

Lecture 5

Plant anatomy

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C- Vascular tissue systems: - It consists from the phloem and xylem which are called the conducting tissues (Xylem and phloem).

A- Xylem

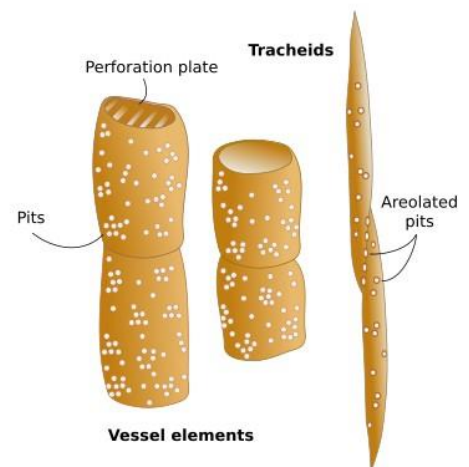
It is the principal water-conducting tissue in a vascular plant. It is also involved in the transport of solutes, in support and in food storage. Together with phloem forms continuous vascular system extending throughout the plant body. The vascular plants, also referred to as **tracheophytes**, the terms vascular plants and tracheophytes refer to the characteristic conducting elements of the xylem, the tracheary elements.

Cell types of the xylem:

1- Tracheids (Tracheary elements):- They are the conducting cells of the xylem which are thin, long tubes with tapering end walls to allow the maximum number of pit-pairs between consecutive cells, thickened with lignin and non-living at maturity, found in all plants.

Characters of Tracheids

- 1- It is the only tracheary component in pteridophytes, and gymnosperms.
- 2- They are containing lignin in their thick and hard secondary cell walls.
- 3- These cells lose their cytoplasmic contents during differentiation.
- 4- The secondary cell wall of the tracheary cells show a variety of thickenings that can be visualized with light microscopes, including annular, helical, reticulated, or dotted patterns. The kind of thickening depends on the developmental stage of the organ.
- 5- They are imperforate cells having only pit-pairs on their common walls. In



the most of tracheary elements, almost the entire inner surface of the primary walls is covered by secondary wall, except for pits.

2- Vessels:

They are contained from vessel members (elements) and connected end to end forming long vessels, they are connected end-to-end to form long tubes, referred to as vessels. Water is conducted through within the cells, and it crosses from one cell to the next through the perforation plates (perforations (which are areas lacking both primary and secondary walls through which the vessel elements are interconnected).

A perforation plate may have

- **Simple perforation plate:** it is single perforation.
- **Multiple perforation plate:** are several perforations.

The perforations in a multiple perforation plate may be:

A- Scalariform: ladder which are elongated and arranged in a parallel series.

B- Reticulate: or in a reticulate manner.

C- Foraminate: or as a group of approximately circular holes.

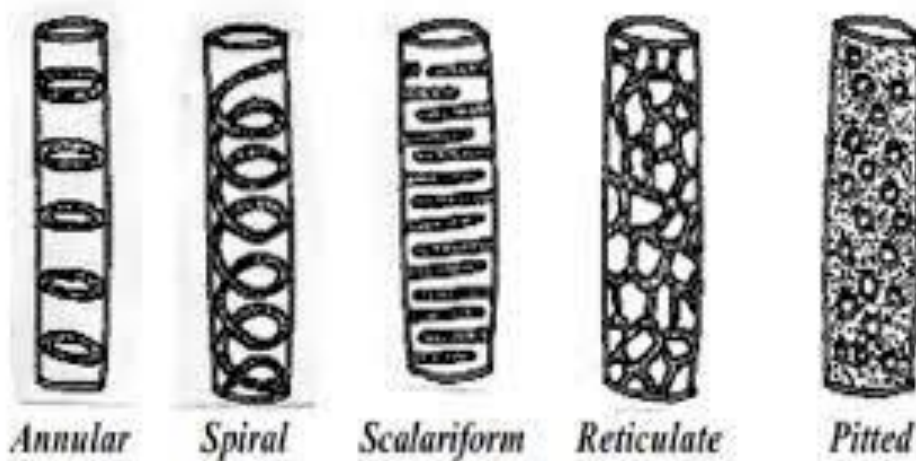


Fig. Types of secondary wall thickenings in tracheids

Vessel elements	Tracheids
Main conducting cells of angiosperms	Main conducting cells of gymnosperms and ferns
Short cells arranged in rows forming large tubes	Long cells with overlapping ends
Large inner diameter and thinner cell walls	Small inner diameter and thicker cell walls
Small and abundant pits	Large and less abundant pits
Perforated plates	No perforated plates
Higher efficiency in water conduction	Lower efficiency in water conduction

