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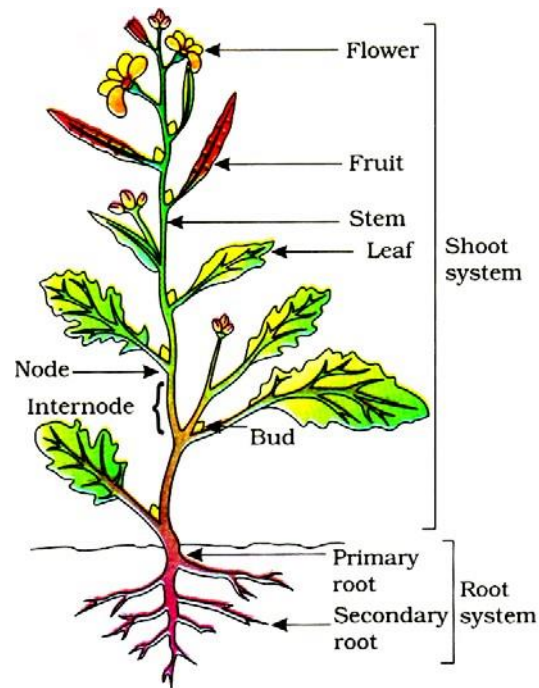
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**IIIBSCBTEM -18UBT7- MORPHOLOGY AND TAXONOMY OF ANGIOSPERMS- UNIT I & II-  
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# **PLANT MORPHOLOGY**

# PLANT MORPHOLOGY

## ✓ INTRODUCTION ::



Parts of a flowering plant

**Morphology** – (Morphe = form + logos = study). It deals with the **study of forms and features** of different plant organs like roots, stems, leaves, flowers, seeds, fruits etc.

The body of a typical angiospermic plant is differentiated into :

- ✧ an underground root system
- ✧ an aerial shoot system.

The shoot system consists of stem (including branches), leaves, flowers and fruits.

The roots, stems and leaves are **vegetative parts**, while flowers constitute the **reproductive part**.

## ✓ CLASSIFICATION OF PLANTS ::

Depending upon their life span, plants are classified as –

**Annuals** – Complete their life cycle in **one year** or **single growing season** or few weeks to a few months. They pass the unfavourable period in the form of **seeds** eg. Mustard, Pea.

**Biennials** – Complete their life cycle in two years-**growing, vegetative** and storing food **in the first year, flowering and fruiting in the second year**. They die off after producing flowers and fruits eg. Radish, turnip, carrot are **biennial** in **colder** areas. They become **annual** in **warmer** places.

**Perennials** – **Survives for several years**. These plants usually bears flowers and fruits every year and do not die after producing flowers. eg. Mango, Banana, Guava

# ROOT

Radicle comes out/arise from the seed coat in the form of soft structure and move toward the soil. It develops and forms primary root.

## General Characters :

Roots are **non green, underground**, (+) geotropic, (-) phototropic and (+) hydrotropic.

Roots do not bear buds.

Buds present for vegetative propagation in sweet potato (*Ipomea*) and Indian red wood (*Dalbergia*)

Roots do not bear **nodes** and **internodes**.

Roots have **unicellular** root hairs.

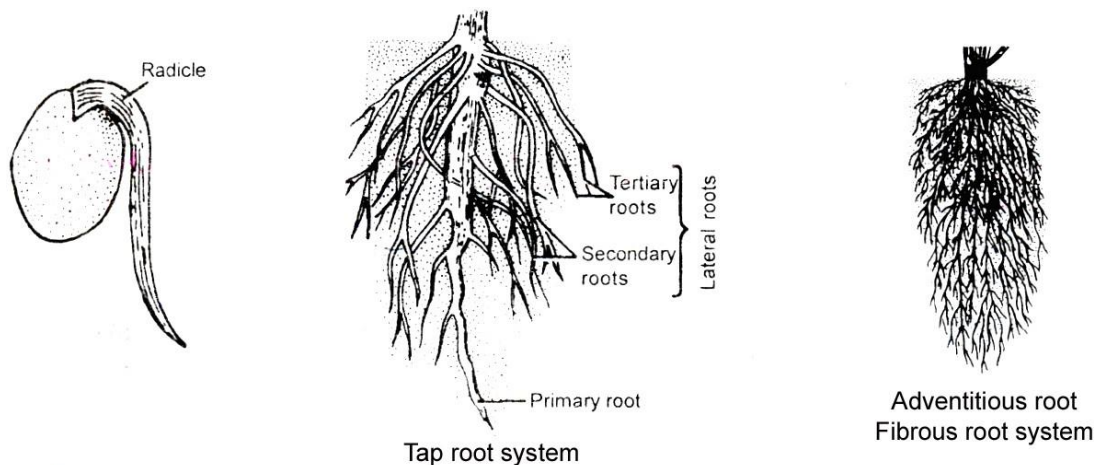
## ✓ TYPES OF ROOTS ::

Roots are of two types :

✧ Tap root      ✧ Adventitious root

**Tap root :** It develops from radicle and made up of one main branch and other sub branches. The primary roots and its branches constitute tap root system. e.g. Dicot roots.

**Adventitious roots :** In some plants, after sometime of the growth of tap root which arises from radicle, stops and then roots, develop from other part of plant, which are branched or unbranched, fibrous or storage, are known as adventitious roots and constitute fibrous root system. e.g. Monocot roots.



## ✓ REGIONS OF ROOTS ::

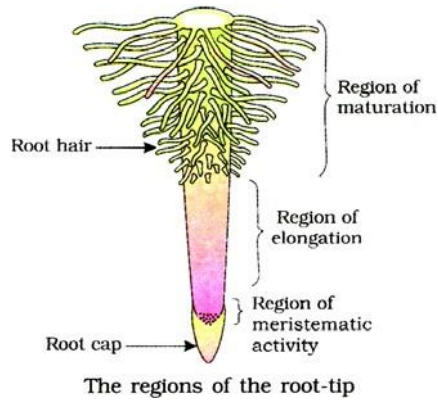
Morphologically four distinct regions are present in roots.

**Root cap :** It is terminal structure. It protects tender apex of root.

**Meristematic zone :** Cells of this regions are very small and thin walled. They divide repeatedly and increase cell number

**Elongation region :** The cells proximal to meristematic zone undergo rapid elongation and enlargement and are responsible for rapid growth of roots.

**Maturation region :** Cells proximal to region of elongation gradually differentiate and mature. Root hairs are present in maturation zone.



## ✓ MODIFICATION OF ROOTS ::

### 1. Modified tap root for storage :

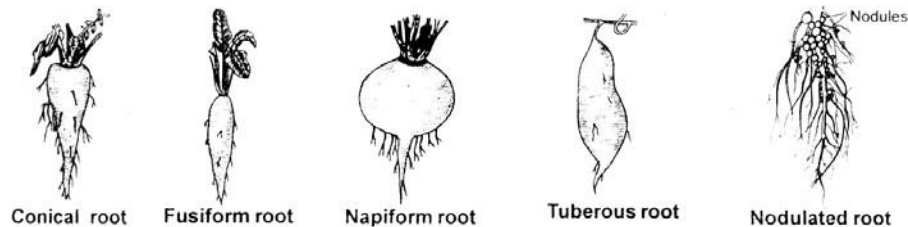
**Fusiform roots :** These roots are thicker in the middle and tapered on both ends. In this type of roots both hypocotyl and root help in storage of food. **eg. Radish.**

**Conical roots :** These roots are thicker at their upper side and tapering at basal end. **eg. Carrot.**

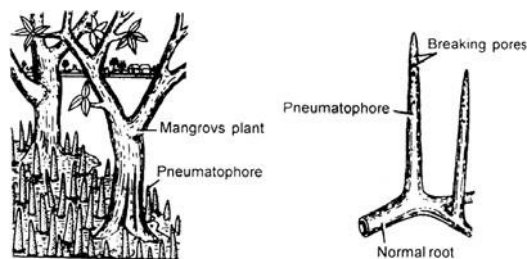
**Napiform :** These roots become swollen and spherical at upper end and tapered like a thread at their lower end. **eg. Turnip (*Brassica rapa*), Sugarbeet**

**Tuberous root :** Such roots do not have regular shape and get swollen & fleshy at any portion of roots. **eg. Mirabilis.**

### 2. Nodulated root : Nodules are formed on branches of roots by nitrogen fixing bacteria, (*Rhizobium*). eg. Plants of leguminosae family (Papilionatae) – **Pea.**



### 3. Respiratory roots : Halophyte or mangrove grow in oxygen deficient marshy area. Some branches of tap root in these plant grow vertically & comes out from soil. These roots are called pneumatophores through which air entered inside the plant. **eg. Rhizophora, Heritiera, Sonaritia and other mangrove plant.**



Respiratory roots (Pneumatophores) of *Rhizophora*

**Modification of adventitious roots :**

**1. Storage adventitious roots**

- ❖ **Tuberous root** : When food is stored in these roots, they become swollen and form a bunch. eg. **Sweet potato (*Ipomea batata*)**
- ❖ **Fasciculated** – Roots arise in **bunch** (cluster) from lower node of the stem and become fleshy eg. ***Dahlia, Asparagus.***
- ❖ **Nodulose** : In this type, tips of roots swell up. **eg. *Melilotus, Curcuma amoda.***
- ❖ **Beaded or moniliform** : When root swells up like a bead at different places after a regular interval. **eg. *Vitis, Momordica (Bitter gourd), Portulaca.***
- ❖ **Annulated** : Roots having series of ring like swellings **eg. *Psychrotia***



**Tuberous**



**Fasciculated roots**



**Moniliform**

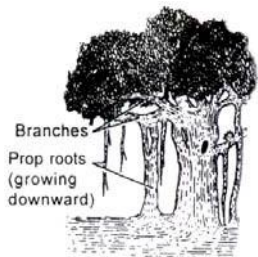


**Nodulose**

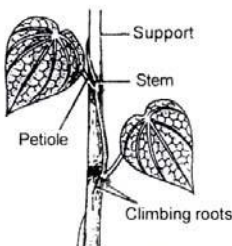


**Annulated roots**

2. **Stilt roots or brace roots** : When root arises from lower nodes and enter in soil obliquely, known as stilt roots **eg. *Maize, Sugarcane, Pandanus (screw pine)***
3. **Prop root or pillar roots** : when root arises from branches of plant and grows downward towards soil. It function as supporting stem for the plant. **eg. *Banyan.***
4. **Butteress root** – Such roots appear from the basal part of stem and spread in different directions in the soil. **eg. *Ficus, Bombax, Terminalia.*** It is a characteristic feature of tropical rain forest.
5. **Climbing roots** – These roots arise from nodes and helps the plant in climbing. **eg. *Money plant (Pothos), Betel, Black pepper, Techoma.***
6. **Foliar roots or Epiphyllous roots** – When roots arise from leaf they are called as foliar roots. **eg. *Bryophyllum, Bignonia.***
7. **Sucking or haustorial roots or Parasitic roots** : In parasitic plant roots enter in the stem of host plant to absorbed nutrition from host. **eg. *Dendrophthoe, Cuscuta, Viscum.***



**Prop root**



**Climbing root**



**Foliar root**

8. **Assimilatory roots** : The aerial roots of *Tinospora* and submerged roots of *Trapa* (Water chestnut) become green and synthesize food. *Podostemon* also has green assimilatory roots.
9. **Hygroscopic roots** : These are found in epiphytes, specially in orchids and help in absorption of moisture from the atmosphere using special tissue called **velamen**. eg. *Orchids, Banda*
10. **Contractile roots** : They shrink 60 – 70% of the original length and bring underground organ at proper depth in the soil e.g., corm of *Crocus* (saffron), *Fresia*.
11. **Root thorns** : These are hard, thick and pointed thorns e.g. *Pothos armatus*.

