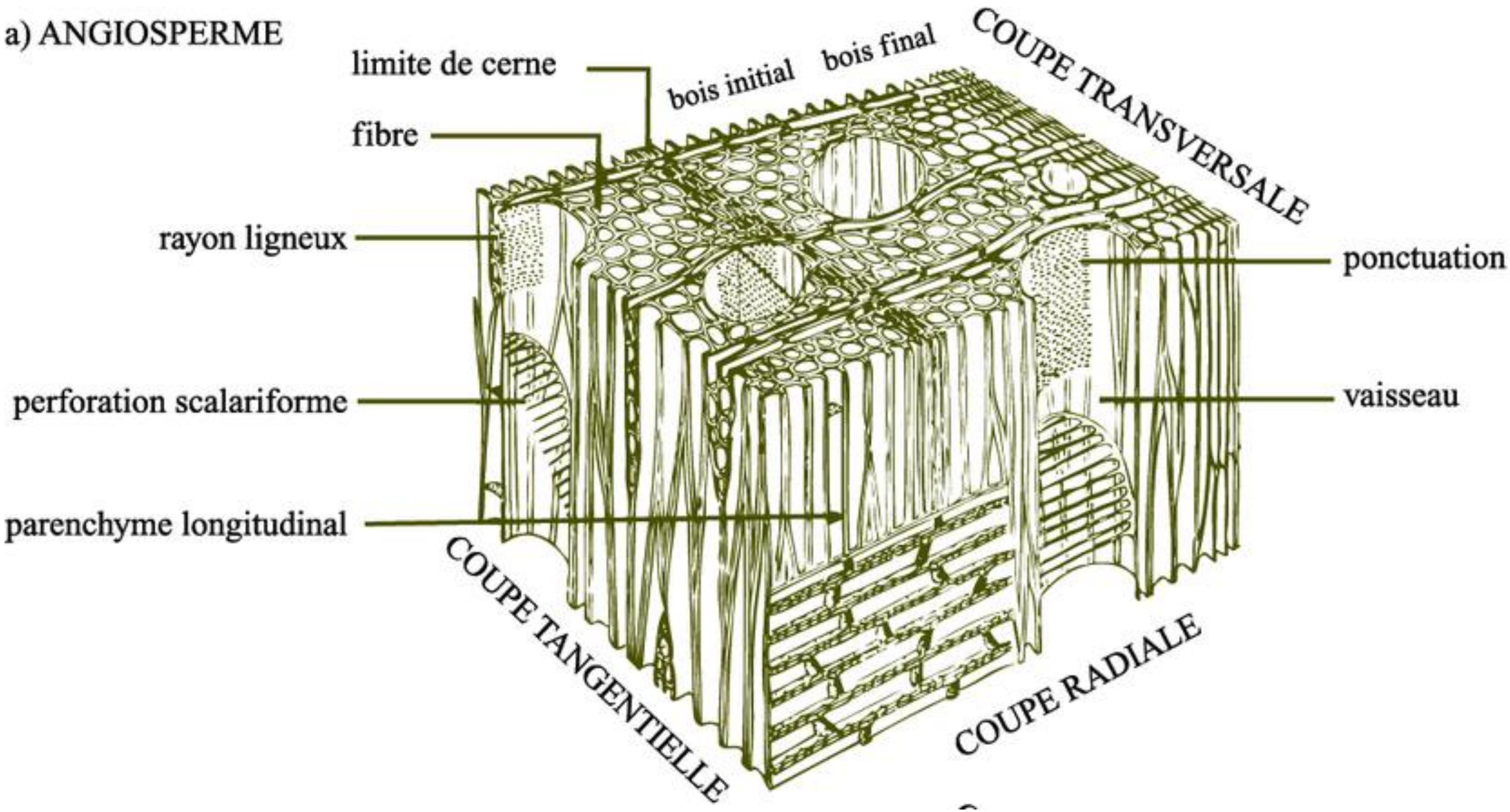


Diagram showing the three anatomical planes from which the woody structure of angiosperms can be observed.

