SECONDARY GROWTH

Apical meristem forms the permanent internal structure of organs. This structure is completed within a few weeks of the first year. This is called **primary growth**.

Secondary Growth:

- Increase in the girth of the plant organs due to the formation of secondary tissues in stelar & extra stelar regions by the activity of secondary lateral meristems (cambium and cork cambium) is called secondary growth. Normally secondary growth takes place in roots and stem of dicotyledons and Gymnosperms.
- Due to lack of cambium in monocotyledons, secondary growth is absent. But exceptionally secondary growth has been reported in some monocotyledons. Such as Palm, Yucca, Dracaena, Smilax, Agave, Coconut etc.

Secondary growth in dicot stem:

(I) Intra Stelar Secondary growth:

• The growth in this region starts earlier than extra stelar region.

Formation of ring of vascular cambium:

- A cambium that lies inside the vascular bundle is called **intrafascicular cambium**.
- This is a type of primary meristem.
- Firstly the parenchymatous cells of medullary rays in the line with intrafascicular cambium becomes meristematic and develop a new cambium called as interfascicular cambium, which is secondary lateral meristem.
- Intrafascicular and interfascicular cambium are joined to form vascular cambium.
- The latter is formed in the form of a complete ring composed of single layer of cells.
- In diocot stem some part of vascular cambium is primary and some part is secondary.

Two types of cells are found in the ring of this vascular cambium.

(i) Fusiform initials (form secondary xylem and phloem)

(ii) Ray initials (form secondary medullary rays)

Fusiform initials are long with pointed ends, while ray initials are spherical. Activity of fusiform initials is more in vascular cambium.

Activity of vascular cambium:

(a) Activity of fusiform initials:

- Periclinal divisions occur in fusiform initials, as a result few cells are formed towards the radius (periphery) differentiated into secondary phloem or bast and some of the cells are formed towards the central axis and these cells are differentiated into secondary xylem or wood.
- Secondary xylem is formed 8-10 times more as compared to sec. phloem.
- By the pressure of secondary phloem, primary phloem is pushed towards the outside and gets crushed.
- Primary xylem however remains more or less intact, in or around the centre.



Annual ring or Growth rings:

- In temperate regions the cambium is more active in spring, hence more xylem is formed.
- It is called spring wood.
- Spring wood mainly has vessels having broad lumen, less thickenings and light in colour (having lower density).
- In autumn, generally the cambium is comparatively less active or inactive. Less xylem is formed.
- Xylem of this season has more thickening with small lumen and it is dark coloured (having higher density).
- This xylem contains more fibre. It is called as autumn wood.
- Spring wood is also called early wood and autumn wood as late wood.
- Spring wood and autumn wood look different from each other and are present in concentric rings.
- These two rings together called **annual rings**.

Wood can be classified in to various types

A. Depending upon the nature of xylem elements. Wood is of two types.

(i) Heart wood

(ii) Sap wood

- After a few years of secondary growth, the central part of xylem becomes dark coloured whereas the peripheral part becomes light coloured.
- The dark coloured, central xylem (wood) is called heart wood and light coloured, peripheral xylem (wood) is called sap wood.
- The heart wood is non-functional because their elements get blocked due to the deposition of various organic substances like oil, gum, resins, tannins, volatile oil etc. and are unable to do the function of conduction.
- Heart wood is very hard and resistant to the harmful effects of bacteria, fungi and moisture.
- Heart wood is also called as duramen while the sap wood is also known as alburnum. Sapwood performs conduction of water & minerals.
- The bladder like ingrowth of parenchyma cells which enter the lumen of vessels (mainly) & tracheids through the pits in their wall. These are called as tyloses (AIPMT-2016).
- Tyloses blocks the conduction of water. In gymnosperms tylosoids are formed in place of tyloses.
- If the heart wood is destroyed in any stem, then there will be no effect on plants (any vital function is not effected), but if the sap wood is destroyed, then the plant will die due to blocking of conduction of water.
- Heart wood provides stiffness to the stem.
- The waste materials of heart wood are antiseptic in nature. Heart wood has a power of repelling insects.
- So it is resistant to the termites and in rainy season it does not imbibe water.
- Thus it is the best quality of wood. It is use in manufacturing furniture.

