SREE SIDDAGANGA COLLEGE
OF ARTS, SCIENCE and COMMERCE
B.H. ROAD, TUMKUR

(AFFILIATED TO TUMKUR UNIVERSITY)

BOTANY
II BSC IV SEMESTER
PAPER-IV
(Plant Anatomy, Morphology of Angiosperms, Plant Propagations)

Study material

THEORY SYLLABUS

Unit-1: (14 Hrs).
Meristamatic tissues – structure, classification based on origin, position and function.
Theories of Apical meristems -Histogen theory, Tunica-Corpus theory.
Permanent tissues-Simple and Complex and Secretary Tissues.

Unit-2: (8 Hrs).
Structure of Dicot & Monocot Root, Stem and Leaf.

Unit-3 :(10 Hrs).
Secondary growth in Dicot stem, Anamalous secondary growth in *Dracena* and *Boerhaavia.*
Wood anatomy-A brief account, types of wood (spring, autumn, Duramen, Alburnum, Porus wood and Non Porous wood).

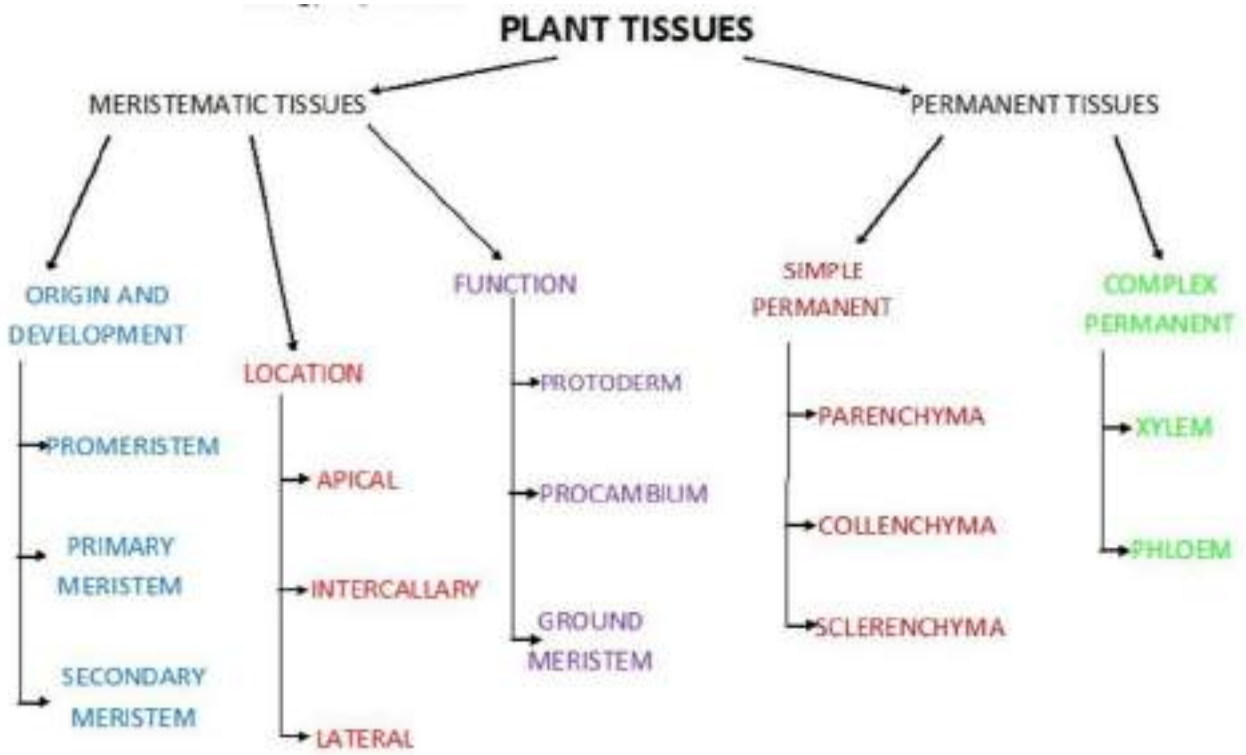
Unit-4 :(20 Hrs)
Morphology of Angiosperms-Root System and its modifications,
Shoot system and Stem modifications, Leaf and its modifications, Inflorescence, Floral morphology and Fruits
.
Unit-5:(8 Hrs.)
Plant Propagation-Methods of Vegetative propagation-
Natural- Rhizome, Tuber, Corm, Bulb, Sucker, Stolon and offset,
Artificial-Stem Cutting, Grafting and Layering.

Unit-1: (14 Hrs).

Meristamatic tissues – structure, classification based on origin, position and function.
Theories of Apical meristems -Histogen theory, Tunica-Corpus theory.
Permanent tissues-Simple and Complex and Secretary Tissues.

Plant Tissue System

A group cells which are alike in origin, structure and together perform a specific function is called "Tissue". There are 2 types of Plant Tissues. They are:-
Meristematic tissues and Permanent tissue.



Meristematic tissue:

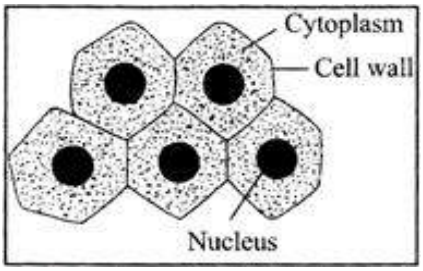
Meristematic tissue is a group of immature, young. **Undifferentiated cells** that has **power of continuous division.** Meristematic tissue is commonly called as meristem. **. Present in Root and Shoot apex** They assist in the **growth in length and diameter** of the plant.

Characteristics of Meristematic Tissue

The characteristics of meristematic tissue are as follows:

1. .Meristematic tissues consists of **living cells** with power of continuous division . It is, commonly called **meristems. Carl Wilhelm von Nägeli coined the term "meristem".**

2. The cells of the meristematic tissue are **undifferentiated, young and immature**.
3. Each cell is **oval, rounded, polygonal** or rectangular.



4. Cells are **compactly arranged without intercellular spaces**.
5. **The cell wall is thin made up of Cellulose.It encloses dense protoplasm**
6. They possess a **single, large and prominent nucleus.**
7. **Vacuoles are very small and few .**
8. They **do not store food**, but exhibit a very high metabolic activity.
9. The meristematic tissues **heal the wounds of an injured plant.**

Types of Meristematic tissue

Meristematic tissue is classified based on its origin in the plant body, **based on its position in the plant body and Based on Function it perform.**

1.Types of meristematic tissue Based on origin : Based on the origin Meristematic tissue is classified into 3 types as follows:-

1. Promeristem (primodial meristem)
2. Primary meristem
3. Secondary meristem

1.Promeristem: It is: embryonic in origin It is earliest and youngest meristematic tissue present in growing root and shoot tip.. It give rises to primary meristem,

2.Primary meristem: It arise from Promeristem. Cell are always active and dividing, Present below promeristem in the shoot and root tip, and also in intercalary position.It give rises to secondary meristem, and primary permanent tissue.

3.Secondary meristem: It arise **from primary meristem.** It is developed later on life.**It give rises to secondary permanent tissue**

2.Types of Meristematic tissue Based on position; Based on the position in the plant body Meristematic tissue is classified into 3 types as follows:-

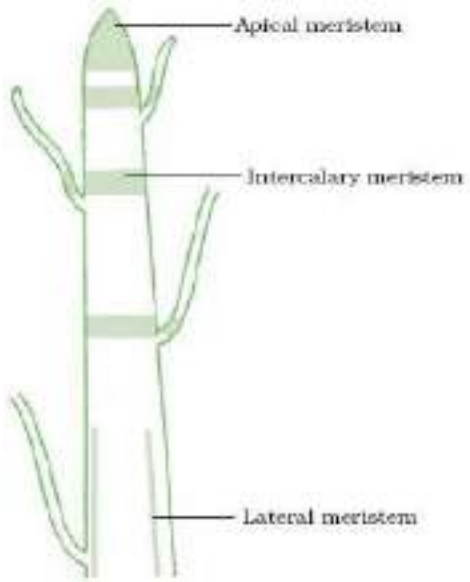
a) Apical meristem
b) Intercalary meristem
c) Lateral meristem

a) **Apical Meristem**:It is present at apical parts of plant such as root tip and shoot tip. It helps **in increase in height of plants.** Apical meristem has two distinct zone:

- **Promeristem zone** which contains group of **dividing cell (apical initials).**
- **Meristematic zone**: that contains **protoderms** (epiderm),
- **procambium** (primary vascular tissue) **and ground meristem** (cortex and pith).

b)Intercalary Meristem: It is **present in intercalary position in the leaves and internode.** It is a part of apical meristem**.** It also a**dds to height of plants.** Commonly present in monocots, grass and pines

c)Lateral Meristem: It is **present on lateral side of stem and root. It helps in increases the diameter or thickness of plants. Example: vascular cambium (primary meristem) and cork cambium (secondary meristem).**



3.Types of meristematic tissue Based on function; Based on the function it performs in the plant body Meristematic tissue is classified into 3 types as follows:-

a. Protoderm
b. Procambium
c. Ground meristem

a.Protoderm: It is the outermost meristematic tissue. It gives rise to Epidermis that gives protection from mechanical injury.

b.Procambium: It is the innermost meristematic tissue, It gives rise to vascular tissue (xylem and phloem). It transport of water and nutrition

c.Ground meristem: It gives rise to cortex, endodermis, pericycle and pith in dicot and hypodermis, ground tissue in monocot.Function: various functions.

Theories of meristematic tissues.

Several theories are proposed **to explain the origin of Apical meristem**. They are as follows: - **1. Histogen theory 2. Tunica – corpus theory**

1.Histogen theory (histogen means tissue builder).

Hanstein in 1868 put forward histogen theory

According to this theory the tissues of a plant body originate from a mass of meristem where the following three (histogens) can be distinguished

(a) Dermatogen:(In Greek meaning skin).

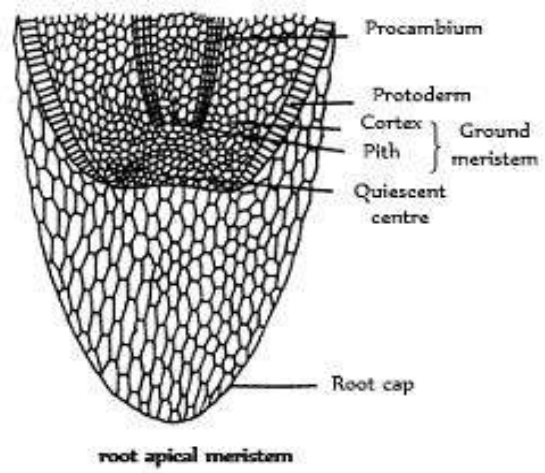
It is the **outermost layer of the meristem. It gives rise to epidermises of root and stem**.

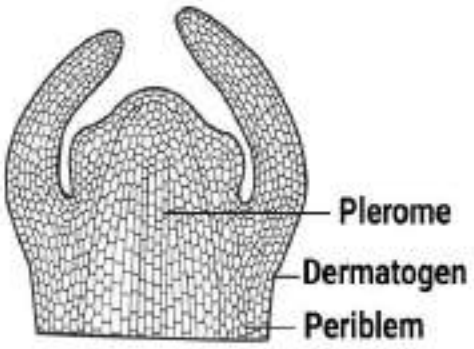
(b) Periblem:(In Greek meaning clothing).

This region occurs **internal to dermatogen** but peripheral to plerome. This histogen is destined to form cortex of root and shoot and inner tissues of leaves. It surrounds plerome.

(c) Plerome:(In Greek meaning that this fills).

This **region gives rise to vascular cylinder of stem and root** and pith. It is the central core of stem and root and the cells composing this zone are enveloped by a layers represented by dermatogen and periblem.





Root apex **Shoot apex**

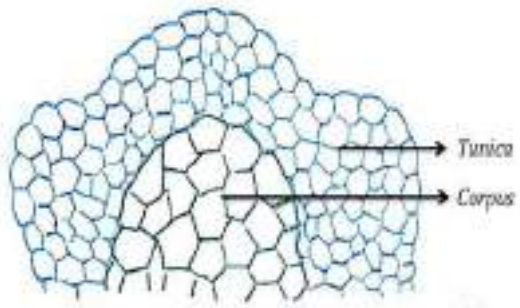
Demerits of Histogen theory

1.There is no clear clear demarcation between Periblem and Pleurome in Gymnosperns and Angiosperms.

2.The roles of three Histogens is nor demonstrated.

2. Tunica – corpus theory

Schmidt in 1924 proposed Tunica corpus theory on the basis of studies of shoot apices of angiosperm. tunica- corpus theory Tunica-corpus theory is applicable only to **shoot.** According to this theory there are two zones of Apical meristem. Tunica and Corpus.



Apical Meristem Organization in Shoot
Tunica-Corpus Theory

Tunica: -

Tunica is the outer zone consisting of one or more peripheral layers of small uniform cells normally divide anticlinally (Perpendicular to the Surface).In Dicots it is 1to 5 layered, in Monocots it is 1 to 4 layered. It is responsible for the surface growth in the apex as a sheet but not in thickness. **To increase in thickness it has to divide periclinally**. Normally it does not occur except at the point of origin of leaf primordium and axillary bud.

Cytological 2 zones are recognized in Tunica. The **first one is central apical zone** and **second is occurs between Central apical zone and leaf primardium.**

Corpus:-

Corpus is the **inner zone of shoot apex** composed of **undifferentiated mass** of larger cells enclosed by Tunica. It **divides in all palnes to increase volume** of shoot apex. **It gives rise to cortex and Vascular tissue**.

It consists of several zones such as: **Central mother cells**: - It is the **uppermost zone** of Corpus; **Pith rib meristem**: - Occurs below the **Central mother cell zone; Flank meristem**: - It **surrounds both Central mother zone** and pith rib meristem.

Merits of Tunica corpus theory.

- It deals with planes of **cell division**, description of meristem becomes precise.
- It **explains growth pattern clearly** in shoot apex of Angiosperms.
- It enables to understand **development of leaves** as they arise close to apex.
- Specific **variation of number of Tunica layer may be of Taxonomic importance** as in Grass.
- It has topographical value in the study of **development of different tissue system in** plants.
- The **destiny of derivatives of corpus is not predetermined**.

Permanent Tissue

The tissues which are Differentiated, mature cells that have lost the ability of division are known as **permanent tissues**. it is of 2 types. Namely

A] Simple permanent tissue B] Complex permanenent tissue.

A] Simple Permanent Tissue

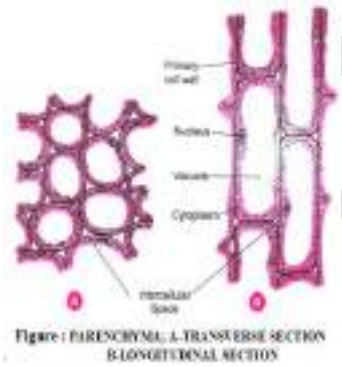
The tissue which is composed of **group of identical cells (Homogenous) which together perform common function** is called **Simple Permanent Tissue.** Simple permanent tissue is divided into three categories: They are as follows:-

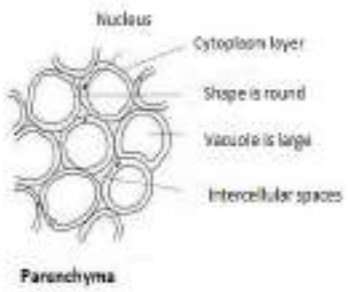
1. **Parenchyma**
2. **Collenchyma**
3. **Sclerenchyma**

1.Parechyma

Parenchyma is a living Simple permanent tissue present in almost all parts of the plant such as pith and cortex of stems and roots, mesophyll of leaves, reproductive cells like spores, gametes. the flesh of succulent fruits and in the endosperm of seeds, and along with other tissues like Xylem and Phloem

Structure of Parenchyma Cells

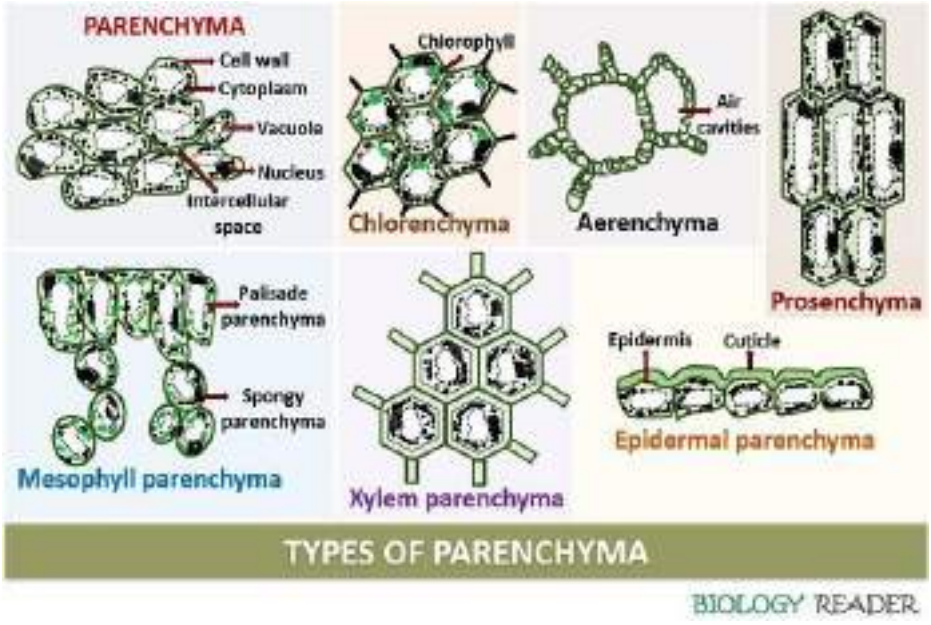




- **Parenchyma is a living, simple permanent tissue.**
- The cells of parenchyma are **isodiametric or polyhedral in shape**. They may be polygonal, oval, round or elongated
- These cells are **closely packed** or may have **small intercellular space**
- They are made up of thin **cell wall made up of cellulose**, hemicelluloses Plasmodesmata join the cells of the parenchyma tissue.
- Cell wall encloses **prominent nucleus, protoplast**. and **small vacuoles.**

Types of Parenchyma Cells

Parenchyma cells can be categorised based on their structure, location and functions performed. The main parenchyma tissues are:



1.Chlorenchyma: Cells which have **chloroplast and perform photosynthesis.** Ex: The **mesophy**ll cells in leaves which differentiate into palisade and spongy cells, In the other green parts of the plants like **stems, sepal** , in areas of absorption and secretion in plants like **nectarines and in carnivorous plants**

2. Vascular Parenchyma: The **parenchyma cells associated with vascular tissues.**
Ex: **Phloem Parenchyma: E**longated, cells having dense cytoplasm. Absent in monocotyledons. **Xylem Parenchyma:** It is made up of thin-walled cells.

3.Storage Parenchyma: These **store various substances like water, starch, proteins** etc. They act as a food and water reservoir.(Stored protein is a source of nitrogen ,starch ,in potato tubers, the endosperm, amyloplasts.water storage in succulentssuch as Cactaceae

4. **Prosenchyma:** These are **thick-walled fibre-like elongated cells**, which provide rigidity **and strength to the plant**

5.Aerenchyma: These contain very **large intercellular spaces filled with air**. Aerenchyma helps in the **buoyancy in floating :Hydrophytes**,.

6.Epidermis Parenchyma: Parenchyma **found in the epidermis** of the leaves of some gymnosperms. these have cutinised cell wall, reduces transpiration

7.Conjunctive Parenchyma: parenchyma is **present in the root system.**

Functions of Parenchyma cells

Parenchyma tissues perform various important functions:

1. **Storage:** Parenchyma cells have large intercellular space which is ideal for storage

2.Transport: Parenchyma cells transport nutrients and other chemicals.The Xylem parenchyma helps in radial transportation of water and minerals

3.Photosynthesis: Chlorenchyma present in the mesophyll and the other green parts of the plant, have chloroplasts and perform photosynthesis

4.Gas Exchange: Aerenchyma cells help in the gas exchange and floating(Buoyancy) in Aquatic plants.

5.Protection: In gymnosperms, the parenchymatous cell have spiny projections that help in the protection from predators

6.Totipotent: Parenchyma cells have an ability to transform to the other types of cells and act as a precursor for other types of cells

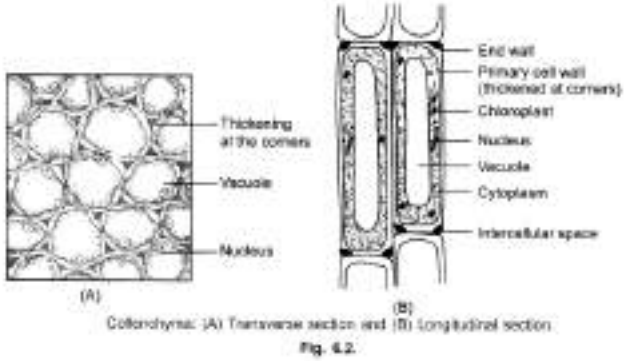
7.Healing and regeneration: Parenchyma cells which regain their ability to divide even on maturity help in regeneration and wound healing.

8.**Tyloses** present in the xylem parenchyma help in preventing damage to vascular tissues in the condition of drought.

Collenchyma

Collenchyma tissue is a living, flexible and mechanical ,simple permanent tissue. It is found in the Pedicel, Petiole. ,Peduncle, epidermis and the vascular bundle of dicot leaf.

Structure of Collenchyma



Collenchyma: (A) Transverse section and (B) Longitudinal section

Fig. 4.2.

- **Collenchyma tissue is a living, mechanical ,simple p ermanent tissue.**
- Each cell is elongated, Unevenly thick walled , Intercellular space: may be present or absent
- The **cell wall** is made up of **cellulose and pectin in intercellular space.**
- It encloses vacuolated cytoplasm and prominent Nucleus.
- The amount of chloroplast is less in the cells.
- The cells have **no intercellular spaces.**

Types of collenchyma tissue:

Collenchyma is classified based on deposition of Hemicellulose and Pection in cell wall into 3 types. They are as follows:-

1. **Angular collenchyma**: **thick cell wall at corner of cell**; without intercellular space
2. **Lacunar collenchyma: thick wall at boarder of cell; large intercellular space**
3. **Plate or lamellar collenchyma:** thick wall at **tangential wall; without intercellular space.**

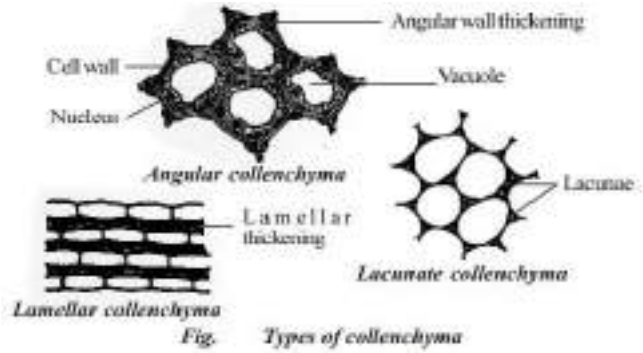


Fig. Types of collenchyma

Functions of collenchyma

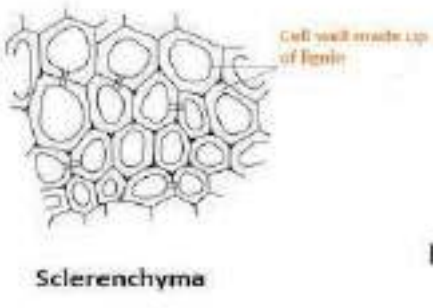
1. **collenchyma** provides **mechanical support and elasticity to the stems of dicot** plants.
2. Cells possess chloroplast; then, it is involved in **manufacturing sugar and starch.**
3. Provides tensile **strength and flexibility to the plant body**.

Sclerenchyma:

(Gr. *scleros*, hard + *enchyma*, infusion, in reference to the infusion of lignin in the secondary cell walls)

Sclerenchyma is a dead, Mechhanical simple permanent tissue. These tissues are present in stem, covering of seeds, nuts, around the veins of the leaves, around vascular bundles.

Structure of Sclerenchyma:

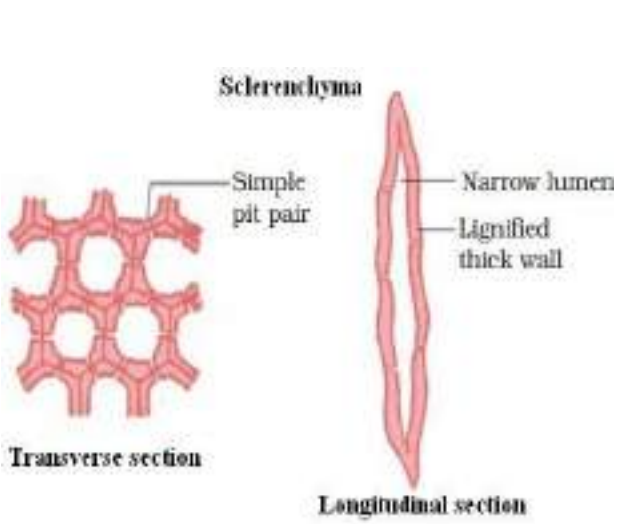


- Sclerenchyma is a,**dead mechanical, simple tissue present** in Pericarp, seed coat which makes the plant hard and stiff.

- Cells have h extremely thick cell walls(secondary wall) **lignified(** The walls of the cell are thick due to the presence of lignin.)
  - It is composed of **elongated cells pointed at both end.**
  - Cell **lack protoplasm.**
  - Cell wall encloses an **empty cavity called 'Lumen'.**
  - Sclerenchyma gives **strength and rigidit**y to the plant body

Types of sclerenchyma tissue

Sclerenchyma is composed of 2 types . They are 1) Fibres ,2) Sclereids



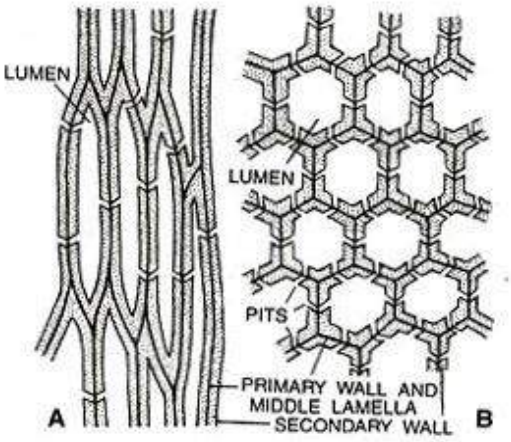


Fig. 6.9. Sclerenchyma Fibres. A, longitudinal section; B, transverse section.

i. Fibres:

- Fibres are **thick walled, elongated, spindle shaped cells with pointed tips.**
- Cell wall enclosed **narrow lumen** with simple **rounded pits and lignified secondary wall**
- It is Distributed in cortex, pericycle, xylem and phloem

Types of Fibres: fibres are classified into 3 types as follows:-

a**. Surface fibres**: found on fruit wall and seed coat (e.g., coconut)
b**. Xylary or Wood fibres**: associated with xylem
c**. Extraxylary or Bast fibres**: seen associated with cortex, pericycle and phloem

Function of Fibres:

- Fibres Provide **mechanical support** to the plant parts
- **Surface fibres help in seed and fruit dispersal**

ii. Sclereids (stone cell):

- Sclereids are extremely thick **walled cell** with **spherical, oval or dumbbell shape.**
- Cell wall **contains simple pits**
- **Present in hard part of plants, pulp of fruits**

- Provide local mechanical **supports**
- **These are classified based on their shapes as follows:-**

1.Stone cells:- The sclereids are **isodiametric a**nd resemble parenchyma cells.,commonly known as **stone cell** due to **hard walls**. Ex: Flesh of fruits of Pyrus, Cinnamomum stem.