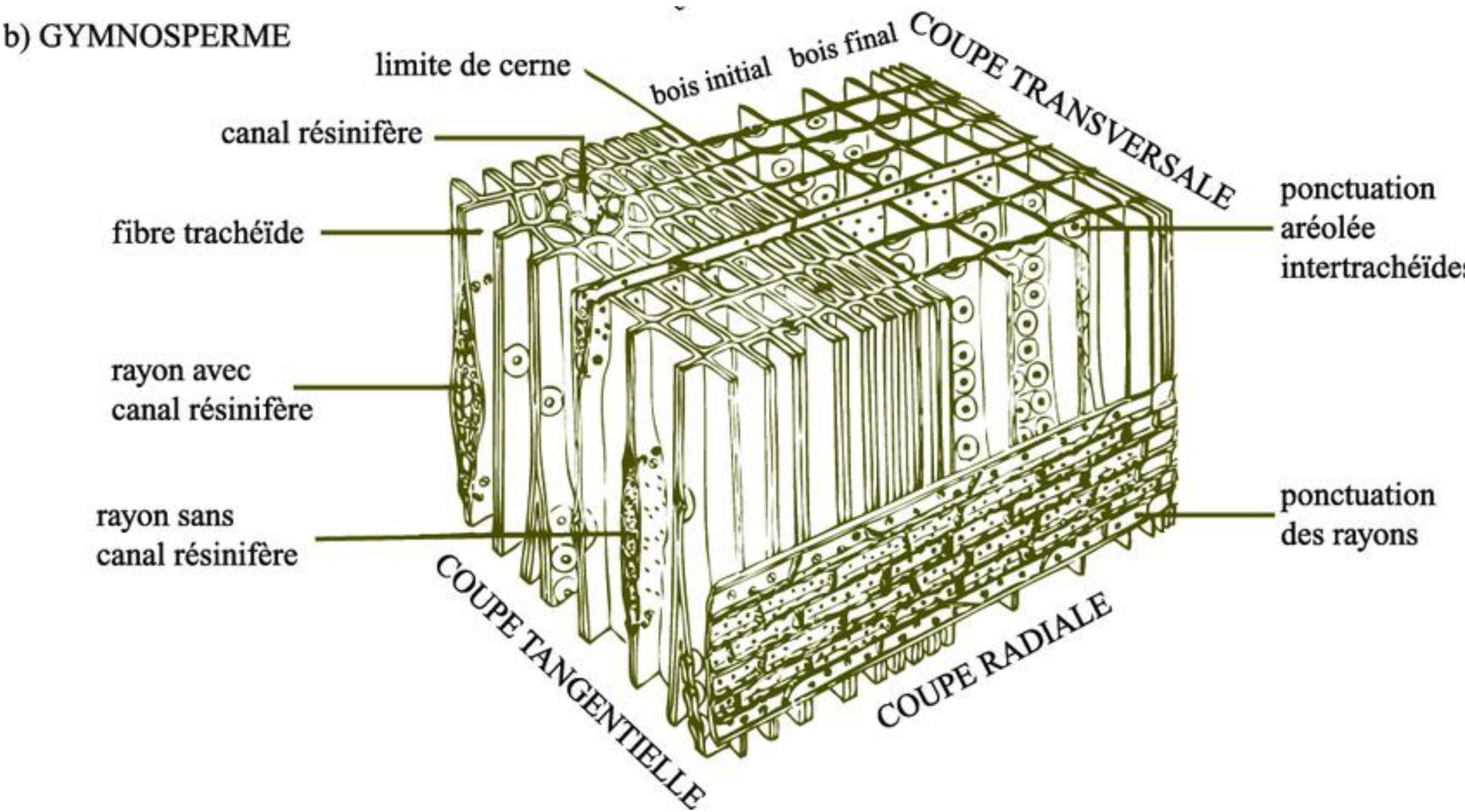


Diagram showing the three anatomical levels from which the woody structure of gymnosperms can be observed.

b. Wood

Wood is also known as secondary vascular tissue or secondary woody tissue. It is a tissue that conducts raw sap.

a. Wood is composed of conductive and non-conductive elements.

