# ANATOMY OF FLOWERING PLANT





## Syllabus

### ANATOMY OF FLOWERING PLANT

Meristem Atic Tissue, Permanent Tissue, Complex Permanent Tissue, Tissue System, Dicot Stem, Monocot Stem, Dicot-Root, Monocot root & Leaf of Structure, Secondary Growth

**Name :** _____ **Contact No.** _____

# ANATOMY OF FLOWERING PLANT

## LEVEL - I

**1.** Tea leaf of legume seed coat shows presence of -
(A) Parenchyma (B) Collen chyma (C) Sclerid (D) None

**2.** Trichome present with -
(A) Cortex (B) Endodermis (C) Epidermis (D) All

**3.** Grass leaf stomate guard cell shape is -
(A) Kindey (B) Dumble (C) both (D) Heart

**4.** Closed vascular bundle shows -
(A) Open (B) Closed (C) both (D) None

**5.** Secandary grow the shows by -
(A) Dicot leaf (B) Monocot leaf (C) both (D) Dicot root

**6.** Scattered vascular bundle show by -
(A) Dicot root (B) Dicot leaf (C) Monocot leaf (D) Monocot stem

**7.** Secondary growth done by following respancible tissue/tissues -
(A) Lateral meristem (B) Cark lambium
(C) Vascular cambium (D) 2 & 3
(E) All

**8.** Active cell division shown by -
(A) Cortex (B) Meristem (C) Both (D) Xylem vessel

**9.** Monocot root show presence of xylem bundle -
(A) 2 (B) 4 (C) 2 - 4 (D) More than six

**10.** Starch sheath with vascular bundle shows by -
(A) Dicot root (B) Dicot show (B) Both (D) Only monocot stem

**11.** Buliform cell present with -
(A) Epidermis (B) Cortex (C) Palisade tissue (D) Vascular bundle

**12.** Buliform cells helps plants for -
(A) Water loss protection (B) Vascular supply
(C) Liven ions (D) None

**13.** Monocot stem shows -
(A) Secondary growth (B) Primary growth
(C) Absence of xylem (D) None

**14.** Phloem parenchymon absent in -
(A) Dicot stem (B) Dicot root (C) Monocot stem (D) Monocot root

**15.** Lenticle present with -
(A) Leaf (B) Bark (C) Root (D) All

**16.** Passage cell present with -
(A) Cortex (B) Epidermis
(C) Vasscular bundle (D) All

**17.** Very small pitn present -
(A) Dicot stem (B) Dicot root (C) Both (D) None

**18.** Hypodermis present in -
(A) Dicot root (B) Dicot leaf (C) Dicot stem (D) All

**19.** Canjoint, collateral, endarch & closed vascular bundle present in -
(A) Monocot root (B) Monocot stem (C) Monocot leaf (D) 2 & 3

**20.** Periderm is/are -
(A) Phellogen (B) Phellem (C) Phelloderm (D) All

## Answer Key (Level - I)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | C | **2.** | C | **3.** | B | **4.** | A | **5.** | D | **6.** | D |
| **7.** | E | **8.** | B | **9.** | D | **10.** | B | **11.** | A | **12.** | A |
| **13.** | B | **14.** | C | **15.** | B | **16.** | A | **17.** | B | **18.** | C |
| **19.** | D | **20.** | D | | | | | | | | |

## LEVEL - II

**1.** Your are given a fairly old piece of dicot stem and a dicot root. Which of the following anatomical structure will you use to distinguish between the two ?

(A) Secondary xylem (B) Secondary phloem
(C) Protoxylem (D) Cortical cells

**2.** Which of the following part of dicot root is made up of cells with suberin deposition in tangential as well as radial walls ?

(A) Epidermis (B) Endodermis Cortex (D) Xylem

**3.** Which of the following characters are not applicable to the anatomy of dicot stem and choose the correct options given below ?

I. Collenchymatous hypodermis
II. Polyarch xylem
III. The presence of casparian strips on the endodermis
IV. Open vascular bundle
V. The presence of medullary rays of these

Selec the correct answer using the codes given below :

(A) I, IV and V (B) II and III (C) II and V (D) I, II and III
(E) III, IV and V

**4.** Which of these characters does/do not apply to the vascular bundle of monocot stem ?

I. Conjoint
II. Endarch protoxylem
III. Open
IV. Phloem parenchyma is absent

Select the correct answer using the codes given below :

(A) I and II (B) II and III (C) III and IV (D) Only III
(E) I and IV

**5.** When one wood is lighter in colour with a lower density, the other wood is darker with a higher density. They are -

(A) Spring wood and autumn wood (B) Heartwood and late wood
(C) Spring wood and early wood (D) Sap wood and spring wood
(E) Autumn wood and spring wood

**6.** Choose the incorrect statement.

(A) Gymnosperms lack vessels in their xylem
(B) The cell wall of collenchyma is made up of cellulose, hemicellulose and pectin
(C) The first formed primary xylem elements are called protoxylem
(D) The cell wall of parenchyma is made up of pectin
(E) Gymnosperms have albuminous cells and sieve cell in their phloem.

**7.** In dicotyledonous stem, which of the following is the sequence of tissue from inside to outside ?

(A) Pith, phloem, cambium, protoxylem, metaxylem, pericycle, parenchyma collenchyma, endodermis and epidermis
(B) Pith, cambium, phloem, protoxylem, metaxylem, pericycle, endodermis, parenchyma, collenchyma and epidermis
(C) Pith, phloem, protoxylem, metaxylem, cambium, pericycle, endodermis, parenchyma, collenchyma and

epidermis
(D) Pith, protoxylem, metaxylem, cambium, phloem pericycle, endodermis, parenchyma, collenchyma and epidermis

**8.** A piece of wood having no vessels (trachea) must belong to -
(A) teak (B) mango (C) pine (D) palm

**9.** Which one of the following characters is not found in transverse section of monocot stem ?
(A) Sclerenchyma bundle sheath
(B) Lysigenous cavity
(C) Sclerenchymatous hypodermis
(D) Starch sheath

**10.** Identify for correct pair of statements.
I. Functions of sieve tubes are controlled by the nucleus of companion cells.
II. Albuminous cells are present in angiosperms.
III. In dicot root, the vascular cambium is completely secondary in origin.
IV. Cylindrical meristerms contribute to the formation of primary plant body.
**Codes :**
(A) I and III (B) III and IV (C) I and II (D) II and III

**11.** Age of a tree can be estimated by -
(A) its hight and girth (B) biomass
(C) number of annual rings (D) diameter of its heartwood

**12.** In barley stem vascular bundles are -
(A) open and scattered (B) closed and scattered
(C) open and in a ring (D) closed and radial

**13.** Find out the wrong statement about angiosperm roots -
(A) Xylem is centripetal in growth in the young roots
(B) Cuticle is absent in young stages
(C) The apex is protected by root cap
(D) Vascular bundles are collateral

**14.** The age of tree by counting annual rings is called -
(A) Dendrochronology (B) Ageing
(C) Chronology (D) Countrology

**15.** A monocot stem with secondary growth is -
(A) Lilium (B) Cocos (C) Yucca (D) Asparagus

**16.** Old dicot roots differ from dicot stem in -
(A) The absence of cortex (B) The absence of primary phloem
(C) The absence of vascular bundles (D) The presence of xylem

**17.** In dicotyledonous roots, the initiation of lateral roots takes place in -
(A) endodermal cells (B) cortical cells
(C) epidermal cells (D) procambial cells
(E) pericycle cells