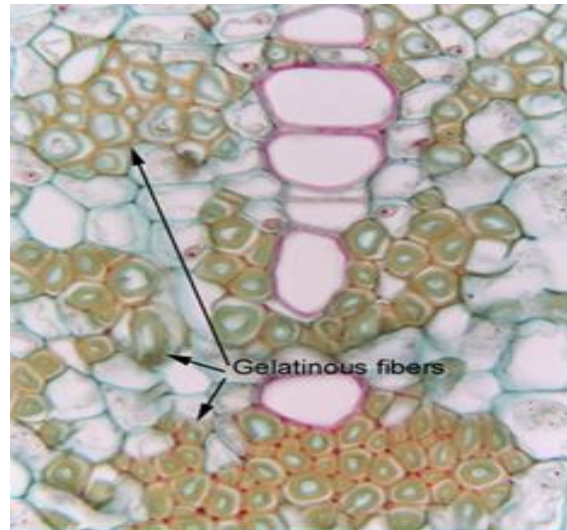
3- Fibers:

The fibers are long cells with secondary, commonly lignified walls. The walls vary in thickness but are usually thicker than the walls of tracheids in the same wood.

a) Fiber-tracheids: They have bordered pits with cavities smaller than the pit cavities of tracheids or vessels in the same wood. These pits have a pit canal with a circular outer aperture and an elongated or slit-like inner aperture.

b) Libriform fibers: It usually resemble phloem fiber, has thick walls, simple pits which have slit-like aperture toward the cell lumen, longer than fiber tracheids.

c) Gelatinous fibers: They are a modified type of fibers which found in the secondary xylem of dicot. In these fibers, the innermost layer of the secondary wall contains much alpha cellulose and is poor in lignin, this layer termed as G-layer, absorbs much water and may swell so as to fill the entire lumen of the fiber.



(Transverse section of root of lupine (*Lupinus*). The large cells with red walls are vessel elements, the smaller cells with thick greenish-yellow walls are gelatinous fibers).

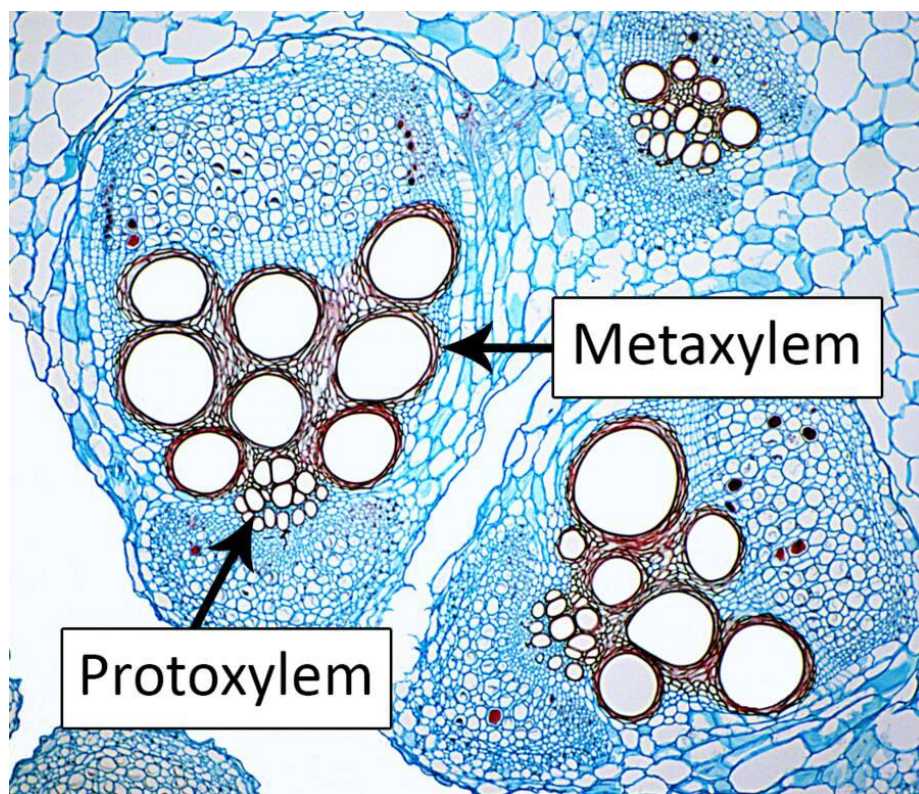
4- Xylem parenchyma:

They are responsible for most of the storage function of xylem, many of them have secondary lignified walls, particular in wooden plants. In other cases, these cells have thin primary walls with areas of plasmodesmata called **primary pit fields**, through which cell to cell movement of water and mineral nutrients can take place. Mature xylem parenchyma cells in active xylem tissue retain functional protoplasm and can store carbohydrates in the form of starch, these cells play an important role in wound healing by forming callus and can differentiate to regenerate functional xylem cells.

*****Primary Xylem:** The primary xylem is the initial form of xylem that arises during the formation of an organ in the plant. First, it is protoxylem, followed by the metaxylem. The protoxylem is developed from the procambium meristem during the growth of organs. The protoxylem fully matures and disappears later due to the compressive mechanical forces produced by the growth of the organs. The xylem in primary growth is composed of protoxylem and a later formed part, the metaxylem.

1- Protoxylem:

It differentiates in the parts of the primary plant body that have not completed their growth and differentiation like in the stem and leaf but usually matures before these organs undergo intensive elongation. It occupies particular position in the primary vascular system of plant organ, its consist of tracheids, vessels and parenchyma while the fibers being usually absent. In stem it occurs near the pith while in root its located farthest from the center. The primary cell wall of its cells are of cellulose while secondary materials are deposited in form of annular and spiral thickenings. The protoxylem elements are narrower than the metaxylem. The secondary wall of conducting cells of the protoxylem (vessel elements and tracheids) initially shows annular thickenings that later become helical.



2- Metaxylem:

It commonly begins to differentiate in the still growing primary plant body, but matures largely after the elongation is completed. It is therefore less affected by the primary extension of the surrounding tissues than the protoxylem. When tracheary elements destroyed, they remain thin walled or become lignified, with or without the deposition of secondary walls. The metaxylem appears after the protoxylem, when the organ enlarges and matures once the growth begins to slow. It also arises from the procambium. Their cells show larger diameters than those of the protoxylem, and the cell walls of the conducting cells have reticulated thickenings first and perforated thickenings later. The metaxylem is the mature xylem in those organs that don't go through secondary growth.