Wood composition in gymnosperms and dicotyledonous angiosperms

BOIS			
1.Eléments conducteurs		**2.Eléments non conducteurs**	
Gymnosperm	Angiosperm dicotylédon	Gymnosperm	Angiosperm dicotylédon
-Tracheid areolated: Obtained by DPIF)	**- Vessels** Obtained by DPIF)	**-Parenchyma ligneux horizontal** (Obtained by DPIR)	**-Vertical ligneous parenchyma** **(**Obtained by DPIF) **-Horizontal woody parenchyma** (Obtained by DPIR) **-Wood fibre** **(**Obtained by DPIF)

Types of cambium division :
DPIF: Periclinal division of fusiform initials
DPIR: Periclinal division of radial initials

C. Cork (=liber)

- The **liber** is also called secondary sieve tissue.
- It is a tissue that conducts the elaborated sap and is added to the phloem.
- As the phloem, the liber is composed of conductive and non-conductive elements.

Composition of the **cork** in gymnosperms and dicotyledonous angiosperms

cork			
Conductive elements		**Non-conductive elements**	
Gymnosperm	Angiosperm dicotyledon	Gymnosperm	Angiosperm dicotylédon
-Sieve cell Obtained by (DPIF)	**-Sieve Tube** Obtenu par (DPIF)	**-Contact cells** (albumen cells (Strasburger) cells)Obtained by (DPIF) **-Vertical cork Parenchyma** Obtained by (DPIF) **-Horizontal Liberian parenchyma** Obtained by (DPIR) **-Cork fibers**	**-Contact cells** (companion cells) Obtained by (DPIF) **-Vertical cork Parenchyma** Obtained by (DPIF) **-Horizontal cork parenchyma** Obtained by (DPIR) **-Cork fibers**

Types of cambium division :
DPIF: Periclinal division of fusiform initials
DPIR: Periclinal division of radial initials