**18.** In grasses, certain adaxial epidermal cells along the veins modify themselves into large empty, colourless cells called -

(A) bulliform cells (B) companion cells
(C) guard cells (D) subsidiary cells
(E) albuminous cells

**19.** In an annual ring, the light coloured part is known as -

(A) early wood (B) late wood
(C) heartwood (D) sapwood

**20.** Heartwood differs from sapwood in -

(A) The presence of rays and fibres
(B) The absence of vessels and parenchyma
(C) Having dead and non-conducting elements
(D) Being susceptible to pests and pathogens

## Answer Key (Level - II)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | C | **2.** | B | **3.** | B | **4.** | D | **5.** | A | **6.** | D |
| **7.** | D | **8.** | C | **9.** | D | **10.** | A | **11.** | C | **12.** | B |
| **13.** | D | **14.** | A | **15.** | C | **16.** | B | **17.** | E | **18.** | A |
| **19.** | A | **20.** | C | | | | | | | | |

## LEVEL - III

**1.** The difference in phloem of gymmosperms and angiosperms is due to -
(A) parenchyma (B) sieve cell
(C) compound cell (D) fibres

**2.** The cells without nuclei are present in -
(A) vascular cambium (B) root hair
(C) companion cell (D) members of sieve tube

**3.** Bicollateral vescular bundles are found in the members of this family -
(A) Malvaceae (B) Fabaceae
(C) Caesalpiniaceae (D) Cucurbitaceae

**4.** The quiescent centre in root meristem serves as a -
(A) Site for storage of food which is utilised during maturation
(B) Reservoir of growth hormones
(C) Reserve for replenishment of damaged cells of the meristem
(D) Region for absorption of water

**5.** **Assertion (A)** :- Libriform fibres are true fibres.
**Reason (R)** :- Libriform fibres develop from non-functional tracheids by reduction.
(A) Both A and R are correct and R is the correct explanation of A
(B) Both A and R are correct, but R is not the correct explanation of A
(C) A is correct, but R is incorrect
(D) A is incorrect, but R is correct

**6.** Casparian thicknings are found in the cells of -
(A) pericycle of the root (B) endodermis of the root
(C) pericycle of the stem (D) endodermis of the stem

**7.** In which of the following, root system is poorly developed ?
(A) Phaene (B) Hydrilla (C) Halophyte (D) Xerophyte

**8.** Aerenchyma is helpful in plants by -
(A) providing buoyancy in hydrophytes (B) absorption in stilt roots
(C) giving mechanical strength to plants (D) giving flexibility to plants

**9.** Complex tissue includes -
(A) collenchyma (B) apical meristem (C) conducting tissue (D) idioblast

**10.** Vessels differ from tracheids -
(A) in being living
(B) in being derived from a single cell
(C) in having vertical row of cells with crosswalls dissolved
(D) because they conduct water

**11.** Quiescent centre is a -
(A) weak zone (B) active zone (C) inactive zone (D) strong base

**12.** Root caps are absent in -
(A) mesophytes (B) xerophytes (C) hydrophytes (D) lithophytes

**13.** The histogens are classified on the basis of -
(A) cells they contain
(B) cells they give rise to future tissue
(C) meristematic activity
(D) cell division

**14.** Meristematic cells have -
(A) thick cell wall and large intercellular spaces
(B) thick cell wall and no intercellular spaces
(C) thin cell wall and large intercellular spaces
(D) thin cell wall and no intercellular spaces

**15.** Fascicular interfascicular and extra-stelar cambium together constitutes -
(A) ground meristem (B) apical meristem
(C) intercalary meristem (D) lateral meristem
(E) primary meristem

**16.** The phloem of angiosperms differs from that of other vascular plants by the presence of -
(A) vessels (B) companion cells
(C) tylosoides (D) albuminous cells
(E) secretory cells

**17.** Complementary cells are associated with -
(A) lenticels (B) hydathodes (C) rhytidome (D) bark

**18.** Pith is a central part of the ground tissues generally made up of -
(A) parenchyma (B) collenchyma (C) chlorenchyma (D) sclerenchyma

**19.** Tyloses are balloon-like ingrowths in vessels developing from the adjoining -
(A) fibres through pits on vessel wall
(B) fibres through the general surface of vessel wall
(C) parenchyma through pits on vessel wall
(D) parenchyma through the general surface of vessel wall

**20.** The function of a vessel is conduction of -
(A) food (B) water and minerals (C) hormones (D) All of these



## Answer Key (Level - III)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | C | **2.** | D | **3.** | D | **4.** | C | **5.** | C | **6.** | B |
| **7.** | B | **8.** | A | **9.** | C | **10.** | C | **11.** | C | **12.** | C |
| **13.** | B | **14.** | D | **15.** | D | **16.** | B | **17.** | A | **18.** | A |
| **19.** | C | **20.** | B | | | | | | | | |

# Meristem Atic Tissue

**Tissues :-**

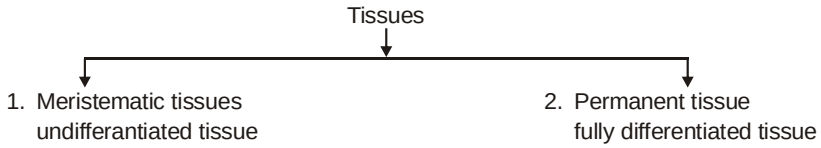
A group of cells which is having similar shape, function and having a common origin is called tissues.

Approximately, all types of tissues originates by divisions of meristem in the form of parenchyma.

The term tissue is coined by **Nehemiah Grew**. (Father of Plant Anatomy)

All the cells of tissues may be a similar or of different forms.

The tissues divided in to two groups by Karl Nageli :-




**Characteristics of Meristematic tissues**

1. Meristematic tissues or meristem is a undifferentiate tissue.
2. Cell cycle of meristem is in continuous state of division. It means they have the capacity to divide.
3. Meristematic cells have only primary cell wall which is thin and flexible (elastic). Secondary cell wall is absent.
4. Cells of meristem are small.
5. They have dense cytoplasm.
6. Normally vacuoles are absent in meristematic cells but if present then small vacuoles.
7. They have prominent and large nucleus.
8. Meristematic cells are metabolically highly active.
9. Lack of reserved food in these cells.
10. Plastids are absent in meristems. If they are present, then only at the proplastids stage.
11. Their mitochondria and endoplasmic reticulum having simple structure and internal structures not developed.
12. They do not have intra cellular spaces. Cells are closely fitted (packed) togather.



**Classification of Meristematic Tissues :-**

Meristematic tissues are classified in different ways on the basis of certain factors as follows :-

## A. Meristems Based on origin

On the basis of origin, meristems can be divided in to following two types.

### i. Primary meristem

It is the initial meristem which is formed during embryonic stage and still retains its meristematic activity.

They are the meristems developed from primary permanent tissues. They are not present at the very begining stage of the plant.

Some of the cells of the primary tissues becomes meristematic and constitute the secondary meristem. It means meristems is formed from any permanent tissues is called dedifferentiation.

## B. Meristematic tissues based on location (position) in plant Body

On the basis of position the meristematic tissues can be divided into the following three types :-

### (a) Apical Meristem

These tissues are found at the apices of root and stem. They are respondible for increasing in length of plant organs. Apical meristem has two regions at embryonic stage -

**First** - PROMERISTEM or PRIMORDIAL MERISTEM -

It is the meristem which develops very beginning during embryonic stage.

**Second** - EUMERISTEM -

This meristem is formd the divisions of primordial meristem.