**Reproductive roots** : These are fleshy, adventitious roots used for vegetative reproduction e.g., sweet potato (*Ipomea batata*), Dahlia.

**Leaf roots** : In *Salvinia*, one leaf of each node modifies into root like structure for balancing the plant in water.

### ✓ FUNCTIONS OF ROOT ::

Fixation (Primary function)

Absorption of water and minerals

Storage of food

Conduction of water

Photosynthesis and respiration

## STEM

Stem is a part of plant which lies above from surface of soil i.e. it shows negative geotropic growth. It has nodes and internodes. Branches, leaf, flower bud and bracts are developed from nodes. Stem arises from plumule.

### ✓ FORMS OF STEM ::

**Caudex** : It is unbranched, erect, cylindrical stout stem and marked with scars of fallen leaves. Crown of leaves are present at the top of plant. eg.: Palm

**Culm** : Stem is jointed with solid nodes & hollow internodes. eg. Bamboo (Graminae)

**Excurrent** : The branches arise from the main stem in acropetal succession and the tree assumes a cone like appearance e.g. *Pinus, Eucalyptus, Casuarina*, etc.

**Decurrent (Deliquescent)** : The lateral branches grow more vigorously and outcompetes the main trunk, giving a dome-shaped appearance, e.g., mango (*Mangifera indica*), shishem (*Dalbergia sissoo*) and banyan (*Ficus bengalensis*).

**Aerial stems (Epiterranean stem) :**

It may be reduced, erect and weak.

**Reduced** – Stem reduced to a disc. eg., Radish, Carrot, Turnip.

**Erect stem** - It is strong and upright e.g., maize, wheat, mango.

**Weak stems** – These are thin, soft and weak and need support. They can be upright or prostrate.

✧ **Creepers** – The stem creeps on earth and the roots arise at the nodes, e.g., Grasses, Strawberry, Oxalis.

✧ **Traliers** – The stem creeps on the ground, but the roots do not arise at the nodes. They may be of two types :

◆ **Prostrate or procumbent** – The stem creeps on ground totally, e.g., *Evolvulus*, *Tribulus*.

◆ **Decumbent** – When prostrate stem projects its tip, e.g., *Portulaca*, *Linderbergia*.

✧ **Lianas (Stem climber)**. Woody perennial climbers found in tropical rain forests are lianas. They twin themselves around tall trees to secure sunlight, e.g., *Hiptage*, *Bauhinia vahlii* (Phanera).

✧ **Climbers** – Plants are with long weak stem and have organs of attachment to climb the object. They may be of following type .

◆ **Rootlet climbers** – Roots produced at nodes help in climbing e.g., *Tecoma*, *Pothos*, *Piper betal* (pan).

◆ **Hook climbers** – In *Bougainvillea*, *Duranta* and *Carrisa*, the thron is modification of axillary vegetative bud which helps in climbing. In *Bignonia*, terminal leaflet is converted into hook.

◆ **Tendrils climbers** – Tendrils are thread like structure which help the plants in climbing. Tendrils are modifications of :

- Entire leaf e.g. *Lathyrus sativus*.
- Leaflet e.g. *Pisum sativum*
- Petiole e.g. *Clematis*, *Nepenthes*.
- Stipule e.g. *Smilex*.
- Leaf apex e.g. *Gloriosa*
- Inflorescence e.g. *Antigonon*.
- Stem e.g., *Vitis* (grapevines), gourds, *Passiflora* (modified axillary bud).

✧ **Twiners** – The stem body twines around the support without any special organ of attachment. e.g., *Cuscuta*, *Dolichos*.

**Sub-aerial modification :**

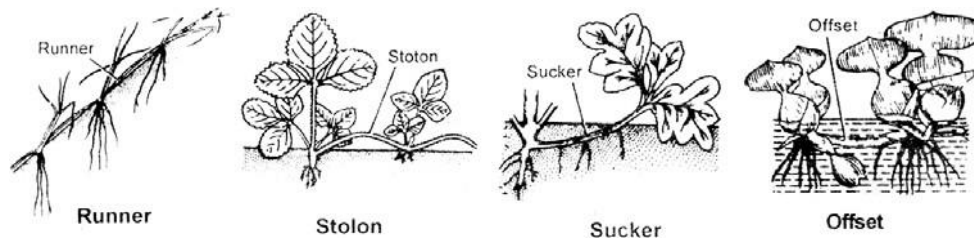
**Runner** – When stem grows and spread on the surface of soil. Roots are developed at lower side and leaves from upper side from node eg. *Cynodon dactylon* (**Doob grass**), *Oxalis*.

**Stolon** – In it branches are small and stem condensed and grow in all direction. After sometime, of growing, their apical region comes out from the soil. eg. *Fragaria* (**Wild strawberry**), **Jasmine Peppermint**.

**Sucker** – In it the main stem grow in the soil horizontally and branches develop obliquely from nodes above the soil, eg. **Mint, Pineapple, Chrysanthemum.**

**Offset** – A lateral branch with short internode and each node bearing a rosette of leaves and tuft of roots at base. eg. **Pistia, Eichhornea.**

These modification are also involved in vegetative reproduction.



**Underground modification :**

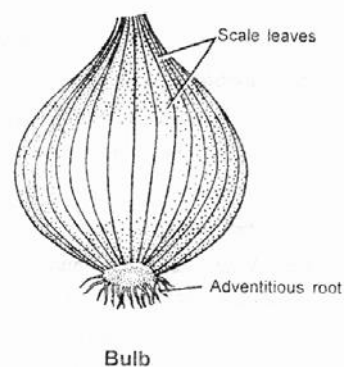
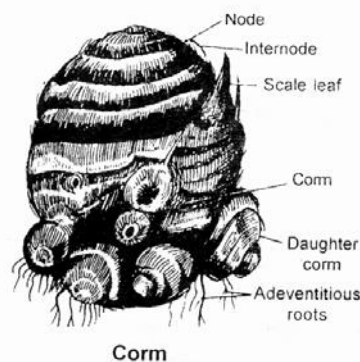
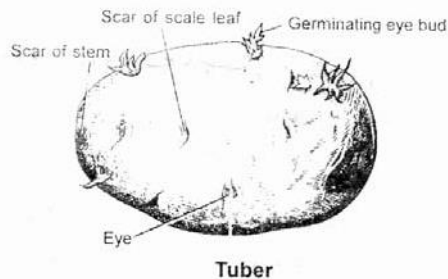
This type of modification occurs generally for food storage and vegetative propagation.

**Tuber** – The tips of underground branches become swollen in the soil. Eyes are found on them which are axillary buds and covered with scaly leaves. eg. **Potato, Helianthus tuberosus**

**Rhizome** – It is fleshy and horizontally stem found below in soil. Small nodes and internodes are found which are covered by scaly leaves. eg. **Ginger, Turmeric, Canna, Water lily, Banana.**

**Corm** – It is condensed structure which grow vertically under the soil surface. They are having spherical node and inter node eg. **Colocasia, Alocasia, Zaminkand, Saffron, Gladiolus, Colchicum**

**Bulb** – This stem is reduced and has disc like structure and surrounds with numerous fleshy scaly leaves. Many roots arise from its base. Food is stored in fleshy leaves. They show apical growth eg. Onion, Garlic.



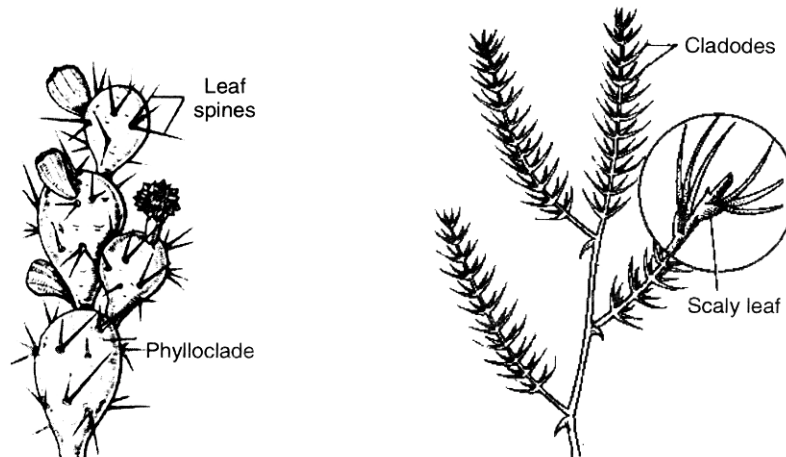


## Special stem modification :

**Phylloclade** – It is green photosynthetic flattened or rounded succulent stem with leaves either feebly developed or modified into spines e.g., *Opuntia*, *Casuarina*, *Euphorbia*, *Cactus*.

**Thorn** – It is modification of axillary bud, e.g., *Bougainvillea*, *Duranta*, *Carissa*. Thorns of *Alhagi* possess flowers, while thorns of *Duranta* bears leaves.

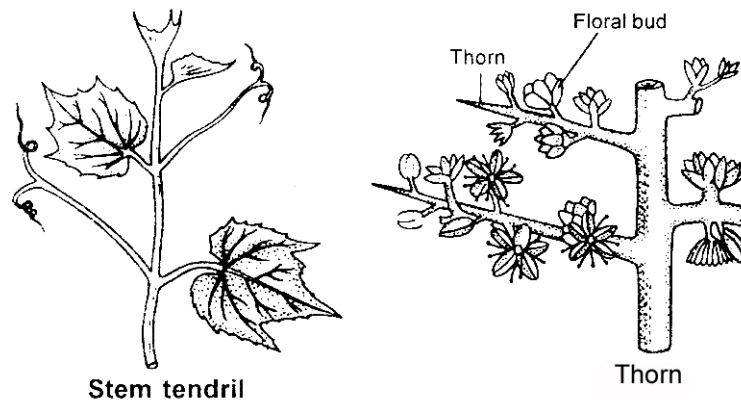
**Cladode** – Phylloclade usually having one or two internode long & succulent is called cladode, e.g., *Asparagus*, *Ruscus*.



**Phylloclade of *Opuntia***

**Cladode of *Asparagus***

**Stem tendrill** – it is a leafless, spirally coiled structure found in climbers. It may be a modification of Axillary bud, e.g. *Passiflora* or terminal bud e.g., *Vitis*.