2. Macrosclereids: . Macrosclereids are **rod like scklereids** present in bark and seed coat of Leguminous plants.

3.Osteo sclereids: The osteosclereids **are columnar ,the end may be lobed or branched** or simply enlarged like a narrow bone, e.g. the seed coats of Pisum, the leaves of Hakea etc**.**

4.Astro sclereids: Astro sclereids **are stellate cell**(deeply lobed or branched) ,resembles stars, e.g. leaves of Thea (tea),petiole of Nymphaea etc.

5.Filiform sclereids: Filiform sclereids are **hair like elongated cell with branches,** which extends into the intercellular spaces, e.g. leaves of Olea, Nymphaea, and aerial root of Monstera etc.

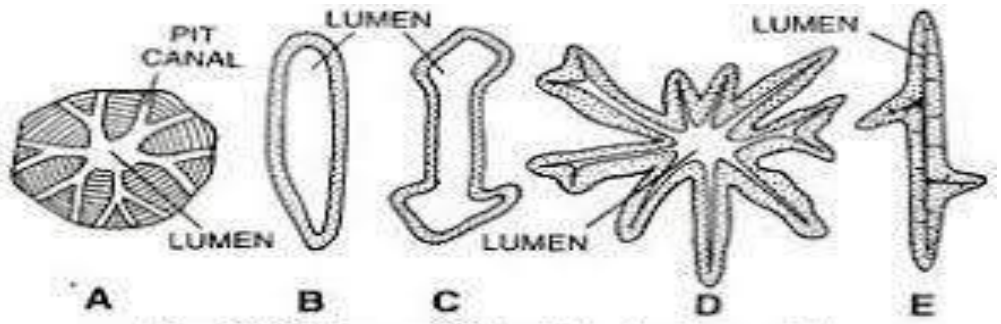


Fig. 6.10. Types of Sclereids. A, stone cell. (branchysclereid) with pit canals; B, macrosclereid; C, osteosclereid; D, astrosclereid; E, filiform sclereid.

Function of Sclereids :

- Sclereids are **mechanical cells and support the** tissues in which they occur.
- Sclereids, form **a continuous layer at the periphery, protect the inner tissues**.
- It makes the plant body **rigid, flexible, and elastic.**
- **Provides hardness to stony fruits** such as nuts, coconut, almond etc

- **The difference between the three simple tissues**

Parenchyma	**Collenchyma**	**Sclerenchyma**
It consists of thin-walled living cells.	It consists of thin-walled living cells	It consists of dead cells.
They are involved in food storage.	They are the chief mechanical tissue in young plants, particularly dicot stems.	It is mainly a mechanical tissue.
They are involved in food storage.	It comprises an uneven cell wall and is made up of pectin and hemicellulose	It comprises the hard and thick cell wall and is made up of lignin

Complex permanent tissue

The complex tissues **are heterogeneous in nature**, being composed **of different types of cell** elements. Xylem and phloem are the complex tissues which constitute the **component parts of the vascular bundle**. They are also called **vascular tissues.** These are the two most important complex tissues in a plant, as their primary functions include **the transport of water, ions, and soluble food substances throughout the plant.**

I. Xylem also known as wood

- Xylem is a **complex tissue** it consists of different types of cells and elements, **living and non-living.**
- Xylem is a complex tissue forming a **part of the vascular bundle**.
- Primary xylem **originates from the procambium of apical meristem**, and **secondary xylem from the vascular cambium**

- The function of xylem is to **transport water and minerals from** the root to the leaves of plants.
- It also provides mechanical **support to plants.**
- Xylem is composed of four types of cells-**Tracheids, Vessels, Xylem fibres and Xylem parenchyma.**

Components of Xylem(Elements of Xylem):

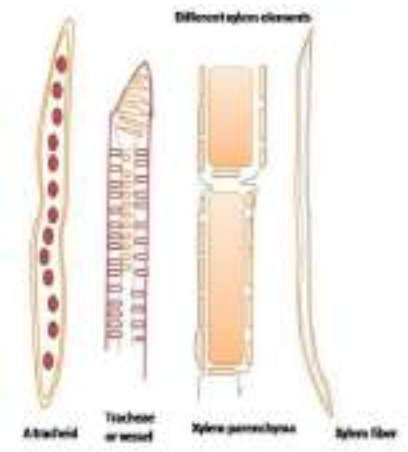
xylem is composed of 4 elements(Components).They are

1)Tracheids- Dead component.

2Ttracheae or vessels - Dead component

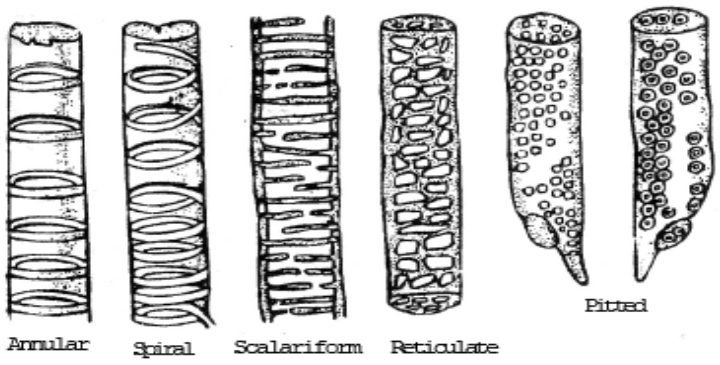
3) Xylem fibres, called xylem fibres or wood fibres- Dead component

4)Xylem parenchyma, referred to as xylem or wood parenchyma – **living component**



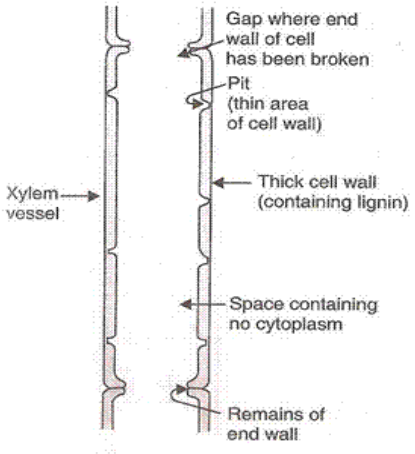
1)Tracheids(Dead component).

- A **Tracheid is an elongate cell** occurring along the long axis of the organ. The cells are **devoid of protoplast**, and hence **considered as dead component**.
- Tracheid **has a cavity, lumen** without any contents and tapering blunt ends.
- Tracheids are **round or polyhedral in cross-section.**
- Tracheids are most primitive and fundamental element in xylem element found in the fossils of seed-plants. In modern plants they occur predominately in lower vascular plants, the pteridophytes and gymnosperms
- The **wall is hard, thick and lignified**.
- **Secondary walls are deposited in different manners,** so that the tracheids may be **annular, spiral, reticulate, scalariform or pitted.**



Different types of thickening on the walls of tracheids and vessels

2.Tracheae(vessels)



The structure of xylem vessels

- **Vessel or a** Trachea originates from a row of meristematic cells of procambium or vascular cambium which remain attached end on end in longitudinal series
- They **do not occur in some xerophytes, parasites and aquatic plants**.
- Trachea or vessel is formed from a row of **cylindrical cells arranged in longitudinal series like a tube.**
- **Perforations are present in end-walls,** may rarely occur on the lateral walls
- The vessels have distinct **'perforate'** bodies which makes **translocation of solutes easy.**
- **perforations** remain either in more or less parallel series like bars called **scalariform perforation** or in form of a network known as **reticulate perforation**, or even may form a group of **circular holes** (foraminate perforation). The perforation occurs in form of a **single large circle**, referred to as simple perforation

- Elements are **devoid of protoplast and have hard and lignified cell-wall with different types of localised thickenings such as** ring-like, spiral, scalariform, reticulate or pitted. The pits are mostly of bordered types.
- **Transpor**t **of water and solutes**, and, secondarily, for mechanical support.

FIG. 539. Tracheae—different types. A. With multiple perforation plate in L.s. and t.s. B, C & D. With simple perforation plates.

3.Xylem Fibres:

- **Sclerenchyma fibres remain associated with other elements in xylem.**
- They give **mechanical support**.
- Fibres are very much **elongated, dead cells with lignified walls**.
- Xylem fibres or wood fibres are mainly of two types: **fibre-traeheids and libiriform fibres.**
- **Fibre-tracheids are intermediate** forms **between fibres and tracheids**, possess bordered pits,
- **Libiriform fibres** are narrow with highly thickened secondary wall.

4.Xylem Parenchyma:

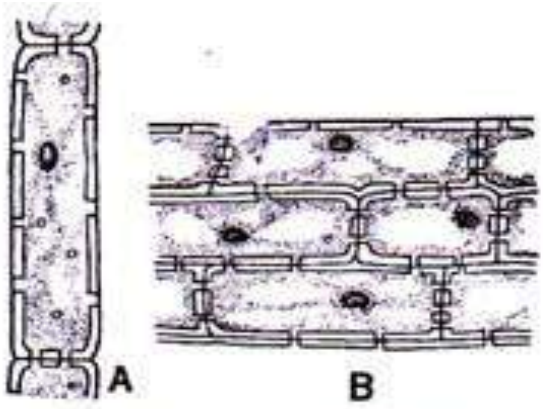


FIG. 541. Xylem Parenchyma.
A. Parenchyma. B. Ray cells.

- **Xylem Parenchyma** is **living parenchyma associated with other xylem elements**
- The cells may be **thin-walled or thick-walled**. If lignified secondary wall is present.
- These are **meant for storage of starch and fatty food**; Tannins, crystals, etc., may also be present.
- They are **involved in conduction of water and solutes** and mechanical support.

Phloem (Bast and leptome)

Phloem is a complex tissue forming a part of the vascular bundle Phloem originate from the **procambium of apical meristem or the vascular cambium**. It is meant for **translocation of organic solutes**—the elaborated food materials in solution. It is composed of

1. **Sieve elements**
2. **companion cells**
3. **PhloemParenchyma**
4. **Phloem fibres.**

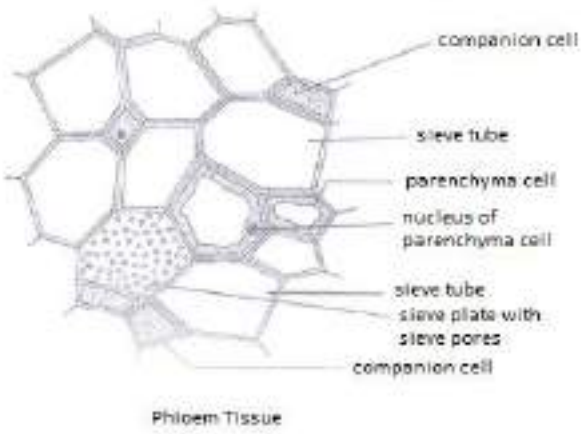
1.Sieve Elements:

The constituents of phloem sieve elements is composed of a**)sieve tubes and b)sieve cells.**

a)sieve tubes

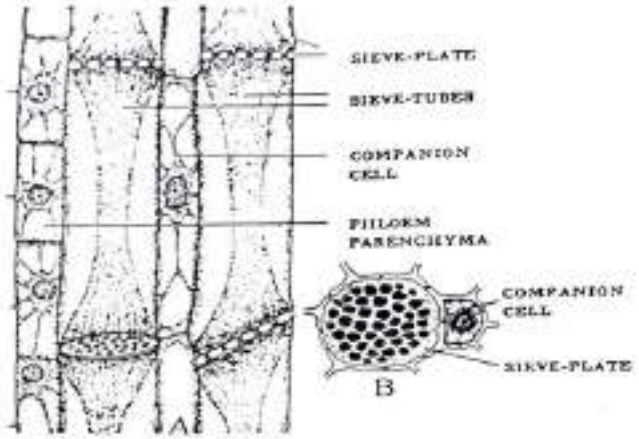
- **Sieve tubes are long tube-like structures** formed arranged in longitudinal series.
- **The end-walls of Sieve tube are perforated** in a sieve-like manner. The perforated end-walls are called **the sieve plates**. Through **which cytoplasm connections are established between adjacent cells.**

- Sieve plate is called **simple , if it has only one sieve area**, Sieve plate is **compound, if it has several sieve areas arranged in scalariform, reticulate or other manners.**



Phloem Tissue

Transvers section of Phloem



Longitudinal section of Phloem

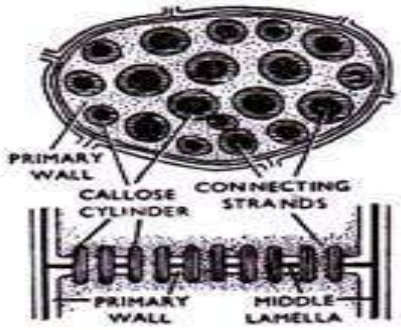


FIG. 543. Sieve tube. Structure of sieve area of an angiosperm in surface (upper) and sectional (lower) views (diagrammatic).

b)Sieve cells

- Sieve cells are **more primitive than the sieve tubes**.
- They occur in lower vascular plants and gymnosperms.
- Sieve cells are **narrow elongated cells without conspicuous sieve areas.But** with **inclined walls.**
- They originate from the mother cells which are usually short cylindrical or elongate ones.

2.Companion Cells:

- Companion cells occur **abundantly in angiosperms**, particularly in the monocotyledons. They **are absent in some primitive dicotyledons.**
- The **procambial mother cell divides longitudinally into two daughter cells**, one of which serves as the **sieve element** and the **other one becomes the companion cell. Hence companion cell is considered as Sister cell to sieve tube.**Companion cells remain associated with the sieve tubes of angiosperms,
- These **are smaller cells, having dense cytoplasm and prominent nuclei** without Starch grains. The wall between the sieve tube and companion cell is thin and provided with primary pit fields. Controls the activity of sieve tube.
- In **transverse section** it appears as **a small triangular, rectangular or polyhedral** cell with **dense protoplast.**

3.Phloem Parenchyma:

- Parenchyma cells associated with sieve elements are referred as Phloem Parenchyma.
- It is absent in the phloem of monocotyledons.

- These are **elongated cells and occur with the sieve elements along the long axis**
- These are **living cells with cellulose walls having primary pit fields**.
- In secondary phloem they may be of two types. namely
  phloem parenchyma-It occurs in **vertical** series and **Ray cells**-It occurs in horizontal planes.
- They are meant **for storage of organic food matters. Tannins, crystals** etc.

4.Fibres:

- **Sclerenchymatous fibres associated with phloem** is referred as **Phloem fibres** or **Bast fibres**. They are rare in pteridophytes and some spermatophytes.
- These fibres are used for the **manufacture of ropes and cords**. Provides mechanical strength to the plant.

Unit-2: (8 Hrs):- Structure of Dicot & Monocot Root, Stem and Leaf.

Structure of Dicot & Monocot Root

A typical Angiosperm is distinguished into 2 parts. They are 1) Root system 2) Shoot system
I.Root system: -

Root system is an underground, non green descending organ of the plant developed from Radicle part of an embryo. It is positively geotropic, positively hydrotropic. Perform function of Anchorage, absorption and conduction.
There are 2 types of Root system. Namely 1) Tap root system 2) Fibrous root system.

1. Tap root system: - Ex: - Dicot plants

In Tap root system Radicle develops into single, central main root called 'Primary root'. It develops lateral secondary roots which in turn branches to form tertiary and quaternary roots. Lateral roots bear unicellular root hairs which take part in absorption of water and mineral nutrients from soil. Tap root grows deep into the soil and persists throughout life of the plant.

2. Fibrous root system: - Ex: - Monocot plants.

In Fibrous root system Radicle develops into primary root. It is short lived and soon replaced by cluster of slender, fibre like root. They bear root hairs which help in absorption. Fibrous root does not grow deep into the soil (Surface feeders), and they are periodically renewed.

Study of Anatomy of Root

Anatomy of Dicot root. EX;-Cicer root

Transverse section of Cicer root shows following Anatomical features:-

1. **Epiblema:** Epiblema is the outermost layer of Root. It is consists of single layer of compactly arranged, rectangular, thin walled cells. Some of the cells develop into unicellular, tubular cells called **'Root hair'. It is meant fro absorption.**

2. Cortex: Cortex is composed of many layers of Parenchyma cells with intercellular spaces. **Endodermis** is innermost layer of the cortex. It consists of single layer of barrel shaped cells with casparian strips on their radial walls. Few endodermal cells opposite to ProtoXylem are thin walled called **'Passage cells".**

3. Stele: Stele is composed of Pericycle, Vascular bundle, Conjunctive tissue and Pith.

a) Pericycle: Pericycle is the outermost layer of stele present next to endodermis. It is made up of single layer of parenchyma cells.

b) Vascular bundle: - Vascular bundle is Radial, Tetrarch and Exarch.(Radial-Xylem and Phloem are present alternately at different radii**, Tetrarch-** There are 4 patches of Xylem alternating with 4 patches of Phloem**,Exarch-** Protoxylem is present towards pericycle and Meta Xylem towards Pith.)

c) Conjunctive tissue: - Parenchyma tissue present between Vascular bundle is called '**Conjunctive tissue'.**

d) Pith:-Central region of stele made up of parenchyma tissue is constitutes **'Pith'.** It is small.

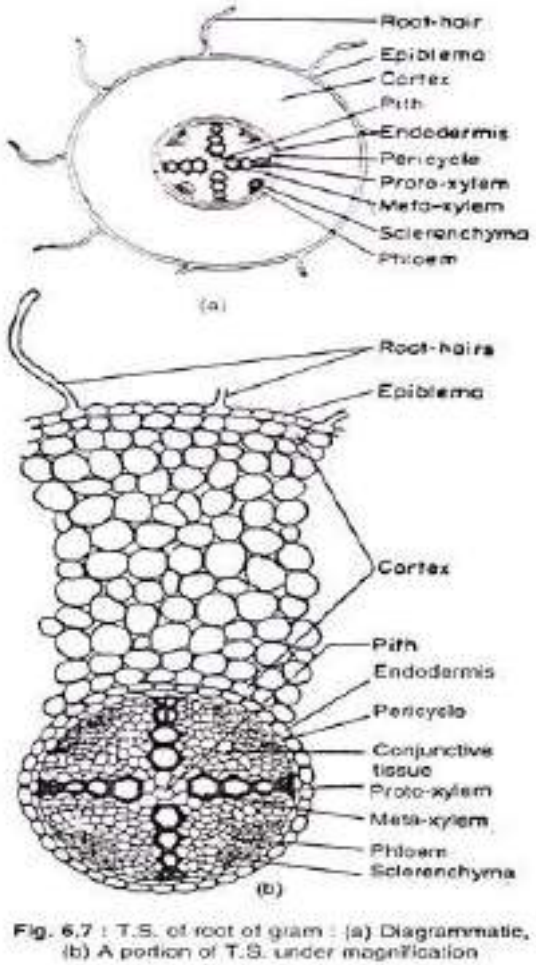


Fig. 6.7 : T.S. of root of gram : (a) Diagrammatic, (b) A portion of T.S. under magnification

Fig

Anatomy of Monocot root. EX;-Canna root

Transverse section of Canna root shows following Anatomical features:-

1. **Epiblema:** Epiblema is the outermost layer of Root. It is consists of single layer of compactly arranged, rectangular, thin walled cells. Some of the cells develop into unicellular, tubular cells called **'Root hair'. It is meant fro absorption.**

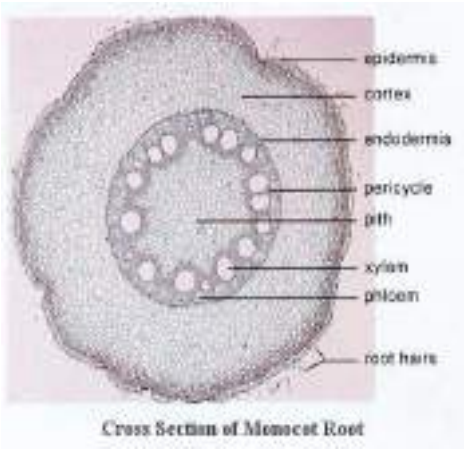
2. Cortex: Cortex is composed of many layers of Parenchyma cells with intercellular spaces. **Endodermis** is the innermost layer of the cortex. It consists of single layer of barrel shaped cells with casparian strips on their radial walls. Few endodermal cells opposite to Proto Xylem are thin walled called **'Passage cells".**

3. Stele: Stele is composed of Pericycle, Vascular bundle, Conjunctive tissue and Pith.

a) Pericycle: Pericycle is the outermost layer of stele present below endodermis. It is made up of single layer of parenchyma cells.

b) Vascular bundle: - Vascular bundle is Radial, Polyarch and Exarch.(Radial-Xylem and Phloem are present alternately at different radii**, Polyarch-** There are many patches of Xylem alternating with equal number of Phloem Patches **,Exarch-** Protoxylem is present towards pericycle and Meta Xylem towards Pith.)

c) Conjunctive tissue: - Parenchyma tissue present between Vascular bundle is called 'Conjunctive tissue'.**d) Pith**:-Central region of stele made up of parenchyma tissue is constitutes **'Pith'. It is very large.**



Cross Section of Monocot Root

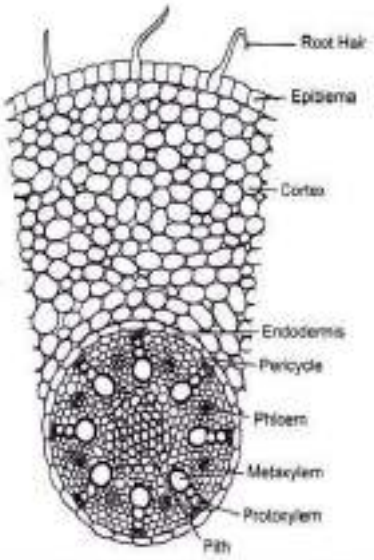


Fig. 4.5 ii Detailed structure of a portion of T.S. of Maize root (Monocot root)

Differences between Monocot and Dicot root:-

Sl. no	Dicot root	Monocot root
1	Well defined Exodermis is absent	Well defined Exodermis is Present
2	Pericycle gives rise to Lateral roots and cambium	Pericycle gives rise to Lateral roots only
3	Vascular bundles vary from 2 to 6	Vascular bundles are numerous
4	Pith is absent or Very small	Pith is large

Shoot system: - Shoot system is an aerial, green, ascending organ of the plant developed from Plumule part of an embryo. It is Positively Phototropic in nature. It consists of stem, leaves and Flowers.

Anatomy of Dicot Stem. EX;-Tridax stem

Transverse section of Dicot stem shows following Anatomical features:-

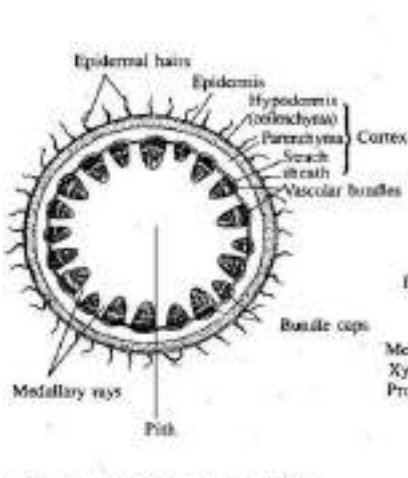


Fig. 3.5.1 : T.S. of young dicot stem (Sunflower) ground plan

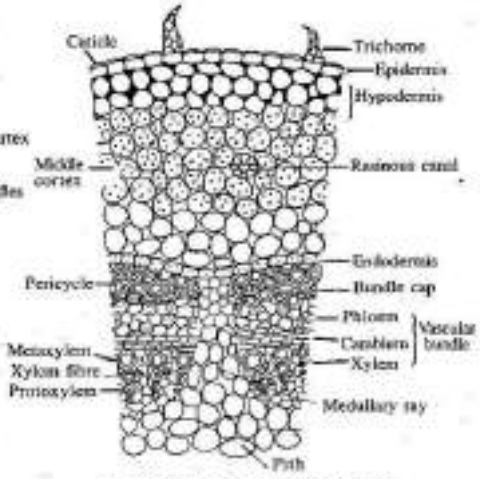


Fig. 3.5.2 : T.S. of young dicot stem (Sunflower) - A sector enlarged

1. Epidermis: -

Epidermis is the **outermost, single layer of compactly arranged**, tubular cells with cuticle on their outer walls. It bears multicellular epidermal hairs.

2. Cortex: -

Cortex is present internal to Epidermis. The outer zone of Cortex present below the epidermis consists of few layers of **Collenchyma cells called "Hypodermis**". Inner to Hypodermis is several layers of thin walled parenchyma cells. Its Outer cells contain chlorophyll. The innermost layer of the cortex is called Endodermis. It is made up of a single layer of barrel shaped cells with abundant starch and hence, called **"Starch sheath".**

3. Stele: - Stele is composed of Pericycle, Vascular bundle, Medullary rays and Pith.

a) Pericycle:-Pericycle is the outer layer of stele. It is sclerenchymatous in nature. There are more layers of Sclerenchyma opposite to Vascular bundles.

b) Vascular bundle:-Several Vascular bundles are arranged in a ring (Eustele). Each Vascular Bundle is Conjoint, Collateral , Open with Endarch xylem.(**Conjoin**t-Xylem and Phloem are in a compact bundle, **Collateral- xylem and Phloem lie in same radius, open** – Strip of Cambium is present between Xylem and Phloem ,**Endarch-** Protoxylem towards pith and Meta xylem towards Pericycle.,) Phloem is outer and Xylem is inner in position. (Xylem contains Vessels, Tracheids, Parenchyma and Fibers).

c) Pith (Medulla):- Centre of the stem is occupied by well developed parenchymatous Pith.

Anatomy of Monocot Stem. EX;-Canna stem

Transverse section of Monocot stem shows following Anatomical features:-

1. Epidermis: -

Epidermis is the outermost, single layer of compactly arranged, tubular cells with cuticle on their outer walls. Epidermal hairs are absent, and Few Stomata are present.

2. Ground tisssue: -

Ground tissue is present internal to Epidermis. Just below epidermis few layers of Sclerenchyma cells are called **"Hypodermis".** Rest of the ground tissue is Parenchymatous in which vascular bundles are scattered (Atactostele).Endodermis; Pericycle, Medullary rays and Pith are absent.

b) Vascular bundle:-

Vascular bundles are many scattered in the ground tissue. (Atactostele).Peripheral vascular bundles are small closely arranged; Central bundles are larger, less crowded. Each Vascular Bundle is **Conjoint, Collateral, and Closed with endarch xylem**. (**Conjoin**t-Xylem and Phloem are in a compact bundle, **Collateral-**Xylem and Phloem lie in same radius**, Closed** – Cambium is absent between Xylem and Phloem, **Endarch-** Protoxylem towards center and Meta xylem towards Periphery,) Phloem is outer and Xylem is inner in position. (Xylem contains irregularly arranged Tracheids, Four distinct Vessels arranged in the form of letter 'Y'. 2 smaller vessels towards centre constitute Proto xylem and two bigger vessels present laterally constitute Meta xylem. Cavity formed due to breaking of proto xylem forms '**Water containing cavity**". Phloem consists of Sieve tubes and companinion cells. There is no Phloem parenchyma.