**According to Haberland, eumeristem divided into three regions :-**

**(i)** **Protoderm :** This is the outer layer of eumeristem by the activities of these tissues the epidermal tissue system is formed.

**(ii)** **Procambium :** These cells are long and it gives rise to the vascular tissue system.

**(iii)** **Ground Meristem :** The cells of their region are large, thin walled and isodiametric. Ground tissue system is formd by the activity of these cells. The functional activity of these are gives rise to hypodermis, cortex, endodermis, pericycle, pith-rays and pith.

**(b) Inter calary Meristem**

This is the separated region from apical meristem. It is lies between the masses of plant. The activity of these meristem also add to the length of the plant or its organs. They may be present either the base of internode of grasses or at the base of node of Mint and at the base of leaves petiole by the activity of these meristem, length of the leaves increases.

**(c) Lateral Meristem**

These meristem are present along the lateral sides in the plant organs. A margin meristem is found in leaves is a type of lateral meristem. The activity of these tissues increase the width of leave. Intrafascicular cambium is also a type of lateral meristem. It is found in the stem of dicotyledons and Gymnospermic plants. This is cambium lies between xylem & phloem. Excluding this cambium, remaining all types of cambium is secondary lateral cambium. All the type of cambium is lateral also. The functional activity of cambium to increase the girth of the plant organs.

A group of meristematic tissues present at the tips of root and stem is called Apical meristem. The structure of apical meristem is different in various levels (categories) of plants.

☞ Apical meristem is absent in lower plants i.e., Algae and Fungi. All the cells of these plants are divisible. Thus each type of growth in these plants, is called diffused growth. Diffused growth is also occur in animals.

☞ Apical meristem in Bryophytes and some Pteridophytes consist of single cell. This cell is known as apical cell. This apical cell is in pyramid shaped and divided into two lateral planes.

☞ Apical meristem in Ferns. Gymnosperms and Angiosperms consist of many cells.

Several views have been available in relation of structure and growth habit of apical meristem. A few of them are discussed here as -

**1. Apical Cell theory -**

This theory proposed by **Karl Nageli** and **Hofmeister.**

According to Nageli and **Hofmeister** the apical meristem composed of single apical cell. This view is only applicable for Bryophytes and some Pteridophytes.

**2. Histogen Theory -**

It was propounded by **Hanstein** (1870).

According to him, the root and shoot apices distinguished into three meristematic region of three layers of histogen cells. They are as follows.

**i.** **Dermatogen :-** This is the outermost single layer of cells. These cells forms dermis through anticlinal divisions.

**ii.** **Periblem :-** This region is situated just below the dermatogen. Hypodermis, cortex and endodermis are formed by the division of these cells.

iii. **Plerome :-** This is the innermost region. Stele formation takesplace by division of these cells.

It means formation of pericycle, vascular bundles medullary rays and pith.

☞ This theory is not applicable to shoot apex, because shoot apex is not clearly visible into three layers. This is seems to be applicable for root apex.

☞ Excluding above described three histogens, a fourth type of histogen is formed in monocotyledons. This is known as Calyptrogen. Root cap is produced by Calyptrogen. Root cap is only produced by dermatogen in dicotyledons.

☞ A group of inactive cells is present between the dermatogen and calyprogen is called Quiescent Centre. These cells contain less amount of DNA and synthesis of protein is also less quiescent centre name coined by "Clowes".

☞ As the calyptogen get damaged, this zone becomes active to form new cells of calyptrogen.

**Exception**

These is only one histogen is present in Ranunculus. Two histogens occurs in Casurina.

Due to presence of root cap position of root apex is sub terminal. So maximum growth in root takes place behind the apex.

Two zones in the shoot apex :-

**(I)** **TUNICA :-** This is periphiral layer. Epidermis is formd by this layer. The plane of cell division of cells of Tunica is only anticlinical. Anticlinical division occurs at right angle to longitudinal axis of cell. Surface area of the plant organs increases due to anticlinal divisions.

Generally, tunica represent only single layer, but some times it is multi layered, then the outer most layer forms the epidermis and remaining layers from another types of tissues with the association of corpus.

**(II)** **CORPUS :-** The inner Mass of cells present below the tunica is called Corpus. The cell of this zone dividing in all directions resulting increases in volume. The mass of these cells mainly forms teh cortex. The cells of corpus usually larger than those of tunica.

**4. MANTLE CORE THEORY**

This theory was proposed by "Popham and Chan". They were compared the mantel to the tunica and core compared with the corpus. According to them corpus or core is distinguished into these zones -

i. **Sub-Apical Meristem :-** This is present just below the mantle. The re-establishment of mantle is functional activity of this zone if the mantle is damaged.

ii. **Central-zone Meristem :-** This is the inner most zone. This zone is responsible only for formation of pith.

iii. **Pheripheral Meristem :-** This region only responsible for the formation of cortex and vascular tissues.

**5. NEWMAN'S THEORY :-**

According to his, meristematic tissues of shoot apex is of three types -

i. **Monoplex :-** This is the such type of shoot apex in which meristematic cells arranged in groups inplace of meristematic layers. Such type of shoot apex is found in **Ferns.**

ii. **Simplex :-** Such type of shoot apex is formed by single layers of cells. It is found in Gymnosperms.

iii. **Duplex :-** Such type of shoot apex is formd by two layers of cells. Peripheral layer is called tunica and inner layer is called corpus. Such shoot apex is present in Gnetales and Angiosperms.

**Note -** According to Newman, the tunica and Corpus of shoot apex in Ferns and Gymnosperm is non distinguished.

**6. KORPER-KAPPE THEORY -**

This theory was proposed by **"Scheupp".** Its view is applicable for root apex. According to them root apex has two regions - The central region of root apex is know as Korper. The cells are located vertically - 'T' forms in this region.

The peripheral region is called Kappe. Kappe is also known as "Calyptra" or "Covering". The cell are arranged inverted 'T' form in this region. This theory is not applicable on root apex or shoot apex.

## C. CLASSIFICATION BASED ON PLANE OF CELL DIVISION

On the basis of plane of cell division, three types of meristem occurs -

**(I)** **RIB-MERISTEM :-** Such meristem in which division occurs only in one plane. For example tunica is a type of rib-meristem.

**(II)** **PLATE-MERISTEM :-** Such meristem which divides into two planes. By this division a plate like structure is formed and increases in the area. The leaves of the plants is formed through this type of meristem.

**(III)** **MASS-MERISTEM :-** Such meristem which divides in all possible planes resulting in the increase in volume of plant body (organ).

**Example -** The formation of embryo and endosperm is takes place by this kind of meristem.

# Permanent Tissues

A group of cells which have lost the property of division and differentiates into different forms to perform different function, are called permanent tissue. Their cells may be living or dead. Permanent tissues are of three (3) types :-

A. Simple tissue B. Complex tissues C. Special tissues

These tissues are made up of similar cells that perform a common function. Simple tissues are of three types :-

I. Parenchyma II. Collenchyma III. Sclerenchyma

## I. Parenchyma

It is very primitive type of tissue. Remaining all different types of tissues are derived from this tissue.

Name coined by Grew.

**Characteristic features :-**

- ☞ This is living tissue.
- ☞ This is a universal tissue, it means it is found in all parts ex. root, stem, leaf.
- ☞ All the cells of parenchyma are thin walled.
- ☞ Each cell containing big central vacuole.
- ☞ Inter cellular spaces are present between cells.
- ☞ The cell are isodiametric.

**Functions :-**

The main function of this tissue is storage of food. Some cells of parenchyma store waste materials. They are called **"idioblast cells"**. Idioblast cell stored oils, tanin, crystal of calcium oxalates in the form of food.