(II) Secondary growth in extra stelar region:

- It occurs due to the activity of cork cambium.
- The latter is also known as Phellogen or Extrastelar cambium. (The cells of the cork cambium are rectangular).
- Cork cambium usually originates from the outer layer of cortex because the latter becomes meristematic.
- Cork cambium is formed in the form of a **single layered ring**.
- It forms sec. tissue in cortical region.
- It divides periclinally & forms some cells towards the outside (epidermis) and some cells towards the inside (cortex).
- Those cells formed towards outside are dead due to deposition of suberin in their middle lamella.
- These cells are called Cork or Phellem.
- Those cell formed towards inside are differentiated into parenchyma and may contain chloroplasts.
- These are called secondary cortex or Phelloderm.
- Phellogen, phellem and phelloderm are collectively called periderm.
- Phellogen (cork cambium) + Phellem (cork) + Phelloderm (secondary cortex) = Periderm.
- The highest activity of cork cambium is in winter (Autumn) season.
- Ring of cork cambium remains living only for one year.
- Each year, a new cork cambium is formed below the previous cork cambium.
- This new cambium is derived from the secondary cortex or phelloderm.

Lenticels:

- Lenticels occur on the outer surface of the plant either in small points or in the form of areas of protuberance most of the cells of phellem are dead.
- But at some places living cells are also found.
- Suberin is not deposited in these places.
- These places are known as Lenticels.
- Lenticels are made up of scattered group of **living cells**.
- These cells are known as complementary cells or filling cells.
- Lenticels are found in most of the woody trees, fruits but absent in woody climbers & leaves.



If lenticels are blocked then root will die first due to lack of oxygen.

Function:

- Lenticels perform exchange of gases between plant and atmosphere.
- Transpiration is also performed by the lenticels that is called lenticular transpiration.

Bark:

- All the tissues formed outside the vascular cambium (phloem, pericycle, cortex and periderm) is called bark.
- The dead tissue present outside the cork cambium is generally called **outer bark** & phloem, pericycle and secondary cortex is called inner bark.
- Sometime outer bark is made of combined dead cell layers of periderm.
- All the dead tissues formed outside the inner most cork cambium (cork & many periderm) is called Rhytidome.
- Rhytidome includes cork and tissues which become dead due to the pressure of cork.

Secondary growth in dicot root:

Conjunctive tissue becomes meristematic below phloem bundles and form separate curved strips of vascular cambium during the secondary growth in a dicotyledon root.



- Now the cells of pericycle lying opposite to protoxylem also becomes meristematic to form additional strips of cambium.
- In this way a complete ring of vascular cambium is formed due to joining of these two.
- The shape of ring of vascular cambium is wavy in the beginning, but later on it becomes circular due to the pressure of secondary xylem.
- The activity of vascular cambium of root is similar as activity of vascular cambium of stem.
- Vascular cambium forms secondary xylem towards the inner side and secondary phloem towards the outer side.
- The portion of vascular cambium which is formed by pericycle is responsible for the formation of pith rays. These are made up of parenchyma. These pith rays are known as primary medullary rays (Multiseriate).
- A few medullary or pith rays are also formed from remaining vascular cambium. These are called secondary medullary rays (uniseriate). Thus two types of medullary rays are found in the secondary structure of roots.

- Annual rings are bands of secondary xylem and xylem rays. Each annual ring shows the growth of one year. Thus by counting the number of annual rings, at the base of main stem of plant we can calculate the age of the plant. This branch of science is called **dendrochronology**. Now a days increment borer, an apparatus is used to calculate the annual rings.
- 2. In tropical regions, the cambium is almost equally active throughout the year, thus there is no distinction like spring & autumn wood. The whole wood consists of uniform xylem elements, thus no annual rings are found. e.g. Chennai, Mumbai.
- **3.** More distinct annual rings are formed in **temperate deciduous** plants. In deserts annual rings are less distinct.
- 4. The secondary xylem formed during secondary growth is called **wood**.

On the basis of presence or absence of vessels, wood is classified in two categories -

- (a) Porous wood: Vessels are present in xylem, it is called hard wood due to presence of vessels. It is also called as heteroxylous wood.
 - On the basis of arrangement of vessels. porous wood is divided into two groups.
 - (i) Ring porous wood : Vessels are arranged in the form of a ring in it. Such wood conducts water more efficiently. e.g. Dalbergia.
 - (ii) Diffused porous wood: Vessels are distributed asystematically in it. e.g. Neem (Azadirachta).
- (b) Non-porous wood : Vessels are absent. It is called **soft wood** due to absence of vessels and abundance of parenchyma. It is also called as **homoxylous wood**. **e.g. Gymnosperm**.
- (C) On the basis of amount of parenchyma wood is classified into two groups.
 - (i) Manoxylic wood : It has more living parenchyma. It is soft and loose wood. e.g. Cycas.
 - (ii) Pycnoxylic wood : It is compact wood that bears less amount of living parenchyma. It is hard wood. e.g. Pinus, Mango, Acacia, Tectona, Dalbergia.
- Study of wood is called Xylotomy. If a wood is exposed freely in air then decomposition of sap wood takes place rapidly.
- If xylem is blocked then shoot will die first and if phloem is blocked then roots will die first.
- Bark can be of following types.