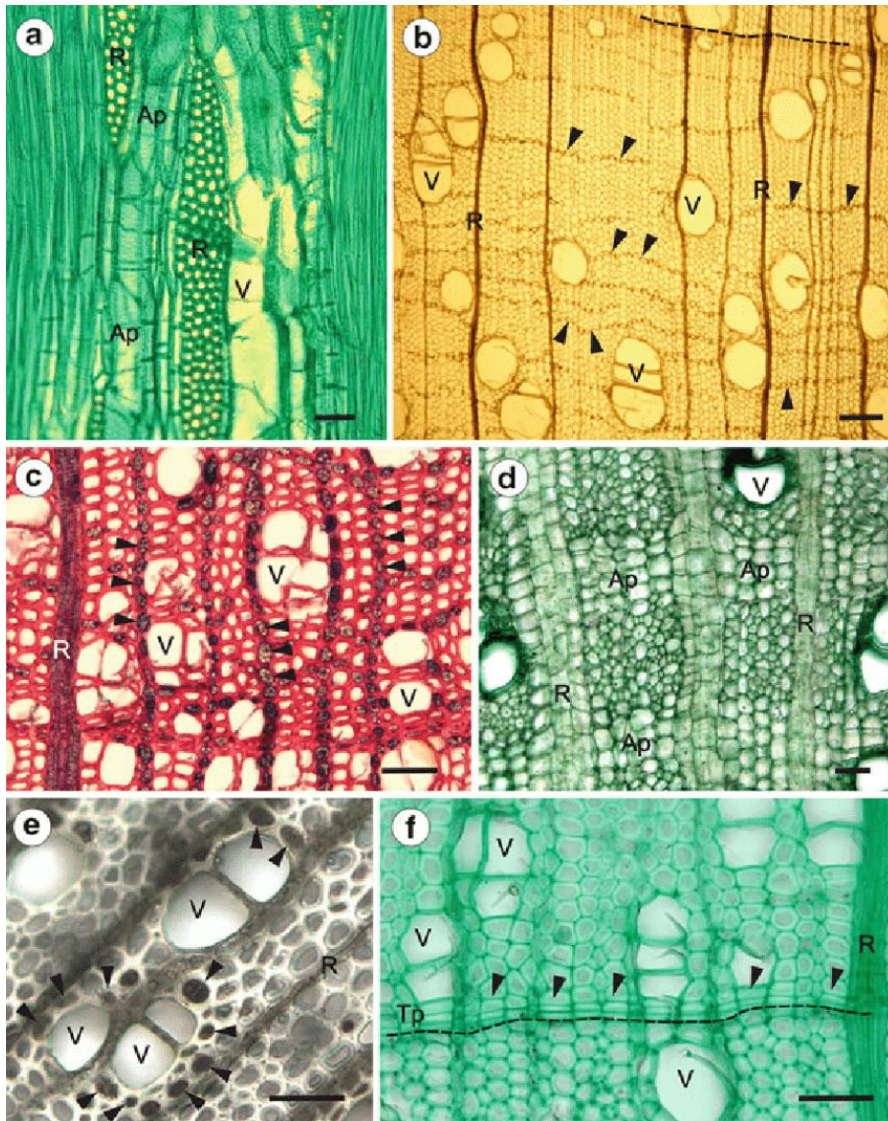
Characteristics of metaxylem:

- 1-Its tracheary elements are generally wider and retaining their protoplasts after primary growth is completed.
- 2- In addition to tracheary elements and parenchyma cells, the metaxylem may contain fibers.
- 3- The parenchyma cells may be dispersed among the tracheary elements or may occur in radial rows.

***** Characters of Wood (Secondary xylem): -**

- 1- Secondary xylem is made up of an **axial system** of longitudinally oriented cells, derived from the fusiform initials of the vascular cambium and a **radial system** consisting of rays derived from the ray initials of the vascular cambium.
A- In gymnosperms the axial system consists of tracheids and axial parenchyma and in many conifers resin ducts also develop as part of both the axial and radial systems.

In angiosperms the axial system consists of tracheids, fibers, vessel members, and axial parenchyma. Secretory ducts as well as secretory cavities also occur in some angiosperms and contain, in different species, a variety of substance.



The axial system of xylem parenchyma in angiosperms. Ap axial parenchyma, R xylem ray, Tp terminal parenchyma, V vessel

It is mainly composed of tracheary elements (tracheids , vessels, fibers, both of which have highly thickened secondary cell walls and xylem parenchyma also forms a minor component.

2- Fibers have thick and uniformly deposited walls to provide support and protection.

Gymnosperm wood (conifer and Ginkgo wood)

In conifer woods (and gymnosperms generally), the **axial** water conducting system is composed largely of:

1- Tracheids (imperforate cell involved in water transport, i.e. with intact pit membrane between it and adjacent cell).

2- The torus (a central thickening on the pit membrane) which is characteristic of tracheid pits in conifers.

3- Thickened areas between the pits termed bars of **Sanio**. These are characteristic of conifer wood.

4- There are no vessel elements.

5- Fibers are not normally found in conifer woods; if present, they run alongside the tracheids, axially.

6- Axial parenchyma cells are rare; the cells are narrow, elongated axially, are situated alongside the tracheids, and have square end walls.

***Angiosperm wood:**

1-The cell types of dicot wood include vessel elements, fibers and parenchyma cells.

2- Tracheids are rare in dicots, but occur in some species such as oaks and chestnuts.

3- Two types of fibers are common in dicot wood: fiber tracheids and libriform fibers, fiber tracheids have thick walls with bordered pits.

4- The intercellular spaces or ducts in angiosperm woods contain secondary plant products such as gums and resins. They occur in both the axial and the radial

systems.