**Shape :-**

The cells of parenchyma spherical in shape. Each parenchymatous cells composed by planes of 14 lateral lines. These are known as Tetrakaidecahedron. This characteristic of cells is due more flexibility.

**Modifications of Parenchyma :-**

1. **Prosenchyma :-** The cells of this parenchyma are long with pointed ends. This parenchyma forms the pericyle of roots.

2. **Aerenchyma :-** This parenchyma is made up of by rounded cells. These cells surrounds the large air chambers. It is present in hydrophytic plants, which help in buoyancy to plants.

3. **Stellate parenchyma :-** The cells of this tissues are stellate and branched. Air spaces also present in these tissues. Main function of this parenchyma is to provide mechanical support. These tissues are found in leaf bases of Banana. It is providing strength to leaf base. Leaf base of Banana perform the functions of stem. Rhizome is found in Banana.

4. **Chlorenchyma :-** This a such parenchyma is which (sufficient) abundant quantity of chloroplants present. Two types of chlorenchyma present in the leaves :-

a. **Palisade tissues :-** Palisade tissues lack of intercellular spaces. Their cells are tightly fitted togather. Palisade tissues manly located below (near) the upper epidermis. Palisade tissues usually present in xerophytes. Number of chloroplast is more in palisade tissue as compare to spongy tissue.

**Origin of Parenchyma :-**

- ☞ Parenchyma is found in cortex pith, mesophyll and some organs of flower, is derived from ground tissue.
- ☞ Parenchyma is present in vascular tissues which is formed from procambium and vascular cambium.
- ☞ Parenchyma of secondary cortex is formed by cork cambium.

## II. Collenchyma

Ferm coined by Schlieden.

**Main Characteristics -**

- ☞ Collenchyma is living mechanical tissue.
- ☞ It is made up of elongated cells.
- ☞ It is made up of thin walled cells. Cell wall of these cells thickened at the some place. These thickened places mainly composed by pectin. The presence of thickening of pectin is the characteristics features of collenchyma.
- ☞ Cytoplasm of the cell is vacuolated.
- ☞ Collenchyma is not a universal tissue. This is mainly found in the stems of herbaceous dicotyledons.
- ☞ Collenchyma is basent in parts of woody plants, roots and monocotyledons.
- ☞ Collenchyma forms the hypodermis of stem during the secondary growth. Thus collencyma is absent in plants after the secondary growth.
- ☞ Chloroplast is found in the cells of collenchyma. Thus chloroplast may be present in hypodermis of dicotyledons stem.
- ☞ Lamina margins of leaves also bears collenchyma. This is protects the cracking of lamina margin due to the action of wind.

**Types of Collenchyma**

**Majumdar** divided collenchyma into three types :-

1. **Lamellar / plate collenchyma :-** The cells of collenchyma arranged in lamellar forms. The cell having thickening on the tangential walls. Due to such type of deposition, cell looks like a lamellar or plates. Ex. Raphanus
2. **Angular collenchyma :-** This collenchyma is formed abundantly. The cells of this tissue is angular. The deposition of pectin at the angles of cell. eg., Datura, cucurbita
3. **Lacunar collenchyma :-** Large intracellular spaces are present in between these cells. Deposition of pectin on the wall of intracellular spaces. Intera cellular spaces of collechyma thickened. ex. Sunflower stem.

## III. SCLERENCHYMA

Name coined by mettenius - Main features :-

- ☞ Sclerechyma is the main mechanical tissue.
- ☞ These cells are long, nerrow, thick walled and dead.
- ☞ Cell wall of their cells is thick and lignified.
- ☞ Various tyhpes of pits are formed due to the deposition of lignin on hard wall.

**Type of Sclerenchyma**

Sclerenchyma cells are of two types - Sclereids & Sclerenchymatous fibres

**I. Sclereids -**

These cells are small extremely thick walled and their ends without pointed. Sclereids are isodiametric or irregular in shape, Sclereids cells have more pits and lumen is almost very small. Their pit cavity (lumen) is branched. Tsirch classified the sclereids on the basis of their shapes :-

**a. Stones cells of Barchy - sclereids or Grit cells :-**

These cells are spherical or oval in shape. They are found in endocarp of drupe fruits, so that endocarp becomes hard.

**Example -** They are present in endocarp of coconut, mango, almond, walnut etc.

Basides drup fruit brachysclereids also present in flesy (edible) part of pear. Grittness in pear fruit is due to this sclereids.

**b. Macro-sclereids or Rod cells or Malpighi cells :-**

They are small and rod like cells. They are present in seed coats.

**Example -** They form part of seed coat in leguma plants. Due to their presence seed coat becomes hard. Seed coats of lotus is hardest (stony). Seed coat of french bean is harder amongs the leguminous plants. So dormancy is found in leguminous seeds.

**c. Osteio-Sclereids :-**

These are known as prop-cells. These are pillar like cells. Both end of pillar like cells spreads to form bone like structure.

**Example -** These cells are found in leaves of two plants Hakea and osmanthus.

**d. Astero Sclereids :-**

These cells are stellate shaped. They are found in floating leaves.

**Example -** The leaves of victoria, lotus etc.

**e. Trichoselereids :-**

These are also known as internal hairs. They are spines like, bifurcated cells which is present in floating leaves.

**Example -** Victoria, Nelumbo, Nymphea.



**II. SCLERENCHYMATOUS FIBRE**

On the basis of structure fibres classified into two parts :-

**a. Libriform fibres :-**

They are extermely thickned long fibres. They posses simple pits. Libriform fibres are present in phloem, xylem, pericycle and hypodermis. Maximum in phloem.

**b. Fibre Tracheids :-**

They are highly thickened as compared to others. Bordered pits are present in these fibres. They are only found in xylem.

☞ On the basis of position fibres divided into three types -

**(i) Surface fibres -** They are also called “Filling fibres”. They are present on the surface of plant bodies.

Example - Cotton fibres are formed by the out growth of seed coat. They are not a any type of tissues. Cotton fibres composed of cellulose and not lignified. So that cotton fibres are not true fibres. Two types of fibres are found in cotton. Long fibres are called ‘lint’ and small fibres known as ‘fuzz’. Fuzz is filling fibre. Coires of coconut is also type of surface fibres. They are derived from the mesocarp. It is true fibres.

**(ii) Xylary or wood fibres :** They are hard fibres. They are lack of flexibility. They can not be knitted so that they are not useful. They are found in xylem. ex. munj fiber.

**(iii)** **Bast fibres :-** They are also known as commercial fibres. They are flexible and can be knitted. These fibres obtained from the phloem and pericycle of plants.

- ☞ The best fibres of Corchorus spp(Jute) and Crotalaria juncia (Sun hemp) are obtained from the phylum.
- ☞ The base fibres of hemp (Canabis sativa) and Linum usitatissimum (flax) are obtained from pericycle. This bast fibres has great economic value.

# Complex Permanent Tissue

A complex tissues are a collection of different type of cells. This is a heterogenous group of cells.

- Complex tissue is absent in gametophytes.

Complex tissues is of two types -

a. Xylem b. Phloem

## A. Xylem

The term 'Xylem' is coined by Nagelie. Xylem is also provide mechanical support to the plant in addition with the conduction of water and minerals. On the basis of development xylem divided into primary xylem and secondary xylem. Primary xylem originates from procambium. Parenchyma of primary xylem is not differentiate and medullary rays is also absent. Secondary xylem originate through the secondary growth. The elements of xylem are (i) Tracheids, (ii) Vessev or tracheae xylem fibres.