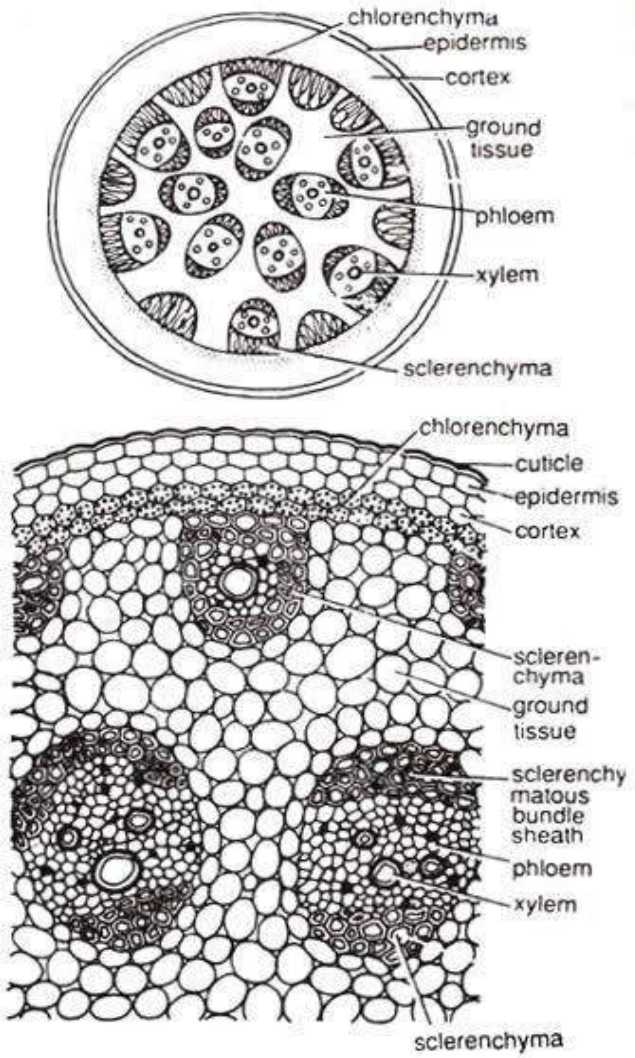


Fig. 109. *Canna* : **Upper** – T. S. stem (diagrammatic); **Lower** – T. S. stem (A part cellular)

Differences between Monocot and Dicot Stem

Sl. no	Dicot Stem	Monocot Stem
1	Multicellular Epidermis are more common	Multicellular Epidermis are not common
2	Hypodermis is Collenchymatous	Hypodermis is Sclernchymatous
3	Ground tissue is differentiated into Cortex and Endodermis.	Ground tissue is Undifferentiated.
4	Endodermis and Pericycleand Pith are present	Endodermis and Pericycleand Pith areabsent
5	Cambium is Present in Vascular bundle, Hence said to be Open type.	Cambium is absent in Vascular bundle, Hence said to be Closed type.
6	Vascular bundles are arranged in a ring (Eustele)	Vascular bundles are scattered in the ground tissue (Atactostele).
7	Phloem parenchyma is present	Phloem parenchyma is absent
8	Vascular bundles are wedge shaped	Vascular bundles are Oval shaped
9	Lysogenous cavity is absent	Lysogenous cavity is present in Vascular bundle

Anatomy of Leaf

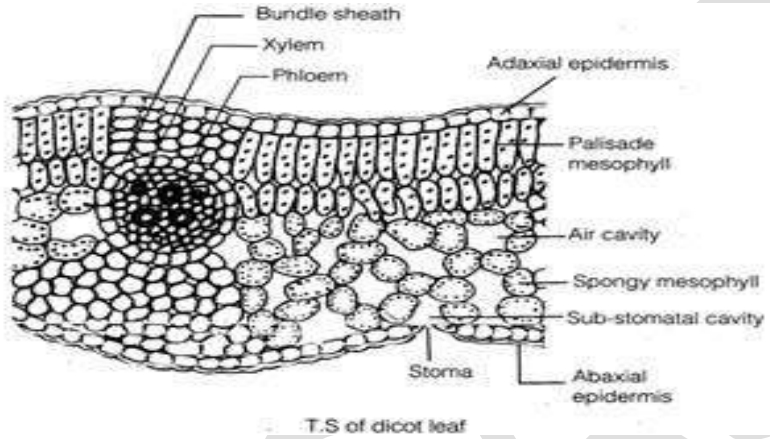
Introduction:-

The leaf is a flat, expanded structure borne on the stem at nodal region. It has expanded part called "Leaf lamina" or "Leaf blade".

In Dicot plants Leaves grows Horizontal (at right angles) to stem, hence upper surface gets more light than lower surface. Due to this unequal illumination the leaves shoes differences between upper and lower (Dorasal and Ventral) surface both externally and internally. Hence it is called 'Dorsiventral leaf.'

Anatomy of Dorsiventral leaf:-Transverse section of Dicot leaf

Dicot leaf shows following anatomical features;-



T.S of dicot leaf

1**. Upper Epidermis:-**It consists of single layer of continuous and compactly arranged rectangular cells with thick Cuticle. Multicellular hairs are present. It is protective in function.

2. Lower Epidermis: - It consists of single layer of discontinuous and compactly arranged rectangular cells with thick Cuticle. Few stomata are and multicellular hairs are present.

3:-Mesophyll;-Parenchyma tissue present in between Epidermal layers in leaf is called **"Mesophyll". It is** differentiated into **a) Palisade Parenchyma: -** It consists of 2 to 3 layers of cylindrical, elongated compactly arranged Parenchyma cells with plenty of chloroplasts. It is placed at right angles to epidermis**. b) Spongy Parenchyma: -** It is composed of loosely arranged, isodiametric parenchyma cells with less number of chloroplasts. It is present between palisade parenchyma and Lower Epidermis**.**

4. Vascular bundles: - Mid and veins in Lamina are the regions of Vascular bundles. Phloem is present towards Lower epidermis and Xylem towards Upper Epidermis. Each Vascular bundle is surrounded by Sclerenchymatous Bundle sheath.

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2) Isobilateral leaf. Ex: Monocot leaf.

In Monocot plants grows parallel to stem, so they are equally illuminated on both the surfaces. Hence they do not show differences between upper and lower surfaces. Hence they are called "Iso bi lateral Leaves".

Anatomy of Iso bi lateral leaf:-Transverse section of Monocot leaf shows following anatomical features;-

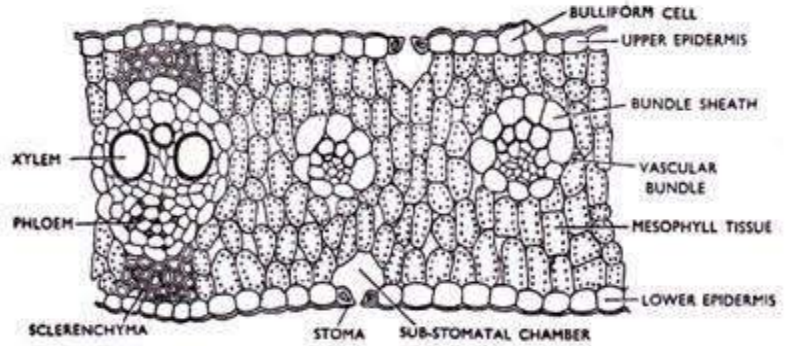


FIG. 619. A portion of leaf of *Zea* (maize) in transverse section.

1. **Upper Epidermis:-**It consists of single layer of compactly arranged, thick walled, rectangular cells with Cuticle. It contains Stomata and Bulliform cells. Each Stoma consists of 2 dumb-bell shaped guard cells and 2 triangular subsidiary cells. '**Bulliform cells' are also called as'Motor cells'**. It consists of groups of thick walled cells which occur in longitudinal rows. In dry atmosphere, these loose water and bring bout longitudinal rolling of lamina. Thus reduce rate of transpiration. It is protective in function.

2. Lower Epidermis: - It consists of single layer of discontinuous and compactly arranged rectangular cells with thick Cuticle. Few stomata are present.

3:-Mesophyll;-Parenchyma tissue present in between Epidermal layers in leaf is called "Mesophyll". It is not differentiated into Palisade Parenchyma Spongy parenchyma. It consists of uniform, compactly arranged isodiametric cells containing chloroplasts.

4. Vascular bundles: - Lamina shows parallel venation; hence many larger smaller vascular bundles are seen in a section. In each vascular bundle Phloem is present towards Lower epidermis and Xylem towards Upper Epidermis. Each Vascular bundle is surrounded by parenchymatous Bundle sheath. Bundle sheath extension is Sclerenchymatous.

Differences between Monocot and Dicot Leaf:-

Sl. no	Dicot Leaf	Monocot Leaf
1	Dicot leaf is Dorsiventral	Monocot leaf is Isobilateral
2	Venation is Reticulate	Venation is Parallel
3	Upper Epidermis is continuous	Upper Epidermis is Discontinuous
4	Stomata are present in Lower epidermis only (Hypostomatic)	Stomata are present in both upper and lower epidermis -Amphistomatic
5	Motor or Bulliform cells are absent in upper epidermis.	Motor or Bulliform cells are present in upper epidermis.
6	Mesophyll is differentiated into Palisade Parenchyma and spongy parenchyma	Mesophyll is uniform. It is not differentiated into Palisade Parenchyma and spongy parenchyma
7	Stomata consist of small pore guarded by 2 kidney shaped Guard cells.	Stomata consist of small pore guarded by 2 Dumb-bell shaped Guard cells.
8	Bundle sheath is Sclerenchymatous	Bundle sheath is Parenchymatous

Unit-3 :(10 Hrs).

Secondary growth in Dicot stem, Anamalous secondary growth in *Dracena* and *Boerhaavia.* Wood anatomy-A brief account, types of wood (spring, autumn, Duramen, Alburnum, Porus wood and Non Porous wood).

Secondary growth in Dicot stem

In Dicot stem each Vascular Bundle is **Conjoint, Collateral, and Closed with endarch xylem**. (**Conjoin**t-Xylem and Phloem are in a compact bundle, **Collateral**-Xylem and Phloem lie in same radius**, Closed** – Cambium is absent between Xylem and Phloem, **Endarch-** Protoxylem towards center and Meta xylem towards Periphery,) Phloem is outer and Xylem is inner in position. Secondary growth in Dicot stem takes place as follows:-

1. Secondary growth in stellar region
2. Secondary growth in extra stellar region

Secondary growth in stellar region due to activity of the vascular cambium

i. Formation of cambium ring:

- In vascular bundles of a dicot stem, the cambium is present in between the xylem and phloem. It is known **as intrafascicular cambium.**
- During secondary growth, some cells **of medullary rays become active and show meristematic activity** which form a **strip of cambium** in between vascular bundles called **inter-fascicular cambium**.
- Both the **intra-fascicular and inter-fascicular cambium unite together** to form a complete ring called the cambium ring.
- The activity of the cambium ring **gives rise to secondary growth.**

ii. Formation of the secondary tissues:

- The **cambium ring acts as a meristem** which divides.
- The cambium layer consists of a **single layer of cells.**
- These cells divide in a direction parallel with epidermis.
- A cambial cell divides into two daughter cells, one of which remains meristematic and other differentiates into secondary vascular tissue.
- The cell formed **towards inner side develops into secondary xylem.**
- Likewise, the cell formed **towards outer side develops into secondary phloem**.
- Normally, more secondary xylem cells are formed towards the center due to which cambium ring moves towards the periphery.
- Due to the formation of secondary xylem and secondary phloem, the primary xylem **and primary phloem which were initially closed, moves towards inner and outer side respectively.**
- As a result, they become separated apart.

- The layers of secondary tissues gradually added to the inner and outer side of the cambium continuously throughout the life of the plant.

iii. Formation of secondary medullary rays:

- Certain cells of the cambium instead of forming secondary xylem and phloem for some **narrow bands of living parenchyma cells.**
- These form two or three layers of thick radical rows of cells passing through the secondary xylem and secondary phloem and are called **secondary medullary rays.**
- These provide the radial conduction of food from the phloem, and water and mineral salts from the xylem.

iv. Formation of annual rings:

- The activity of cambium is affected by variations in temperature.
- In moderate climate, the cambium **becomes more active in the spring** and forms **greater number of vessels with wider cavities**, whereas in winter **it becomes less active and forms narrower and smaller vessels.**
- The **wood formed in the spring is known as spring wood or** early wood and that **formed in the dry summer or cold winter is autumn wood** or late wood.
- These two kinds of wood **appear together as a concentric ring known as the annual ring** or growth ring, as seen in transection of the stem and successive annual rings are formed year after year by the activity of the cambium.
- The growth of the **successive years appears in the form of concentric or annual rings,** each annual ring representing the one year's growth.
- The **age of the plant thus, can be approximately determined by counting the number of annual rings**.

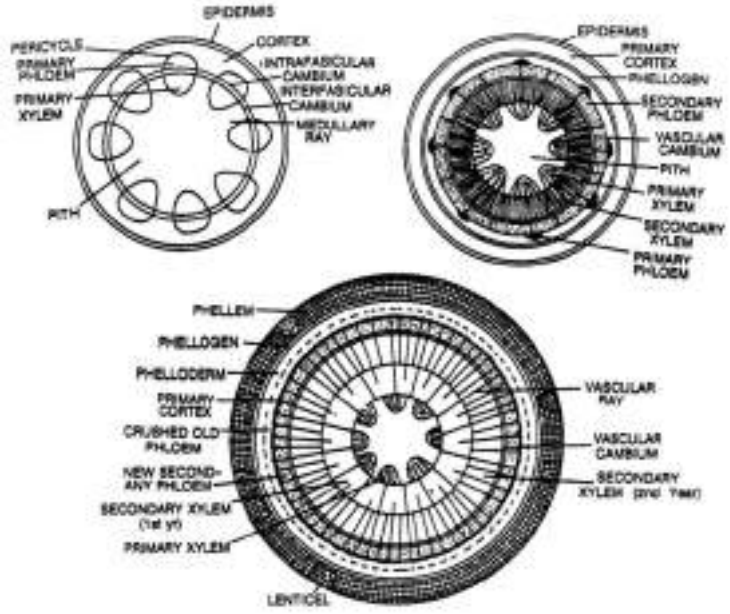
v. Formation of heart wood and sap wood:

- In the old trees, where sufficient amount of secondary growth has taken place, the secondary wood of **inner side lose the power of conduction.**
- **Their cells get filled with tannins, resins, gums, essential oils** which makes the plant part hard and darker called the **heart wood or duramen**.
- The heart wood ceases the function of conducting tissue and simply provides mechanical support to the stem.
- The **outer region of secondary wood, which consists of younger living xylem cells, remains yellow in colour** called the **sap wood or laburnum**.
- It functions as the conducting tissue and also as the food storage tissue.

Secondary growth in extra stellar region due to activity of cork-cambium:

- The **marked increase in diameter or thickness of stem brought about by the secondary thickening exerts a great pressure on the outer tissues**.
- This results in the rupture of the cortex and epidermis, the **outer cortical cells become meristematic** and begins to divide. This is known as cork **cambium or phellogen.**

- The **cork cambium divides** to form secondary tissue on both the sides i.e. internal and external but its activity is more on the outer side than on the inner side.
- The **cells formed on the outer side constitutes the phellem or cork** and those on the **inner side form secondary cortex or phelloderm.**
- The **phellogen, phellem and phelloderm together are called periderm.**
- With increase in number of tissues, pressure is excerted on overlying Epidermis. hence it get ruptured forming an opening called **Lenticel.** It results in exposure of loosly arranged tissue called **Complementary tissue.**



ANAMOLOUS SECONDARY GROWTH

- **In Dicots** Vascular bundles are **Conjoint, collateral, open and arranged in a ring**. Formation of secondary tissues takes place by **Fascicular cambium in stele and Cork cambium in cortex**.
- **In Monocots** Vascular bundles are **conjoint, collateral, closed** and are s**cattered** in the ground tissue. **Secondary growth is absent.**
- **Any deviation in the above pattern of development in Primary and secondary structure** is called **"Anamolous secondary growth".**

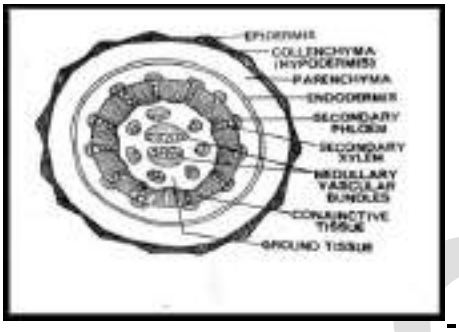
  Anamolous prmary structures are as follows:-

  1. **Scattered vascular bundles in Dicots**.
  2. Arrangement of **Vascular bundles in a ring in Monocots**.
  3. Medullary or cortical vascular bundles.
  4. Presence of intraxylary Phloem or separate Phloem bundles.

  Anomalous Secondary structures are as follows:-

  1. **Abnormal behavior of Fascicular cambium.**
  2. **Origin of Cambium in monocots.**
  3. **Replacement of normal cambium by abnormal accessory cambium.**
  4. **Abnormal behavior of abnormal cambium.**

ANAMOLOUS SECONDARY GROWTH IN BOERHAAVIA STEM.



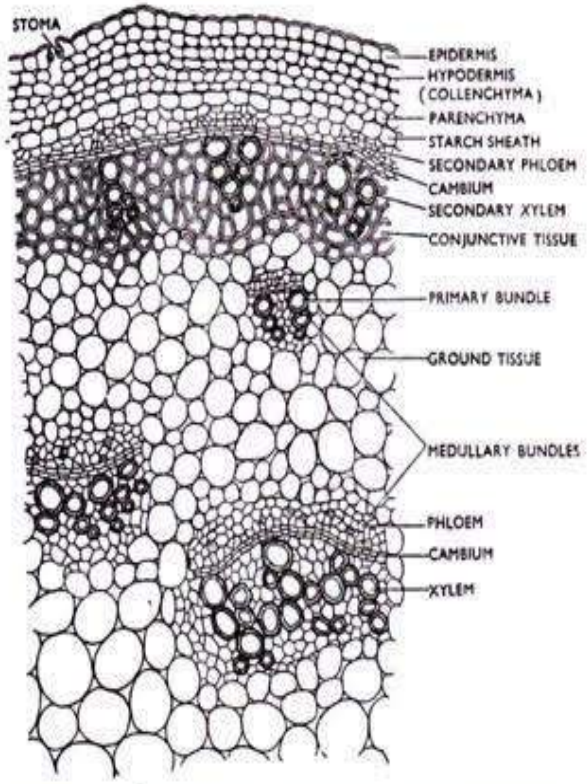


FIG. 653. A portion of stem of *Boerhaavia* in transverse section.

Ground plan

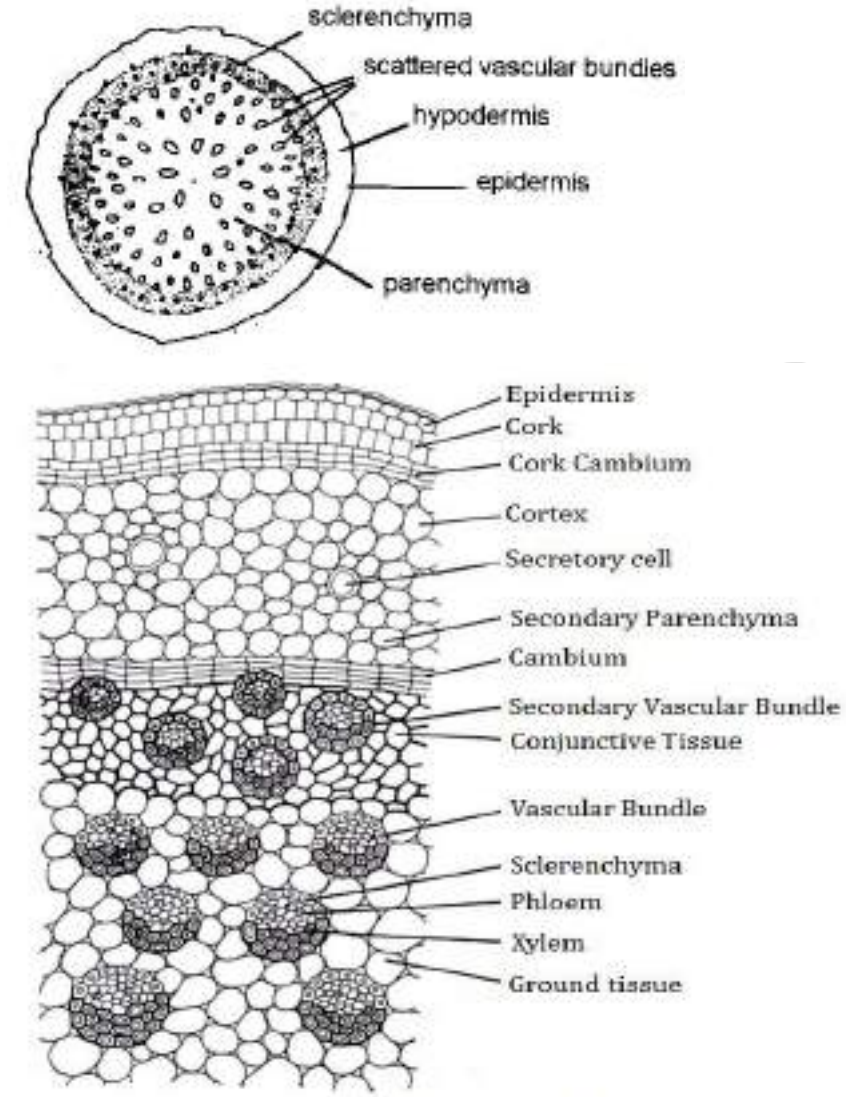
Boerhaavia diffusa is a Dicot plant belonging to Family Nyctaginaceae. It grows few inches off the ground. **It shows following primary structures in the stem:-**

1. **Epidermis with thick Cuticle and stomata.**
2. **Collenchymatous Hypodermis** with below Epidermis.
3. It is followed by **Chlorenchymatous cortex**. Endodermis is clearly defined.
4. Pericycle sometimes contains strands of Sclerenchyma. It encloses vascular bundles and pith.
5. There are **two large Vascular bundles on the sides of the pith**. It is surrounded by number if **small bundles (6-14) in second or middle ring.**
6. **Bigger vascular bundles shows limited amount of growth** in thickness by Fascicular cambium.

In Boerhaavia Secondary growth begins by cambium that arises secondarily from the cells of the Pericycle. Or cells outside primary bundles. **Intra Fascicular cambium form ring of vascular bundles** with **Xylem on the inner side and Phloem on the outer side**. **Interfascicular cambium produces thick walled lignified conjunctive tissue towards inside** and **Parenchyma towards outside**. The cambium ring ceases it activity.

A **New cambial ring gets differentiated outside by cells of pericycle** and Parenchyma cells. It **forms another ring of Vascular bundle in the same manner**. Soon this ceases its activity. One more cambium gets differentiated and functions in the same manner. **Thus several concentric rings of Vascular bundles are formed**. Cork and Lenticels develops outside the Hypodermis.

ANAMOLOUS SECONDARY GROWTH IN DRACAENA STEM



Anomalous Secondary Thickening in *Dracaena (Diagram)*

- In Monocotyledons **Vascular bundle is closed** (Cambium is absent). Hence **Secondary growth is absent.** But rarely seen in woody monocots like Dracaena, Yucca, Aloe, Agave etc.
- **Dracaena** belongs to the Family Liliaceae. Here **secondary growth results in** large amount of **thickness.** In Canary Isles, Dracaena draco is 6000yrs old, measures 14 meters in girth at the base. In 1868 it was destroyed by Strom.
- In Dracaena **Primary structure is typically Monocotyledonous** with numerous **closed, collateral or concentric** (Amphivasal- Phloem at the centre surrounded by Xylem.)Vascular bundles lying scattered in the ground tissue.
- **Secondary growth in Dracaena begins with the formation of secondary meristematic tissue**- the cambium in the parenchyma outside the primary bundles. This parenchyma divides tangentially and forms and of cambium, a few layers in thickness.

- The cambium thus formed **is more active on inner side**, cuts off cells which differentiate into **distinct vascular bundles (secondary) and thick walled, lignified parenchyma (secondary). On outerside Cambium produces thin walled parenchyma**.
- Primary bundles are **scattered and Secondary bundles are radially seriated,** surrounding secondary parenchyma.
- In transverse section **Vascular bundle is oval and Amphivasal**. In some species it may be collateral.
- After secondary growth to some extent, the peripheral parenchyma becomes **meristematic and begins to divide tangentially** and also cells derived from them until a few linear layers are formed. The **cells then become suberised** and differentiate into **cork.**
- Deeper lying **parenchyma again begins to divide**, form new layers of cells and again give rise to strip of cork. Thus **cork in Dracaena appears in seriated bands without formation of Cork cambium (Phellogen**). **This is known as "Storied cork".**

WOOD ANATOMY

Wood is the product of secondary growth in Dicots which takes place by, Vascular cambium in stelar region and Cork cambium in Cortex region.

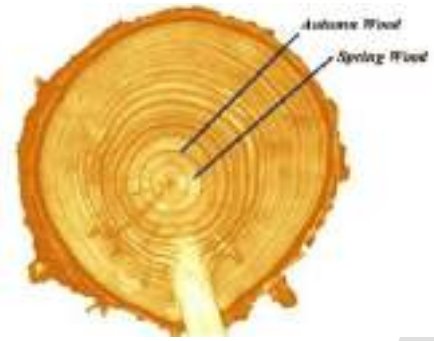
Vascular cambium consists of 2 kinds of initials namely Fusiform and Ray initials. **Fusiform initials**: - These are elongated, spindle shaped with wedge ends. It gives rise to vertical system of wood that is composed of Vessels, Fibers and Parenchyma. **Ray initials: -** These are Isodiamatric cells. It gives rise to horizontal system wood that is composing of elongated Parenchyma cells.
Cork cambium (Phellogen):- In cortex parenchyma cells below epidermis become meristematic to form '**cork cambium or Phellogen'**. It divides tangentially to form '**Cork 'or 'Phellem' outside and' secondary cortex' or 'Phelloderm 'towards** inside.

1I Annular ring:-

Concentric ring of secondary wood in Dicot stem formed during secondary growth is called "Annular ring" or 'Growth rings'. Each annular ring is composed of 'spring wood '(Early wood) and 'Autumn wood' (Late wood).By counting the number of annular rings in the secondary wood of stem, approximate age of the tree can be determined. Wood science that deals with the determination of approximate age of the tree by counting the number of Annual rings is called '**Dendrochronology'.**

- **Spring wood: -** spring wood is formed from 'Vascular cambium in DIcot stem during secondary growth in spring season of the year. It is composed of Xylem vessels with broader cavities.
- **Autumn wood: - Autumn wood is formed from Vascular cambium** Vascular cambium in DIcot stem during secondary growth in Autumn season of the year. It is composed of Xylem vessels with narrow cavity.

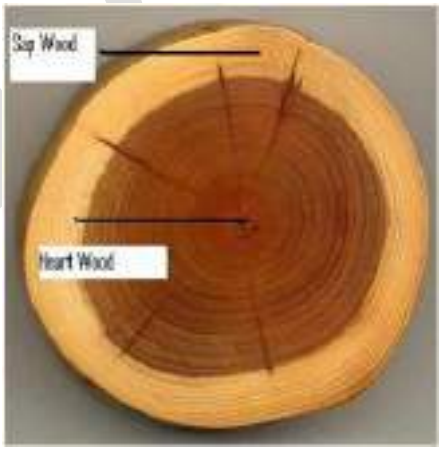
One such Spring wood ring and Autumn wood ring will be produced once in a year. These two types of wood together constitute an **'Annual ring'.**



2) <u>Heart wood and Sap wood:-</u>

Secondary Xylem of Dicot Stem is called 'Wood'. In Dicot stem wood is differentiated into Heart wood and Sap wood**.**

- **Heart wood (Duramen):-** In secondary Dicot stem, the central dark colored, hard wood is called **'Heart wood' or 'Duramen'.** It is composed of dead elements of Xylem. It gives mechanical support to the plant. Xylem elements are filled with Tannins, Gums, and Resins etc. Hence it is dark coloured and hard. Heart wood vessels are clogged with Tyloses, hence it cannot perform conduction.
- **Sap wood (Alburman):** - In secondary Dicot stem, the peripheral zone of wood is soft, light colored called '**Sap wood' or 'Alburman'.** It is composed of both living and dead elements. It has less Tyloses (Balloon like protrusions of Xylem parenchyma cells into the cavities of xylem vessels are called Tyloses). It gives mechanical support and also takes part in conduction.