**Stem tendril**

**Thorn**

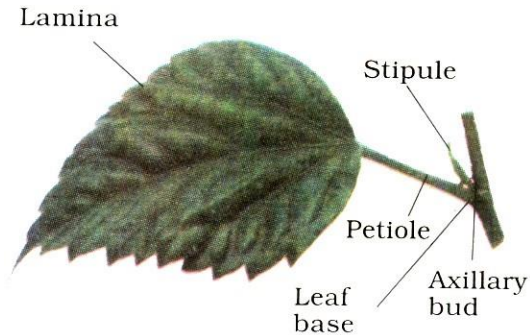
**Bulbils** – A condensed , axillary fleshy bud is called *bulbils*. It helps in vegetative reproduction. eg., *Dioscorea*, *Globba*, *Agave*, *Oxalis*.

## ✓ FUNCTIONS OF STEM ::

The main function of the stem is spreading out branches bearing leaves, flowers and fruits. It conducts water, minerals and photosynthates. Some stems perform the function of storage of food, support, Protection and of vegetative propagation.

## LEAF (PHYLLOPODIUM)

The leaf is a lateral generally flattened structure borne on the stem. The leaves develop from the nodes. Their main function is photosynthesis and food making, axillary buds are found in its axil. All the leaves of a plant is known as phyllome. Axillary bud later develops into a branch. Leaves originated from shoot apical meristem and are arranged in acropetal order.



**Leaf is divided into 3 main parts :**

**Leaf base (Hypopodium) –**

- ✧ Leaves are attached to stem by leaf base.
- ✧ In some plants, leaf base becomes swollen and is called **pulvinus** which is responsible for sleep movement e.g., Cassia, mimosa, bean.
- ✧ In some plants, leaf base expands into **sheath (Sheathing leaf base)**, e.g., grasses and banana (monocots).
- ✧ When the leaf base partially encloses the stem, it is called **semi amplexicaul** e.g., Prickly poppy, *Calotropis procera* (Madar).
- ✧ It completely encloses the stem, it is called **amplexicaul** e.g., *Sonchus*, *Polygonum*.

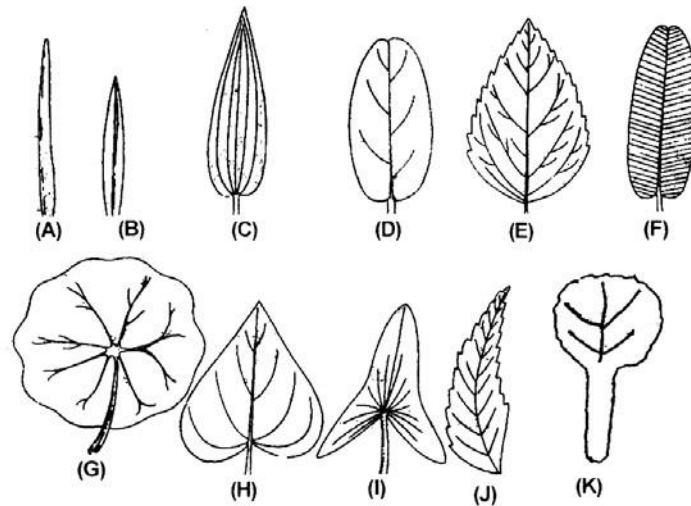
**Petiole (Mesopodium) –**

- ✧ The part of leaf connecting the lamina with the branch of stem. Petiole help to hold the blade to light.
- ✧ In *Eichhornia* petiole swell and in citrus it is winged.
- ✧ Petiole is modified in tendrils in *Nepenthes*.
- ✧ In Australian acacia petiole is modified in phyllode.
- ✧ Long thin flexible petiole allow leaf blade to flutter in air, thereby cooling the leaf and bringing fresh air to leaf.

**Lamina (Epipodium) –** It is a broad and flattened part of leaf. Its main functions are photosynthesis and transpiration. Shape of lamina are :

- ✧ **Acicular** – Lamina is long and pointed, like a needle. eg. *Pinus*
- ✧ **Lanceolate** – In this type lamina is pointed or narrower at the ends while broader in the middle. eg. **Bamboo, Nerium**
- ✧ **Linear** – The lamina is long and narrow having parallel margins. eg. **Grass**
- ✧ **Ovate** – In this type lamina is egg-shaped having broad base with slight narrow top. eg. *Ocimum*, Banyan, **China rose**.
- ✧ **Cordate** – Its shape is like a heart. eg. Betel.

- ✧ **Oblong** – Long and broad lamina. eg. Banana
- ✧ **Sagittate** – The lamina is triangular in shape. eg. *Sagittaria*
- ✧ **Spathulate** – The lamina is broad spoon shaped. eg. *Calendula*
- ✧ **Orbicular or Rotund** – In this types the lamina is spherical. eg. **Lotus**.
- ✧ **Elliptical or Oval** – In this type the middle part of lamina is broad while the ends are narrow and oval. eg. **Guava**.
- ✧ **Oblique** – In this types midrib divides, lamina into two unequal halves. eg. *Bignonia*, **Neem**.



**Shapes of lamina :**  
 (A) Acicular, (B) Linear, (C) Lanceolate,  
 (D) Elliptical, (E) Ovate, (F) Oblong, (G) Rotund,  
 (H) Cordate, (I) Sagittate, (J) Oblique (K) Spathulate

### Stipules :

Leaves of some plants have lateral appendages on either side of leaf base, known as stipules. If stipules are present in leaf it is called stipulated leaf, if it is absent then leaf is called exstipulated.

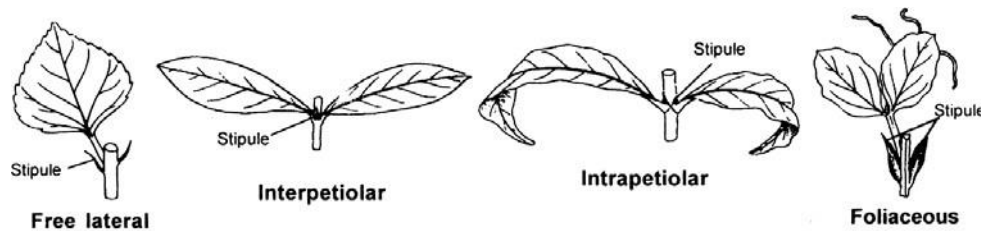
### Stipules are of various types –

**Free lateral** – They are independently present on both sides of leaf base. eg. *Hibiscus rosasinensis* (China rose)

**Interpetiolar** – When two leaves are meet oppositely at the node then nearest stipules of each leaf join with each other. In this way only two stipules of two leaves are found in place of four. eg. *Ixora*, *Anthocephalus*.

**Intrapetiolar** – In this type both stipules of a single leaf join with each other to form a single stipule. eg. *Gardenia*

**Foliaceous** – These type of stipules form a leaf like structure. eg. **Pea**





**Scaly** – Stipules are dry, small and paper like. eg. *Desmodium*

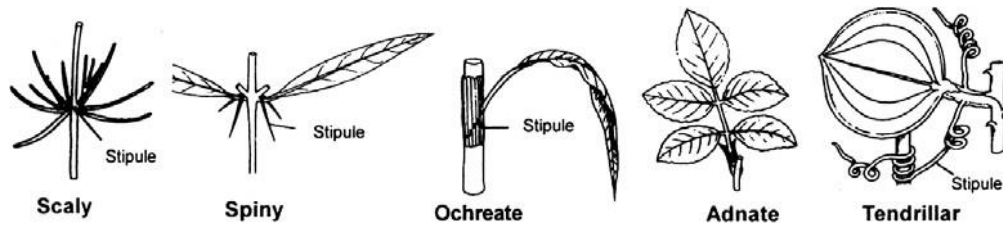
**Spiny** – Stipules modified into spine. eg. *Zizyphus* (Beri), *Acacia*.

**Ochreate** – When both stipules of leaf combine together and form a tube like structure, It is called ochreate. eg. **Polygonum**

**Adnate** – Both stipules are attached with petiole. eg. **Rose**

**Tendrillar** – Stipules are modified into tendrils like structure. eg. *Smilax*

**Bud scale** – Protect the young Bud. e.g. **Ficus**

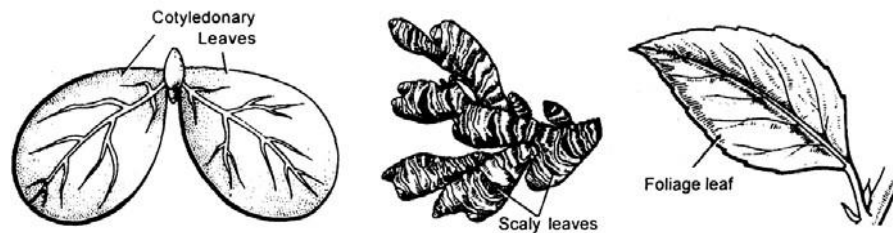


✓ **TYPES OF LEAVES ::**

**Foliage leaf** – They are usually green coloured and their main function is photosynthesis.

**Cotyledonary leaf** – This leaf comes out during germination and helps in nutrition until the first leaf is not formed.

**Scaly leaf (Cataphylls)** – Such leaves are usually dry membrane like and they can not perform photosynthesis

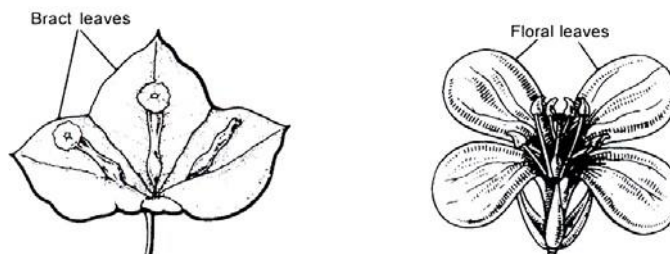


**Bract (Hypsophyll)** – Bract are the leaves which is present in flower axis.

**Bracteole** – These are leaf like structure found on pedicel.

**Floral leaf** – Sepals, petals, stamen and carpel are found in flower which are included in this type of leaf.

**Perianth** – In some flowers, Calyx and Corolla are not distinct and are termed as Perianth and unit of perianth is called tepal. eg. *Lily*



### Duration of leaf :

**Persistent / Evergreen** – Leaves of such plants are found in all season and do not (fall) shed combindly. eg. *Pinus, Saraca indica, Datepalm.*

**Deciduous** – All leaves of such plants shed at the same time eg. *Azadirachta.*

**Caducous** – Leaves fall soon just after appearance or after opening of bud. eg. **Rose**

### Leaf insertion :

**Cauline leaves** – When the leaves are found on node of stem, then these are called cauline leaves. eg. **Maize, Hollyhock.**

**Ramal leaves** – When leaves are found on branches, then these are called ramal leaves. eg. *Delbergia, Zizypus.*

**Radical leaves** – During favourable season, leaves develop from the nodes of under ground stem and seem that they are developing from roots. This type of leaves are known as radical leaves. eg. **Radish, Turnip.**

## ✓ VENATION OF LAMINA

The arrangement of veins and veinlets in leaves (Lamina) is known as venation. It is of 2 types

**Reticulate** : It is found in dicots. Exception – *Calophyllum, Eryngium.* It has parallel venation.

**Parallel** : It is found in monocots. Exception – *Smilax, Dioscorea, Alocasia, Colocasia.* It has reticulate venation.