- Tracheids are elongated cells with tapering ends.
- Tracheids having a large humen as compared to the fibres.
- Tracheids joint togather from their ends to form a long rows. These rows extending from the roots via stem to the leaves.
- A transverse septum lies between each two tracheids. It bears pits.
- Tracheids are dead and lignified cells. The deposition of lignin on cell wall is responsible to form a different type thickenings. Lignification is also to form various types of pits. Pits are the nonthickened areas.
- Bordered pits are mainly present an the wall of tracheids. The maximum bordered pits are found in the tracheids of Gymnospermic plants.
- Maximum deposition of lignin is in pitted thickenning.
- Different type of thickening of lignin is found in tracheids.
- Spiral, annular and reticulate thickning of lignin is found in protoxylem.
- Pitted thickening of lignin is found in metaxylem.
- Tracheids of pteridophytes have long or elongated bordered pits. Such type of pits are called scalari form pits.



## 2. Vessels :-

Advance conductive element of xylem.

- The basic structure of vessels is the same as tracheids.
- They are also dead elements of xylem.
- The luman of vessels is wider than the tracheids.
- Vessels are only found in xylem of angiosperm but exceptionally it is also present in some Gymnosperms like Ephedra, Gnetales and Welwitschia.
- Similarly vessels are absent in some Angiospermic plants such as Dracaena, Yucca, Dazinaria, Drymeace, Vintera, tetracentron and trochodendron etc.
- Transverse septum is absent between two cells. If even it is present then it is porous. Thus vessels are more capable than tracheids.
- Vessels usually contains simple pits thickning of wall is the same as tracheids.
- Due to the absent of transverse septum or porous, vessels work as a pipeline during conduction of water.

**3. Xylem fibres :-**

This is also dead part of xylem.

- ☞ Xylem fibres provides strength to the tracheids and vessels. Mainly they provide strength to the vessels. They are present more abundant in secondary xylem.
- ☞ This is the living part of xylem.
- ☞ The radial conduction of water is the function of xylem parenchyma.

**Water Conduction Elements of Xylem :-**

Tracheid and Vessels collectively known as water conducting elements or "Hadrome". Development of conducting elements by three types :-

**I.** **Centrifugal :-** In this type of development, the protoxylem formed near the centre axis and metaxylem is formed away from the centre towards the periphery. This condition is known as endarch. ex. stem of angiosperm & Gymnosperm.

**II.** **Centripital :-** In which protoxylem is formed away from the centre near the pericycle and metaxylem is formed towards the centre. This condition is called exarch. ex. Roots.

**III.** **Centrifugal and Centripital :-** In which elements of metaxylem is formed from both side of the elements of protoxylem. So that protoxylem is surrounded by metaxylem. This condition is known as Mesarch ex. stem of fern.

**B. PHLOEM**

The fern 'Phloem' is coined by Nageli. The main function of phloem is the transport of organic materials from one place to another place. On the basis of development, phloem is classified into two categories primary and secondary phloem. Primary phloem is derived from procambium and secondary phloem is derived from vascular cambium. Phloem remains active for less duration as compared to xylem. Phloem consist of 4 types of cells as below :-

**1. Sieve cell :-**

Sieve element is discovered by Harting.

- ☞ Sieve element is living and thin walled cells.
- ☞ A matured seive cell lack of nucleus. Thus these are non nucleated living cells.
- ☞ Central vacuole is present in each seive cells. Cytoplasm of seive cells is streaming in the form of thin layer around the vacuole (cyclosis).
- ☞ In Angiosperms seive cells are arranged with their ends and form sieve tube.
- ☞ Seive plate (transverse perforated septa) is present between the two seive cells. It is porous Materials only transport through these pores.
- ☞ Callose id deposited on the radius of pores during dropping (falling) season of leaves to form a thick layer. This is called Callus pad.
- ☞ Seive plate protected by callus pad. It also prevented from bacterial infection and drough. Callose is a β-1-3-glucan.
- ☞ Callose is dissolves during spring season.
- ☞ In Gymnosperm and pteridophytes, seive cells do not form seive plates and arranged irregularly. Seive elements have seive plates on their lateral walls.

  Thus conduction of food in zig-zag manner.
- ☞ Seive cells contains special type of protein-**P-protein** which is related with conduction of food and it repairs damage sieve cells.

- ☞ Seive cell and companion cell originates togather. Both of them originates from a single cell. called sister cells.
- ☞ The companion cells and seive cells maintain close cytoplasmic connections with each other through plasmodesmata.
- ☞ Companion cells are only found in Angiosperms (exception - Austrobaileya).
- ☞ Comapanion cells is a living with large neuceus this nuceus is also controls the cytoplasm of seive cells.
- ☞ Special type of cells attached with the seive cells in conifers. they are called albuminous cells.

**3.** **Phloem fibres :-** A fiber which are present in phloem is called **Libriform** fibres. These fibres provide support to the seive cells. The main function of that fibres to provide mechanical support. They are used for making ropes, rough clothes and mats etc.

**4.** **Phelom Parenchyma :-** It is also known as bast parenchyma. They are living and thin walled cells. They store various food materials. Pholem parenchyma is absent in monocotyledon plants. The main function of phloem parenchyma is conduction of food in radial direction and storage of food. The vascular part of pholem seive cells is called Leptom.

## Special tissue or secretory tissue

**I.** **Lactiferous tissue :-**

They are made up of long, highly branched and thin walled cells. These cells filled with milky juice, it is called Latex. Latex is known as plant milk Latex obtained from the plants that is called **petrocrops**. Latex is the mixture of saccharides, starch granules, alkaloids minerals and waste materials. Starch granules present in latex are dumble shaped. Latex, provide protection to the plant. It is also protected to plants from grazing animals. It prevents the infection of bacteria in fungus. Lactiferous tissue is of two types - Latex cells and latex vessels.

**i.** **Latex cells -** They are non articulated latex ducts/tubes. They are long branched and multicleated cells. Such types of cells are called coenocytic cells.

**Example :-** Latex cells are found in Calotropis, Euphorbia and Nerium.

**ii.** **Latex vessels :-** They are articulated vessels. Latex vessels are formed due dissolution of cells wall of meristematic cells. Thus they are syncytic cells. Latex vessels are also multinucleated.

**Example :-** Latex vessels are present in Heavea, (Banyan tree ficus), Papaver etc. Highly developed latex vessels are found in the fruit wall of Opium.

As the name indicates this tissue is present in the form of glands. These glands contains secretory or excretory materials. Glandular tissues have two types of glands.

Glands are found in Urtica-dioica (Bicchubutti) are unicellular, these cells are present on the surface of the leaves. They are spiny glands in which formic acid is filled. Multicellular glands are of two types.

**1.** **External Glands :-** They are located on the surface of the plants, or arising as a outgrowth from the epidermis. These glands are of various types :-

**i.** **Digestive glands :-** Digestive glands are found in insectivorous plants. These insectivorous plant compansate their deficiency of $N_2$. They are found in Utricularia, Drosera, Dionia etc. plants.

**ii.** Oil Glands :- These glands are secreting volatile oil. These gland are present in the leaves of Eucalyptus and external fruit wall of citrus (Lemon).

**iii.** **Nector Glands :-** These glands are embedded in the tissues. They are found in floral parts mainly in thalamus. These giands secreter nector to attraching the insects.