***Classification of angiosperm woods according to porosity:**

The word porous is used by the wood anatomist to refer to the appearance of the vessels in transverse sections:

1- **Diffuse-porous woods:** are woods in which the vessels, or pores, are rather uniform in size and distribution throughout a growth ring.

2- **Ring-porous woods:** the pores of the early wood are distinctly larger than those of the latewood, resulting in a ring-like zone in the early wood. The ring-porous condition appears to be highly specialized and occurs in relatively few woods, most being species of the north temperate zone.

***Growth Rings:**

It is resulted from the periodic activity of the vascular cambium which is a seasonal phenomenon in temperate regions related to changing day lengths and temperatures, produces growth increments, or growth rings in the secondary xylem. There are types of growth rings:

1- Annual ring:

It such a growth layer represents one season's growth.

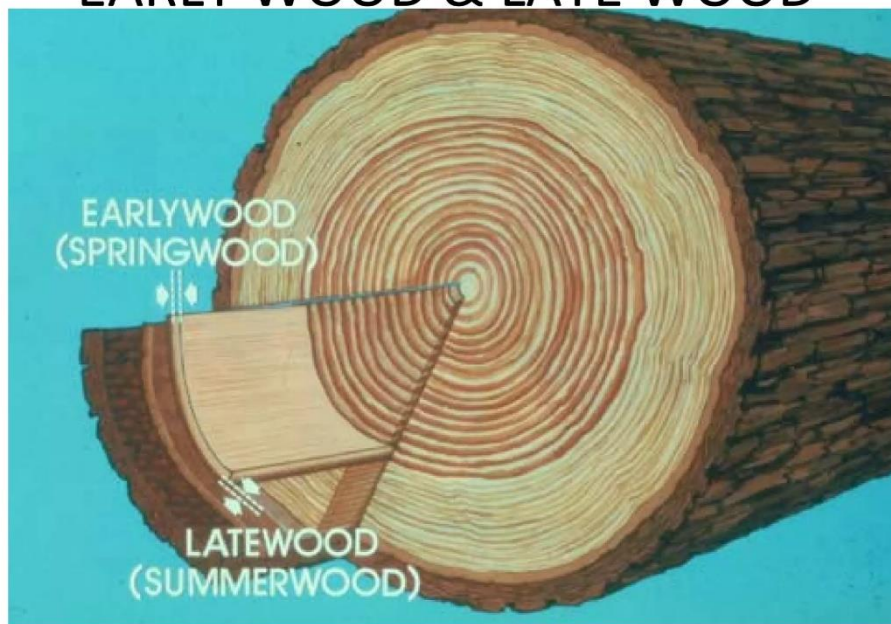
2- False annual ring:

It is additional ring in a given year which produced either by changes in available water and other environmental factors or injuries by insects, fungi, or fire. False annual ring and the annual growth rings consisting of two or more rings is termed a multiple annual ring. Sometimes, it is difficult to judge the age of such trees as in very suppressed or old trees the lower portions of the stem or of some branches may fail to produce xylem during a given year. Thus, the estimation of age may be inaccurate as some rings are "missing" or if false annual rings are present. Trees that exhibit continuous cambial activity, such as those in wet tropical rainforests, may lack growth rings entirely.

***Heartwood and sapwood:**

Heartwood: It is darker part of the woody stem filled with resinous materials and polyphenols, this happens after a variable number of years, cavitation occurs in most of the vessels and tracheids and the rest of the xylem cells in the growth ring die resulting to this while the outer water-conducting part of the stem is called **sapwood**. In many species, as sapwood is converted to heartwood, air-filled vessels in the sapwood are often sealed off by the intrusive growth of surrounding parenchyma cells. These intrusions are called **tyloses** and together with the resinous materials, serve to prevent fungal growth.

EARLY WOOD & LATE WOOD



Sap wood (Alburnum)	Heart wood (Duramen)
It forms outer wood of an old stem.	It forms the central wood of an old stem.
It is light –coloured.	It is dark –coloured.
It is lighter in weight.	It is heavier.
It contains living cells.	Living cells are absent
It is the functional part involve in ascent of sap	It is dead and non functional part.
Tyloses are absent	Tyloses are present