### Reticulate venation :

In it main vein divided into various branches (veinlets) and form a net like structure. Reticulate venation is of 2-types.

**Unicostate or pinnate** – In this type of venation leaf have only one principal vein or midrib that give off many lateral veins which proceed toward margin and apex of lamina of the leaf and form a network. eg. **Mango, guava, Peepal,**

**Multicostate or palmate** – In this type of venation many principal veins arising from the tip of petiole and proceed towards tip of lamina. This is again two types –

✧ **Multicostate divergent** – Many principal veins arising from the tip of petiole, diverge from the another toward the margin of leaf blade eg. Cotton, Caster, Cucurbita, grape.

✧ **Multicostate convergent** – Many principal veins arising from the tip of petiole. At the base of leaf they are closely arranged but diverge from one another in middle part and converge towards the apex of leaf. eg. Camphor, *Zizyphus*, Tejpat, Chinarose, plum.



Reticulate unicostate  
(Pinnate)



Multicostate (Palmate)  
Divergent



Multicostate (Palmate)  
Convergent

## Parallel venation :

In this type of venation, all veins run parallel to each other and they do not form a network. They are of 2 types.

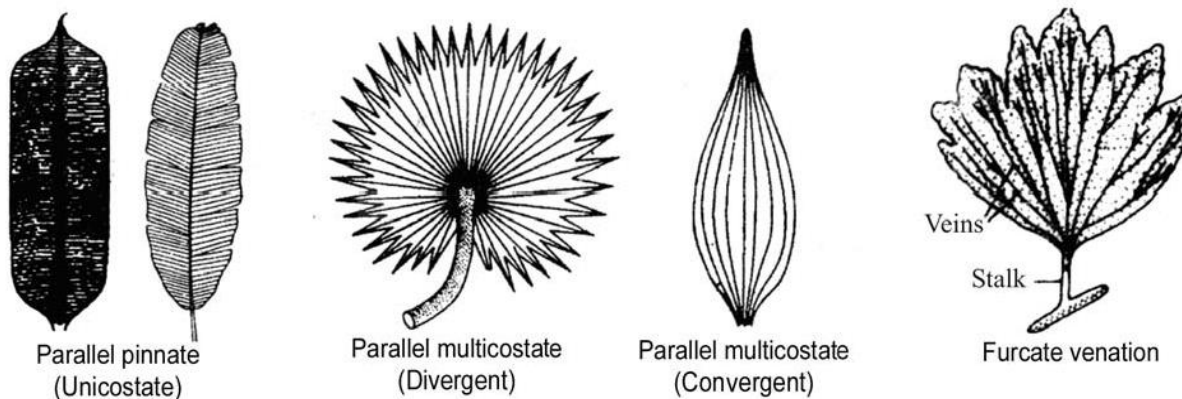
**Unicostate or pinnate** – This type of pattern having only one principal vein, that gives off many lateral veins, which proceed toward the margin of leaf blade in a parallel manner but they do not have veinlets. eg. **Banana, Ginger, Canna.**

**Multicostate or palmate** – Having many principal veins arising from the tip of the petiole and proceeding upwards.

✧ **Multicostate divergent** – Many principal veins arising from the tip of petiole and diverge toward the margin of leaf. They do not divide into veinlets and do not form a network. eg. **Coconut, Date palm**

✧ **Multicostate convergent** – Many principal veins arising from the tip of petiole run in a curved manner in lamina and converge towards the apex of leaf blades. eg. – **Wheat, Sugar-cane, Bamboo.**

**Furcate venation** – The veins branch dichotomously but the reticulum is not formed by the finer branches. eg. **Adiantum** (fern).



## ✓ TYPES OF LEAF ::

### Simple and Compound Leaf :

**Simple Leaf** – A leaf which may be incised to any depth, but not down to the midrib or petiole, then this type of leaf called simple leaf. eg. **Mango, Chinrose, Ficus,** etc.

**Compound leaf** – A leaf in which the leaf blade is incised up to the midrib or petiole, thus dividing it into several small parts, known as leaflets. This type of leaf is known as compound leaf.

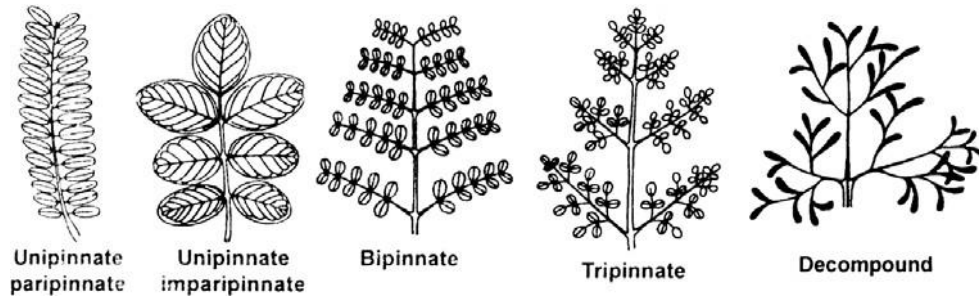
**It is of two types –**

**Pinnately compound leaf** – In this type of leaf mid rib is known as rachis. Leaflets are arranged on both sides of rachis. eg. **Neem.**

**It is of following types -**

✧ **Unipinnate** – In this type of leaf, division occurs only once and leaflets are directly attached on both sides of rachis.

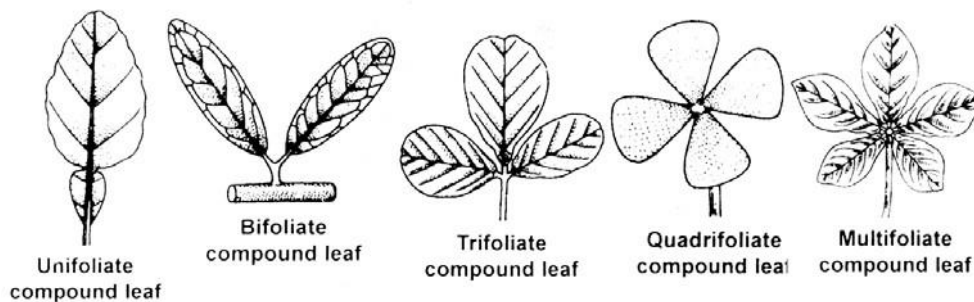
- ✧ If the number of leaflet is even, then leaf is known as paripinnate. eg. *Cassia fistula*, *Sesbania*
- ✧ If the number of leaflet is odd, it is known as imparipinnate. eg. **Rose**, **Neem**.
- ✧ **Bipinnate** – A twice pinnate compound leaf eg. *Acacia*, **Gulmohar**, *Mimosa*.
- ✧ **Tripinnate** – A thrice pinnate compound leaf eg. *Moringa*.
- ✧ **Decomound** – A compound leaf, which is more than thrice pinnate. eg. **Carrot**, **Coriander**.



**Palmate compound leaf** – In this type incision of leaf are directed from leaf margin to apex of petiole and all leaflets are attached on the upper end of petiole.

It is of following types -

- ✧ **Unifoliate** – When single leaflet is found. eg. **Lemon**
- ✧ **Bifoliate** – When two leaflets are present. eg. *Bauhinia*, *Regnelidium*, *Bignonia*.
- ✧ **Trifoliate** – When three leaflets are attached. eg. *Oxalis*, *Aegle*, *Trifolium*
- ✧ **Tetrafoliate** – When four leaflets are attached to the petiole. eg. *Marsilea*.
- ✧ **Multifoliate** – when more than four leaflet are found, then leaf is called multifoliate palmate compound leaf. eg. **Silkcotton**.



### Phyllotaxy :

It is of following type –

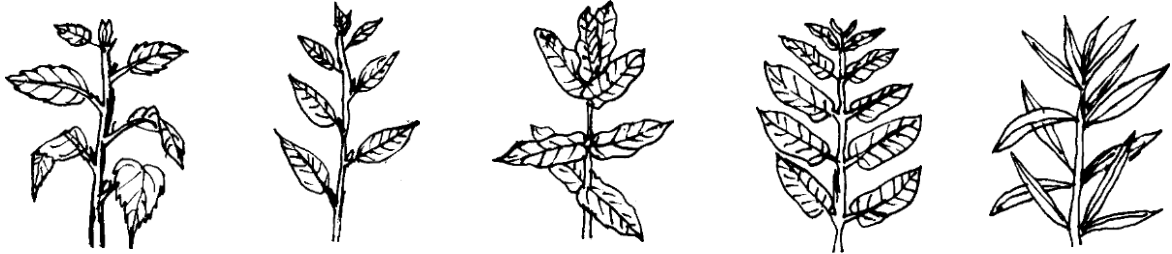
**Alternate or spiral** – Single leaf arising at each node. eg. *Cyprus rotandus*, Chinarose, mustard & Sunflower,.

**Opposite** – Leaves occurring in pairs at the node, they may be –

✧ **Decussate** : Leaves that stands at right angle to next upper or lower pair eg. *Calotropis*, *Mussaenda*.

✧ **Superposed** : Successive pairs of leaves stand directly over a pair in the same plane eg. *Psidium* (guava), *Ixora*.

**Whorled** – More than two leaves at each node eg. *Nerium*, *Alstonia*.



**Spiral**

**Alternate**

**Opposite decussate**

**Opposite superposed**

**Whorled**

**Heterophylly** – It is the occurrence of more than one type of leaves on the same plant. It is of three types –

**Developmental Heterophylly** : Leaves of different forms and shape occur at different period or places on the same plant eg. Mustard, Sonchus, Eucalyptus.

**Environmental Heterophylly** : It is aquatic adaptation which is commonly found in rooted emergent hydrophytes. In this, submerged leaves differ from the floating and aerial leaves. eg. *Limnophila*, *Heterophylla*, *Ranunculus aquatiles*, *Sagittaria*.

**Habitual Heterophylly** : Due to habit mature leaves differ in their shape and incissions eg. *Artocarpus* (Jack fruit).

### ✓ MODIFICATION OF LEAVES ::

**Leaf tendril** – In it, whole leaf is modified into thin thread like structure which is called leaf tendril eg. *Lathyrus aphaca* (wild pea).

**Leaflet tendril** – When leaflet is modified into tendril like structure than it is called leaflet tendril. eg. *Pisum sativum* (Garden pea), *Lathyrus odoratus* (sweet pea)

**Leaf spine** – Leaves or any part of leaflet are modified into pointed spine. eg. *Asparagus*, *Opuntia*, *Aloe*, *Argemone*.

**Leaf scale** – In it, leaves become thin, dry and form a membrane or paper like structure and serve to protect axillary buds as in *Ficus* and *Tamarix*, *Ruscus*, *Casurina*.