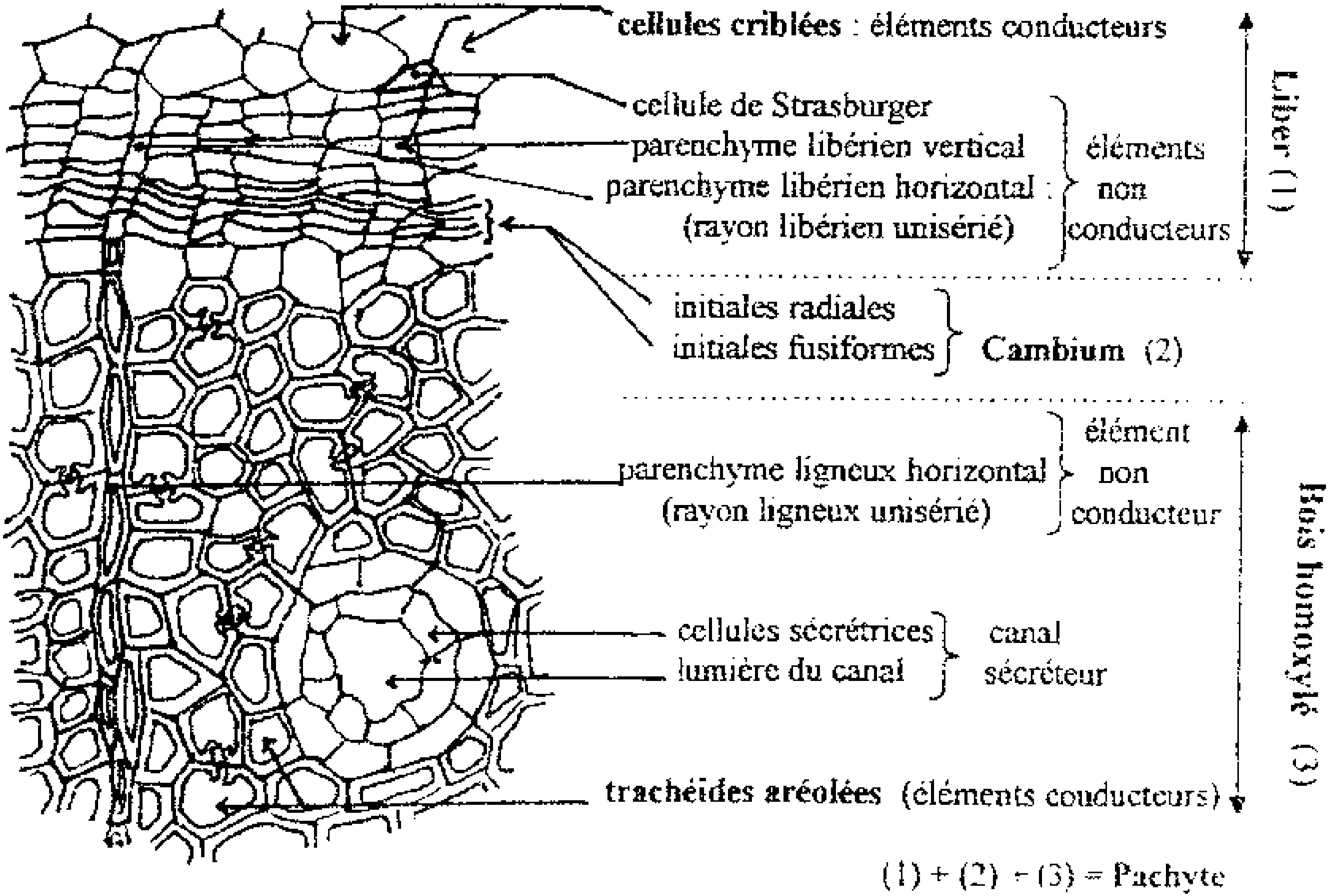
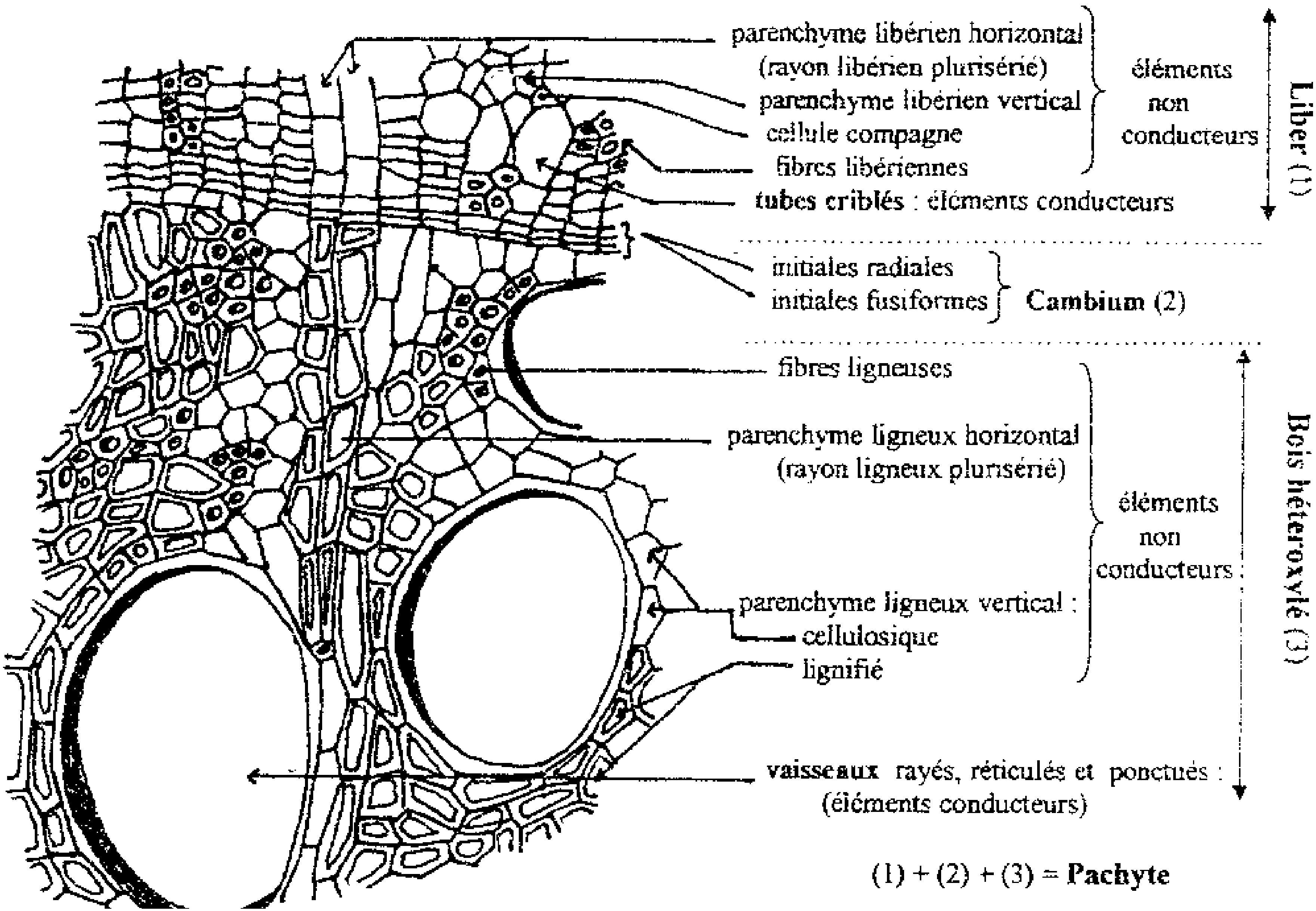