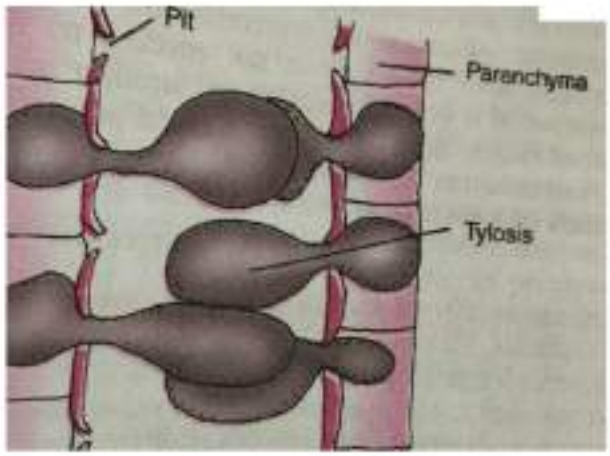
Tyloses:-

Balloon like protrusions of Xylem parenchyma cells into the cavities of xylem vessels are called **Tyloses**. It is formed due to **enlargement of pit membrane** and protrusion of Xylem parenchyma

cell into the cavity of Xylem vessel. Tyloses formed contain **Cytoplasm, Nucleus, some amount of reserves like Starch, Resin etc.** These are frequently **formed in Heart wood in Dicots.**

Tyloses by **blocking the cavity of Vessel obstruct the conduction of water and minerals** through vessels. Sometimes it **is advantageous as infectious agents like bacteria; fungi** which move along with the fluids **can not enter vessel** and **helps in longevity and durability of wood.**

In Gymnosperms **Epithellial cells that surround the Resin duct senlarge and protrude into the cavity in the from of balloon**. These are called '**Tylosoids. (False tyloses).** They **never protrude into the Vessel through pit.**



3. Porous wood and Non porous wood

The secondary growth product of an Angiosperm in Dicot and Gymnosperm is called Wood. There are 2 types of wood. Namely 1) Porous wood and 2) Non- porous wood.

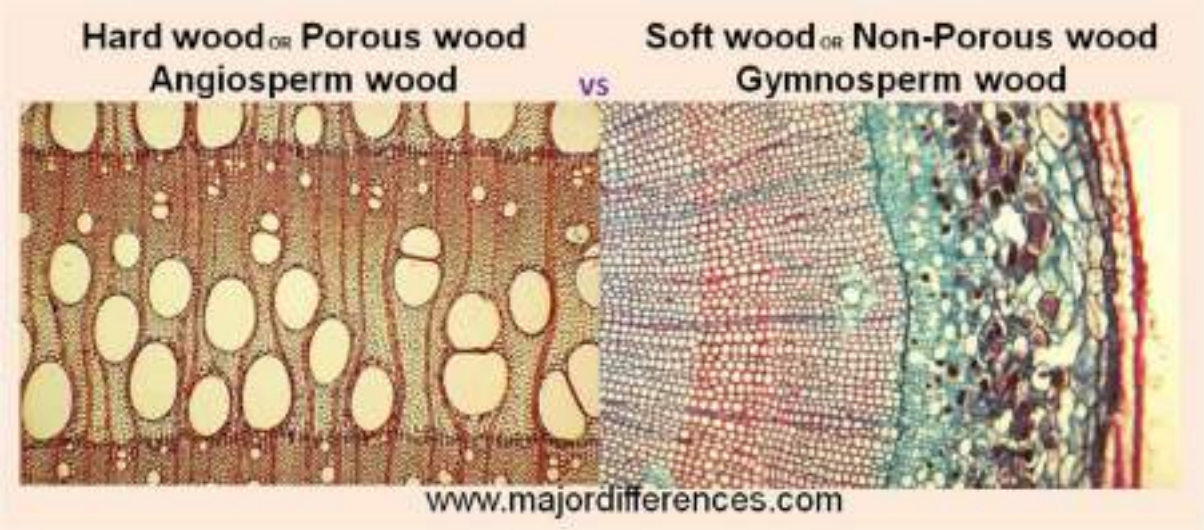
- **Porous wood: -** In this type the wood contains **Xylem vessels which appear as circular pores** in transverse section, it is called 'Porous wood'. Ex: Secondary wood of Dicot stem. The porous wood is divided into 2 types. they are :-

a) Ring porous wood:-In Ring porous wood, **pores are arranged in concentric rings** of spring wood and autumn wood. There is clear distinction between rings. Ex: Ulmus, Betula wood.

b) Diffuse porous wood:-In Diffuse porous wood, **pores are scattered in the ring**. As there is gradual increase in size of the pore from Autumn wood to Spring wood, there is no clear demarcation between Spring wood and Autumn wood. Ex: Juglans.

- **Non- porous wood: -** In this type the wood contains only Tracheids. **There will be no circular pores in transverse section**. Ex: Gymnosperm wood.

  Presence or absence of pores, arrangement of pores helps in identification of type of wood.



Properties of wood

Wood shows following properties:-

- **Weight: -** Wood with narrow Lumen is heavier than wood with broad Lumen.
- **Strength:** - It is **measured in terms of stiffness, toughness and hardness.** Ability to withstand **mechanical forces like crushing,pulling and breaking** is called '**Strength of wood'**. Tracheids and fibers makes wood strong.
- **Durability:** - Capacity of wood to **resist fungal and bacterial attack is called 'Durability'**. Heart wood is durable, as it consists of Tanin and Oil which acts as antibacterial and antifungal agent.
- **Stiffness:**-Ability of **wood to external forces that changes its shape is called 'Stiffness'.**
- **Toughness:** - Ability of wood **to resist repeated blows undergoing any change** is called **'Tough wood'. It is hard to split.**
- **Hardness: -** Power of wood to **resist abrasions** is called **'Hardness'.**
- **Grain and figure: - Position and arrangement of cells** in wood is called **'Grain'.** Figure is represented by grains.
- **Moisture content**: - Moisture content of wood is important quality of wood. **Wood of low moisture is of great value.**
- **Porosity: - Size and abundance of the cell cavities** in wood is called **'porosity'.** It is important in painting and preservation of polishing of wood.
- **Wood seasoning: -** The process of **drying wood before it is used for any purpose** is called **'Seasoning'**. It **prevents wood from crack, shrunk or break and helps to maintain its shape**. It is done by 2 methods**.**
- **In Air seasoning Wood** is exposed to heat of Sun with alternate keeping in shade**.**
- **In kiln seasoning wood** is enclosed space by circulating hot air. It takes shorter period than air seasoning.

SECRETORY TISSUES

The non utilizable by product of metabolism which is isolated from the living protoplast or removed from the plant body are "Secretions". Ex: Gums, Resins, Latex, Essential oils, Nectar.
The tissues concerned with non utilisable byproduct of metabolism such as Gums, Resins, and Latex are called **"Secretary Tissues".** These are widely distributed in the plant body.

TYPES OF SECRETARY TISSUES

Secretary tissues are grouped into 2 types. They are

A) Glandular tissue

B) Laticiferous tissue.

A) GLANDULAR TISSUE: -

The glandular tissue consists of **special structures**; the Glands which contain some **secretary or Excretory products.** A Gland may consist of **isolated cells or small group of cells with or without central cavity**. They are of various types. They may be internal or external. It can be classified into 2 types. They are a**) Secretary cells b) Glands.**

1) Secretory cells :(**Internal Glands):-**

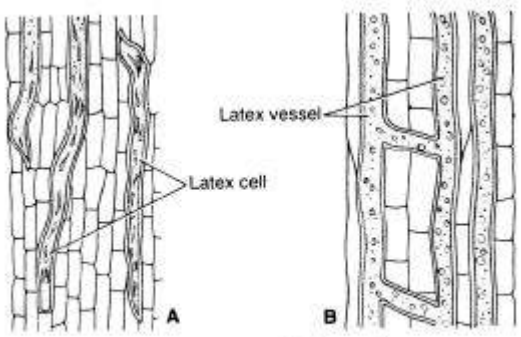
- Secretary cells are found in members of **Umbelliferae, Rutaceae**. These cells contain **inconspicuous cytoplasm and cell is filled with secretion** which **does not exude.**
- **Oil gland** secreting essential oils, as in Fruits, **leaves of Orange, Lemon Eucalyptus** etc.
- **Mucilag**e secreting glands, as in **the Betel leaf.**
- **Special water** secreting glands at the **tip of the Veins**.
- Some **secretary cells contain granular cytoplasm** with prominent Nucleus. These **exude the secretion such as Gum**. These are called **"Excretory cells'.**

2) Glands :-(External Glands):-

- **External glands are commonly short hairs tipped by glands**.
- In Plants Gland is defined as a Plant structure **located on or near the plant surface or externally which secretes one or more products**.Ex: **Glandular hairs, Nectaries.**
- Glandular hairs secreting Gum like Substances as in Tobacco, Plumbago etc.
- **Hydathodes** are **Water secreting Gland.** (Water contains Salts, Sugars and organic substances).
- **Glandular hairs** secreting **irritating, Poisonous substances** as in Nettles (Utrica dioica-Utricaceae, stinging perennial herb.
- **Honey secreting glands called" Nectaries"** (Sugary fluid derived from phloem). As in Euphorbia.
- **Fragrance emitting glands called "Osmophores**" as in members of Araceae and Asclepiadaceae. Or produced from volatile oil distributed through out Epidermis of Petals.

B) LATICEFEROUS TISSUE

Thin walled, greatly elongated, much branched ducts containing a milky or yellowish or watery fluid called "**Latex"** is called "**Laticeferous tissue**". These are irregularly distributed in the mass of parenchymatous cells. They contain numerous nuclei. They are of 2 types. Namely
a) Latex cell or Non – articulate Latex ducts. and b) **Latex Vessels or Articulate latex.**



Laticiferous tissue : A. Laticiferous cells, B. Laticiferous vessels

a**) Latex cell or Non – articulate Latex ducts.**

Laticiferous cells **originate from Promeristem.** The **cell wall is thick, encloses many Nuclei**. These are **independent units** which extend as branched structures for long distances in the plant body. They originate as minute structures, **elongate quickly and by repeated branching ramify in all directions but do not fuse together**.Ex: Vinca rosa, Calotropis. Euphorbia.

b) Latex Vessels or Articulate latex.

Latex vessels **originate from Meristem**, grow more or less as **parallel ducts which by branching and frequent anastomise to form a complex networ**k. These are found in members of papavaraceae, Moraceae, Compositeae, Euphorbiaceae.etc.

Functions:-

Laticiferous tissue may act as food storage organs or Reservoir of waste products.
They may also act as translocatory tissue.

Unit-4 :(20 Hrs)

Morphology of Angiosperms-Root System and its modifications, Shoot system and Stem modifications, Leaf and its modifications, Inflorescence, Floral morphology and Fruits.

ANGIOSPERMS

Angiosperms are highly evolved flowering plants in **which seeds are enclosed with in Fruit**. They represent **major community in the plant kingdom** (with 416 Families, approximately 13164 genera and 295, 383 known Species). They grow in all habitats as herbs, shrubs, Trees, Vines, Annuals and perrinials.

The term Angiosperm is derived from Greek word where ‘Angieion’ means ‘closed’ and ‘Sperma’ means ‘Seed’.

GENERAL FEATURES OF ANGIOSPERMS

1. The **plant body is Sporophyte** differentiated into **Root, Stem and Leaves**.
2. They produce highly specialised organ “**Flower’ for sexual reproduction.**
3. Flower develops **male reproductive organ Androecium and female reproductive organ Gynoecium.**

4. **Androecium** is Collection of Stamens and they produce Pollen grains or Microspores that contain male gametes.
5. **Gynoecium** consists of carpels. Each carpel has basal Bulbous ovary, middle elongated style and an apical Stigma. Ovary encloses ovules which produce megaspores
6. **Double fertilization takes place in Angiosperms**.(One male gamete fuse with Haploid Egg to form Diploid Zygote. Another haploid male gamete fuse with Diploid secondary nucleus to form triploid Primary endosperm Nucleus).
7. **Angiosperms include Monocotyledons and Dicotyledons.**

DIFFERENCES BETWEEN MONOCOTYLEDONS AND DICOTYLEDONS.

Sl. no	character	Monocots	Dicots
1	Seed/ Embryo	One cotyledon	Two cotyledons
2	**Root**	**Fibrous root**	**Tap root**
3	**Stem**	**unbranched**	**Branched**
4	**Leaves**	**Isobilateral with sheathing leaf base**	**Dorsiventral without sheathing leaf base**
5	**Venation**	**Parallel**	**Reticulate**
6	**Flower**	**Trimerous**	**Tetra/ pents merous**
7	**Secondary growth**	**Absent**	**Present.**

TAXONOMY OF ANGIOSPERMS: -

Taxonomic description of plants for the purpose of **classification and identification** involves a detailed account of the **various plant parts**. Each part of the plant is **carefully and precisely described** so as to help in its identification. **The branch of taxonomy dealing with the description of plant parts is called 'Phytography'.**

TAXONOMIC TERMS

Taxonomic terms used to describe plant parts are as follows:-

Habitat: The **environment in which plant lives**.
Habit: External **appearance of the plan**t.
Herb: A **small plant with Green, soft stem**.
Shrub: A **bushy or woody plant** with profuse **branching.**
Tree: A **tall woody** plant with an erect and hard stem.
Annual: Plant that **complete their life** cycle in **one year.**
Binnial : Plant that complete their life cycle in **2 year**.
Perennial: A plant that survives and grows for **many years**.
Epimeral: A plant which is very **short lived**.

Parts of Typical Angiosperm Plant

A typical Angiosperm is distinguished into 2 parts. They are 1) Root system 2) Shoot system

I. **Root system**: - Root system is an **underground, non green descending organ** of the plant developed from **Radicle part of an embryo**. It is positively **geotropic, positively hydrotropic**.

II. **Shoot system**: - Shoot system is an **aerial, green, ascending organ** of the plant developed from **Plumule part of an embryo**. It is Positively Phototropic in nature. It consists of stem, leaves and Flowers.

Root system: -

Characters of Root system:-

1. Root is **Descending**, vegetative axis of the plant developed from **Radicle part of an Embryo**.
2. It **is positively geotropic, positively hydrotropic and positively phototropic.**
3. Root consists **of Primary Root and Lateral secondary and Tertiary root**. Each root is protected by a small **root cap.**
4. Lateral roots produce **unicellular root hair**. These take part in **absorption** of water and mineral nutrients.

Functions of Root system:-

1. Root fixes the Plant body firmly to the soil. **(Fixation).**
2. It absorbs water and minerals from the soil (Absorption).
3. It conducts water and minerals to shoot system. (**Conduction)**.

TYPES OF ROOT SYSTEM

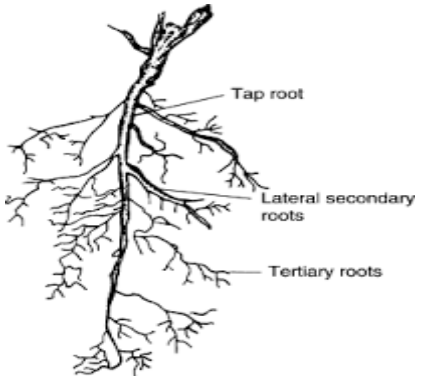
There are 2 types of Root system. Namely 1) Tap root system 2) Fibrous root system.

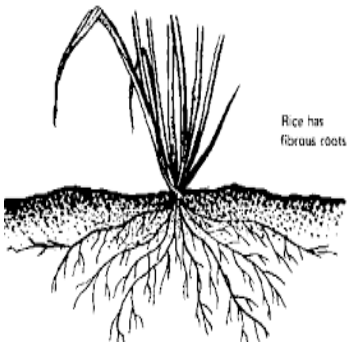
1. Tap root system: - Ex: - Dicot plants

In Tap root system Radicle develops into single, central main root called '**Primary root'**. It develops **lateral secondary roots** which in turn branches to **form tertiary and quaternary roots**. Lateral roots **bear unicellular root** hairs which take part in absorption of water and mineral nutrients from soil. Tap root **grows deep into the soil** and **persists throughout life of the plant**.

2. Fibrous root system: - Ex: - Monocot plants.

In Fibrous root system Radicle develops into **primary root. It is short** lived and **soon replaced by cluster of slender, fibre like root.** They bear root hairs which help in **absorption**. Fibrous root **does not grow deep into the soil** (Surface feeders), and they **are periodically renewed**.





Adventitious root system:- Ex:- Dicot and monocot plants.

The roots developed **other than the radical are called 'Adventitious roots**". They may be **aerial or underground**. It may develops **from any part of the plant like branches, nodes** etc. It performs various functions like providing **mechanical support, storage of food, absorption** etc.

Modifications of Root system:-

Any **change in normal form and structure of Root, in response to the need** of the plant is called **'Root modification'**. To perform special functions like food storage, to give mechanical support and to help in vegetative propagation both tap root and adventitious root are modified.

I.UNDERGROUND ROOT MODIFICATION.

In some plants both Tap root and Adventitious Root are modified for storage of food material.

A) TAP ROOT MODIFIED FOR FOOD STORAGE.

In many cultivated plants Primary root store food, become fleshy and enlarged. Based on its structure at maturity, it is classified as follows:-

1. **FUSIFIRM ROOT :-**
   In Fusiform type **primary root is broad in the middle, tapers at both the ends and become spindle shaped to st**ore the food material. Ex: Radish (Raphanus sativa).

2. **CONICAL ROOT:-**
   In Conical type **primary root is broad at the base and gradually tapers towards the apex and become cone shaped to** store the food material. Ex: Carrot (Dacus carota).

3. **NAPIFORM ROOT:-**
   In Napiform type **primary root is almost spherical shaped above and abruptly tapers towards apex to** store the food material. Ex: Beet root (Beta vulgaris).

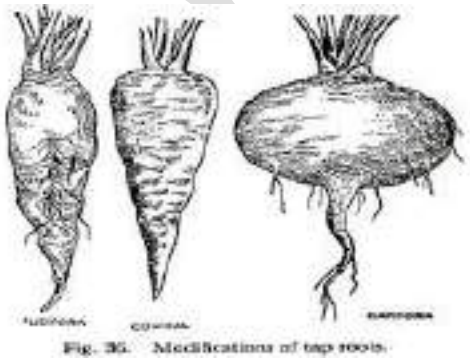


Fig. 36. Modifications of tap roots.

B) ADVENTITIOUS ROOT MODIFIED FOR FOOD STORAGE.

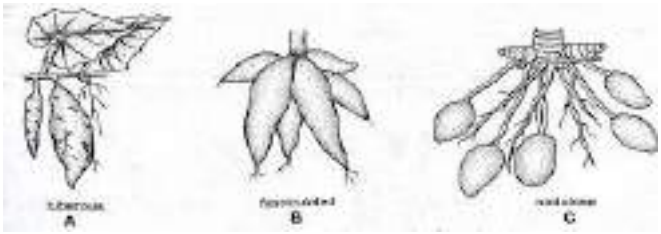
In some Angiosperms underground adventitious roots are modified for food storage.

1. Tuberous root:-

In Tuberous root cluster of adventitious root are developed at each node of Runner. Amomg them only one of adventitious root become irregular bulged due to storage of food. Ex Sweet potato (Ipomea batatus)

2. Fasciculated root:-

In Fasciculated root **cluster of adventitious root are developed from the base of the stem.** All these roots become irregularly bulged due to storage .Ex: Dahlia (Dhalia variablis).



II.AERIAL MODIFICATION OF ROOT.

Adventitious roots growing from the aerial parts of the shoot system perform many functions like to give mechanical support, to help in breathing, sucking food material and absorption of water.

A) Adventitious root modified for giving mechanical support:-

Adventitious roots growing from the aerial parts of the shoot system are modified to perform functions like to give mechanical support. Based on the type of development it can be classified as follows:-

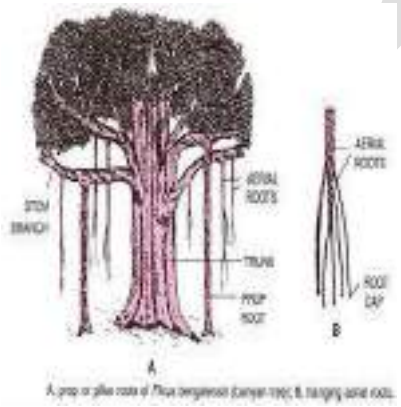
1. Prop root:-

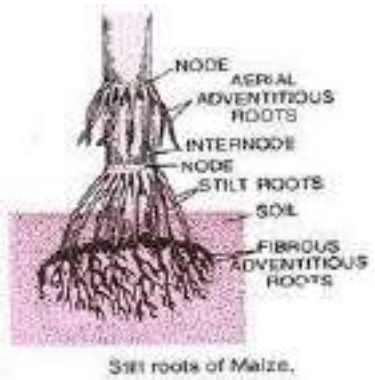
Adventitious roots **develops from horizontal branches of a tree, grows downwards, reaches the soil, become thick , woody, acts like pillar**s and gives additional mechanical support**.** Ex: Banyan (Ficus benghalensis).

2. Stilt root:-

Stilt roots aerial adventitious root**s developed from lower nodes of the stem. These grow obliquely downwards into the soil and give** additional mechanical support**x: Sugarcane. (Saccharum officinarum).**

3.Climbing root:-Climbing t roots aerial adventitious root**s developed from nodes of the stem in climbers.Weak stemmed plants). They clasp the supporting object and help to climb upon** it. Ex: Pepper (Piper nigrum), Betel (Piper betel), Pothas.





Still roots of Maize.

B) Adventitious root modified for special physiological functions

1. Pneumatophores:-

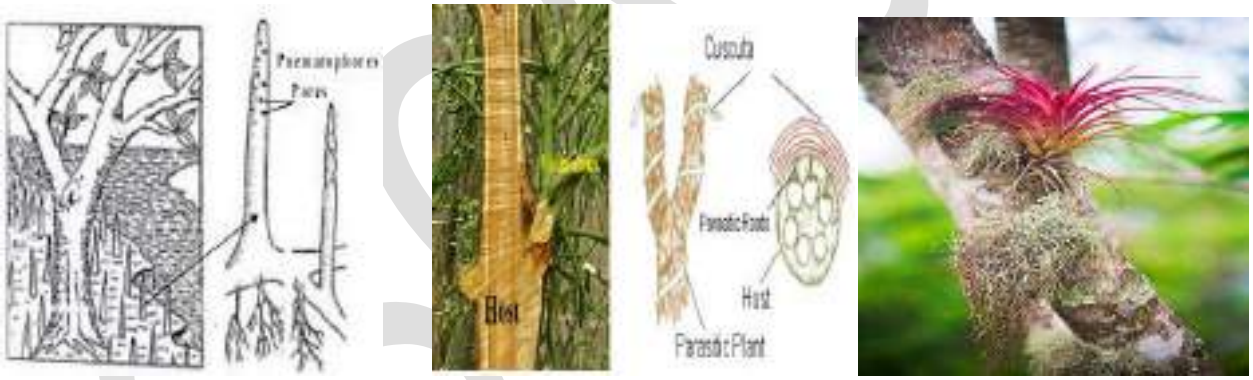
The roots of plants growing in water **logged soil like swamps and marshes** are buried in salty and oxygen free soil. The roots of these **plants produce special branches that grow vertically above** the soil surface, develop pores called **'Lenticels' which facilitate aeration. Such roots are called 'Pneumatophores' or 'Breathing roots' or 'Respiratory roots'. Ex: Avecinia, Rhizophora.**

2. Sucking roots:-

Some plants depend on other plants for both food and shelter. Such plants are called Parasites. **These plants develop special button shaped roots called 'Haustoria' that penetrates deeply into the host tissue, reach vascular bundle and absorb food from it. These are also called as 'Sucking roots**'.Ex: Cuscuta, Loranthus, Viscum

3. Epiphytic roots:-

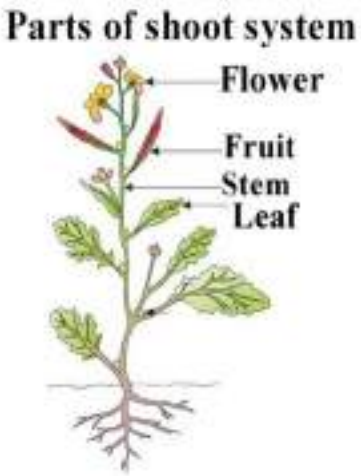
The plants that **depend on other plants for shelter are called 'Epiphytes'**. These plants never absorb food from it. They develop 2 types of roots, namely '**clasping roots 'and 'Hanging roots'. Clasping roots helps to hold the plant firmly** to the branch. **Hanging roots hang freely in the air .They are made up of special spongy tissue called 'Velamen'** which **absorbs moisture** from the **atmosphere.** Ex: Vanda (Orchid).



SHOOT SYSTEM

Characters of Shoot system

1. Shoot system is an **Aerial, Ascending organ of the plant body developed from Plumule** of an embryo. It is Green in colour.
2. It is positively **phototropic and negatively geotropic.**
3. It consists of **Central, cylindrical axis called 'Stem'.**
4. Stem consists of **distinct nodes**; region between nodes is called as '**Internode'**.
5. At each node develops Flat**, Green, Lateral appendage called 'Leaf'.**
6. In the axil of the **'Axillary bud' is present**. At the tip of the stem' **Terminal bud' is present**.



Forms of stem:-

Stem are classified into 2 kinds. They are **1) Erect Stem. 2) Weak stem.**

1) **Errect Stem: -** The aerial stem which stands Errect without any support is called '**Errect stem'**. It includes following types:-
   a) **Herbs: -** The small plants with **soft, Sacculent, green, less branched stem** are called '**Herbs'**. Ex: Sunflower, Paddy.
   b) **Shrubs:** - The medium sized plants with **Hard, woody stem which is branched** giving bushy appearance are called 'Shrubs'. Ex; Hibiscus, Custard apple.
   c) **Trees:** - The large, **tall plants with very hard, woody stem which possess distinct trunk** and profusely branched are called 'Trees'. Ex: Mango, Eucalyptus.

2). Weak stem:-The aerial **stem which cannot stand erect is called 'Weak stem'**. It includes following types:-

a) Creeper: - The weak stem **which grows horizontally on the surface of the soil** is called 'Creeper'. Ex: Sweet potato.

b) Decumbent: prostrate **stem with top becoming vertical**.

c) Climber: - The **weak stem which climb upon other erect support** with the help of special structures developed on them is called 'Climbers'. Ex: Betel, Pothas (Money plant).

- **Cylindrical:** Cylinder like stem. **Quadrangular:** Four angled stem.
- **Solid:** When it is completely **filled u**p. **Fistular:** central portion is **hallow. Jointed:** distinct joints are seen at nodes.
- **Herbaceous**: Soft. **Woody**: hard. **Branched**: Stem with many branches.
- **Weak:** A stem which cannot grow erect by itself.
- **Glabrous**: **Smooth** surfaced stem.
- **Pubescent:** stem having **hairy** out growth.