**Leaf pitcher** – Leaves of some plants are modified to pitcher shape. eg. *Nepenthes*, *Dischidia*.

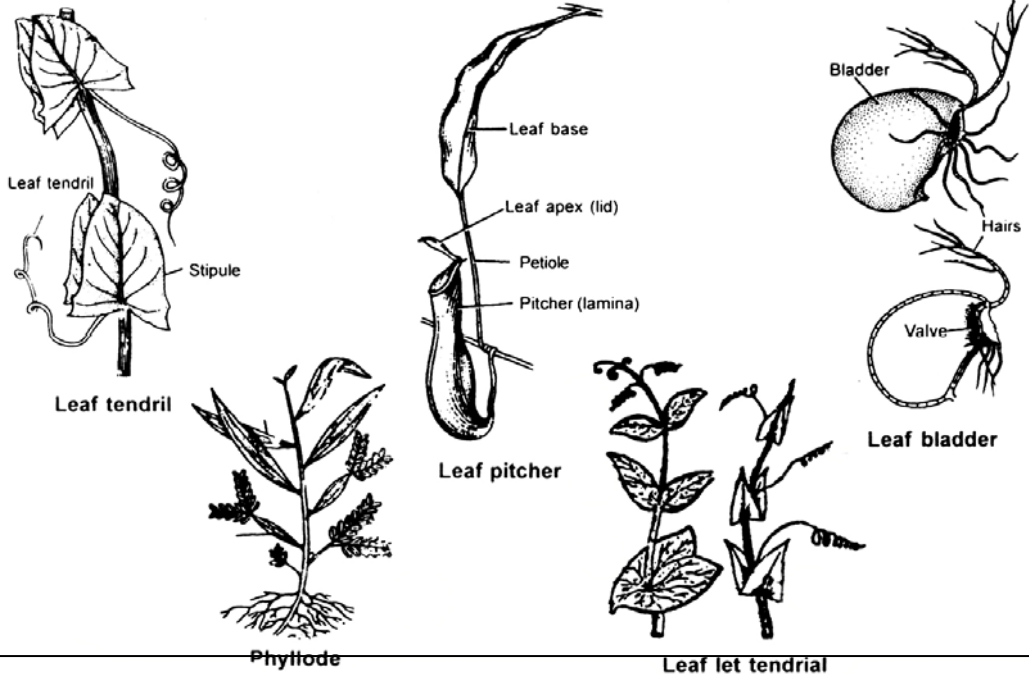
**Leaf bladder** – In some plant , leaves are modified into bladder like structure eg. *Utricularia*.

**Leaf Hooks** – In some plants terminal leaflets are modified into curved hooks for helping the plant in climbing. eg. *Argemone*, *Opuntia*, *Aloe*, Cat's nail (*Bignonia unguis – cati*)



**Phyllode** – In its, petiole becomes flat structure and function as normal leaf. eg. *Australian acacia*.

**Flashy leaves** – In onion and garlic food storing fleshy leaves are present.



## INFLORESCENCE

Arrangement of flower on floral axis is called inflorescence.

**Racemose** – In this type of inflorescence the main axis continues to grow and does not terminate in a flower and give off flower laterally in acropetal manner where old flowers are arranged toward base and young flowers are at tip. When peduncle is broad then flowers are centripetally arranged.

This is of following different types :

**Raceme** – When peduncle (main axis) is elongated and flowers are pedicellate.

eg. **Radish**, characteristic feature of cruciferae family

When peduncle is branched and each branch bear pedicellated flowers like racemose and are arranged in acropetal manner known as compound raceme or panicle. eg. Gulmohar, Neem.

**Spike** – In it peduncle is elongated but flowers are bisexual and sessile.

eg. *Achyranthes*

When peduncle is branched and each branch bear spike, like inflorescence then the small branch having flower is called spikelet and this arrangement is called as spike of spikelet. Characteristic inflorescence of family gramineae.

**Catkin** – In it peduncle is thin, long and weak, and flowers are sessile and unisexual. Peduncle is pendulus.

eg. mulberry, betula, oak.

**Spadix** – In it peduncle is thick, long and fleshy and have small sessile and unisexual male and female flowers covered with one or more green or colourfull bracts known as spathe.

eg. **Colocasia, Maize, Aroids, Palms.**

**Corymb** – In it peduncle is short and all flowers are present at same level because the lower flower has much long pedicel than the upper one eg. Candytuft (*Iberis amara*).

If in this type of inflorescence peduncle is branched, then each branch has flower cluster then this type of inflorescence is called compound corymb.

eg. **Cauliflower,**

\* In mustard corymbose raceme type of inflorescence is present

**Umbel** – An inflorescence in which the flower stalks of different flowers are of more or less equal length, arise from the same point. At the base of flowers stalks, there is whorl of bracts forming the involucre.

eg. **Centella**

If in this type of inflorescence, peduncle is branched then each branch has flower cluster then this type of inflorescence is called compound umbel.

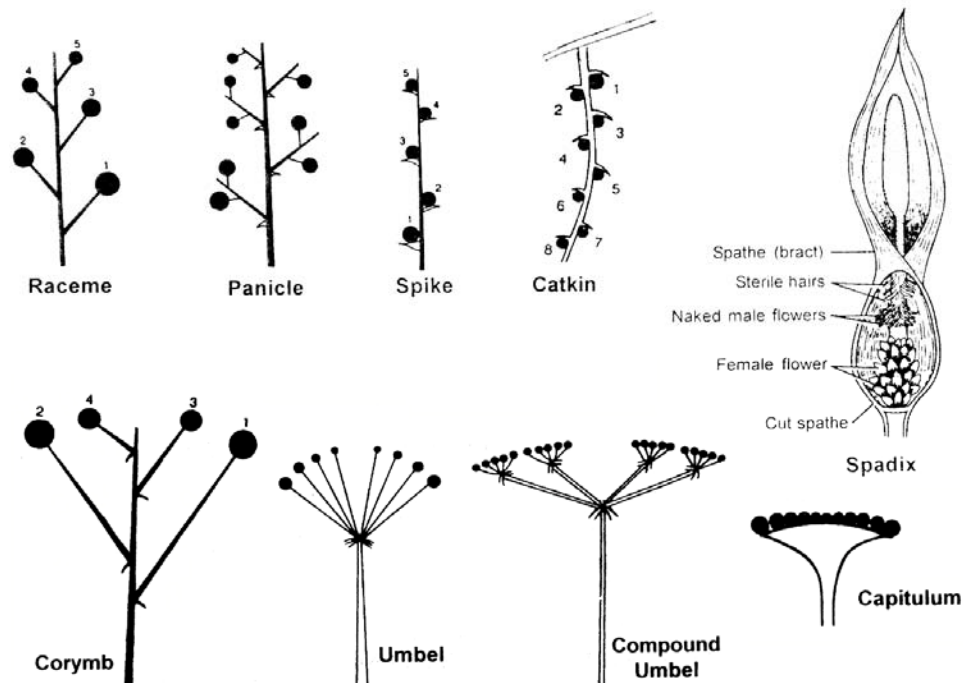
eg. **Coriander, Foeniculum, Cuminum.**

Characteristic feature of umbeliferae.

\* **Scapigerous umbel is found in onion**

**Capitulum / Racemose head** – In it the growth of peduncle is retarded and it become broad, flattened concave or convex. On it small flowers are found. These flowers are called floret. If all the flower of capitulum are same , then it is called homogamous. If two different type of floret, ray floret and disc floret are present in same inflorescence than it is known as heterogamous. In this type of inflorescence florets may be unisexual, bisexual and sterile. This inflorescence is surrounded by one or more involucre. It is most advanced type of inflorescence. eg. **Sunflower, Zinnia, Marigold, Cosmos.**

Characteristic feature of asteraceae family.



## ✓ CYMOSE ::

In this type of inflorescence, the peduncle terminate in a flower. In it the older flowers are present at tip and young buds are arranged towards base. This arrangement is called basipetal succession.

It is of following types.

**Uniparous cyme / Monochasial cyme** - The peduncle ending in a flower producing lateral branch at a time of ending in flower. It is of two types -

**Helicoid cyme** – When all lateral branches developed on the same side on peduncle then it is called helicoid cyme. eg. *Heliotropium*, *Saraca*, *Atropa*, *Datura*.

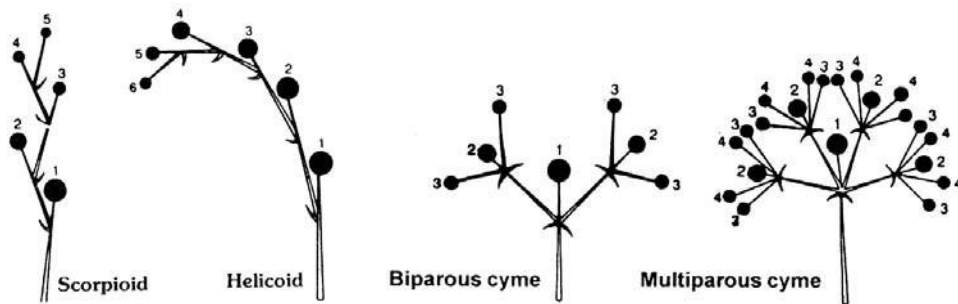
**Scorpioid cyme** – In it the lateral branch is alternately develop on left and right side. eg. *Bignonia*,

**Rhipidium** – In monochasial cyme all flowers are borne on same plane. eg. *Solanum nigrum*

**Dichasial or biparous cyme** – In it peduncle ends in a flower, from the basal part of peduncle two lateral branches arise, which also end in a flower, now this same arrangement occur on these lateral branches.

eg. *Bougainvillea*, *Jasmine*, *Teak*, *Mirabilis*, *Dianthus*, *Nyctanthes*.

**Multiparous cyme / polychasial** – In it peduncle ends in a flower and from the base of it many lateral branches arise which also terminates in flower, this arrangement now also occur on these lateral branches. eg. *Calotropis* (Madar), *Nerium*, *Asclepias*, *Hamelia*.



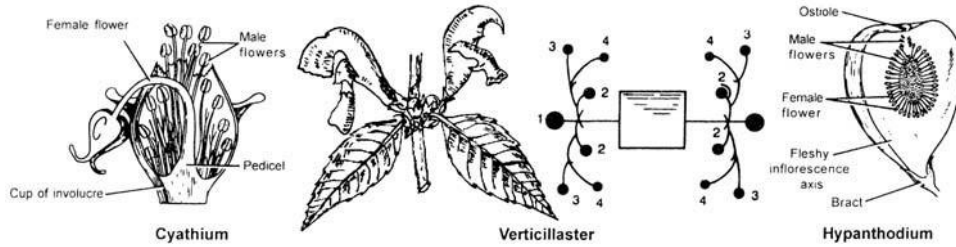
## ✓ SPECIAL TYPE OF INFLORESCENCE ::

**Cyathium** – The bracts or the involucre become fused to form a cup shaped structure on the margin. In the central part of cup shaped structure a single female flowers is found, which mature earlier. Due to the growth of pedicel this come out from the cup shaped structure. Female flower are surrounded by large no. of small male flowers. The male flower, which lie toward centre mature earlier than the flower which are towards periphery. This inflorescence is found in Euphorbiaceae family like *Euphorbia*, *Poinsettia*, *Pedilanthus*.