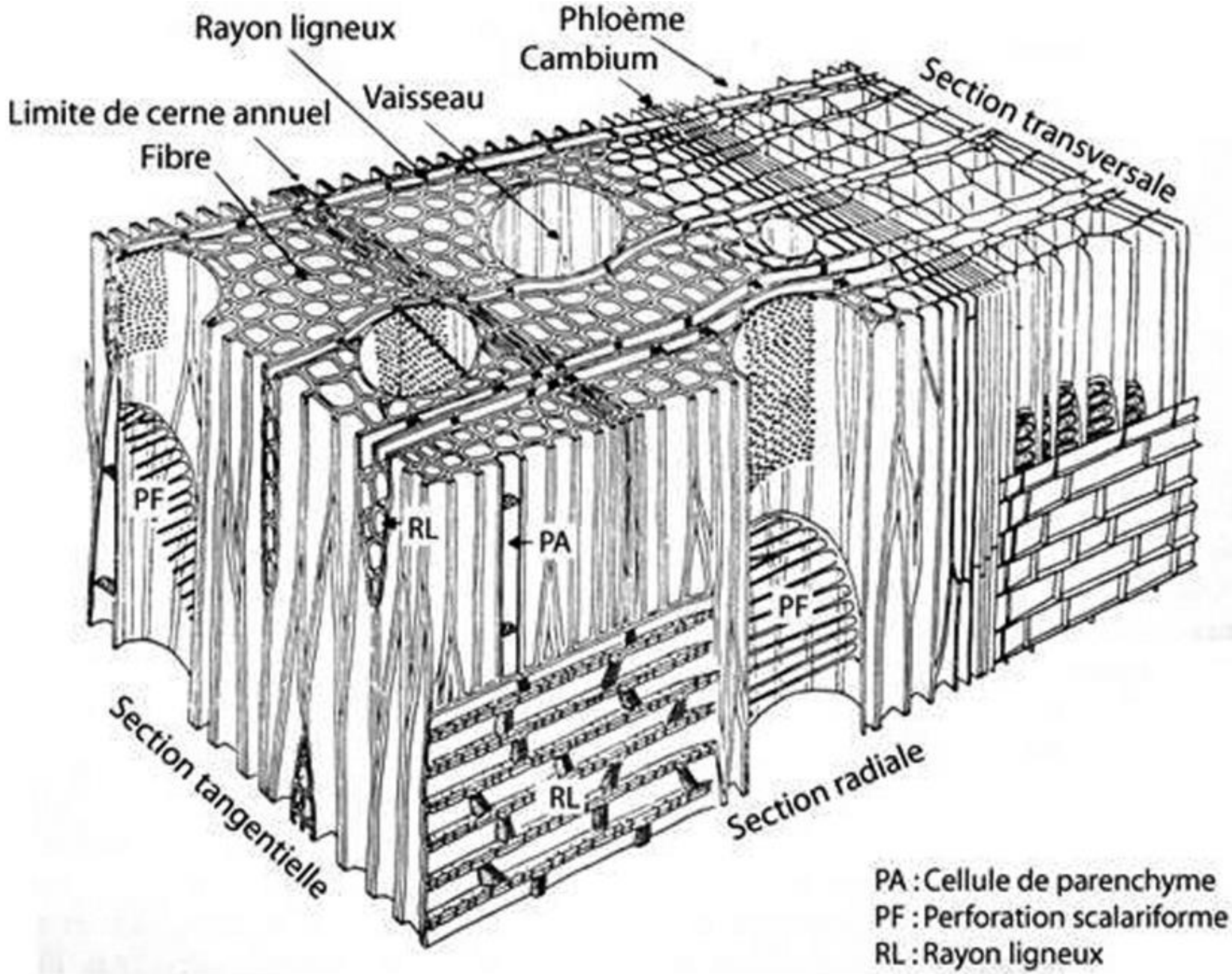