(A) Ring bark:

When cork cambium is formed as a ring then the outer bark is also formed in the form of a ring. It is called ring bark. **e.g.** *Betula utilis* (Bhojpatra), *Eucalyptus.*

(B) Scaly bark:

If the cork cambium is formed in small strips, the bark is also formed in small fragments. It is called scale bark. **e.g. Guava, Mango,** *Tamarindus.*

(C) Smooth bark:

When the cork cambium activity is slow then the bark formed is of smooth type e.g. Indian birch.

(D) Rough bark:

When activity of cork cambium is fast then the bark is furrowed. This bark is called rough bark. e.g. Neem

Resonate the Concept

- Leptom–Soft walled conducting part of phloem.
 Hadrom–Conducting part of xylem.
 Haberlandt –Coined the term leptom & hadrom.
- 2. Albuminous cells : These are found in pteridophytes & gymnosperms instead of companion cells in phloem. They are discovered by strasburger.
- 3. **Cavities :** On the basis of origin, cavites are of three types.
 - (a) Lysigenous : It is formed by breakdown or degeneration of cells, e.g. Oil cavities in citrus and Eucalyptus.
 - (b)Schizogenous : Cavity formed by separation of cells or enlargement of intercellular spaces, e.g. Resin canals of Pinus, oil ducts of Sunflower.
 - (c) Schizolysigenous : It is formed by both separation and deterioration of cells, e.g. Protoxylem cavity of maize stem.
- 4. Sieve cells / Sieve Tube Elements : Resemble with RBCs in being without nucleus in the mature state.
- Vessels : They are characteristic feature of an angiosperms. Exceptionally five families of dicots do not bear vessels. The five families are Chlorantheceae, Winteraceae, Tetracentraceae, Trochodendraceae and Amborellaceae. Vessels occur in some nonangiospermic plants. e.g. gnetales, Selaginella, Equisetum, Pteridium, roots of Marsilea and Regnellidium.
- 6. **Rhytidome :** Outer part of bark consisting of dead cells.
- Homoxylous : Wood without vessels. e.g. Gymnosperms except gnetales. Heteroxylous–Wood with vessels. e.g. Angiosperms.
- 8. Stereome (stereom) : Mechanical tissue including sclerenchyma, collenchyma and hardened cells of vascular tissues. In mosses the central thick walled cylinder is also called stereome.
- **9.** Endodermoid : Casparian strips are absent in endodermis/starch sheath of Dicot stem. This endodermis is called endodermoid.
- 10. Wood : 90–95% tracheids in gymnosperms and 90–95% vessels in angiosperms. Axial or longitudinal system consists of tracheary elements, wood fibres and small amount of wood parenchyma. Radial system is made of ray parenchyma. (The two systems also occur in secondary phloem).

11. Knots :

The bases, scars / wounds of fallen branches get covered by growth of secondary tissues. They form knots in the wood.

12. Oldest Layer :

- (a) Oldest layer of heartwood is present just outside the primary xylem.
- (b) Oldest layer of sapwood occurs just outside the heartwood.
- (c) Oldest phloem is crushed primary phloem present inner to cortex or pericycle.
- (d) Oldest secondary phloem occurs inner to primary phloem and on the outer periphery of secondary phloem.
- (e) Oldest xylem is primary xylem found in the centre.

13. Youngest Layers:

- (a) youngest xylem (secondary xylem, sapwood) occurs just inner to vascular cambium.
- (b) youngest phloem (secondary phloem) is found just outside the vascular cambium.
- (c) Youngest heartwood lies just inner to sapwood.

14. Thyloses and Thylosoids:

(i) Thylosis, tylosis or thylose (Plural thyloses, tyloses) is outgrowth of parenchyma cell in a vessel.

(ii) Thylosoid or tylosoid is a structure resembling tylosis which is parenchymatous proliferation into a resin duct, sieve tube or any canal other than vessel.

15. Healing of wounds:

Wound is formed due to injury of any plant part. Boundary of the wound is developed outside and composed of similar type of living cells (Parenchyma) called **callus**. Living cells of wound are responsible to form a cambium. This is called wound Cambium. It is also called inducible cambium. This newly formed cambium forms cork towards outside. This cork covers the wound entirely. Wound cambium is a secondary lateral meristem.

16. Abscission:

Separation of leaves, bracts, flowers, floral parts, fruits and foliage branches from the plant without causing any injury is called **abscission**. ABA induces the formation of abscission layer.