**2.** **Internal Glands :-** These glands are embedded in the tissues. Internal glands are of following types.

**i.** **Mucous secreting glands :-** These glands secretes mucous. They are found in the levaes of betel.

**ii.** **Oil glands :-** Oil glands are of both types external and internal. These secretes oil. It act as a antiseptic. These glands are found in lemon orange etc. fruits.

**iii.** Tanin, resin, gum secretory glands are also internal glands. Maximum resin glands are present in palm. Gum glands are found is (Acasia (Babool). Resin ducts are schizogenous.

**iv.** Water gland :- Water glands aer open on Hydathode. These glands related with guttation. Hydathodes are present in Tomato, Pistia, Ichornia Nasturtium etc. It is related with epitheme tissue.

# Tissue System

On the basis of division of labour tissue categorised into three different system. Each system usually consist of an association of tissues which perform specific function.

1. **The epidermal tissue system :-** This system includes epidermis and its related cells, hairs, pores etc.
2. **Ground tissue system :-** It is the largest tissue system. It includes hypodermis, cortex, endodermis, pericycle and medullary rays (pith rays).
3. **Vascular tissue system :-** This tissue system originates from the cambium. It consists of xylem and pholem.

**Types of vascular Bundles**

On the basis of arrangement of different parts of vascular bundles are devided into three categories.

I. **Conjoint colleteral vascular bundles -** When the xylem and pholem are present on the same radius in vascular bundle. In this vascular bundle order of condition is found. This vascular bundle is found in gymnosperm and angiosperm. Open vascular bundle is found in dicotyledons and gymnosperm. Closed V.B is found in monocots.

II. **Conjoint bicolletral vascular bundle** - These are two patches of pholem one on each side of xylem. In such a vascular bundles there are two strips of cambium one on each side of xylem. Only found and vascular bundle is open. Such type of vascular bundle is known as bicolletral vascular bundle. ex. stem of family cucurbitaceae.

III. **Radial vascular Bundles :-** When the xylem and phloem are present on different radii. Such vascular bundles are called radial vascular bundle. All the roots of plants contains radial vascular bundle. The development of xylem in these vascular bundle is centripetal. Thus, these vascular bundles are called exarch.

IV. **Concentric vascular bundles :-** In this vascular bundle either xylem surrounds the phloem surrounds the xylem. Concentric vascular bundles are always closed. They are of two types -

i. **Amphicribal or Hadrocentric :-**The xylem is in the centre surrounds on all sides by phloem. Such vascular bundle is termed amphicribral. The development of xylem in these vascular bundles either centripetal or centrifugal manner. These are known as mesarch vascular bundle. Such types of vascular bundles are found in ferns in lower Gymnosperms.

ii. **Amphivasal or Leptocentric :-** In this type of vascular bundle xylem is completely surrounds the pholem. It means pholem present in the centre of the vascular bundles.

Such type of vascular bundle is termed endarch. Such vascular bundle exceptionally formed in Angiosperms e.g. Dracaena, yucca etc,

The stele is the whole central mass of vascular tissue with or without pith surrounded on the outer side by endodermis. **Vantieghem** and **Douliot** put forward the hypothesis about stele. According to him stele is the central part of core of Co axis of the plant which includes the vascular system and its relative structures.

The tissues which is lies inside the stele is called intrastelar tissues and the tissues which lies out side the stele is known as extra tissues. Stele surrounded by endodermis but endodermis is originally the part of cortex.

1. **Protostele or Monostele :-**

Protostele is the most primitive and simplest type of stele. It consist of solid mass of xylem completely surrounded by pholem. Such type of stele devois of pith. Solid stele is of following types :-

i. **Haplostele :-** In this stele, xylem surrounded by a smooth layer (some thickness) of pholem. Central xylem is in cylindrical form.

ii. **Actino stele :-** Actino stele is that in which the central xylem has radiating ribs and assume a star shaped appearance.

Example - Psilotum & isoetes.

III. Plecto Stele :- A such type of solid stele in which the xylem divides into a number of separate plates which lie parallel to one another.

Example - Most of the species of lycopodium.

2. Siphono stele -

Siphono stele is that stele in which the pith is present in centre of hollow vascular cylinder. Siphono is of following two types -

i. Ectopholic siphonostele - In such type of vascular tissue of stele pholem always present out side of the xylem.

Example - Equicetum, Osmunda

ii. Amphiphloic siphonostele - The vascular tissu of such type of stele in which xylem is surrounded by pholem on the both sides

Example - Adiantum, Marsilea

3. Soleno Stele :-

Solenostele is that stele in which leaf gaps produced in the main vascular tissue. Leaf gaps are produced by breaking of main vascular tissues due to the leaf. These broken pieces ofo stele is called soleno stele.

☞ Solino stele also may be Ectophloic or Amphi phloic

**4. Dictyo Stele -**

When the production of many leaf gaps in solenostele main vascular cylinder, breaks into many fragments, then such type of solenostele is called Dictyo stele. Each divided fragment (piece) is called meristele. Each meristele has its own separate endodermis and pericycle. Dictyo stele is well developed type of stele is Pteridophytes.

Example - Pteridium, Pteris, Dryoteris

**5. Eustele -**

In this type of stele, vascular bundle present in circle and medullary rays located in between them. Such type of stele is found in gymnosperm and dicotyledon plants.

**6. Atacto Stele -**

Many vascular bundles are distributed in the ground tissue. Such type of stele is called atactostele. This is highly developed type of stele. Endodermis and pericylce is absent in atacto stele. Such type of stele is the main characteristic feature of mono cotyledons.

# Dicot stem

Primary structure of a typical dicto stem shows following features -

1. Epidermis - Epidermis is the outermost layer of the stem. It is made up of single layer of cells and lack of chloroplast Multicellualr hairs and stomata are found on epidermis. Epidermis play a significant role in protection.

2. Hypodermis - It is present just below the epidermis. It is provides additional support to the epidermis. It is thick multicellular layer. This layer is composed of collenchyma and their cell contain chloroplast. So that hypodermis is green and photosynthetic.

3. Cortex - This part is composed by parenchyma. Storage of food is the main function of the cotex. The innermost layer of the cortex is termed endodermis.

4. Endodermis - This is thick single cellular layer. The cells of endodermis are barrel shaped. These cells accumulate more starch in stem of dicot. Thus, it is known as **"starch sheath".**

5. Pericycle - This layer situated in between the endodermis and vascular bundles (below the epidermis) and above the vascular bundle). The pericycle of stem is multi layered and made up of scerenchyma. Pericyle is also known as **Hard bast.** In stem of sunflower, pericycle is made of alternate bands of parechymatous and sclerenchymatous cells. In which cells of pericycle in front of the vascular bundle is made up of sclerenchyma and remaining is composed by parenchyma. A pericycle situated in fornt of vascular bundle is known as **Bundle cap.**

6. Vascular Bundle - The vascular bundle of dicot stem arranged in a ring. Well developed pith is present below their ring. Each vascular bundle is **conjoint colletral endarch**, and **open**. Each vascular bundle is made of phloem and xylem, Eustele is present indicot stems.

# Monocot Stem

The following structure is seen in a typical monocotyledon stem -

1. **Epidermis -** Epidermis is the outermost one called thick layer. It is covered with thick cuticle with stomata. Multicellular hairs are absent comparatively of stomata are is also less.

2. **Hypodermis -** Hypodermis of monocotyledon stem is made up of **scerenchyma.** This are is made of 2-3 layer of sclerenchyma.

3. **Ground tissues -** The entire mass of parenchyma cells next to hypodermis and extending to the centre is called ground tissues. These is no differentiation in between endodermis, cortex pericycle etc. parts.