Figure 1. Coupe transversale d'une tige âgée de Pin (Gymnosperme) montrant le **bois homoxylé** et le **liber.**



Coupe transversale d'une tige âgée de mercuriale (angiosperme dicotylédone) montrant le **bois hétéroxylé** et le **liber**.



Rayon ligneux
Phloème
Cambium
Limite de cerne annuel
Vaisseau
Fibre
Section transversale
PF
RL
PA
PF
RL
Section tangentielle
Section radiale
PA : Cellule de parenchyme
PF : Perforation scalariforme
RL : Rayon ligneux

3. Secondary covering tissues (or secondary protective tissues)

1. Definition

- This is an impermeable, resistant covering tissue on the surface of stems and roots.

- This tissue is derived from the secondary sub-phellodermal meristem (phellogen) which, after differentiation, produces cells with sub-perforated walls, which are dead cells.

2. Origin

- In young stems, protection is provided by the epidermis;
- The **protective tissue of the young roots** of dicotyledons is the subereous base;
- The protective tissue of the young roots of monocotyledons is the suberoid.

2. Origin

- In **older stems** and **roots** (Fig. 1), the outermost layers are destroyed as a result of the increased thickness of the organs (stems and roots).
- During the **generation** of **suber** or cork by the phellogen, the cell walls undergo suberization and the cell contents degenerate, leading to cell death.