Functions of stem:-

1. Stem gives **support to branches, leaves, Flowers and Fruits.**
2. It **conducts water and minerals from root system to different parts of shoot system and food from leaves to the root system.**
3. In some plants, stem perform **Photosynthesis.**

Stem modifications:-

Modifications of Shoot system:- Any change in normal form and structure of shoot or its parts, in response to the need of the plant is called '**stem modification'**. It is classified into 3 types. They are 1) Underground stem .2) Sub-aerial stem and3) Aerial stem modification**.**

1) Underground stem Modification:

Stem with in the soil is modified for food storage, Vegetative propagation and perennation. It includes 4 types. They are: - **A] Rhizome] Tuber C] Corm D] Bulb**

A] Rhizome: -

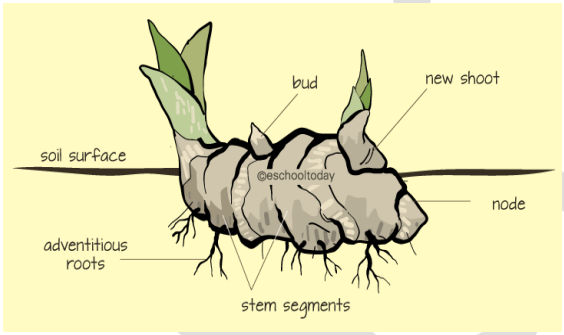
Rhizome is a **modified underground stem that grows horizontally below the soil surface**. It consists of number of **Nodes and Internodes**. At nodes **Scales are present**. In the Axil of scale leaf **Axillary bud and at the apex of Rhizome Terminal bud is** present. Towards lower sides of the Nodes **Adventitious roots are present**.

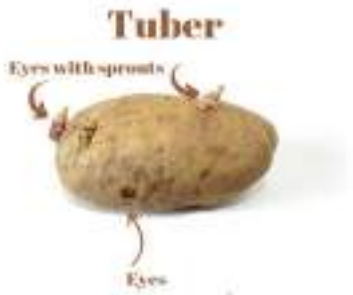
The terminal bud develops into Leafy shoot and axillary bud develops into daughter Rhizome. These on separations from the mother plant, it develops into an independent plant. **Ex: Ginger, Turmeric**

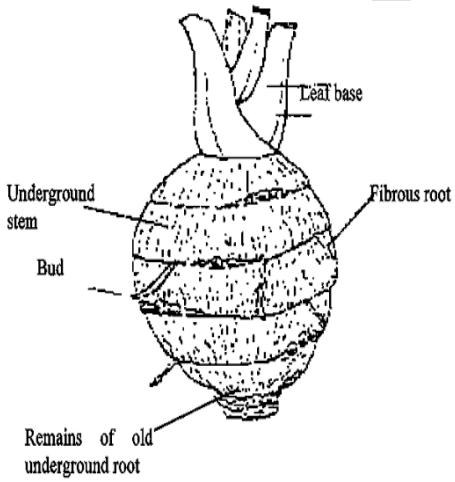
B] Tuber:-

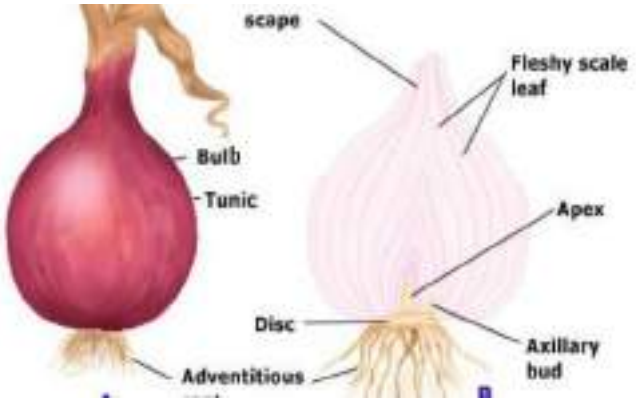
Tuber is **a bulged tip of lowermost branches of stem just below the soil surface.** Tuber contains number of **eyes that represent nodes**. Each Eye consists of reduced scale leaf with axillary bud in its axil.

When Eyes of the Tuber separates from the mother Tuber and placed in moist soil, axillary develops into daughter plant. **Ex:Potato**









C] Corm: - Corm is an **Underground stem. It is thick, Fleshy, Spherical shaped, grows vertically** below the soil. It bears **Scale leaves**. In the axil of Scale **leaves axillary buds** are present. In its lower **surface Adventitious roots are present. Single terminal** bud develops into Leafy shoot. Axillary bud develops into daughter corm; this on separation from mother plant develops into independent plant**. Ex: Amorphophallus (Yam)**

D] Bulb: - Bulb is an underground **modified stem meant for vegetative propagation and storage of food.** In Bulb **Stem** is very much **condensed into Disc like** structure. From its **lower surface number of adventitious roots** develops and from its **upper surface concentrically arranged fleshy scale leaves are present**. In the axil of Scale leaf Axillary bud, at the central region terminal bud is present.

Terminal bud develops into flowering shoot and axillary bud develops into daughter buds. This on separation from mother Bulb develops into in dependent plant. **Ex: Allium cepa (Onion).**

II] By Sub-aerial stem:-

In some plants stem **grows horizontally just above or just below the soil.** They are mainly meant **for vegetative propagation**. It includes 4 Types. They are: -

A] Runner. Ex: Oxalis

Runner is sub aerial stem modified for Vegetative propagation. **Stem is long, slender**, **branch**. **creeps on the surface of the soil**. At each node it **develops shoots above and adventitious roots below.** These when separates from the mother plant develops into an independent plant.

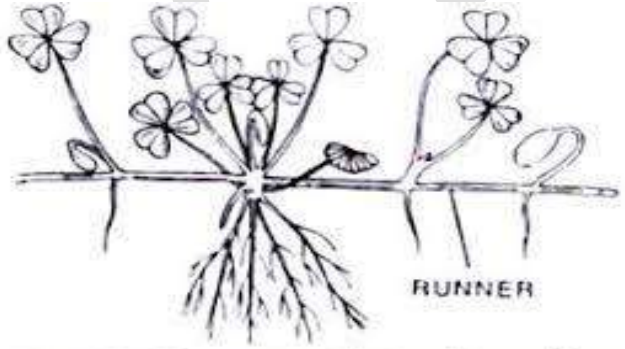


Fig. 12.21. Sub-aerial modification of stem. Runner of *Oxalis*.

B] Stolon .Ex: Colocasia, Metha (Pudina)

Stolon is modified sub aerial stem modified for Vegetative propagation. It is **an elongated structure grows upwards, bends down, touch the soil, and produce roots below and leaves above**. This on sepration from the mother plant develops into an independent plant

.

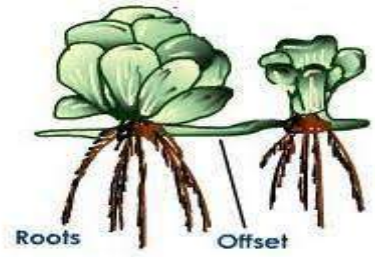
C] Sucker. Ex:Chrysanthimum

Sucker is modified sub aerial stem .It is a **Lateral branch that develops obliquely below the soil from underground stem. When it comes above the surface of the soil, develops into shoot.**

When it separates from the mother plant, it develops into an independent plant. Different parts of the aerial shoot system are modified to perform different functions like protection, climbing, photosynthesis, vegetative propagation etc.

D] Offset. Ex: Pistia, Eichhornia

Offset is a modified **sub- aerial stem in Hydrophytes** (Plants growing in water). Offsets are a **short, stout, prostrate branch that grows in all directions** from mother plant. This on separation from mother plant develops into independent plant



Ex: Pistia **Eichhornia**

III] By Aerial stem:-

In Aerial **stem modification the stem grows above the soil surface.** The entire stem or different parts of the stem are modified to perform special functions like protection, **Climbing, photosynthesis, vegetative propagatio**n etc. It includes 5 types. hey are as follows:

Stem tendril,Stem thorn, phylloclade, Cladode,Bulbil.

1. StemTendril :-

Tendrils are long, slender, coiled modified structures which are sensitive to contact. They help the plants in climbing.

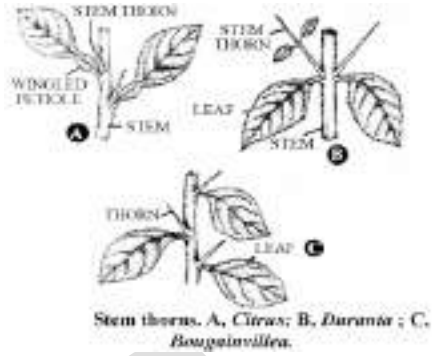
- In **Vitis quadrangularis** terminal bud is modified into Tendril.
- In **Passion flower (Passiflora)** axillary bud is modified into Tendril.

2.Stem Thorn:-

Thorns are hard pointed structures modified to provide protection.

- Ex: **In Canthium** axillary bud,

- **In Carrisa** Terminal bud is modified into thorn.



Stem thorns. A, *Citrus*; B, *Duranta*; C, *Bougainvillea*.

3. **Phylloclade:-**
   Phylloclade is **Green, Fleshy, Cylindrical or Flattened or Spherical structures meant for photosynthesi**s. Here Leaves at nodes are modified into spines or Scales to avoid Transpiration.Ex: - **Opuntia (Prickly pear).**

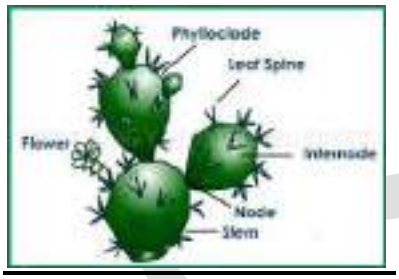
4.Cladode:-

Cladode is a small, green, flat, leaf like modified lateral branch **with only one or two internodes** meant for photosynthesis. Leaves are reduced to small scales.Ex: **Asparagus.**

5. Bul-bil:-

Bul-bils are **bulged vegetative or floral buds** meant for Vegetative propagation.

- Ex: **In Agave** Florl buds**.**
- **In Dioscoria** Vegetative buds are modified.



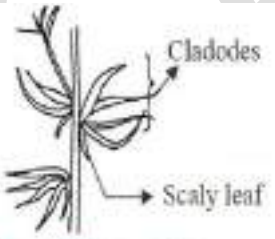


Fig. : Cladodes of *Asparagus*

STUDY OF LEAF

Leaf is a Flat, green, lateral appendage developed at the nodal region on the stem. It is called **Cauline** when Leaves borne only on the main axis and **Ramal** when Leaves borne on the lateral branches.

Typical Dicot leaf posses 3 parts. They are Leaf base, Petiole, Lamina**.**

1. **Leaf base:-The point of attachment of the Leaf to the stem is called "Leaf base".**
2. **Petiole"-The narrow cylindrical, stalk of the leaf is called "Petiole".** The leaf with Petiole is called **Petiolate;** the leaf without Petiole is called **'Sessile.**
3. **Stipule:-**At the base of the Petiole arise a pair of lateral small, green outgrowths called **'Stipules'**. The Leaf with stipule is called:" **Stipulate'**. Leaf without stipule is called " **Ex stipulate".**

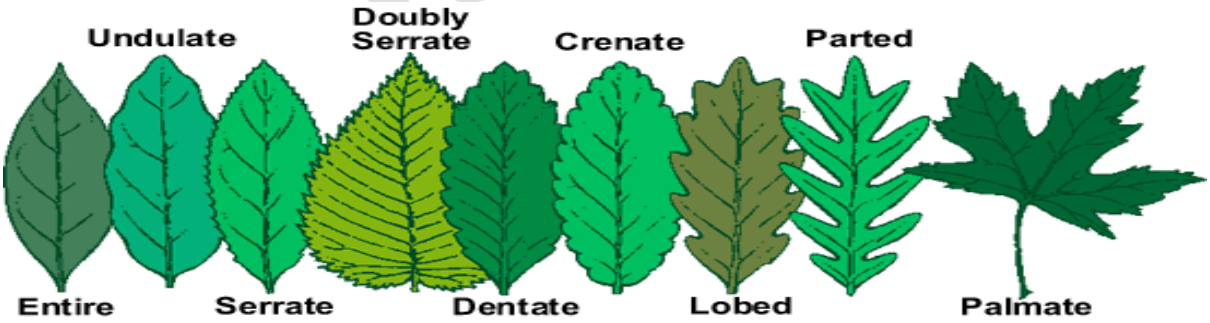
4. **Lamina:**-The flat, Green, expanded part of the Lamina is called **"Lamina "or "Leaf blade".** The tip of the lamina is called **"Leaf apex",** The Edge of the lamina is called **"Leaf margin".** It may be smooth or entire or serrate or undulate or dentate or Spiny. The shape and size of Lamina shows variations.
5. **Mid-rib:-** The main that extends from Petiole to apex in the middle of Lamina is called **"Mid rib",** it is the main Vasculature. It gives rise to variously distributed "**Veins".** These are secondary vasculature (Transport water, dissolved salts and Organic food).It gives rise to delicately branched **"Vein lets".**

Leaf form:-Leaf characteristics such as Shape, Texture, and arrangement are of taxonomic significance and are used in the classification of Flowering plants.

A) Leaf Margin: -

Margin of Lamina is called 'Leaf margin'. It is of following types;-

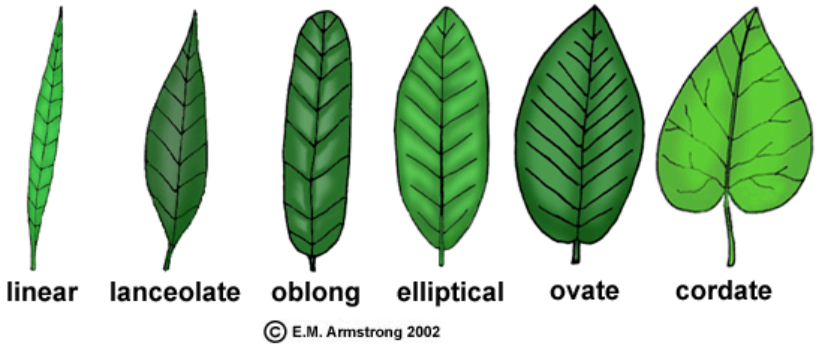
1. **Entire-** Margin is smooth. Ex: Mango
2. **Undulate or wavy:** Margin is wavy. Ex: Polyathia.
3. **Serrate**-margin is saw like teeth. Ex: Rose, Hibiscus.
4. **Dentate**-Margin is toothed. Ex: Water lilly.
5. **Spiny**- Margin is spiny. Ex: Datura.



B) Leaf Shape:-

1. Linear:-Uniformly long, narrow and flat .Ex: grass.
2. Lanceolate: - Apical portion is tapering and shaped like lance .Ex: Nerium.
3. Oblong:-Base and apex are rounded uniformly long. Ex: Banana.

4. Elliptical:-Longer than broad and breadth is uniform. Ex: guava.
5. Ovate: Egg shaped, Broad at base tapering at apex. Ex: China rose.
6. Cordate: - Heart shaped. Ex: Betel.



C) <u>Leaf surface:-</u>

a. **Glabrous: -** Surface is smooth. Ex: Mango.
b. Hairy: Surface is covered with hair. EX; Tomato**.**
c. **Glaucus: -** Surface covered with waxy coat .Ex: Calotropis.

D) <u>Leaf Texture:-</u>

a. **Fleashy(Sacculent):-** Lamina is thick , soft due to storage of water in the form of mucilage. Ex: Aloe vera.
b. **Coriaceous:-**Lamina is firm, dry, and leathery. Ex: Sapota

<u>VENATION</u>

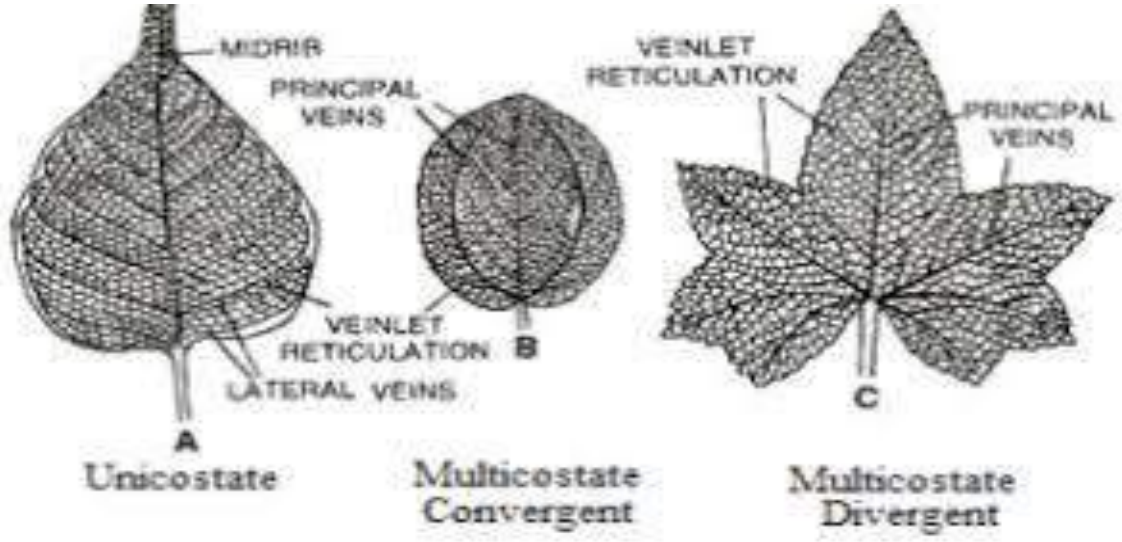
The rib –like, linear structures present in the leaf blade that arise from mid-rib constitutes Veins. It gives rise to lateral Vein lets**. Distribution and arrangement of Veins and Vein lets with in Lamina of leaf is called" Venation".** It represents ramification of fibro vascular tissue system. Based on arrangement of veins and vein lets In Lamina, Venation is classified into 2 major types. **They are 1) Reticulate venation 2) Parallel venation.**

1) <u>Reticulate Venation:</u> -

In Reticulate Venation Veins and Veinlets are **<u>repeatedly branched to form network</u>** or Reticulum**. Ex: Dicot leaf.** It is further grouped as follows:-

- **Unicostate(Pinnate type):-**In this type single midrib gives **<u>out lateral veins on either side like plumes of feather</u>.** Ex: Peepal.
- **Multicostate(Palmate type):-**In this type**<u>, two or more veins are given out from base of Lamina</u>.** It may be Convergent or Divergent.

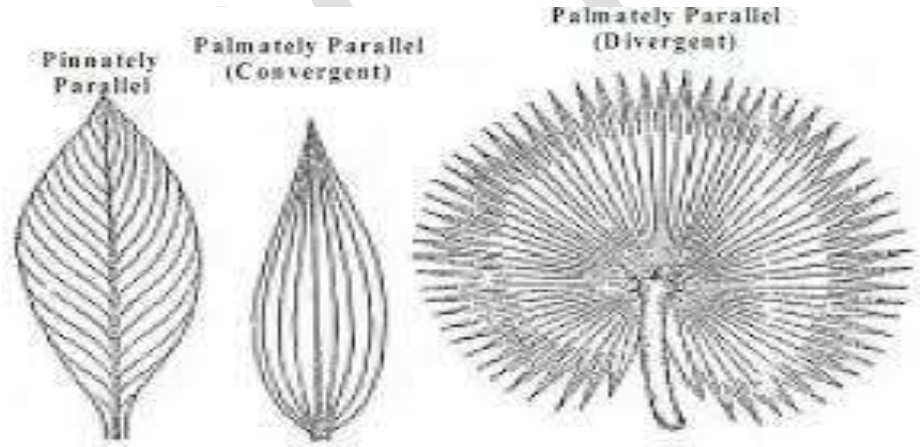
a) **Multicostate Convergent type: -** In This type 2 or more major veins arising from leaf base **<u>converge towards leaf apex</u>.** Ex: ZIzipus.
b) Multicostate Divergent:-In this type 2 or more major veins arise from leaf base and **<u>diverge towards the leaf margin</u>.** Ex:-Castor**.**



2) Parallel Venation:-

In Parallel Venation all **major veins run parallel to one another** either from midrib to margin or from base to apex of the leaf. Ex: Monocot leaf. It is further grouped as follows:-

- **Parallel Unicostate**: - In this type **single mid rib and veins run parallel** to one another.Ex: canna.
- **Parallel multicostate**:-In this type **two or more major veins arise from base pass through lamina and converge towards apex** called' **Multicostate convergent'** as bamboo. **Or diverge towards margin** called '**Multicostate Divergent'** as in palm.



KINDS OF STIPULES

Stipule is a small leafy appendage present at the base of the leaf. It protects leaf in bud condition. The Leaf with stipule is called" **Stipulate"**. Leaf without stipule is called "**Ex stipulate".**

KINDS OF STIPULES

1. **Free Lateral: - Small greenish outgrowths one on either side** of the leaf base is called" Free lateral". It is the simplest type of stipule. **Ex: Hibiscus, Gossypium.**
2. **Adnate(Adherent):-** Two **lateral stipules fused with the petiole for some distance** forming wing like structure .**Ex: Rose**.
3. **Interpetiolar**: In this type Stipules are **present in between the petioles of opposite** leaves.**Ex: Hamelia. Coffee.**
4. **Foliaceous:**-In this type **Stipules are large, green and leaf like** in structure. **Ex: Pea.**
5. **Ochreate**: In this type stipules **fuse to from a tubular structure** covering the stem above the node up to a certain height. **Ex: Polygonum.**

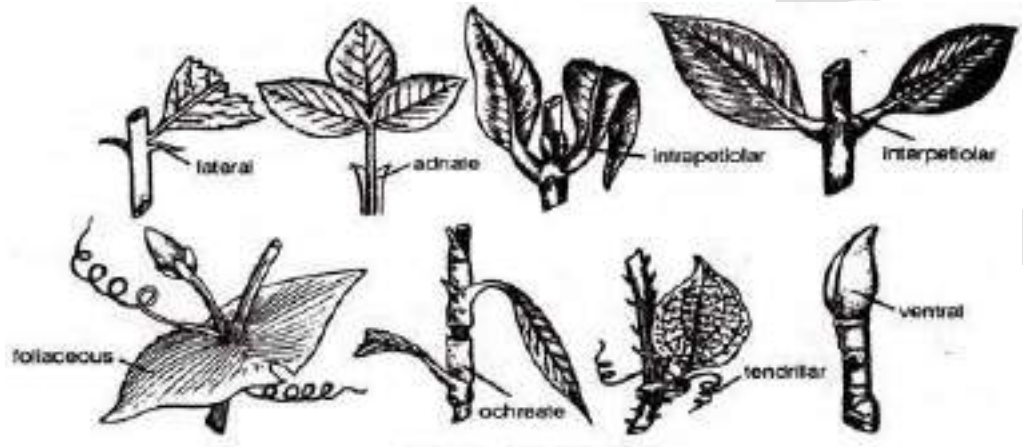


Fig. 74. Kinds of stipules.

PHYLLOTAXY

The pattern of arrangement of leaves on Nodes of the stem at its branches is called "Phyllotaxy". It is derived from Greek term where **'phyllon' means leaf and' taxis' means arrangement. Phyllotaxy can be classified into following types:-**

1. **Alternate (Spiral):-In Alternate type Single leaf at each node alternately. Or in a spiral manner around the ste**m. Ex: Hibiscus.

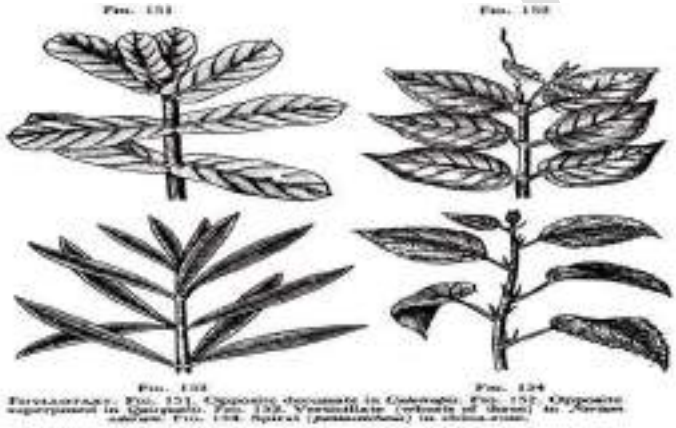
2. **Opposite: -In Opposite type two leaves at each node opposite to each other.**
   A) In **Opposite Decussate, a pair of leaves arise alternating planes at each node**, at right angles to each other. Ex: Calotropis, Ixora.

B)In Opposite Superposed, A pair of leaves arise in same plane at successive nodes are on the same plane. Ex: Guava.

3. **Whorled: -** In Whorls Phyllotaxy **three or more leaves arise in whorls** at every node. Ex: Nerium.



1) **Alternate, 2) Opposite super posed, Opposite deccusate, 3)Whrled**



TYPES OF LEAF

Based on the number of leaf blades per petiole Leaves are classified into 2 types. They are Simple leaves and Compound leaves.

1. **Simple Leaf:**
   Leaf with **single Lamina** is called "**Simple leaf".**

2. **Compound leaves:**

   L**eaf with many leaflets arranged on Rachis is called "Compound leaf"**. (Lamina is divided into many small separate units called' Leaf lets'. Rachis is Petiole of the compound leaf).

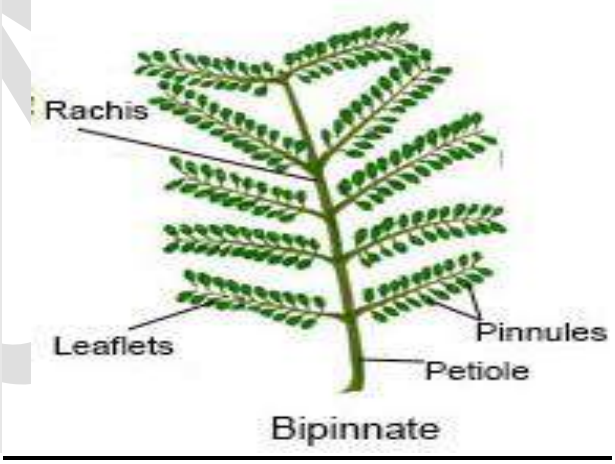
Types of Compound leaf

Based on the arrangement of leaf lets compound leaf is classified into 2 following types: -
I] Pinnately compound leaf, II] Palmately compound leaf

I] Pinnately compound leaf:-

In Pinnately compound leaves leaflets arise along the sides of rachis. It is of following types:-

1. **Unipinnate**: In this type, leaflets are developed on **Primary rachis.**
   If Rachis terminates in a pair of Leaflets it is called **"Paripinnate leaf**"
   .Ex: Tamarind.
   If Rachis terminates in single Leaflet, it is called as "**Immaparipinnate leaf"**. Ex: Rose.
2. **Bipinnate:** -In this type, Leaf lets are developed on **secondary rachis**. Ex: Mimosa pudica.
3. **Tripinnate:-**In this type Leaf lets developed on **tertiary rachis**.
   Ex: Moringa (Drum stick).
4. **Decompound:** Rachis branched many times, with leaf lets **on ultimate branches**.
   Ex: Coriander



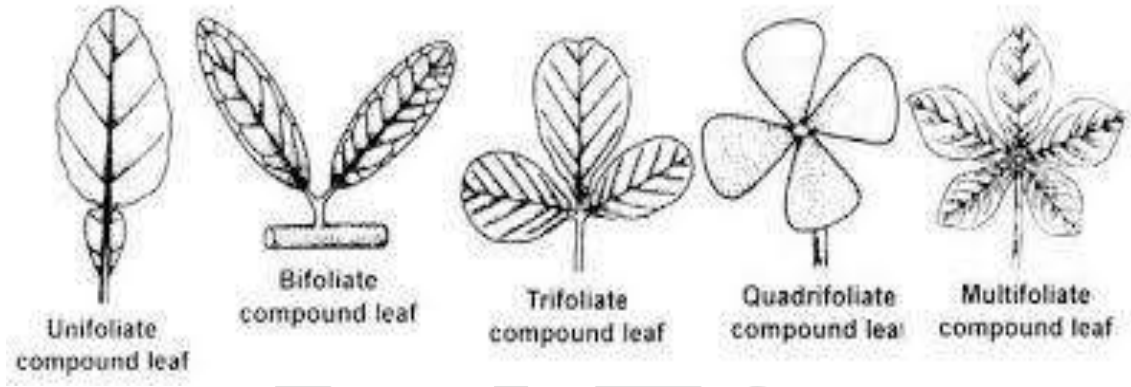
TripinnateEx; Moringa

Decompound, Ex: Coriander

II] Palmately compound leaf:-

In Palmately compound leaves leaflets arise from single point at the tip of the petiole. Based on the number of leaf lets present It is of following types:-

1. **Unifoliate**: - In this type single leaf let is attached to the winged petiole. Ex: Citrus.
2. **Bifoliate**: - In this type two leaf lets are developed from tip of petiole. Ex: Hardwickia.
3. **Trifoliate:** - In this type three leaf let's are developed from tip of the petiole. Ex: Aegle marmelosus (Bilva patrae).
4. **Quadrifoliate**: - In this type Four leaf let's are developed from tip of the petiole. Ex: Marselia.
5. **Multifoliate**: - In this type more than Four leaf lets are developed from tip of petiole. Ex: Silk cotton.