**Verticillaster** - A cluster of subsessile or sessile 3-9 flowers born on a dichasial cyme ending in monochasial cyme (scorpioid) in the form of condensed whorl on either side of the node. The opposite clusters give the appearance of whorl or verticel due to over crowding. The verticels are further arranged in a racemose manner eg. *Ocimum* (Tulsi), *Salvia*. Characteristic inflorescence of labiateae family.

**Hypanthodium** – In it peduncle is modified in narrow cup like structure. At the base of cup female flowers develop while towards mouth male flower develops. All three types of flowers are present in this inflorescence. eg. **Banyan**, **Peepal**, **Ficus species**.

**Coenanthium** : In *Dorsitenia*, the receptacle becomes saucer shaped and its margins are slightly curved. Arrangement of florets are similar to hypanthodium.



**Mixed inflorescence** – Some times flowers are arranged in both racemose and cymose manner on same peduncle called mixed inflorescence.

✧ **Mixed spadix** – Banana

✧ **Cymose raceme or thyrsus** – Grapes.

## FLOWER

Flower is defined as highly condensed and modified reproductive shoot. The part from where flower arise is called bract. Flower has short or long flower stalk which is called pedicel. The upper part of pedicel is swollen, spherical shaped or conical which is called thalamus / Receptacle.

Floral leaves are present on it.

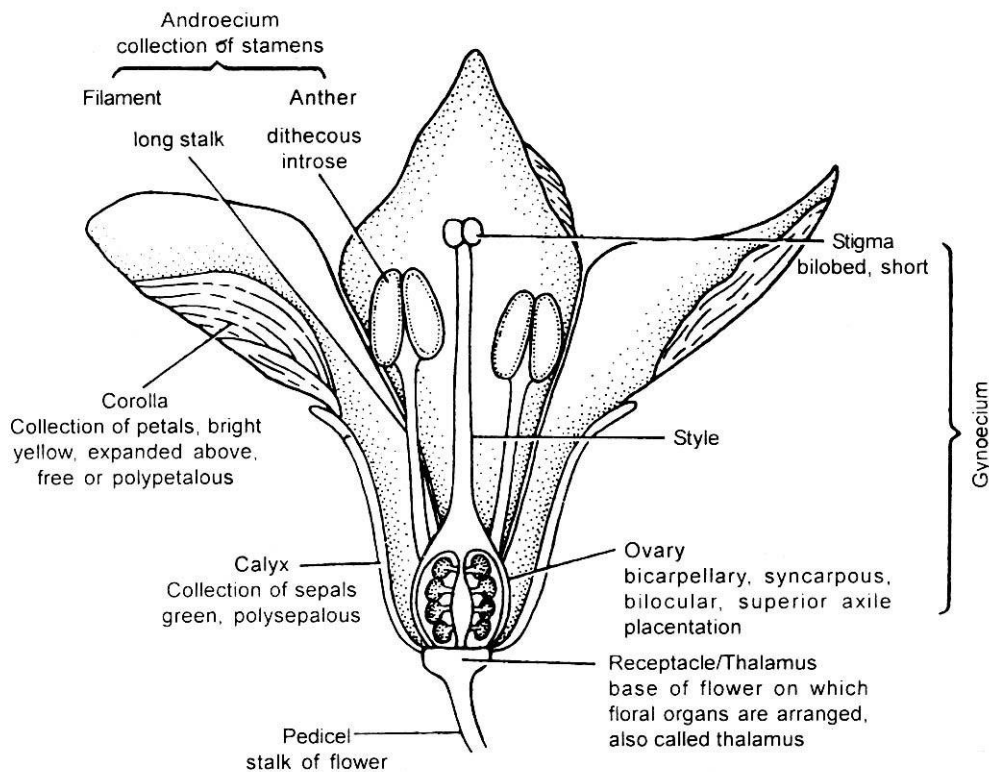
In a flower there are 4 type of floral leaves are found.

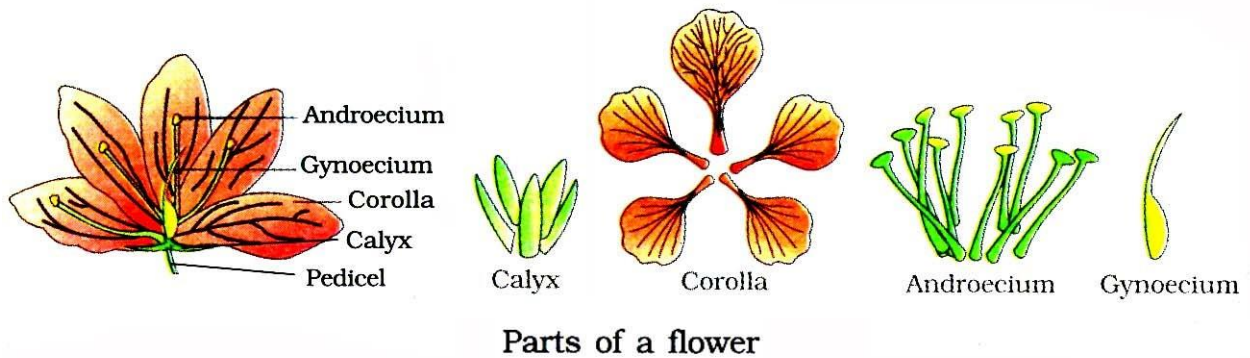
✧ Sepal

✧ Petal

✧ Stamen

✧ Carpel





### ✓ SOME WORDS RELATED TO FLOWER ::

**Complete Flower** – When calyx, corolla, androecium and gynoecium are present.

**Incomplete Flower** – Flower with one of the four whorl missing.

**Bisexual Flower** – Both gynoecium and androecium present in the same flower.

**Unisexual Flower** – Androecium (staminate flower) or gynoecium (Pistillate flower) any one of them are present in the flower.

**Monoecious Plant** – When both male and female flowers are present on the same plant. eg. *Cocos*, *Ricinus*, *Colocasia*, *Zea*, *Acalypha*.

**Dioecious Plant** – When male and female flowers are present on separate plant eg. Mulberry, Papaya.

**Polygamous Plant** – When unisexual (male or female), bisexual and neuter flowers are present on the same plant eg. Mango, Polygonum.

**Monocarpic Plant** – The plant which produces flowers and fruits only once in life eg. Pea, Mustard, Bamboo, Agave.

**Polycarpic Plant** – The plants which produces flowers and fruits many times in life, eg. Pear, Mango,

**Achlamydeous Flower** – Flowers are naked without sepals and petals eg. piperaceae.

✧ **Monochlamydeous Flower** : Only one accessory whorl is present (Perianth) eg. Polygonaceae, Liliaceae.

✧ **Dichlamydeous Flower** : Both accessory whorls present in flower.

**Hemicyclic or Spirocyclic Flower** : Some of the floral parts are in circles and some are spirally arranged. eg. Ranunculaceae.

**Cauliflory** : Production of flowers on old stem from dormant buds eg. *Artrocarpus*, *Ficus*.

**Symmetry of flower** – If the floral leaves are cyclic arranged in a flower, then it is called cyclic flower. If floral leaves are spirally arranged then it is called spiral flower. Floral symmetry is of three type -

**Actinomorphic / Radial / Regular** – When flower is divided by any vertical plane into two equal halves, then it is called actinomorphic flower eg. Mustard, China rose, Datura, Chilli.

**Zygomorphic / Bilateral** – When the flower is divided into two equal halves only by one vertical plane, then it is called zygomorphic flower eg. Pea, Bean, Gulmohur, Cassia.

If it is divided into two equal halves, from median plane, then it is called medianly zygomorphic, eg. **Ocimum** (Tulsi)

But if it is divided into two equal halves, by lateral plane then it is called laterally zygomorphic.

**Asymmetrical / irregular** – When the flower cannot be divided into two equal halves from any plane, then it is called asymmetrical flower. eg. *Canna*.

#### **Internodal elongation in flower :**

**Anthophore** – Internode between calyx and corolla is called anthophore. eg. *Silene*

**Androphore** – Internode between corolla and androecium is called androphore. eg. *Passiflora*

**Gynophore** – Internode between androecium and gynoecium is called gynophore. eg. *Capparis*.

**Gynandrophore or Androgynophore** – When both androphore and gynophore both conditions are found in same flower then this condition is called gynandrophore or androgynophore. eg. *Cleome gynandra*.

**Carpophore** – Elongation of thalamus beyond carpels. eg. **coriandrum**

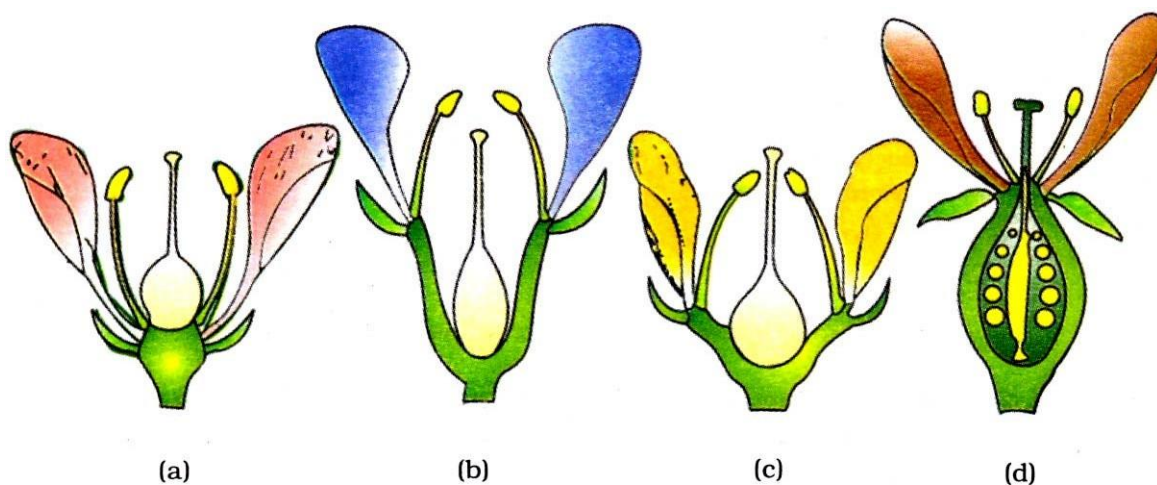
**Note :** - Part of flower which lies near to mother axis is posterior part while the part which is far from mother axis is anterior part of flower.

#### **✓ INSERTION OF FLORAL LEAVES ::**

**Hypogynous condition** – When petals, sepals and stamens are situated below the ovary, the flower is called hypogynous and in this condition ovary will be superior. eg. mustard, Chinrose, Brinjal.

**Perigynous condition** – In it thalamus grow upwardly and form a cup shaped structure. Gynoecium is situated in the centre and other parts of flower are located on the rim of the thalamus almost at the same level. It is called perigynous. The ovary here is said to be half inferior eg. plum, peach, rose.