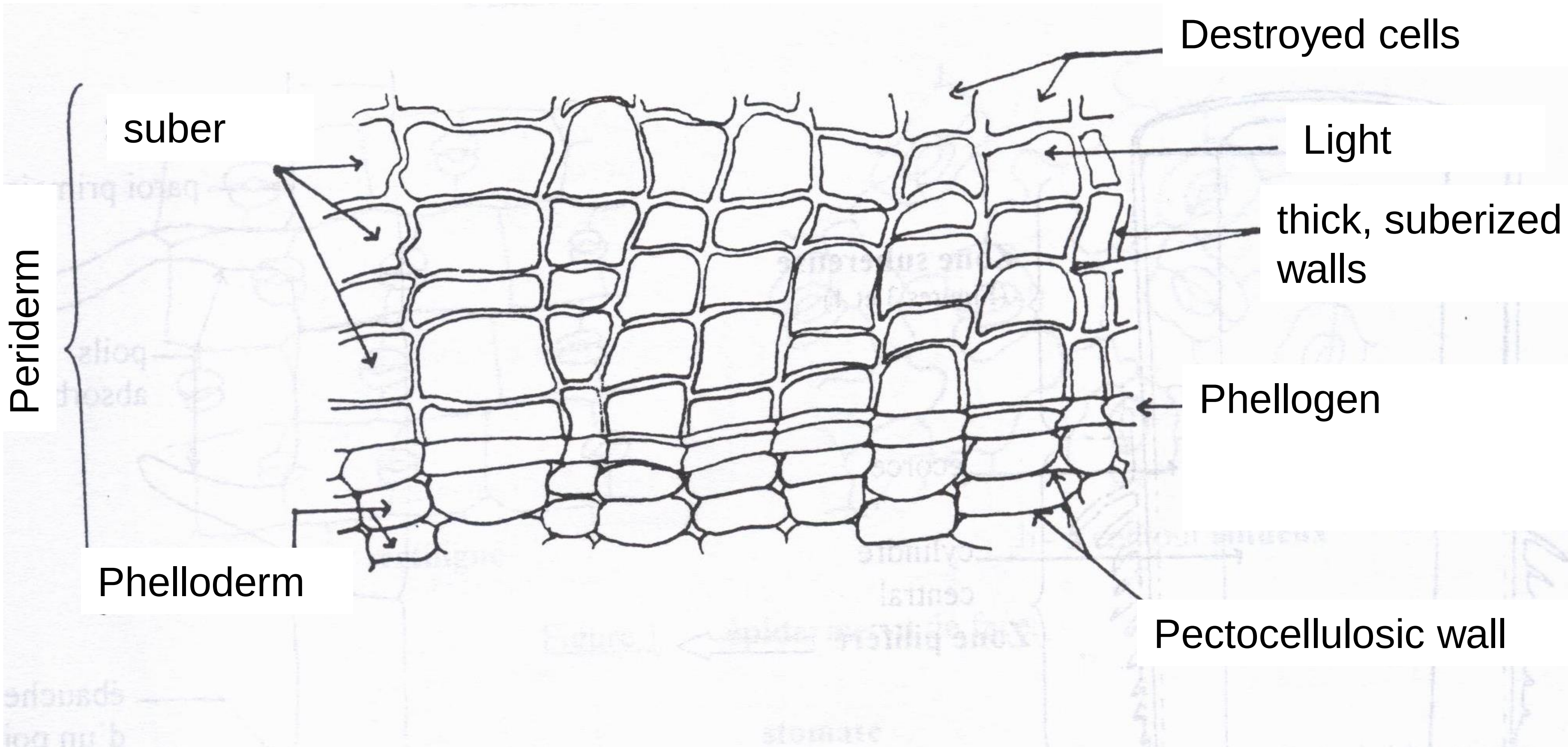


Figure 1. Periderm (suber, phellogen and phelloderm)

3. Lenticels

As the suber is impermeable, gas exchanges between the external environment and the internal tissues of an aged stem take place through button hole-shaped openings called **lenticels** (Fig. 2).