Modification of Leaves

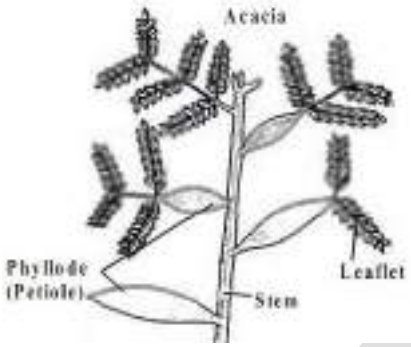
Any change in normal form and structure of leaf or its parts, in response to the need of the plant is called **'Leaf modification'.** According to the nature of Special functions, the following leaf modifications are recognised:-

1. **Leaf tendrils: -** Tendrils are **long, slender, coiled structures which are sensitive to contact** and may develop from any part of the plant, **meant for climbing**. Such plants are called 'Tendril climbers'. Ex: In **Garden Pea terminal leaf let** is modified into Tendril, In Gloriosa **Leaf tip**, In Smilax **Stipules are modified into Tendril.**

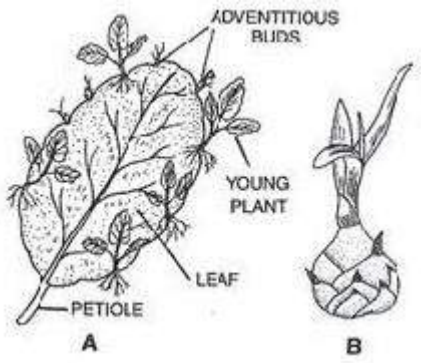


EX;Garden Pea terminal leaf **Gloriosa Leaf tip,** **In Smilax Stipules**

2. **Phyllode:-** Green , flattened leaf like modified petiole or Rachis meant for photosynthesis structures when the Lamina is poorly developed is **called ' Phyllode". Ex: In Acacia melanoxylon (Australian acacia) secondary Rachis and leaf lets are shed during early growth** and Petiole is modified into Phyllode. In Parkinsonia Secondary rachii of a bicompound leaf is modified into a phyllodes and primary Rachis is modified into a spine.



3. **Leaf Buds:** - Leaf buds are **adventitious Buds produced from the surface of the leaf , meant for Vegetative reproduction .** They are also known as Epiphyllous buds. Ex: In **Bryophyllum,** Leaf buds are developed along the margin. They develop roots below and leaves above. This can be developed into an independent plant.



4. **Leaf Spines:-Hard, pointed structure developed** from leaf is called **'Leaf spine'.** It is meant for protection and to **check transpiration**.Ex: In Opuntia leaf is modified to spines, **In Date palm,Agave and Yucca Tip of the leaf is spiny** , in **Argimone margine of lamina is spiny**, **In Acacia stipules are modified into spines**.

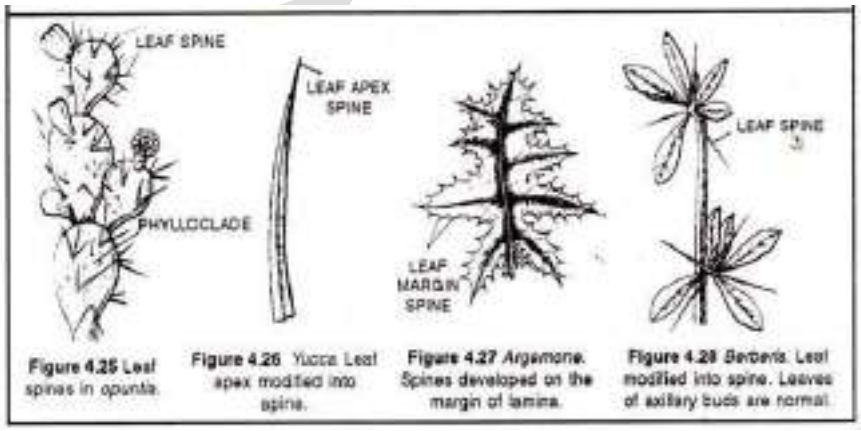


Figure 4.25 Leaf spines in opuntia.
Figure 4.26 Yucca Leaf apex modified into spine.
Figure 4.27 *Argemone*. Spines developed on the margin of lamina.
Figure 4.28 *Berberis*. Leaf modified into spine. Leaves of axillary buds are normal.

5. **Leaf buds:-**

These are adventitious Buds produced from the surface of the leaf , meant for Vegetative reproduction . They are also known as **Epiphyllous buds**. Ex: In **Bryophyllum, Leaf buds are developed along the margin**. They develop roots below and leaves above. **These can develope into an independent plant on seperation from mother plant.**

6. **Insectivorous plants**: - In some plants the leaves are modified for capturing Insects to full fill their Nitrogen fulfilment are called **"Insectivorous plants**" Or **"Carnivorous Plants"**.

Examples:-

1)In **Drosera Lamina is spoon shaped, covered with sticky hairs called Tentacles**, which **shine like dew in sunlight**. Insect confuse it for Nector and alights on it to suck. Sensitive tentacles bends over insects entrap and digest it by its secretions of tentacles.

2)In **Nepenthes (Pitcher)** entire **Leaf is modified into brightly coloured Pitcher, with a lid** to trap the Insects**.** Inner wall of Pitcher bears hairs to prevent insect escape and secrete digestive enzymes to digest its protein. **The edge of Pitcher is slippery**. When an insect alight on pithcher, slips into it and get digested.

3)Dionea muscipulata(Venus fly Trap): It catches prey with a trapping structures formed by **margins of rossete leaves are provided with tiny hair called 'Trigger hair'**. These are sensitive to touch. Inner surface of lamina is brightly coloured

4) **Utricularia (Bladder wort)** a s**ubmerged Hydrophyte, has submerged leaves and Floating leaves. Floating leaf is modified into a Bladder** with Trap door. It allows small aquatic insects to enter, trap door closes and imprison the insect and digest it to full fill Nitrogen requirement.




Ex: **Drosera Nepenthes Dionea Utricularia**

INFLORESCENCE

"Cluster of Flowers produced by a plant, borne on a special reproductive axis is termed as an "Inflorescence".

The main axis of the inflorescence is called **"Peduncle".** Stalk of the Flower is called **'Pedicel'**. Stalked flowers are called **"Pedicillte**" and stalk less flowers are called "**Sessile**". Bract is a leaf like structure which bear flower or an Inflorescence. Flower with bract is called '**Bracteate**' and Flower without bract is called **'ebracteate**. Pair of small, scale like structures developed on either sides of the pedicel between the flower and the Bract is called **"Bracteoles".** Flower with Bracteoles is called 'Bracteolate" and Flower without Bracteole is called **'ebracteolate'.**

TYPES OF INFLORESCENCE

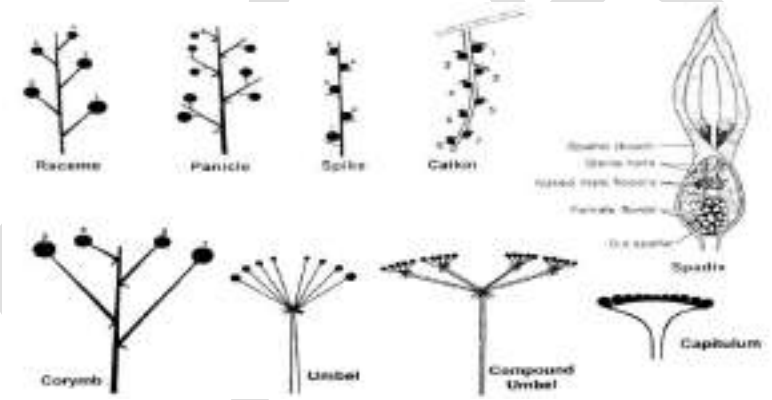
The Inflorescence are classified into 2 main types .They are 1) Racemose or Indefinite type 2) Cymose or Definite

I. Racemose Inflorescence or Indefinite:-

Racemose Inflorescence shows following characters:-

- Peduncle shows **continued growth**; hence it is also called "indefinite growth'.
- Peduncle **never terminates in a Flower**.
- Flowers are arranged in **Acropetal manner** .i.e., The Older flowers are towards the base and Younger flowers are towards the tip.
- The order of opening of Flowers is **'Centripetal'** i.e, Lower (Marginal) flowers in the inflorescence are older and open earlier, while the central flowers are younger and open later.

Types of Racemose Inflorescence:-

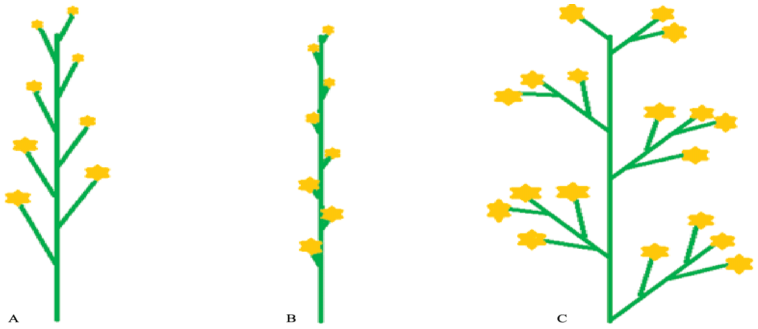


Racemose inflorescence is further classified into following types. They are as follows:-

4. **Simple Raceme:-**

In this type **elongated Peduncle bears Pedicillate flowers in acropetal manner**.Ex Cassia.

5. **Spike**:- In this type **elongated peduncle bears sessile flowers in Acropetal manner.** Ex: Acyranthus
6. If Peduncle is branched and each branch bears pedicillate flowers in acropetal manner it is called **'Compound Raceme" or "Panicle**". Ex: Mango



. **Spadix**:- In this type **Peduncle is thick, fleshy, bears sessile unisexual flowers. Entire inflorescence is enclosed by single, large, coloured bract called" Spathe'.** Ex: Colocasia. If Axis of Spadix is branched , each branch bears unisexual flowers & entire florescence is covered by large woody, boat shaped bract, it is called **"Compound Spadix".** Ex: Musa, Coconut.

7. **Corymb:-**In this type **Peduncle is short and Pedicels of the lower flowers are much longer than upper flowers**, so that all flowers are more or less placed at the same level. Ex; Gold mohur.

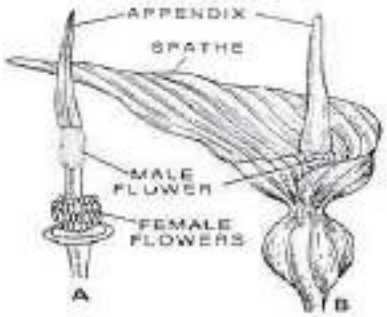
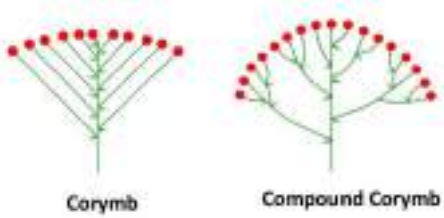


Fig. 34.50. Inflorescence-spadix-A, spadix of an aroid without spathe; B, same with spathe.



2. Compound Corymb: as in F: Cruciferae.

8. Umbel:-

In this type Peduncle is highly condensed, flowers have equal length pedicels arising from same point. Flowers are bracteate and bracts are arranged in a whorl at the base to form Involucre. Ex: Onion. If the main axis is branched and branches are of equal size, which bear flowers with pedicels like Umbel, it is called **"Compound Umbel".** Ex: Carrot, Coriander.


Figure 4.4: (q) Umbel diagrammatic


Figure 4.4: (r) Compound umbel diagrammatic

9. Head or Capitullum:-

It is **characteristic inflorescence** of the family **Compositeae(Asteraceae**)In this type **Peduncle is flattened** to form a circular disc called "**Receptacle"**. On its lower surface it bears large number of **green bracts forming an Involucre.** The Flowers are arranged on the receptacle in a **centripetal manner.** I.e. The central flowers are younger and peripheral ones are older, and the sequence of blooming is from periphery towards the centre.

The sessile small flowers are called 'Florets'. There are 2 types of Florets, the **peripheral Zygomorphic Ray florets and central, actinomorphic 'Disc florets'.** Based on type of florets in an Inflorescence it can be grouped into 2 types, namely:-

1) **Homogamous head** – Head inflorescence **with only one type of Floret**.

2**) Heterogamous head**- Head inflorescence with **both Ray floret and Disc floret.**

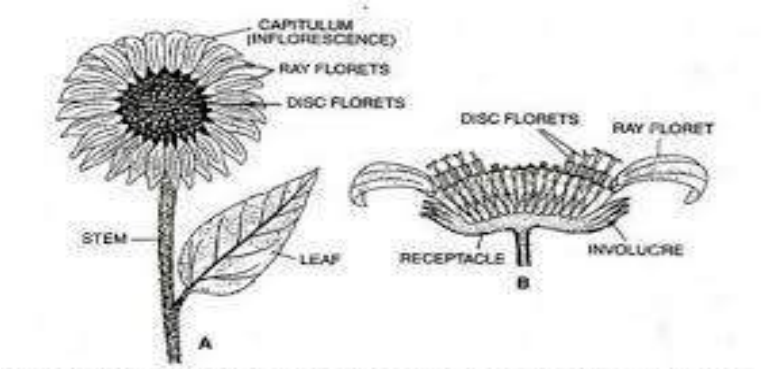


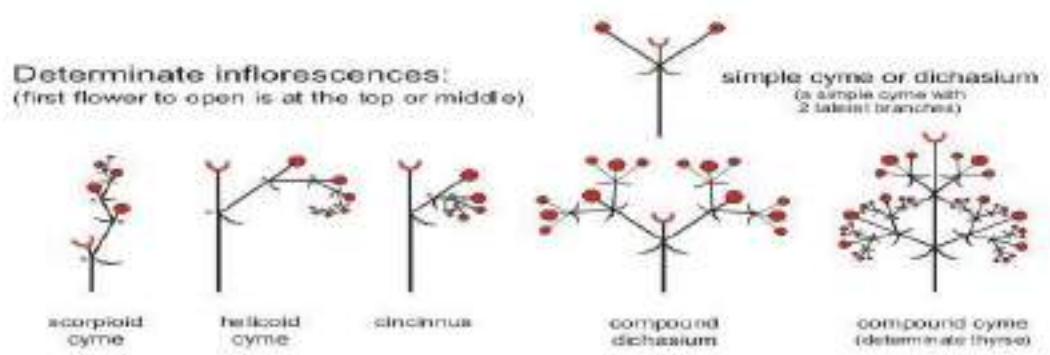
Fig. 5.74. Capitulum of Sunflower. A, entire capitulum; B, vertical section of capitulum.

II. Cymose Inflorescence or Definite type:-

Cymose Inflorescence shows following characters:-

- Peduncle shows **limited growth**; hence it is also called "**Definite Type'.**
- Peduncle **terminates in a Flower**.
- Flowers are arranged in **Basipetal manner** .i.e., The Older flower is present in terminal region and Younger flowers are towards the base.
- The order of opening of Flowers is **'Centrifugal'** i.e., the central older flowers in the inflorescence open first and the younger peripheral ones open later, while the central flowers are younger and open later.

TYPES OF CYMOSE INFLORESCENCE



1. **Solitary cyme:-** In Solitary cyme **Peduncle end up in a single flower.Ex: Hibiscus**

2. **Monochasial or Uniparous cyme**: -

In this type the main **axis terminates in a flower**. It **then produces one lateral branch in the axil of a bract,** which also ends in a flower. On the basis of development of flowers two main forms are recognized. They are:- Helicoid cyme and Scorpoid cyme.

a) Helicoid cyme: - In this type **successive branches are developed on the same side forming helix.** Ex: Hamelia.

b) Scorpoid cyme:-In this type **successive lateral branches are developed from bracts alternately on the opposite sides of the axes resulting in the Zigzag manne**r. Ex: Heliotropium.

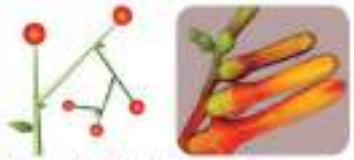


Figure 4.6: (b) diagrammatic, (c) Monochasial Helicoid

Figure 4.6: (d) diagrammatic, (e) Monochasial Scorpioid

3. **Dichasial Cyme: -** In this type **main axis terminates in a flower**, **and then 2 flowers develop from axils of oppositely placed bracts** behind it. Ex; Jasmine. From this various compound Dichasium are developed as in Clerodendron, Ixora.

Figure 4.6: (f) diagrammatic, (g) Simple dichasium

4. **Polychasial Cyme**:-In this type main axis **terminates in a flower**, **then more than 2 lateral branches are developed simultaneously,** each of which behaves in a similar manner. Ex: Calotropois.

Figure 4.6: (j) diagrammatic, (k) Polychasial cyme

III. MXED INFLORESCENCE: -

An Inflorescence which shows characters of both Racemose and cymose inflorescence is called 'Mixed type'. It includes one type. Namely **Thyrsus.**

Thyrsus: - In Thyrsus the **Peduncle grows indefinably as in Raceme**, and it bears flowers in **cymose cluster in an acropetal manner.**Ex: Ocimum sanctum (Tulsi-Basil).

Figure 4.8: (a) diagrammatic, (b) Thyrsus

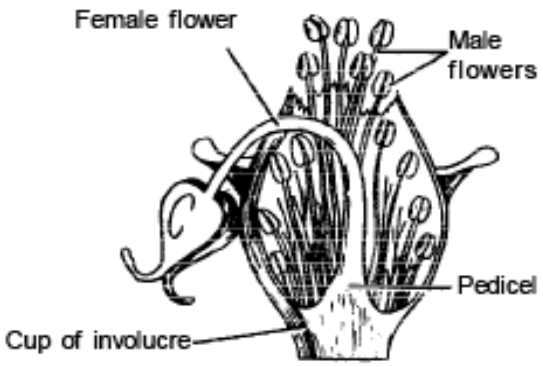
IV.SPECIAL INFLORESCENCE

Special Inflorescence may show characters of racemose or Cymose along with its own special characters. It includes 3 types, they are as follows:-

1. CYATHIUM, 2.HYPANTHODIUM, 3.VERTICILLASTER

1. CYATHIUM: -

Cyathium is a specialized cymose inflorescence. It has **cup like Involucre formed by fusion of bracts**. It encloses disc like axis with **Single centrally placed pistillate flower** (Female flower) with **long pedicel** which brings out of the cup. It is **surrounded by many staminate flowers** (Male flowers) arranged in Zig-Zag manner. Honey secreting disc **called Nector gland** is present towards one side of the cup. Ex: Euphorbia.



Cyathium

2. **HYPANTHODIUM:-**
   In Hypanthodium **Peduncle condenses to form fleshy, cup shaped receptacle** with an **opening** called '**Ostiole**". Receptacle encloses hallow cavity which **bears unisexual flowers. Male flowers are present towards ostiole** and **female flowers towards base**. Between these two are sterile **Goll flowe**rs. Ex: Figs.

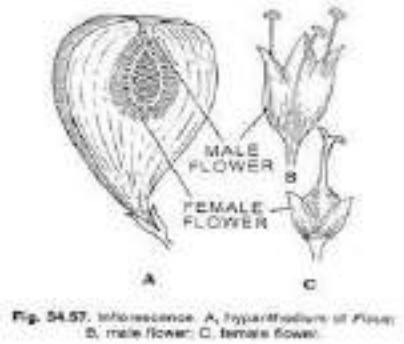
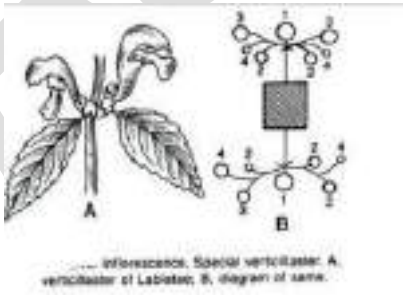


Fig. 24.57. Inflorescence. A, hypanthodium of Ficus; B, male flower; C, female flower.

3. **VERTICILLASTER: -**
   Verticellaster is the characteristic inflorescence of the Family '**Lamiaceae'.** In this type in the axil of **opposite leaves Biparous cyme develops**, Lateral branches of it produces **Uniparous Scorpoid cym**e. The flowers are sessile and form a **false whorl (Verticel)** around the stem.


Figure 4.8: (c) diagrammatic, (d) Verticillaster



... inflorescence. Special verticillaster. A, verticillaster of Labiatae; B, diagram of same.

FLOWER

Flower is a modified shoot meant for Sexual reproduction. A Typical Flower consists of following parts:-

1. **Pedicel: -** Stalk of the Flower is called "Pedicel". Flower with stalk is called 'Pedicillate' and flower without Stalk is called 'Sessile'. It arises from the axil of a leaf like structure called 'Bract'.If it is present it is said to be Bracteate , absent as ebracteate flower.
2. **Thalamus:-** Thalamus is the bulged tip of the Pedicel on which flower whorls like Calyx, Corolla, Androecium and Gynoecium are present.
3. **Calyx (K):-** Calyx is the outermost and protective whorl. It consists of small green Sepals. If sepals are free it is said to be **Polysepalous. If** sepals are fused **Gamosepalous.** Whorl of bracteoles below the calyx is called **Epicalyx.**
4. **Corolla(C)**:-

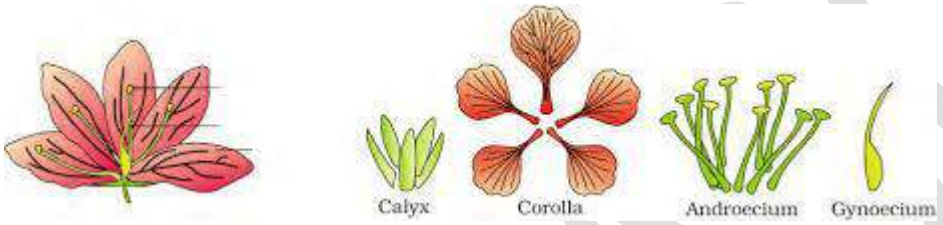
Corolla is the second whorl of the Flower. It **is colored &often scented.** Unit of Corolla l is called Petal. If petals are free it is said to be **Polypetalous.**

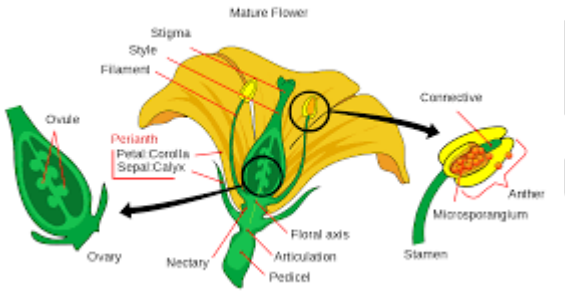
5. Androecium (A):-

Androecium is the third and male reproductive whorl of a Flower. It consists of many Stamens. Each Stamen has long Filaments with 2 Anther lobes bearing pollen grains attached by connective. If Filaments of all the stamens are fused and anthers free, filaments are fused to form one bundle it is called **Monadephous**.

6. **Gynoecium(G)**: -

Gynoecium is the innermost and female reproductive whorl. It consists of Basal Bulbous Ovary, Middle Style and terminal Stigma. Ovary with many carpels **Multicarpellory. If** Carpels fused **Syncarpous ,Multilocular** with ovules on axile placentation.





Terms used to describe Flower

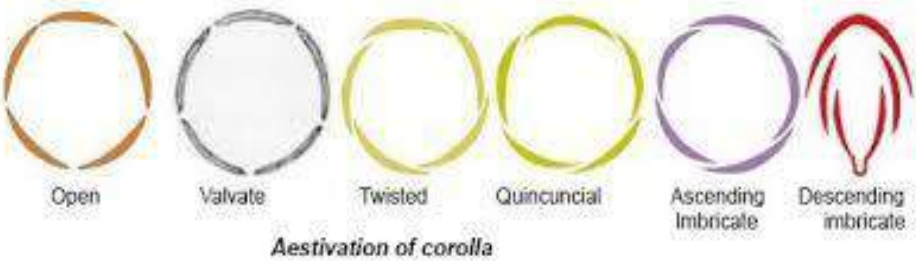
1. **Axillary: - Flower** developed in the **axil of a leaf**.
2. **Terminal: -** Flower developed at **the tip of a Branch.**
3. **Pedicel: Stalk** of the flower.
4. **Pedicillate:** Flower **with stalk**.
5. **Sessile:**- Flower **without stalk.**
6. **Bract:**- Tiny, **leaf like structure from the axil** of which flower develops.
7. **Bracteate:** Flower **with Bract**.
8. **Ebracteate:** Flower **without bract**.
9. **Bracteole: - Small, scale** like structure developed **in pairs on pedicel**.
10. **Bracteolate:**-Flower **with bracteole**.
11. **Ebracteolate:** - Flower **without Bracteole**.
12. **Involucre:**-Bracts and **Bracteoles occur in whorls**.

13. **Complete: -** Flower possessing all the **4 whorls namely K, C, A, G.**
14. **Incomplete: -** Flower **lacking any one** or more whorls.
15. **Acyclic:** Floral organs **arranged in a spiral.**
16. **Cyclic**: Floral organs arranged **in a circle**.
17. **Dichlamydeous (Heterochlamydeous):** A Flower **with calyx and corolla**.
18. **Monochlamydeous (Homochlamydeous)**: **-** A Flower **with perianth**.
19. **Achlamydeous: -** A flower **with either Androecium or Gynoecium**, but **without Calyx and Corolla.**
20. **Pistillate:** - Achlamydeous flower **with only Pistil.**
21. **Staminate: -** Achlamydeous flower **with only Stamens.**
22. **Unisexual: -** A Flower with **only one of the reproductive organ** either Androecium or gynoecium.
23. **Bisexual: -** A flower **with both reproductive organs** Androecium and Gynoecium**.**
24. **Pentamerous: -** A flower **with 5 sepals and 5 Petals** in each whorl.
25. **Tetramerous:** Floral **organs in four or multiple of four**.
26. **Trimerous:**- A Flower **with 3 Tepals**.
27. **Actinomorphic(Regular): -** When flower is cut through the axis **in any plane(Radial symmetry.**
28. **ZYgomorphic(Irregular):-** When flower is cut through the axis , if it gives 2 symmetrical parts **along one plane.* Bilateral symmetry)**.
29. **Glume:** sterile bracts **found in grass**.
30. **Lemma; Fertile** bract **found in grass**.
31. **Staminode: Sterile stamen** is called Staminode.
32. **Epipetalous**: **Stamens attached to petals** is called Epipetalous.