**Epigynous condition** – The margin of thalamus grows upward enclosing the ovary completely and getting fused with it, the other parts of flower arises above the ovary, the ovary is said to be inferior and this condition is known as epigynous eg. Guava, Cucumber and ray florets of sun flower



Position of floral parts on thalamus  
(a) Hypogynous (b) and (c) Perigynous (d) Epigynous

## Notes :

**Bracts :** Bracts are specialized leaves present in axis of flower.

**Bracteate** – The flower which have bract is called bracteate flower.

**Involucre** – The whorl of bract surrounding peduncle is called involucre.

**Involucel** – Group of bracteole is called involucel.

**Spathe** – In flowers when large bract completely encloses whole inflorescence, then it is called spathe. eg. Banana, Maize.

**Petaloid bract** – When the size of bract of flower is greater than size of flower and these are of various coloured then it is called petaloid bract. eg. *Bougainvillea*.

**Glumes** – Small, dry, scaly bracts are called Glumes. eg. Wheat, Grass.

### ✓ CALYX ::

The outermost whorl of flower is called calyx. Each member of this whorl is called sepal when all the sepals are free from each other, then it is called poly-sepalous condition eg. Mustard, Radish. When the sepals are fused each other, then it is called gamosepalous condition eg. Cotton, Datura, Brinjal.

In calyx of *Mussaenda*, one of the sepal enlarge and form a leaf like structure. It may be white or brightly coloured. It attracts the insects and thus act as advertisement flag.

In *Trapa*, calyx is modified into spines and helps in protection of fruit.

In *Argemone* spines are present on the surface of sepal which protect the flower bud.

In larkspur and Balsum, the posterior part of sepal is modified into a narrow tube. This structure is called sepal spur. Nectar is stored in it for insect attraction.

In asteraceae family, sepals are modified into hairy structure. It is called pappus. The pappus is a modified calyx and helps in dispersal of fruit.

### ✓ DURATION OF SEPALS ::

**Caducous** – Sepals fall just at the time of opening of flower bud. eg. Poppy.

**Deciduous** – Sepals fall after pollination eg. Mustard

**Persistent** – If sepals do not fall and remain attached to fruit. eg. Tomato, Capsicum, Brinjal, Cotton, Datura.

\* Sometime below calyx, a whorl similar to sepals is found which is called epicalyx. eg. Malvaceae family

### ✓ COROLLA ::

The second whorl of flower is called corolla and each member of it is called Petals. When the shape and size of petals are similar then it is called symmetrical while when they are not similar then they are asymmetrical. When all the petals are free, then it is called polypetalous while when petals are fused, then it is called gamopetalous.

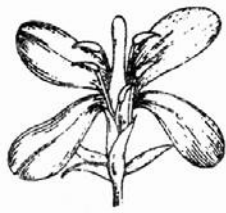
#### Forms of Corolla -

##### POLYPETALOUS

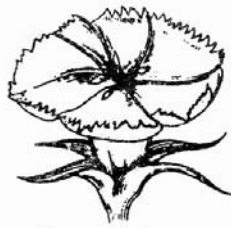
**Cruciform** – 4 petals are present in it. The lower narrow part of petal is called claw while the outer broad part is called limb. These petals are arranged crosswise. eg. **Radish, Mustard**.

**Caryophyllaceous** – It consists of 5 petals the claw of petals are short and the limb of petals from right angle to the claw eg. **Dianthus**.

**Rosaceous** – It consist of 5 or more petals. Claws are absent in it and limbs are spread regularly outwards. eg. Rose, Coconut.



Cruciform



Caryophyllaceous



Rosaceous

## GAMOPETALOUS

**Campanulate** – Five petals are arranged like bell. eg. **Tobacco, Raspberry, Campanula.**

**Funnel shaped or infundibuliform** – Funnel like petals arrangement eg. **Datura, Railway creeper.**

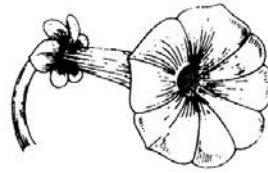
**Tubular** – Petals are like tube eg. **Disc florets of sunflower.**



Campanulate



Tubular



Infundibuliform

## ZYGOMORPHIC POLYPETALOUS COROLLA -

**Papilionaceous** – Five petals are present. It's posterior petal is largest and is known as standard or vexillum. Vexillum covers two lateral petals which are called as wings and the innermost basal petals are united to form a keel or carina. Both lateral parts covers the keel. eg. **Pea, Gram, Arher**



Papilionaceous

## ZYGOMORPHIC GAMOPETALOUS COROLLA -

**Bilabiate** – The petal of gamopetalous corolla is divided into two lips. The place between two lips is called corolla mouth. eg. **Ocimum, Salvia.**

**Personate** – In this case the corolla is bilabiate but the two lips are near to each other eg. **Antirrhinum**

**Ligulate** – The upper part of corolla is long, flattened which is attached with short narrow tube. eg. **Ray florets of sunflower.**



Bilabiate



Personate



Ligulate



## AESTIVATION -

The mode of arrangement of sepals or petals in floral bud with respect to the other members of the same whorl is known as aestivation. It is of following types -

**Valvate** – When the petals of a whorl lie adjacent to each other and just touch it. eg. *Calotropis*, **Custard-apple, Mustard.**

**Twisted** – In it one part of a petal covers adjacent petals and the other part is covered by posterior petal. One margin of the petal overlaps that of the next one, and the other margin is overlapped by the third one. eg. Cotton, Ladyfinger, Chinrose

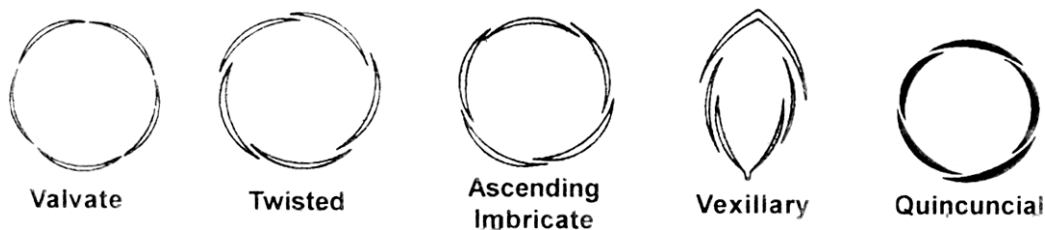
**Imbricate** – When both margins of the one petal are covered by the other two petals and both margins of another one, covers other, Rest are arranged in twisted manner.

It is of two types -

❖ **Ascending imbricate** – The posterior petal is innermost i.e., its both margins are overlapped. eg. *Cassia, Bauhinia, Gulmohur* etc.

❖ **Vexillary or Descending imbricate** – The anterior petal is innermost and posterior petal is outermost & largest. eg. Pea, Bean.

**Quincuncial** – It is a modification of imbricate type. Out of the five petals, two are completely internal, two completely external and in the remaining petal, one margin is internal and the other margin is external. eg. *Murraya, Ranunculus*.



## PERIANTH

When there is no distinction between calyx and corolla the whorl is described as perianth.

Individual perianth segments are called **Tepals**. Green tepals are called **sepaloid** and coloured tepals are called **petaloid**. Tepals are free (polytepalous) or fused (gamotepalous). eg. *Liliaceae* and *Graminae* family

## ✓ ANDROECIUM ::

It constitutes the third whorl of the flower and is made up of one or more stamens. Each stamen consists of filament, anther and connective. Each anther is usually bilobed and each lobe has two chambers the pollensac. The pollen grains are produced in pollensac.

### Attachment of filament to anther lobe :

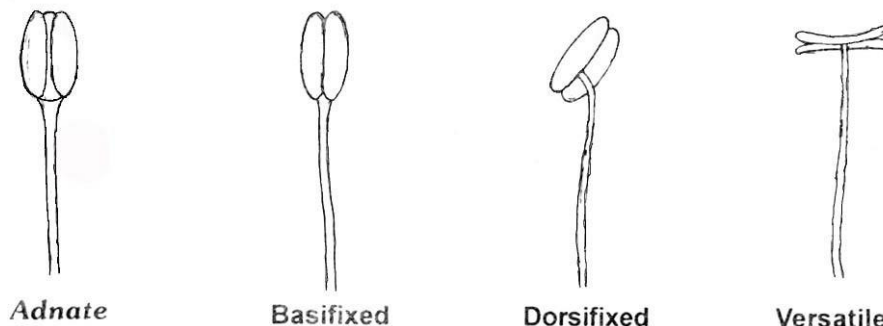
The attachment of filament to another lobe is of 4 type -

**Adnate** – Filament runs through the whole length of the anther from the base to the apex. eg. *Michelia* (Champa), *Magnolia*

**Basifixed** – Filament is attached to anther by its base. eg. **Datura, Radish, Mustard.**

**Dorsifixed** – The filament is attached at the centre to the back of the anther. eg. **Passion flower**

**Versatile** – Filament attached to the back of the anther at a point only, thus the anther can swing freely. eg. Wheat, grass, maize.



### Cohesion of stamens :

When the floral parts of similar whorl are fused, then it is called cohesion. When the stamens of an androecium are free from one another, it is called polyandrous condition.

**Adelphous** : when stamens are united by their filament only, it is called adelphous. It is of following types –

❖ **Monoadelphous** – When all the filaments are united into a single bundle but anthers are free from each other. In this type of cohesion a tube is formed around the gynoecium which is called staminal tube eg. Cotton, Hollyhock, Ladyfinger.

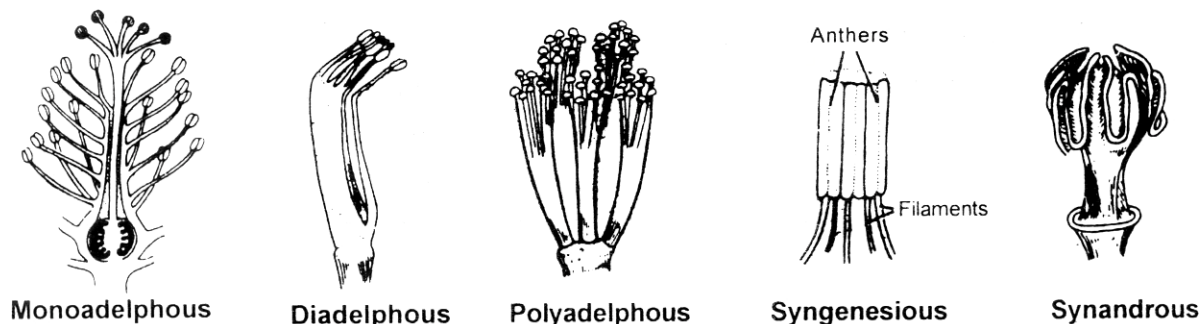
❖ **Diadelphous** – When the filaments are united in two bundles but the anther remains free eg. Gram, Pea, Bean

In these plants from 10 stamens, 9 stamens are arranged in bundle while 1 remains free.

❖ **Polyadelphous** – When filaments are united into more than two bundles. eg. Citrus, Castor.

**Synandrous** – When anthers as well as filaments of stamens are united through their whole length. eg. *Colocasia, Alocasia, Momordica*, Cucurbitaceae family

**Syngenesious** – In it only anthers are united in bundle but filaments remain free eg. Compositae family



### Adhesion of stamens :

When the stamens are attached to other parts of flower, then it is called adhesion of stamens.