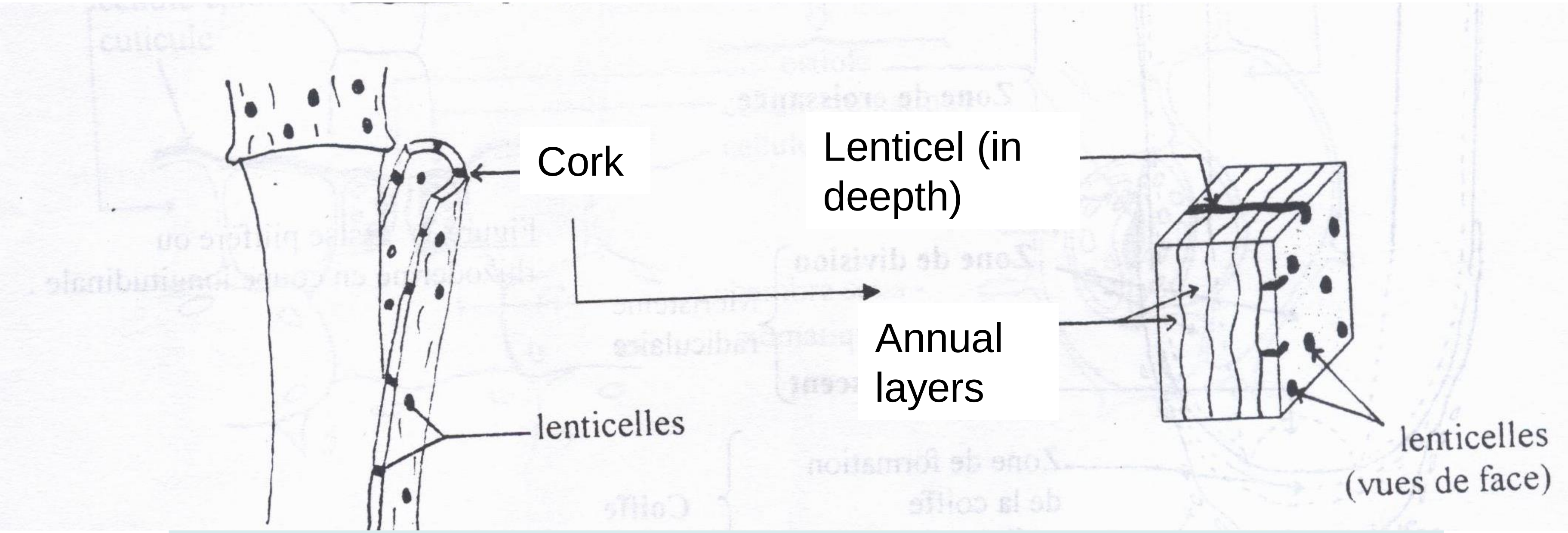


Figure 2. Schematic diagram of a cork oak trunk

3. Lenticels

They form a well filled with dead and suberized cells, which move apart, allowing gas to circulate between the interstices (Fig. 3).

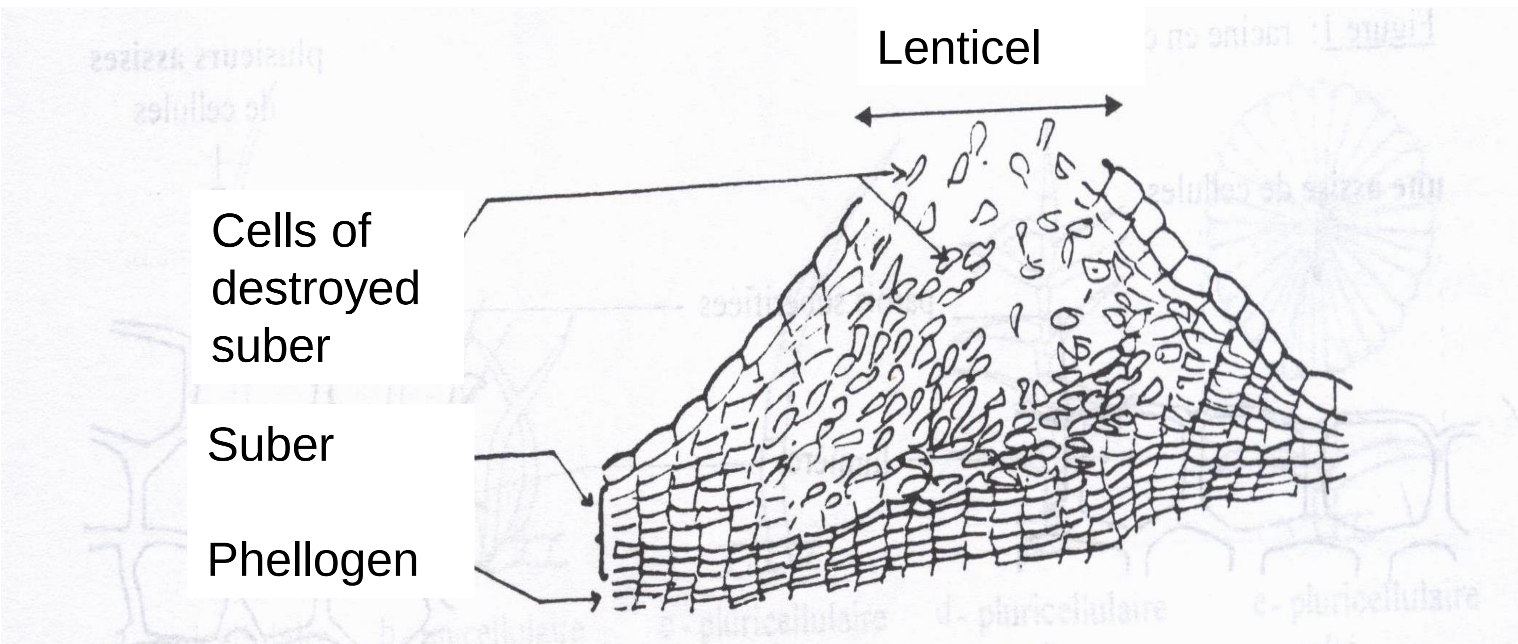


Figure 3. Cross-section of lenticels