Aestivation.

The mode of Arrangement of petals and sepals in bud is called "Aestivation". Aestivation is of following types:-Valvate, Twisted, Imbricate,Quincontial.

1. **Valvate**: Arrangement of sepals and petals without overlapping is called 'Valvate'.ex: Mustard, Annona, Mimosa.



Aestivation of corolla

2. **Twisted (Contorted):** In Twisted aestivation all **Sepal and Petal show one margin in and one margin out.** (Margin of one sepal or petal overlaps the margin of the next). Ex: Hibiscus, Cotton.
3. **Imbricate**: Arrangement of petals and sepals are in such a way **that one petal or sepal shows both margins in, one petal or sepal shows both margins out, rest shows one margin in & other margin** out.Two variations are seen in imbricate aestivation.

- **In ascendingly imbricate** aestivation **overlapping starts from anterior side, so that posterior petal is interna**l Ex: Cassia, Caesalpinia.
- **In Descendingly imbricate** aestivation the **overlapping starts from posterior side, so that anterior petal is innermost.** This is also referred as '**Vexillary aestivation'**. Ex: Pea, Ban, Crotalaria.

4. Quincontial: Two petal or sepal shows both **margins in**, **two** petals or sepal shows both **margins out**, **other shows one margin in & other margin out.**

1.CALYX

Calyx is the outermost protective accessory whorl of the flower. It is green in colour. Sometime it is brightly colored called '**Petaloid sepal'**.
If petals are free it is called' **Polypetalous** 'Ex: Rose.
If Sepals are fused, it is called '**Gamosepalous'**. Ex; Hibiscus.
If sepals are shed as soon as flower opens it is called '**Caducous'**.
If sepals persists as long the Petals it is called 'Deciduous',
If sepals remain after fertilization and present in the fruit , it is called **" Persistant calyx'.**
Ex: Tomato, Brinzal .

2.COROLLA

Corolla is the second accessory whorl of a flower composed of **Petals.** It is **brightly colored, fragrant and attractive whorl**. If petals **are free it is called Polypetalous**. Ex: Hibiscus. If Petals **are fused**, it is said to be **Gamopetalous.** Jasmine.

Function of Corolla:-

1. Corolla **protects essential whorl of a flower**.
2. It attracts Insects for **Cross Pollination**.

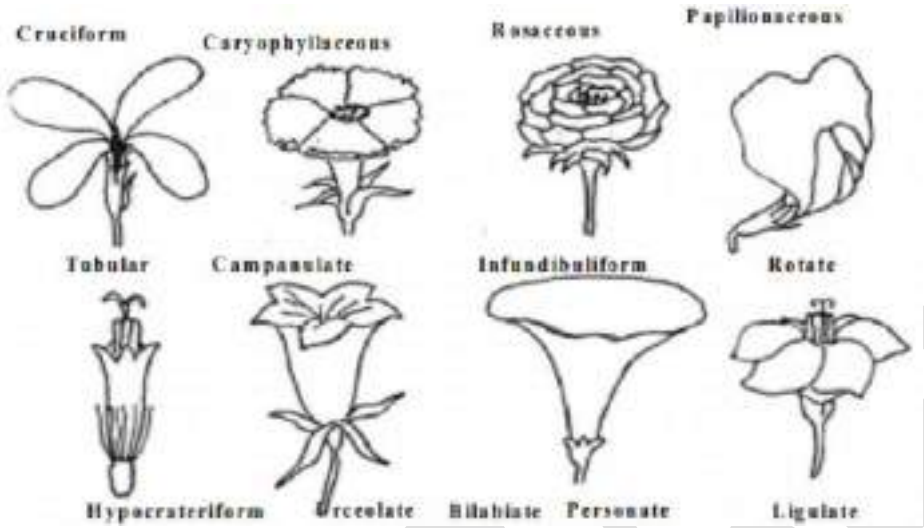
Forms of Corolla.

Based on shape and fusion of Petals Corolla exhibits various forms. Some of them are as follows**:-**

- **Cruciform:** In Cruciform type, Corolla is composed of **4 free clawed petals arranged in the form of cross**. Ex: Mustard, Radish.
- **Papilionaceous:** - (Papilion- Butterfly). This is the characteristics of the Family **Papilionatae**. In this type corolla consists **of 5 un equal petals**. of these posterior **one petal is large called 'Standard petal"**, **two lateral 'Wing petal'or 'Alae'**, and anterior **2 petals**

are united to along one margin forming boat shaped structures called' **Keel petal' or 'Carina**'. It encloses Essential whorls.

- **Companulate**: **Bell shaped**.
- **Tubular**: In this type **united petals** form complete tube. Ex: Florets of Asteraceae.
- **Bilabiate**: Corolla fused to **form two lips like structures**. Ex: Leucas (Tumbae).
- **Infundibulum**: - The corolla produces **funnel like structure** with terminal parts of the petals gradually spreading out. Ex Datura, Ipomoea.



3.ANDROECIUM

Androecium is the **Third whorl and male reproductive** organ of a Flower. It is composed of Stamens. Each Stamen consistsof basal, **slender Filament** (stalk), and an upper **2 Anther lobes** connected by **Connective**. Each Anther lobe has 2 chambers **called Microsporangia** in Tetrasporangiate anthers and one microsporangium in B isporangiate Anther. In stamens following variations may also be seen.

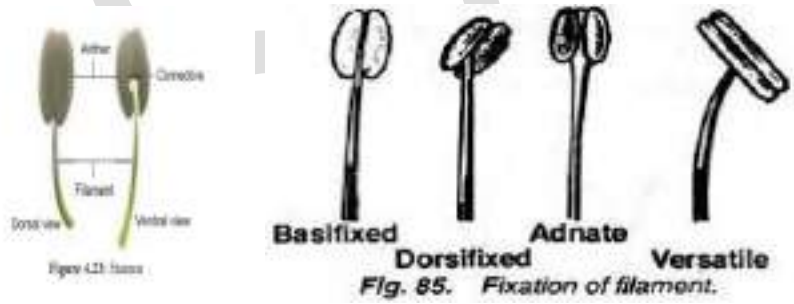


Fig. 85. Fixation of filament.

I. Attachment of Anther to the filament:-

- **Basifixed**:- The Filament is attached to **the base of the Anther**. Ex: Mustard, Radish.
- **Dorsifixed:-** The filament is attached to the Anther **along its back**.Ex: Passiflora,
- **Adnate:**-The filament is attached to the Anther **throughout its length**. Ex: Michelia.
- **Versatile:** - The attachment of Anther is at the **middle of the Anther** so that both ends of Anther are free to swing in air. Ex: Grass.

- **Introrse**: Anther dehiscing towards the **centre of the flower.**
- **Extrorse:** Anther dehiscing towards the **circumference of the flower.**
- **Dithecous**: Anther 2 lobed.
- **Monothecous**: Anther single lobed.

II. Union of Stamens:-

Sometimes stamens in a flower are united by filaments or Anthers or both Anther and filaments. Accordingly they are named as follows:-

1. Adelphous:

In a flower if filaments of all the stamens are United and and anthers are free, such condition is called as**" Adelphous". It is of following types:-**

a) Monadelphous: - In this type **Filaments of all the stamens are united to form single bundle**. Ex: Members of family Malvaceae(Hibiscus, Cotton).

b) Diadelphous:-Filaments in a flower are **united to form 2 bundles.Ex**: Bean, Pea.

c) Polyadelphous:- Filaments are united to from **many bundles of stamens** .Ex: Lemon.

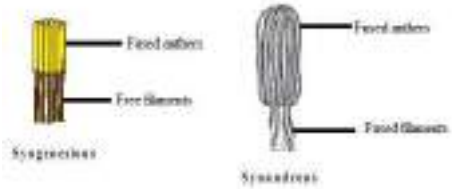
Monadelphous

2. Syngenesious:-

In a flower if **Anthers of all the stamens are united and Filaments are free**, such condition is called as"**Syngenesious".** Ex: Members of the family Asteraceae.(Sun flower).

3. Synandrous Stamens:-

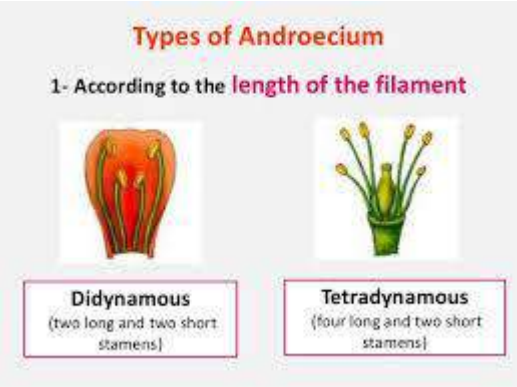
In a flower if **filaments of all the stamens and Filaments are united and such condition** is called as**"Synandrous Stamens".Ex: Members of the family Cucurbitaceae. (Cucumis).**



III. Length of stamens:-

Stamens often attain different lengths and give rise to following conditions:-

- **Didynamous**: In a Flower if there are **4 Stamens out of which 2 are long and 2 are short** Ex: Oscimum, Leucas.
- **Tetrandynamous**: In a Flower if there **are 6 Stamens out of which out of which 4 are long and two are shor**t .Ex: Mustard, Radish.



- **Gynandrous**: Stamens fused with carpels partly or wholly.
- **Obdiplostemnous**: Stamens in two whorls. Outer whorl alternate with petals.

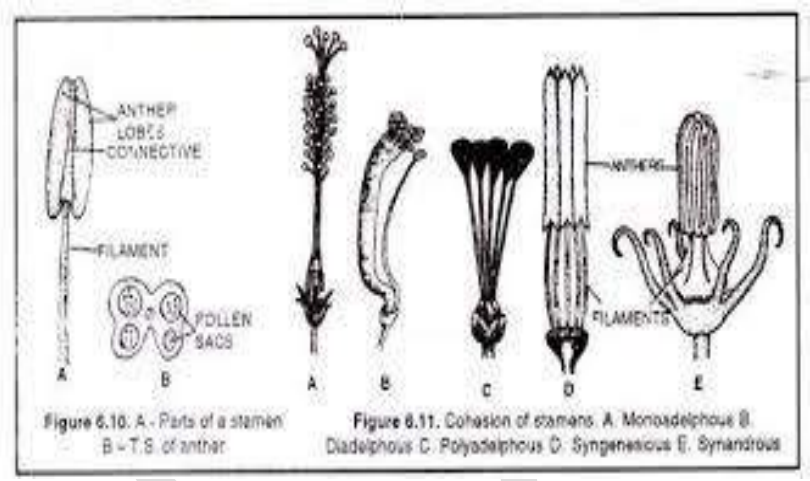


Figure 6.10. A - Parts of a stamen B – T.S. of anther

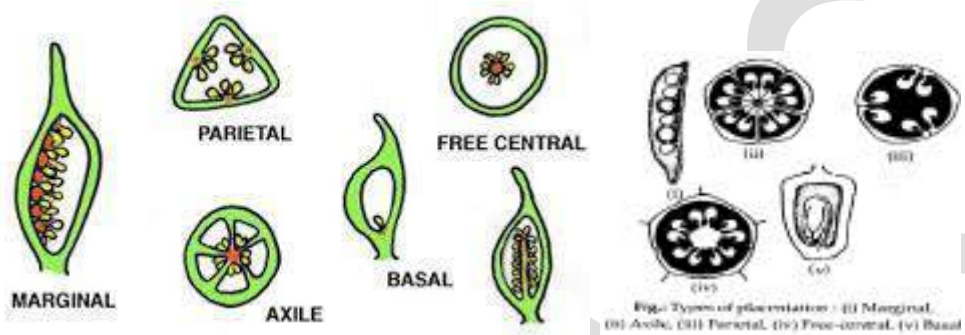
Figure 6.11. Cohesion of stamens. A. Monoadelphous B. Diadelphous C. Polyadelphous D. Syngenesious E. Synandrous

GYNOECIUM OR PISTIL

Gynoecium is the innermost whorl and Female reproductive organ of a Flower. It consists of units **called 'Carpels' or' Megasporophylls**'. Each capel, is composed of swollen basal portion called 'Ovary', a filamentous style, and knob like terminal part called 'Stigma'. Ovary bears small, spherical shaped structure called 'Ovules'.

- **Stigma may be capitate** Like a globose head or **Feathery with** hairy growth or **Bifid with** Stigma divided into two.
- Style arising from the base of the ovary is called **Gynobasic**. A disc surrounding the base of the style is called **Stylopodium.**

- The number of carpels in an ovary is variable. If it contains one carpel called **monocarpellory, 2 carpels- Bicarpellory, 3 carpels- Tricarpellory, 4 carpels –Tetracarpellory, 5 carpels-Penta carpellory, more than 5 carpels- Polycarpellory ovary.**
- If **carpels are free from one another**, they are called '**Apocarpus ovary'.** Ex: Michelia, If carpels are **united,** they are called '**Syncarpus ovary'**, Ex:Ladies finger.
- The **cavity of the ovary,** containing ovules is called'Locule'.The number of locules often indicate the umber of carpels.Ovarly with one locule is called Unilocular, 2 locules –Bilocular, 3 locules-Trilocular and so on.
- **Placenta is a** soft tissue inside the ovary. Arrangement of ovules within the ovary is called '**Placentation'**.



- **Axile** with Ovules attached to central **axis** ex; Hibiscus,
- **Marginal** with ovules attached to **ventral margin.** Ex: Pea,
- **Basal** with ovules attached to **base of the ovary** Ex: Sunflower,
- **Parietal** with ovules attached to **inner walls of the ovary** Ex: Cucumis.
- **Gynophore,:**A stalk bearing gynoecium called **Gynophore**.
- **Gynandrophore** :A stalk bearing both Androecium and Gynoecium is called **Gynandrophore**. **and Gynostegium** :A sheath covering the gynoecium and anthers is called **Gynostegium**
- A stalk bearing gynoecium called **Gynophore**. A stalk bearing both Androecium and Gynoecium is called **Gynandrophore**. A sheath covering the gynoecium and anthers is called **Gynostegium.**

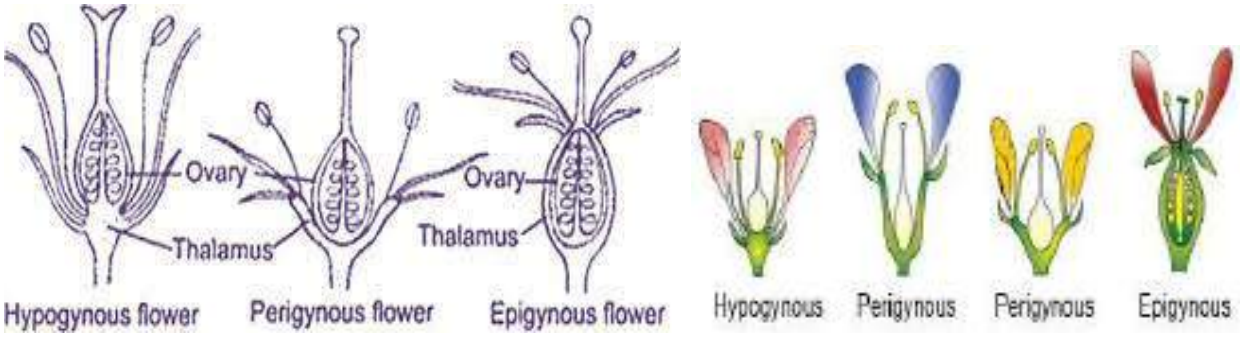
Apocarpous and Syncarpous ovary

The Female reproductive organ of flower gynoecium , number of carpels in an ovary is variable. If it contains one carpel called monocarpellory, more than 5 carpels Polycarpellory ovary.

Apocarpous: If carpels are free from one another, they are called '**Apocarpus ovary'.** Ex: Michelia, **Syncarpus ovary':** If carpels are united, they are called '**Syncarpus ovary'**, Ex:Ladies finger.

Types of Flower

Flower is a modified shoot meant for Sexual reproduction. A Typical Flower consists of Stalk **called Pedicel.Thalamus** is the **bulged tip of the Pedicel** on which flower whorls like Calyx, Corolla, Androecium and Gynoecium are present. **Based on position of the Ovary with respect to the other floral whorls** .Flower can be classified into 3 types as follows:-



1. **Hypogynous:-**The Flower in which **Thalamus is dome shaped** and floral parts **Calyx, Corolla, Androecium and Gynoecium are developed below the Gynoecium** is called "**Hypogynous flower". The position of the ovary is said to be superior.Ex: Hibiscus, Coconut.**

2. **Perigynous:-** The Flower in which **Thalamus is Cup shaped**, **Gynoecium is centrally placed, Calyx, Corolla, Androecium are developed from the rim of cup** is called **"Perigynos flower'.** The position of the Ovary is said to be **'Semi superior' or 'Semi inferior'. Ex: Rose,**

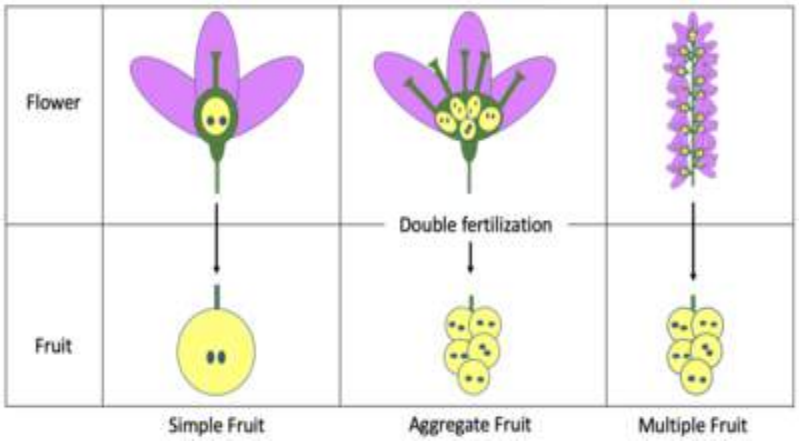
3. **Epigynous**:-The Flower in which **Thalamus is cup shaped and completely united with the ovary** and **Calyx, Corolla, Androecium are developed above the Ovary** is called **" Epigynous".** The position of the Ovary is said to be **'Inferior'.Ex: Guava.**

FRUITS

The Fertilized, ripened Ovary is called" Fruit". The fruit wall is called**" Pericarp**". The fruit developed from Ovary is called '**True fruit'**. Fruit developed from other floral parts in addition to ovary is called '**False fruit'. Or 'Pseudo carp'.** Fruit developed without fertilization is called **'Parthenocarpic fruit'.**

CLASSIFICATION OF FRUITS

Fruits are classified into 3 main types. They are:-



1) Simple fruits: - Fruit developed from **syncarpus ovary of a single flower.**

2) Aggregate fruits: - Fruit developed from **Apocarpus ovary of a single flower.**

3) Multiple fruits: - Fruit developed from **entire Inflorescence.**

1) Simple fruits: -

Fruit developed from Monocarpellory or Polycarpellory syncarpus, ovary of a single flower is called **"Simple Fruit".**

I.TYPES OF SIMPLE FRUIT

Fruit developed from **syncarpus ovary of a single flower. Based on nature of Pericarp at maturity, simple fruits are classified into 2 types. Namely :-**

A] FLESHY FRUITS: Pericarp is thick, fleshy
B) DRY FRUITS: Pericarp is thin and dry.

A) FLESHY FRUITS

Fleshy fruits are simple fruits in which **Pericarp is thick, Fleshy and juicy at maturity. Pericarp is differentiated into outer Epicarp, Middle Mesocarp and Inner Endocarp**. It includes 5 types. They are: - Drupe, Berry, Hesperidium, Pome and Pepo.

1. **Berry:-** Berry is a simple fleshy fruit developing from Bi or **multicarpellory, syncarpous ovary. Entire pericarp is fleshy, juicy and edible**. Ex: Tomato, guava, Sapota.

2. **Drupe: -** Drupe is a simple fleshy fruit developing from monocarpellary, syncarpous, superior or inferior ovary**. Endocarp is hard enclosing seeds**. Ex: Mango, Coconut.
   In Mango- Epicarp forms the skin**, mesocarp is fleshy, juicy and edible**, and **Endocarp is hard.**
   Coconut-Epcarp froms the skin, Mesocarp is fibrous, Endocarp is hard and Endosperm is edible.

3. **Hesperidium:-**Hesdperidium is a simple fleshy fruit developing from multicarpellory, syncarpus ovary with ovules on axile placenta. **It is a characteristic fruit of the family Rutaceae.Epicarp and mesocarp unite to from thick rind, Endocarp is membranous, project inwards, form flakes, edible part is juicy ingrowths of endocarp.Ex: Lemon, Orange**.

4. **Pepo:-**Pepo is a simple, fleshy flase fruit developing from **inferior, Tricarpellory, syncarpous,inferior ovary with Parietal placentation.** It is characteristic fruit of Family **Cucurbitaceae. Placental tissue is fleshy, and edible.** Ex: Cucumis, Pumpkin.

5. **Pome:-**Pome is a simple, fleshy flase fruit developing from inferior, syncarpous ovary. **Thalamus is fleshy, Juicy, edible part. It encloses Pericarp and seeds. Ex: Apple, Pear.**

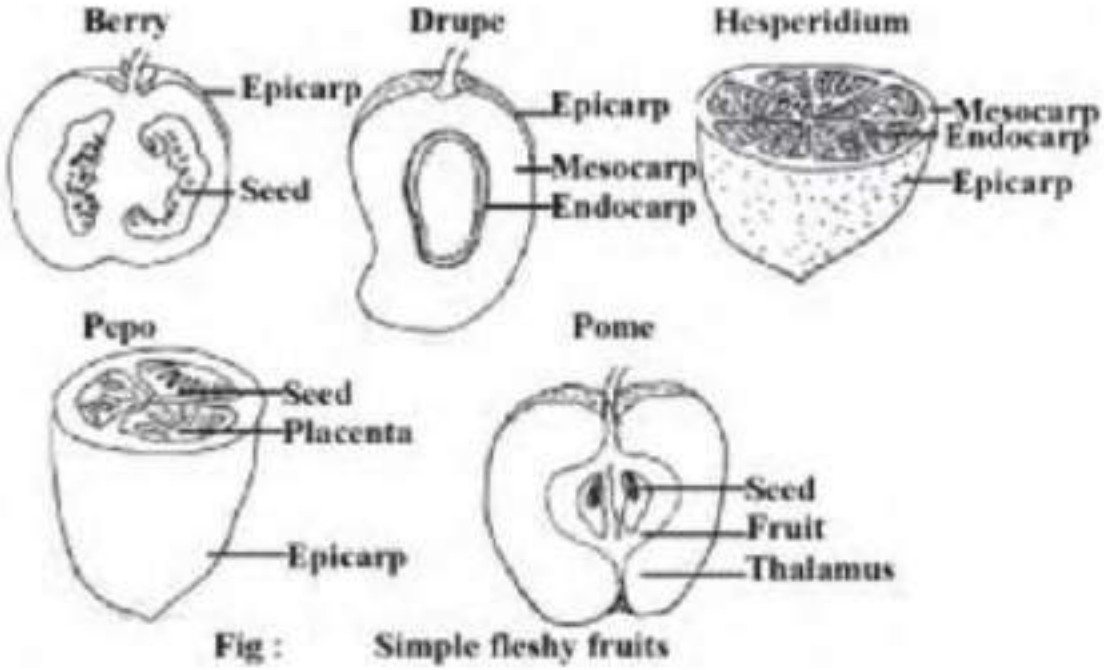


Fig : Simple fleshy fruits

B) Dry fruit

Dry fruits are **Simple fruits in which Pericarp is thin, dry at maturity** without distinction into EPicarp, Mesocarp and Endocarp. Based on the mode of dehiscence of fruit at maturity it is classified into 3 types. They are as follows:-

1. Dry dehiscent fruits: -Pericarp split open to release seeds.
2. Dry Indehiscent fruits: - Pericarp never split open to release seeds.
3. Dry schizocarpic fruits: - Pericarp splits into individual units which **never break open.**

1. Dry dehiscent fruits: - (Pericarp split open to release seeds).

In Simple Dry dehiscent fruits, at maturity Pericarp split open to release seeds. It includes following types:-

a) Legume (Pod):-

Legume is a dry dehiscent fruit that develops from superior, monocarpellory ovary with marginal placenta. It is a characteristic of Family Leguminosae.

At maturity Pericarp dehisce along both the margins to release seeds. Ex; Pea, Bean.

b) Follicle: - Follicle is a simple dry dehiscent fruit developing from superior, monocarpellory ovary. **At maturity pericarp dehisce along only on ventral suture to release seeds.** Ex: Calotropis.

c) Siliqua:-

Siliqua is a dry dehiscent fruit that develops from superior, Bicarpellory, syncarpous ovary with parietal placentation. It is a characteristic fruit of the family Brassicaceae(cruciferae).

At maturity pericarp splits along both the margins from base upwards. Seeds are attached to false septum called "Replum". Ex: Mustard.

d)Capsule:-

Capsule is a Simple, dry dehiscent fruit developing from superior or inferior, multicarpellory , syncarpous ovary with ovules on axile placentation.

At maturity Pericarp may split along the middle of the locule called "Loculicidal capsule". Ex: Cotton, Lady's finger. OR Split along the septa called **"Septicidal capsule**"Ex: Datura.

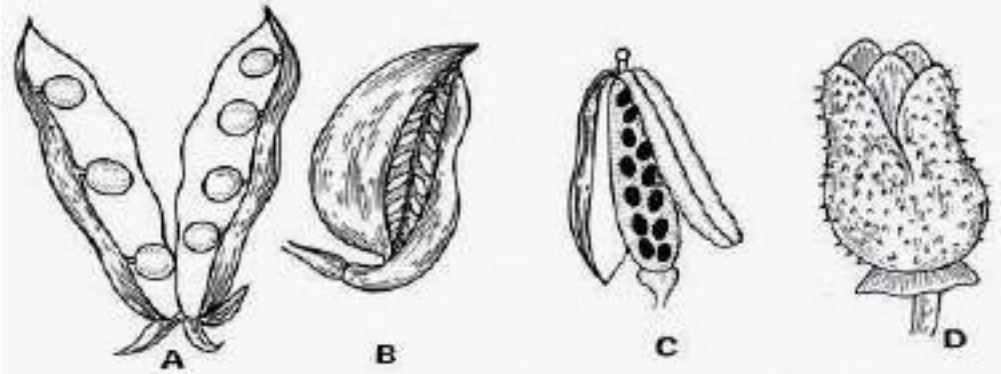


Fig. 34.68. Fruit. A, legume or pod of pea; B, follicle of *Calotropis*; C, siliqua of mustard; D, capsule of *Datura*.

2. Dry Indehiscent fruits (Pericarp never split open to release seeds).

In Simple Dry indehiscent fruits at maturity pericarp never split open to release the seeds. The seeds are released only after the decay of the Pericarp. It includes following types.

a**) Caryopsis:-**

Caryopsis is a Simple Dry indehiscent fruit developing from superior, monocarpelory , unilocular ovary. It is a characteristic fruit of the Family 'Poaceae'.