4. **Vascular Bundle -** Many vascular bundle are scattered in the groud tissue. Vascular bundles lies towards the centre larger and less in number. Vascular bundles situated towards the periphery are smaller but greater in numbers. Each vascular bundle is **conjoint colleteral endarch and closed** type. Vascular bundles surrounded by the layer of sclerenchyma is known as **bundle sheath.** Monocotyledon stem contain only xylem and phloem.

i. **Xylem -** Xylem element of monocotyledon are arranged like a 'Y' and it has limited no. of vascular. Two small vessels positioned radially toward axis in the form of protoxylem. Due to presence of water in this cavity is also called **water cavity.** This cavity is formed by disintigration of the element present below the protoxylem and neighbouring parenchyma.

5. **Pith and stele -** Atactostele is found in monocotyledon. This is highly developed stele. Undifferentiated pith is present in monocotyledon stems.

# Dicot-Root

1. **Epidermis -** It is a uniseriate outermost layer. Unicellular root hairs arising form the some cells of epidermis of root is known as epiblema or **Rhizodermis** or **Piliferous layer.**

2. **Cortex -** This part is made up of parenchymatous cells. The cells of outer part of cortex are suberized in old root. It is called **Exodermis.**

3. **Endodermis -** This layer is situated between the vascular tissues and cortex. Casparian strips present radially in innermost layer of endodermis. These strips are made up of suberin.

4. **Pericycle -** This is a single called thick layer. It is composed by a type of parenchyma, which is called **prosenchyma.** Pericycle of roots is single layered. Cork cambium is formed from this layer during the secondary growth. Lateral root originates from the pericycle. Thus lateral roots are endogenous in origin. The branches of stem are exogenous in origin, because they are originates from the outer part of cortex.

5. **Vascular bundles -** Vascular bundles are radial and exarch, xylem and phloems are separate and equal in number. The number of vascular bundle in dicot is two to six (diarch to hexarch). But exceptionally **ficus** polyarchic condition is found in (Banyan tree). Tissues are situated between the xylem and phloem are called **Conjugative tissue.** These are consist of parenchyma. Vascular cambium is formed from the conjugative tissue during the secondary growth. Thus all cambium is formed after the secondary growth is roots.

6. **Pith -** It is found in the centre and is less developed or absent. Flexibility occurs due to this.

# Monocot Root & Leaf of Structure

The internal structure of a typical monocot root is the same as dicot root. But number of vascular bundle is more than six in monocot root. But exceptionally the number of vascular bundle in onion is two to six. In monocot root pit is well developed.

**Internal structureo f leaf -**

Generally leaves devided into two categories - Dorsiventral leaves and isobilateral leaves. The difference in between tham as follows -

1. Dorsiventral leaves attached at right angles of the stem while isobilateral leaves attached paralled to the stem.
2. The sturcture of both the surface of dorsiventral leaves is different, while in isobilateral, structure of both surface is similar.
3. Dorsiventral leaves found in dicot but exceptionally, isobilateral leaves also formed in Eucalyptus.
4. Isobilateral leaves occurs in monocotyledon, but **Lilium longiflora** is the exception of this.

# Secondary Growth

"The growth in diameter (girth) of the plant organs, is called secondary growth".

A permanent internal structure of the organs are formed through the apical meristems. This structure is formed in the begining of some weeks of the first year. This structure is known as **primary structure.** Primary structure is only found in Pteridophytes and monocotyledon plants.

A normal secondary growth is found in roots and stem of dicotyledons Gymnosperms. Due lack of vascular cambium in monocotyledons, secondary growth is absent. But exceptionally secondary growth is found in some monocotyledons. Such as **Palm, yucca, Draccaena, Smilax, Agave, Coconut** etc.

## Secondary growth in Dicot Stem

**A. Secondary growth in vascular Region -**

secondary growth in vascular region begins (starts) earlier than the cortical region. It is complete in the following steps -

**I. Formation of ring of vascular cambium -**

A cambium is present in vascular bundle is called **intrafascicular cambium.** This is type of primary meristem. First of all, cells of medullary rays becomes meristamatic and forming interfascicular cambium. Intrafascicular and interfascicular cambium collectively known as **vascular cambium.** Vascular cambium is formed in the form of a complete ring which is made by single layer of the cells. Two types of cells are found in the ring of this vascular cambium.

**Fusiform initials and ray initials.**

Fusiform initials are long with pointed ends, while ray initials are spherical (ovale). More fusiform initials are present in vascular cambium.



**II. Activity of vascular cambium -**

A continous periclinal divisions or tangential division takes place in fusiform initials. The plant of division in periclinal divisions is parallel to longitudinal axis of a cell. Few cells are formed towards the radius (periphery) through this type of activity and these cells differentiates into **secondary phloem or bast.** Some of the cells are formed towards the central axis and these cells are differentiate into **secondary xylem or wood.** Normally more secondary xylem is formed as compared to secondary phloem.
By the pressure of secondary phloem primary phloem pushed towards the outside and gets crushed. Thus epidermis and hypodermis can not be seen during the secondary growth in stem. By the pressure of secondary phloem primary pushed toward the outside gets crushed. Thus epidermis and hypodermis can not be seen during the secondary growth in stem. By the pressure of secondary xylem, all the primary tissues - such as primary xylem, pith, oldsecondary xylem etc. dengerated in the centre of stem because **woody.**

**I. Ring porous wood -** Vessels are arranged in the form of a ring in this wood. Such wood conducted water more efficiently.

**II. Diffused porous wood -** Asystematical distribution of vessels is found in this type of wood.

### Formation of Annual Rings

The activity of cambium do not remains equal but it is changeable in the whole year. In winter or autumn season the activity of the cambium is poor and the secondary xylem or wood formed not extensive through the vascular cambium. Cells formed during this period, are small thick walled and have narrow lumens. This is called **autumn wood** or **late wood.**

The vascular cambium is highly active in **spring** or summer season and secondary xylem formed during this period is extensive and cell of secondary xylem are larger, thin walled and have wider lumen. This wood is known as **spring wood** or **early wood.** The autumn and spring wood is formed in a rings. The ring of any type of wood is called **growth ring.** Thus two growth rings are formed during a year. A ring of autum wood and a ring of spring wood collectively known as **Annual ring.** Thus a annulal ring consist of two growth ring. The number of annual rings formed in a tree come give the idea of the age of the tree.

The study of determination of age of the plant by this techniques is called **Dendrochronology.** The annual rings are counted form the base of the stem. Because basal part having maximum annual rings and upper past have less. Therefore, counting form the basal region can give the correct idea. A piece is taken from the stem up to central region with the help **increment borer** instrument. The annual ring counted from that piece and again inserted (fitted) into the same stem at the same place. Annual ring is formed more distinct in changeable seasons.

A more distinct annual ring is formed in temperate plants. A distinct annual ring is not formed in tropical plants. A clear annual ring is not formed in India except Himalaya regions.

Lesser distinct annual ring is formed in seashore regions. Because their climate, remains the same in the whole year. More clear annual ring is formed in deciduous plants as compared to evergreen plants. Periclinical division also going on continuously in ray initials of vascular cambium. Some of the cells are formed inner side and some of the cells are formed outer side through these divisions. All these cells are made up of parenchyma. Radial lines of cells of parenchyma are formed in the stem. They are called **Vascular rays.** Madullary rays are primary and vascular rays are secondary. Both of them conducted water and food in radial direction.