It is one seeded fruit in which Pericarp is united with the seed coat of seed. At maturity Pericarp never split open to release seed. Ex: paddy, Maize, Whea**t.**

b) Cypsella:-

Cysella is a Simple Dry indehiscent fruit developing from inferior, Bicarpelory , syncarpous, unilocular ovary with basal placenta. It is a characteristic fruit of the Family 'Asteraceae'.

It is one seeded fruit in which Pericarp is free from the seed coat of seed. Ex: Sun flower.

c) Nut:-

Nut is a Simple Dry indehiscent fruit developing from superior, monocarpelory , unilocular or polycarpellory ovary.

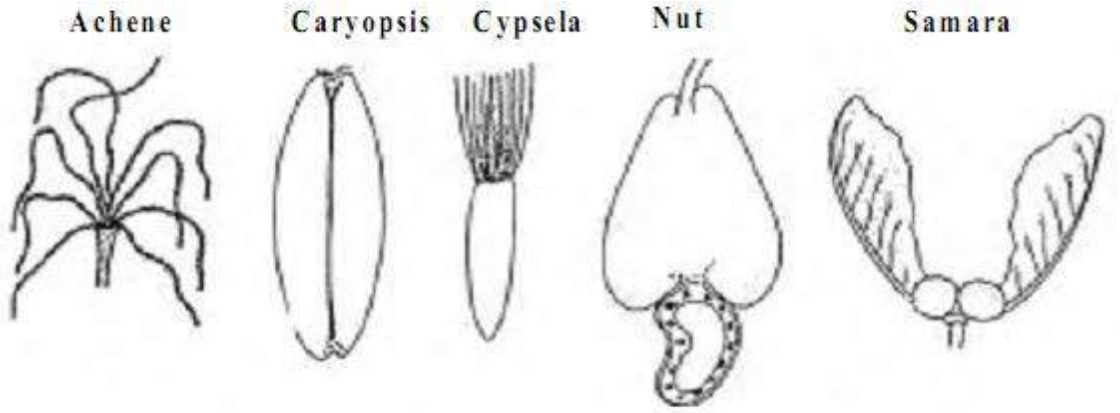
Here Pericarp is stony in nature. Ex: Cashew nut.

d) Samara:-

Samara is a Simple Dry indehiscent fruit developing from superior, Bicarpelory or Tricarpellory ovary. **Pericarp is flattened, wing like structure**. Ex: Hiptage.

e) Utricle:-

Utricle is a **Simple Dry indehiscent fruit developing from superior**, monocarpellary ovary. It is single seeded fruit.Ex: Amaranthus.



3. Dry schizocarpic fruits(Pericarp splits into individual units which never break open).

In Simple dry schizocarpic fruit, at maturity fruit breaks into individual, indehiscent units called 'Mericarps". It includes following types:-

a**) Lomentum:-**

Lomentum is **a simple dry schizocarpic fruit developing from monocarpellory, unilocular, superior ovary with marginal placentation.**

At maturity fruit splits transversly into single seeded units called 'Mericarp'. Ex: Acacia.

b) Cremocarp:-

Cremocarp is a **simple dry schizocarpic fruit developing from inferior, bicarpellory, syncarpous,** inferior ovary. It is the characteristic fruit of family '**Umbelliferae'.**

At maturity fruit splits vertically into 2 mericarps held together by central stalk called 'Carpophore'.Ex: Coriander.

c) Regma:-

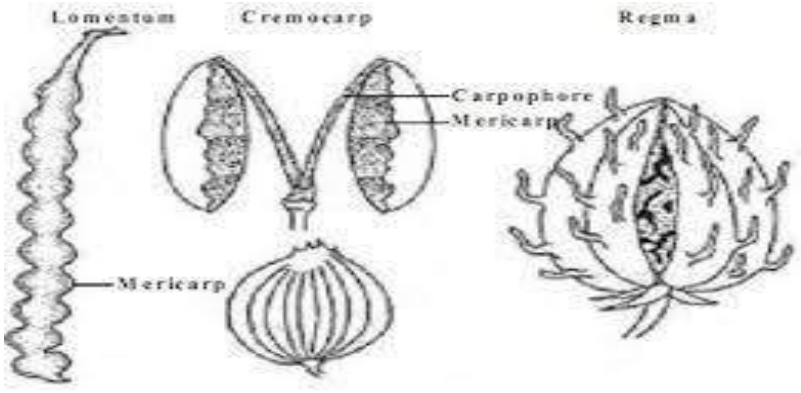
Regma is a simple **dry schizocarpic fruit developing from tricarpellory or multicarpellory, syncarpous, trilocular** or multilocular, superior ovary.

At maturity fruit splits into many units as number of carpels. Each unit is called 'Coccus'.

Ex: Castor, Geranium.

d)Carcerule:-

Carcerule is a simple **dry schizocarpic fruit developing from superior, bicarpellory, syncarpous, tetralocular ovary**. It is the characteristic fruit of family '**Lamiaceae**'.Ex: Leucas.



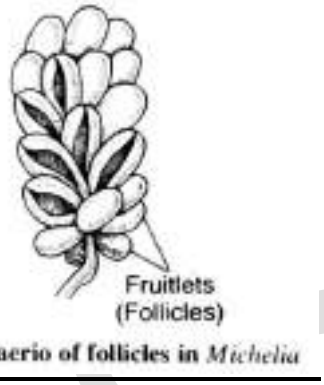
2) Aggregate fruits (Fruit developed from Apocarpus ovary of a single flower).

An aggregate fruit develops from **Multicarpellory, apocarpus ovary of flower**. Each carpel **develops into small fruitlet. Bunch of fruitlets are together called as 'Etaerio '.**
Based on the nature of fruitlets Aggregate fruits are classified into many types as follows:-

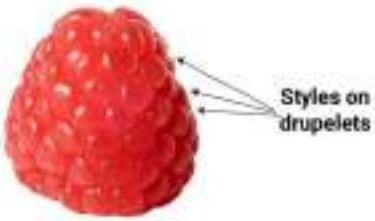
a) Etaerio of Follicle:-
This Fruit develops from **Multicarpellory, apocarpus ovary of flower**. Each carpel develops into **small fruitlet of Follicle** ie, it opens along only ventral suture to release seeds, thus all fruitlets together gives rise to Bunch of Follicle. Ex: Michelia.

b) Etaerio of Drupe:-
This fruit develops from **Multicarpellory, apocarpus ovary of flower**. Each carpel develops into **small fruitlet of drupe.** Ie., endocarp is hard. Thus all fruit lets together gives rise to Bunch of Drupe. Ex: Rasberry.

c) Etaerio of Berry:-
This fruit develops from **Multicarpellory, apocarpus ovary of flower**. Each carpel develops into **small fruitlet of Berry**. ie, Entire pericarp is fleshy, juicy and edible. Thus all fruitlets together give rise to Bunch of Berry. Ex: Custard apple.



Etaerio of follicles in *Michelia*



Aggregate Fruit
Many one-seeded drupelets
produced by a single flower.

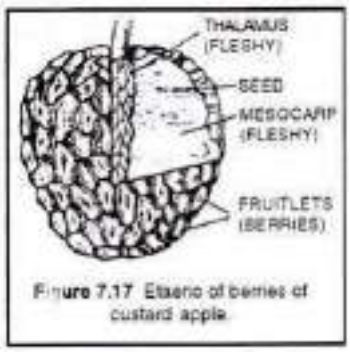


Figure 7.17 Etaerio of berries of custard apple

Ex: Michelia. **Ex: Rasberry.** **Ex: Custard apple.**

3) Multiple fruits (Fruit developed from entire Inflorescence).

Multiple fruit develops **from entire Inflorescence**. It is a False fruit. It includes 2 types. They are: -
a) Sorosis and b) Synconus:-

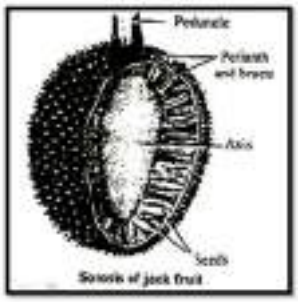
a) Sorosis:-

Sorosis is a Multiple fruit that develops from Spadix or spike or Cat kin inflorescence. Ex: Jack fruit (Artocarpus heterophyllus-Moraceae), Pineapple (Annanus cosmosus - Bromeliaceae) Mulberry(Morus- Moraceae).

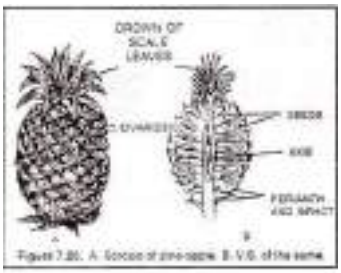
Jack fruit develops from Spadix inflorescence, central axis is peduncle. Fleshy; juicy, yellow and edible part is the perianth of flowers; inside the flake membranous bag containing seed represent pericarp. White, thin, less juicy chaffs are bracts. Spines on the rind are stigmas of the carpels.

Pine apple develops from Spike inflorescence, Fleshy; juicy, edible portion is Peduncle, bract and Perianth. Polygonal marks on the outer surface of the fruit correspond to each flower.

Mulberry develops from Female Cat kin inflorescence. Axis, bract and perianth become fleshy and edible.



Syconia of jack fruit



b) Synconus:-

Synconus is a Multiple fruit that develops from Hypanthodium inflorescence. Fleshy edible portion is the Receptacle.Ex: Figs.

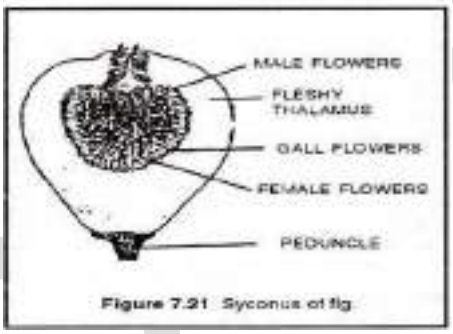


Figure 7.21 Syconus of fig

Unit-5:(8 Hrs.)

Plant Propagation-Methods of Vegetative propagation- Natural- Rhizome, Tuber, Corm, Bulb, Sucker, Stolon and offset, Artificial-Stem Cutting, Grafting and Layering.

Plant Propagation

Multiplication of plants takes place **naturally by Seeds** (Product of sexual reproduction) and by **vegetative organs**. This is referred as **Natural method of Plant propagation. If multiplication of plants takes place by vegetative organs with the involvement of man is referred as "Artificial method of vegetative propagation".**

Advantages of artificial method of vegetative propagation.

Advantages of artificial propagation are as follows:-

1. New plants developed are **exactly identical to the parent plant** without alteration in genotype.
2. Many plants can **be produced from a single plant in a short period**.
3. Growth habit of the **plant can be modified to environment**.
4. Useful characters of **2 different individuals can be made to combine to obtain new variety**.
5. It helps to produce more plants where **seed output is less or plants do not produce seeds.**

I. Natural method of Vegetative propagation.

In plants where they fail to produce fertile seeds, an alternative method for multiplication of plant lets is possible **naturally by various organs of the plant body**. These can be classified into 2 types. They are:

1) **Underground stem Modification**

2) By Sub-aerial stem modification.

1) Underground stem Modification

Stem present with in the soil is variously modified to perform **Vegetative propagation**, **Perennation and food storage**. The **"Underground stems modifications**" for **Vegetative propagation** includes 4 types. They are:

A] Rhizome] Tuber C] Corm D] Bulb

A] Rhizome: -

Rhizome **grows horizontally below the soil surface. It consists of number of Nodes and Internodes. At nodes Scales are present. In the Axil of scale leaf Axillary bud and at the apex of Rhizome Terminal bud is present**. Towards lower sides of the Nodes Adventitious roots are present.

The terminal bud develops into Leafy shoot and axillary bud develops into daughter Rhizome. These on separations from the mother plant, it develops into an independent plant. **Ex: Ginger, Turmeric**

B] Tuber:-

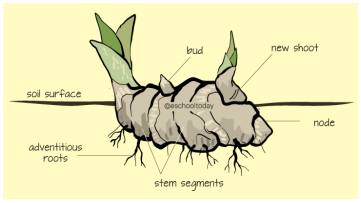
Tuber is a **bulged tip of lowermost branches of stem just below the soil surface**. Tuber contains number **of eyes that represent nodes**. Each Eye consists of reduced scale leaf with axillary bud in its axil.

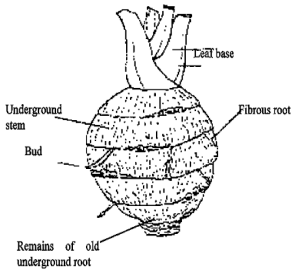
When Eyes of the Tuber separates from the mother Tuber and placed in moist soil, axillary develops into daughter plant. **Ex:Potato**

C] Corm: - Corm is **thick, Fleshy, Spherical shaped, grows vertically below the soil.** It bears Scale leaves. In the axil of Scale leaves axillary buds are present. In its lower surface Adventitious roots are present. Single terminal bud develops into Leafy shoot. Axillary bud develops into daughter corm; this on separation from mother plant develops into independent plant**. Ex: Amorphophallus (Yam)**

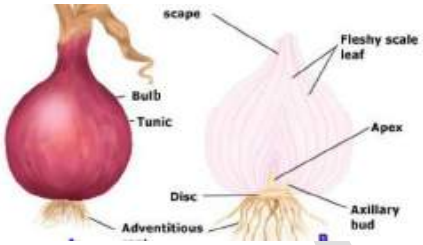
D] Bulb: - In **Bulb Stem is** very much condensed into **Disc like structure**. From its **lower surface number of adventitious roots** develops and from its **upper surface concentrically arranged fleshy scale leaves are present**. In the axil of Scale leaf Axillary bud, at the central region terminal bud is present.

Terminal bud develops into flowering shoot and axillary bud develops into daughter buds. This on separation from mother Bulb develops into in dependent plant. **Ex: Onion.**





Ex: Ginger **Ex: Potato** **Ex: Yam**



II] By Sub-aerial stem modification:-

In some plants stem grows horizontally **just above or just below the soil to perform** vegetative propagation. It includes 4 Types. They are:**Runner, Stolon, Sucker, Offset.**

A] Runner. Ex: Oxalis

In Runner **Stem is long, slender, branch that develops from axils of leaves and creeps on the surface of the soi**l. At each node it develops shoots above and **adventitious roots below**. These when separates from the mother plant develops into an independent plant.

B] Stolon .Ex: Metha (Pudina)

Stolon is an **elongated structure grows upwards, bends down, touch the soil**, and **produce roots below and leaves above.** This on separation from the mother plant develops into an independent plant.

C] Sucker. Ex:Chrysanthimum

In Sucker **Lateral branch develops obliquely below the soil from underground stem**. When it comes above the surface of the soil, develops into shoot.When it separates from the mother plant, it develops into an independent plant.

D] Offset. Ex: Pistia, Eichhornia .

Offsets are a **short, stout, prostrate branch that grows in all directions from mother plant in Hydophytes.**This on separation from mother plant develops into independent plant

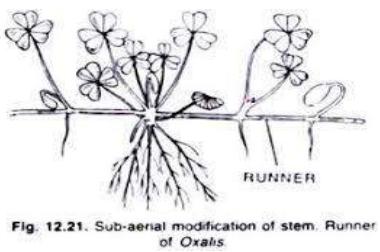
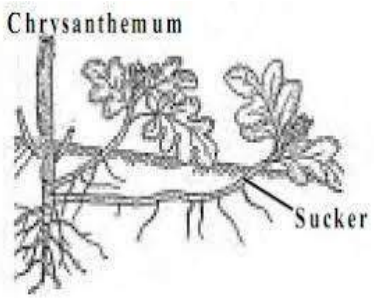
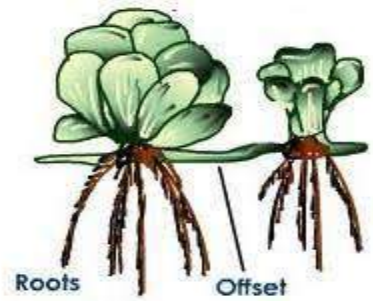


Fig. 12.21. Sub-aerial modification of stem. Runner of *Oxalis*

Ex: Oxalis Ex: **: Metha (Pudina)**





Ex: Chrysanthimum **Ex: Pistia**

II. Artificial method of vegetative propagation

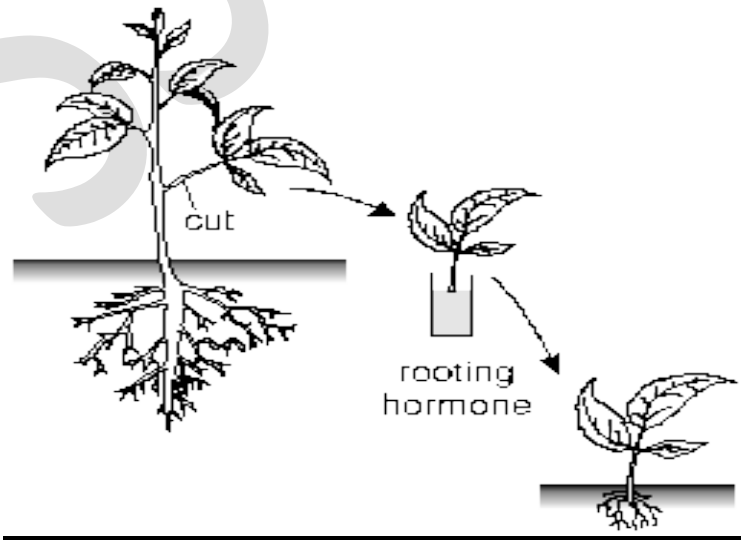
Multiplication of plants by vegetative organs with the involvement of man is referred as "Artificial method of vegetative propagation".

This method is practiced to propagate valuable ornamental and Horticultural plants for Commercial purpose. It is of 3 types. They are **Cutting, Layering and Grafting.**

1. Cutting

Multiplication of plants by vegetative organs with the involvement of man is referred as "Artificial method of vegetative propagation".

cutting is a method of **artificial method of vegetative propagation**. In this method **healthy branch of a plant is selected, cut into several pieces of 8 to 10 inches length**. They are **placed into fertile moist soil.** From the portion of cutting below the soil surface **roots develops** and portion above the soil surface buds develops that grow into leafy shoot. Thus each stem cutting develops into an independent plant. Ex: Hibiscus, Rose, Sugar cane, Grapes.



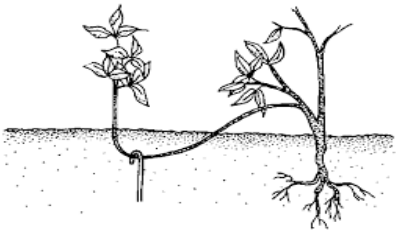
1. LAYERING: -

It is a method **of artificial method of vegetative propagation**. **The development of roots from a branch when it is intact with the stem is called as "Layering"**. The branch which develops roots is called "Layer". The process of Layering involves following steps:-

- **Select healthy branch** of desired plant.
- **Remove a ring of bark** about 1 to 2 inches.
- **Push this portion into moist soil** keeping terminal portion of the branch free.
- **Roots develop** from the bark removed portion **after 30 days**.
- **Cut off this from the main plant** and it can be grown as an **independent plant.**

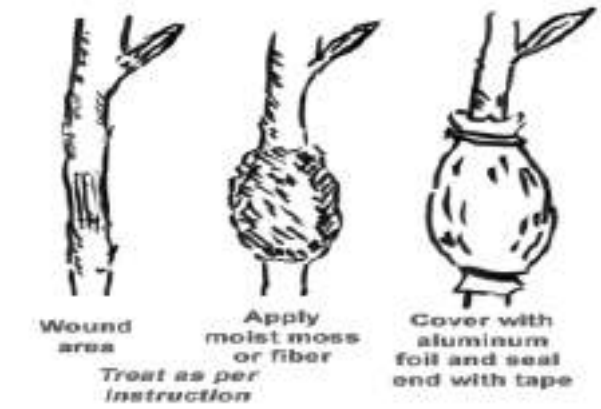
TYPES OF LAYERING: - Layering includes following types:-

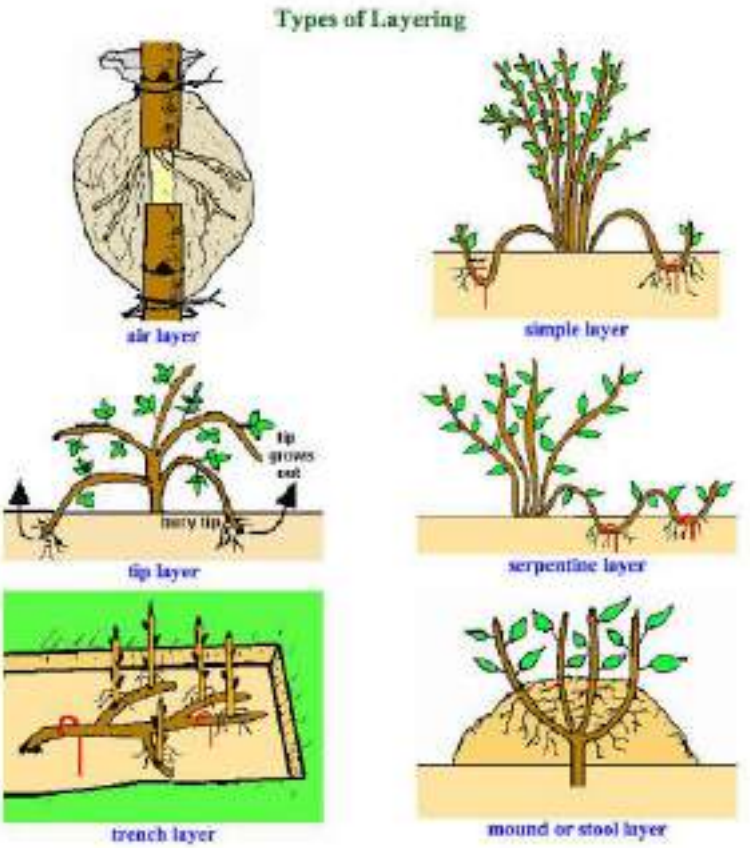
A) Simple layering:- In this method any **healthy branch of a plant is selected**, 1 to 2 inches bark is removed, **pushed into the moist soil**, weight is placed to keep branch in position. **After 30 days roots develops in the layered portion**. This is separated from mother plant and grown as an independent plant.



B) Compound layering: - in this method **long, flexible branch is selected**, **ring of bark is removed at several points**, covered with the soil and watered regularly. After several days' roots develops layered portion below and shoots in exposed region. Then branch is cut into pieces and grown into independent plants.

C) Air layering (Gootee):- It is an **ancient method of Layering** practiced in **woody fruit plants**. In this method woody branch of desired plant is selected, **ring of bark of 2 to 5 cms is removed** , this portion is sprayed with growth promoting hormones, **thick plaster of grafting clay is applied , wrapped with soil and tied using ploythene cover** and regularly wetted. **After 30 days roots develops** in layered portion. Then **separate it from mother plant** by cutting it below the bandage and grown as **an independent plant**.





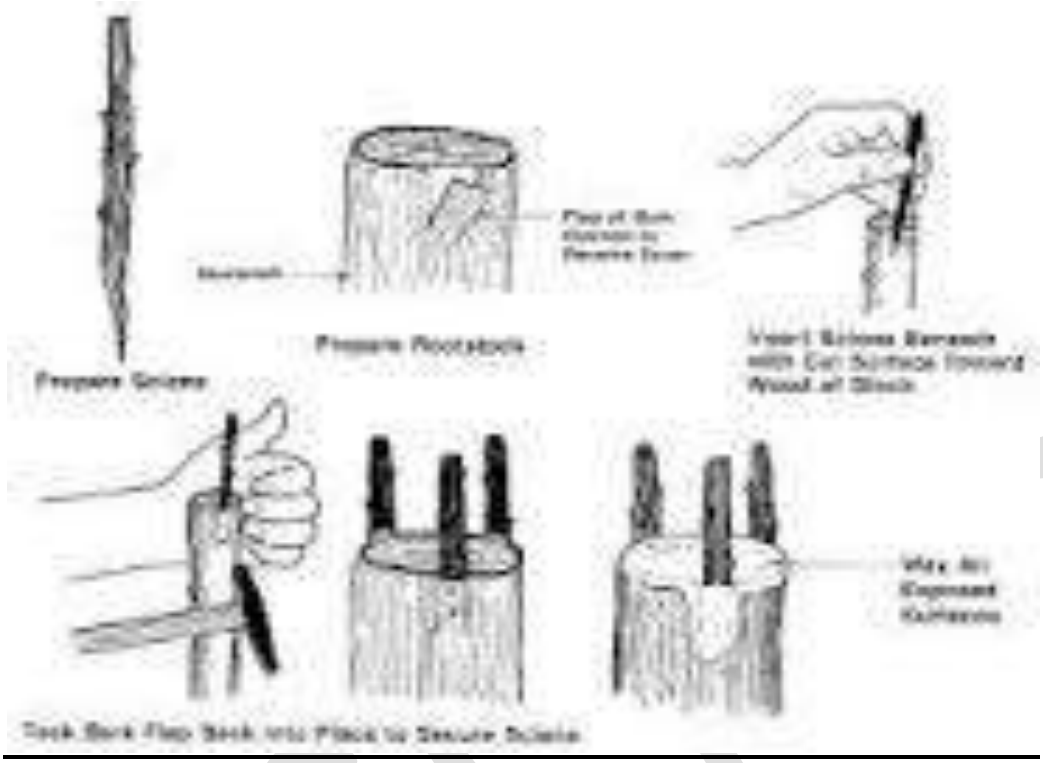
3.<u>GRAFTING-</u>

It is a method of artificial method of vegetative propagation. In this method 2 different plants named as **Stock and Scion** are made to unite covered with grafting clay and grown as a single plant.

The branch selected as **Scion is allowed to grow on the branch of rooted plant which serves as Stock.** It is physically strong, supplies water and nutrition for scion.

TYPES OF GRAFTING:-

Grafting include following types:-



A) **Splice grafting:**
In this **type slanting cut is made in Stock and Scion. Scion is inserted on stock, coated with grafting clay**, allowed to grow for 30 days, it develops roots. Scion portion is separated from mother plant and grown as an independent plant.

B) **Wedge grafting: -**
In this method **'V' shaped cut is made in Stock** and '**wedge shape'** in Scion. **Fit these two, cover with grafting clay** and allow it to grow for 30 days.

C) **Whip grafting: -**
This method is practiced **when stock and scion are of the same size**. **Inclined cut is made in both Scion and Stock**. **Scion is inserted into stock in such a way that cambial regions of both should come into contact.** Exposed part is coated with grafting clay and allowed to grow.

D) **Inarching:-**
In this method a **ring of bark about 2 to 3 inches long is removed in both Stock and Scion.** They are **tied together at the sliced portion, coated with grafting clay**, allowed to grow for 30 days. Later separate from mother plants and grow it independently.

E) <u>Approach grafting:</u>

1. The approach grafting is used if **the base of the root stock plant is thicker than that of the scion plant.**

2. A narrow cut **of 7 to 10 cm long is made in the bark of the rootstock plant** by making two **parallel cuts and removing the strip of bark between**, the cut should be exactly as wide as the scion to be inserted.

3. The stem of the **scion plant should be cut long shallow along one side,** of the same length as the cut in the rootstock plant and deep enough to go through the bark into the wood.

4.This **cut surface of the scion branch should be laid into the slot cut in the rootstock** plant and held thoroughly and covered with grafting wax.

5. After the union has healed, **the rootstock can be cut off above the graft and the scion below the graft.**