**B. Secondary growth in Cortical Region**

As a result of the addition of the secondary vascular tissues, increasing the diameter of circle of xylem region and cortical region, comes under stress and strain. The some cortical tissues ultimately gets ruptured. To make good loss of protective tissues of epidermis is try to compasate but they are failured, and get ruptured at many place. This loss in fulfilled by the activity of cork cambium. Cork cambium is also known as Phellogen or **Extrastelar cambium.** Cork cambium arises from the hypodermis or from the outer layer of cortex because they becomes meristematic.

Those cells formed towards the inside, are differentiate into parenchyma. These are called **secondary ary cortex or Phelloderm.** Phallogen, cork and phelloderm are collectively known as **periderm Phellogen + Phellum (cork) + Phelloderm = Periderm**

Cork is formed in high quantity and secondary cortex is in less quantity from the cork cambium. The highest activity of cork cambium is in winter season. Most of the cells of phellum are dead. But some places living cells are also found. Suberin is not deposited in these places. These places are known as **Lenticles.** Lenticels appears on the outer surface of the plant either in small points or in the form of areas of protruberance. Lenticles are made up of scattered collection (Group) of living cells, These cells are known as **complementary tissue.** Lenticles normally formed below the stomata. Lenticles serve for exchange of gases between the plant and atmosphere. Transpiration is also take place through the lenticles, is know as Lenticular transpiration. Adventitius roots cutting originated from the living cells of lenticles in vegetative reproduction. Lenticles mainly formed on stem and it is never found on leaves. Even lenticles are present all over the plant body. They are also present on fruits. Cork cambium remains living only for the one year. Each year, a new cambium is formed below the previous cambium. This new cambium derived from the secondary cortex on phelloderm.

**Bark**

All the tissue situated out side the vascular cambium is called **Bark. Bark** has two part.

1. **Outer Bark** - Outer bark is dead. All the tissues lies out side the cork cambium are called **outer bark.** It is also known as Rhytidome.

2. **Inner Bark -** The region in between the cork cambium and vascular cambium is called inner bark. Its most of the part is living. The main region of inner bark is the **secondary phloem** or bast. Thus bark

consist of both type of tissues living non living (dead). A plant will die if we removed the complete bark of the plant because maximum loss of water from this. If a ring of bark removed from the base of the plant within a few days a plant dies. Because phloem is separated due to this activity and plant comes in the state of defficiency of food.

**Kind of Bark**

1. Ring Bark - Ring bark is formed around the stem in a complete ring. When the ring of cork cambium is completed then it is known as ring bark.

   Example - Betula vulgaris - Bhojpatra, A complete distinct ring bark is formed in this plant. Its bark used writting material as a paper in the ancient period. Ring bark is also formed in Eucalyptus.

2. Scaly Bark - This bark is formed around the stem in the from of peices or fragments. When the ring of cork cambium is not continuous, the scaly bark is formed.

**Secondary growth in Dicot Root -**

Secondary growth is essential in roots to provide strength to the growing aerial parts of the plants and fulfill the requirement of water and minerals. Secondary growth is not found in monocot roots. First of all, conjunctive tissue becomes meristematic during the secondary growth in a dicot-root to form a vascular cambium which is formd is separate curved strips. Then after, the cells of pericycle lying out side the protoxylem also becomes meristematic to form a additional strips of cambium. In this way a complete ring of vascular cambium is formed. The portion of vascular cambium is formed by pericycle is less. The main portion of vascular cambium is formed by conjunctive tissue.

The shape of ring of vascular cambium is **wavy** in the begining, but latter on it becomes circular due to the pressure of secondary xylem. The portion of vascular cambium is formed by conjunctive tissue becomes meristematic first and form the secondary xylem towards the centre. Resulting ultimately the ring becomes circular by the pressure of secondary xylem (Pushing outwards).

The activity of vascular cambium of root is the same as the activity of vascular cambium of stem. Secondary xylem is formed towards the inner side and secondary phloem is formed toward the outer side by vascular cambium. The portion of vascular cambium which is formed by pericycle is responsible for the formation of **pith rays.** These are made by parenchyma. These pith rays are known as **primary medullary rays.** A few medullary or pith rays are also formed from vascular cambium. These are called **secondary medullary rays.** Thus two types of medullary rays are found in the secondary structure of roots. The presence of two types of medullary rays is basic characteristic features of roots. Only secondary rays are found in stem. Both of the medulary rays conducted water and food in radial direction.



☞ Cork cambium is developed from the **pericycle** in roots. Cork is formed towards the outside and secondary cortex is formed towards the inner side by the cork cambium.

**Functions of secondary meristem (Cambium)**

1. **Healing of wounds -** When wound is formed on any stem, then living cells of the wound is responsible to form a cambium. This is called **wound cambium.** It is also called inducibel cambium. This newly formed cambium to form a cork towards the outside. The cork covers the wound entirely. Thus the wound is healed. a out growth like structure of parenchymatous cells are found on the margins of hte wound. This is known as **Callus.**

2. **Abscission -** The leaves of most of the Pteridophytes and branched Angiosperms are either falls after degeneration of destroyed on the plants.

   The leaves in Gymnosperms and woody dicotyledons are separate through the abscission before their death. Middle lamella is dissolve in abscission layer abscission and primary walls also dissolve partially or completely. The place from where leaf separated, is called **leaf scar.** The living cells present in leaf scar is responsible to form cork cambium. Resulting, cork is formed towards the outside and so that ultimately the relation of the leaf detached from the plant. This is termed abscission.

**Anomalous secondary growth in stem -**

1. **Anomalus/abnormal position of vascular cambium -** Normally vascular cambium is circular, but it is folded in stem of some plants later on these folds breaks and separate from each other. Each fold is responsible to form a complete vascular bundle. Many vascular bundles are formed in stem.

   **Example - Thinowia, Serjania, Bauhinia.**

2. **Abnormal Activity of vascular Cambium -** Parenchyma is formed form the maximum part of the vascular cambium. Only (rarely) in some places xylem and phloem is formed, while generally xylem and phloem is formed from the maximum part of the vascular cambium, and medullary rays are formed from the few part of vascular cambium.

   **Example - Aristolochia, Vitis vinifera (Grape).**

3. **Sequential or successive ring of vascular cambium -** In some of the plants, a new ring of vascular cambium is formed in each year. This is formed out side the previous ring.

   **Example - Cycas, Gnetum, Mirabilis, Boerahvia, Bougainvilia,** etc.

4. **External Stelar vascular cambium -** Vascular cambium is formed from the pericycle in plants of Amranthacear and chinopodiacear family. A complete ring of vascular cambium is formed from the pericycle.

5. **Interxylary Cork -** Parenchyma of secondary xylem becomes meristematic in some of the plants and behave like a cork cambium. It means cork is formed to the interior of wood.

   **Example - Artemesiatridentata etc.**

6. **Cork cambium form Epidermis -** Cork cambium originates from the epidermis in same of the plants.

   **Example - Solanum dulcamara, Quercus suber** (oak). commercial cork is obtianed from the oak.

7. **Secondary Growth in Monocotyledons -** In some members of plants such as Dracaena, Yucca, **Agave, Aloe arboresence, Lomandra, Kingia, Senseviera,** Vascular cambium formed from the outer region of the ground tissues. Parenchyma is formed towards the outside by the vascular cambium and vascular bundles are formed toward the inner side.

   In some plants, the girth of the stem increased without cambium. Such as Palms, Musa, Tulipa etc. The apical meristem of these plants is special type. This is known as **primary thickening meristem.** This apical meristem is responsible for the growth in both length and girth (thickness) of the plant.