**Epipetalous** – When stamens are attached to petals. eg. Brinjal, Datura, Tobacco, Sunflower, Potato.

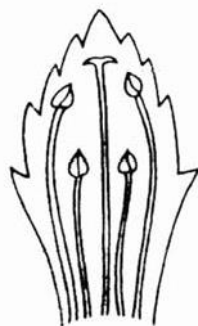
**Epiphyllous** – When stamens are attached to tepals. eg. Onion, Lily.

**Gynandrous** – When stamens are attached to gynoecium either throughout their whole length or by their anther eg. *Calotropis*.

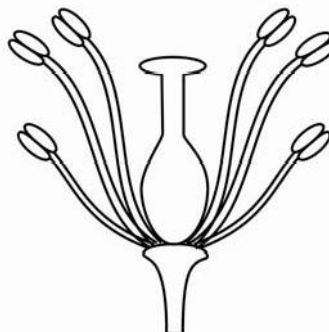
### Length of stamens :

**Didynamous** – When four stamens are present, out of them two are long and two are short, then it is called didynamous. eg. Labiatae family.

**Tetradynamous** – When there are six stamens and they are arranged in two whorls. In outer whorl, there are two short stamens while in inner whorl, there are four long stamens, this condition is called tetradynamous. eg. Cruciferae family.



**Didynamous**



**Tetradynamous**

### Note -

**Inserted** – When the stamens are smaller than corolla. eg. Datura

**Exserted** – Stamens are longer than corolla and are radially outward. eg. Gulmohar.

**Diplostemonous** – The stamens are double the number of petals and present in two whorls. The outer whorl of stamens is alternating with petals (alternipetalous), while inner whorl is opposite to petals (antipetalous). eg. **Liliaceae family**.

**Obdiplostemonous** – It is reverse of diplostemonous. The outer whorl of stamen is opposite to petals, while inner whorl of stamen is alternating with petals. eg. **Caryophyllaceae**.



**Isostemonous**



**Diplostemonous**



**Obdiplostemonous**

**Isostemonous or Haplostemonous** – In such type of condition stamens are present in single whorls. No. of stamens is equal to no. of sepals and petals and generally whorl of stamens is alternating with petals.

**Heterostemonous** – Stamens are of different length in some flowers.

**Staminodes** – When stamens are without pollen grains & remain sterile through out life are called staminodes e.g. *Salvia verbascum*.

### ✓ GYNOECIUM (PISTIL) ::

It is the fourth and second essential whorl of the flower. It is female part of the flower comprising of the inner whorl of megasporophylls in the form of carpels bearing ovules. It consists of ovary, style and stigma. Ovary is the enlarged basal part, on which lies the elongated tube the style, the style connects the ovary to the stigma. The stigma is usually at the tip of the style and is receptive surface for pollen grains. The gynoecium may be monocarpellary or multicarpellary.

If only one carpel is present in gynoecium this condition is called monocarpellary.

If more than one carpel is present in gynoecium this condition is called polycarpellary.

If all the carpels in polycarpellary / multicarpellary condition are free, then condition is called apocarpous.

If all the carpels are fused together, then condition is called syncarpous.

### ✓ COHESION OF CARPEL ::

In syncarpous gynoecium four types of cohesion are found

When ovaries are fused, but stigma and style are separated with each other, eg. **Dianthus, Plumbago**

Ovary and style are fused, but stigma are not fused. Malvaceae family. **Hibiscus rosasinensis**, cotton.

When stigma are fused but the ovary and style are free. eg. **Calotropis, Cassia fistula, Nerium.**

Carpels are completely fused. This condition is found in max. flowers, eg. **Mustard, Radish, Tomato.**

### ✓ PLACENTATION ::

The ovules are attached on ovary walls on one or more cushion called placenta. The arrangement of ovule within ovary wall is known as placentation. It is of following types –

**Marginal** : Marginal placentation is found in unilocular ovary. The placenta forms a ridge along the ventral suture of the ovary and the ovules are borne on this ridge forming two rows. eg. Leguminosae.

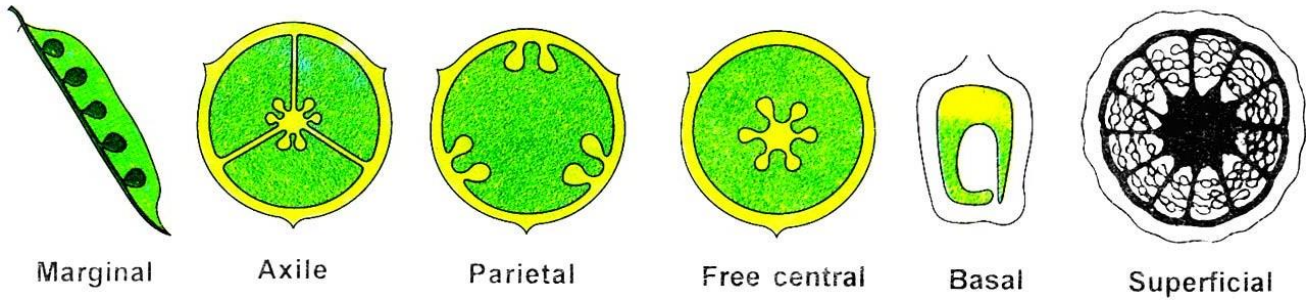
**Parietal** : This type of placentation is found in unilocular syncarpous ovary. In it the ovule develops on the innerwall of the ovary or on peripheral part. Ovary become bi or multilocular due to formation a false septum eg. **Cucurbita, Argemone**, and Cruciferae family (Mustard)

**Axile** : It is found in multicarpellary syncarpous gynoecium. The fusion margin of carpels grown inward and meet in the centre of the ovary. Thus an axis forms in the centre of ovary, thus ovary becomes multichambered. The ovules are born at the central axis. Number of these chambers are equal to the number of carpel eg. **Potato, China rose, Onion, Lemon, Orange, Tomato.**

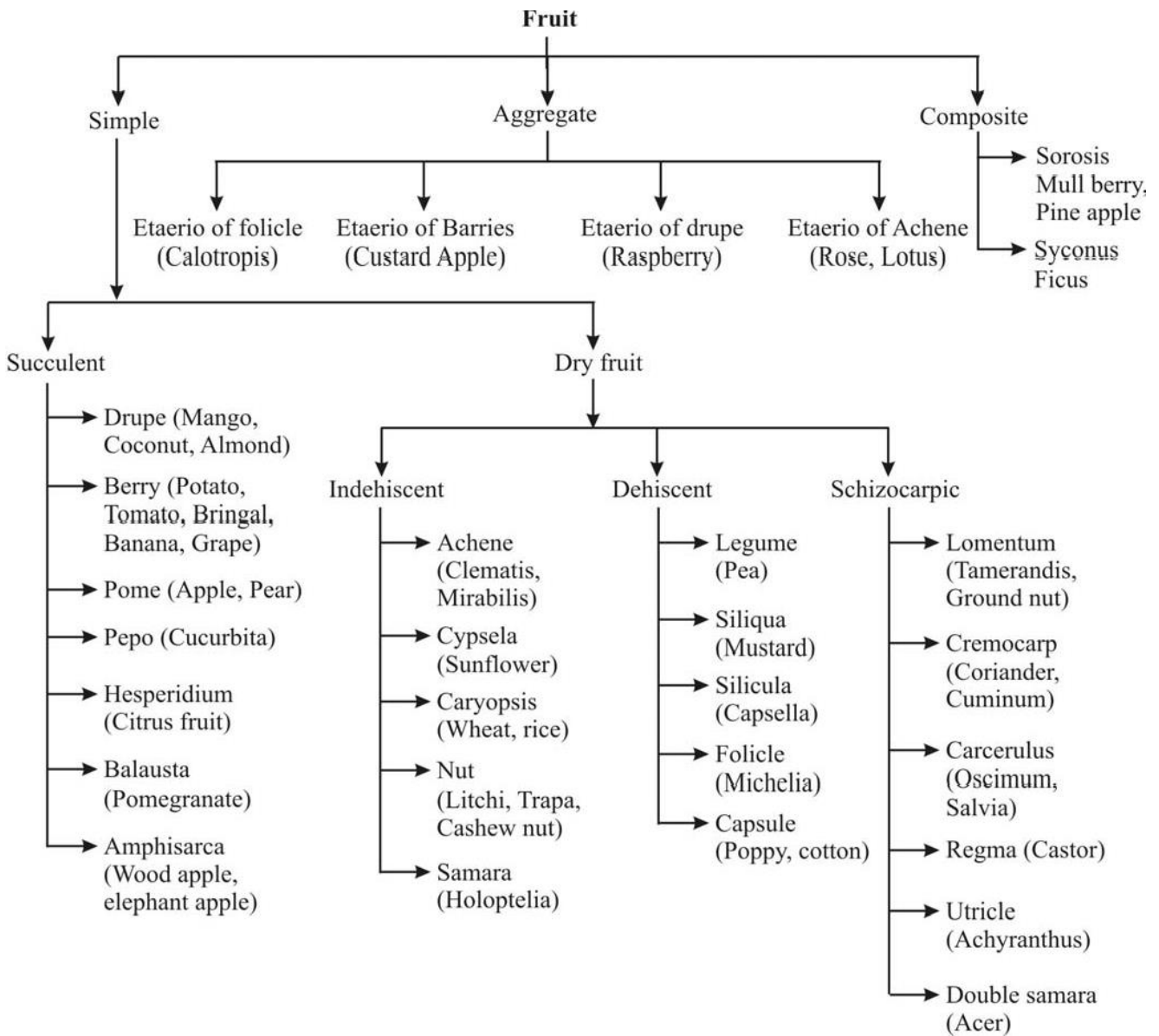
**Free central** : This type of placentation is found in syncarpous gynoecium. In it, the ovary is unilocular and the ovules are borne on the axis in the centre of the ovary. septum are absent in ovary. Placentation is axile in beginning. After sometimes walls of chamber destroy and only ovulated central axis left. eg. **Primrose, Dianthus (Caryophyllaceae)**

**Superficial** – This type of placentation is found in multicarpellary syncarpous gynoecium. The ovules are attached on the walls of locule eg. **Nymphaea** (Water lily) of ovary. eg. Marigold

**Basal :** The ovary is unilocular and a single ovule is borne at the base  
Sunflower (Asteraceae family)



**FRUIT**



Fertilized and ripened ovary is fruit. A Fruit consist of (i) Pericarp (fruit wall), (ii) seed.

The seeds are protected inside fruit. But in some fruits. seeds are not found like in grapes, banana and such type of fruits are seedless fruit.

If a fruit is formed without fertilization of the ovary it is known as parthenocarpic fruit.

**Pericarp :** After ripening, the ovary wall change into pericarp. This pericarp may be thick and fleshy or thick and hard or thin and soft.

Pericarp is differentiated in 3 layers

**Epicarp :-** It is the outermost layer, which is also called rind

**Mesocarp :-** It is the middle layer.

**Endocarp :** It forms the innermost layer.

**TRUE FRUIT :** When the fruit is developed only from the ovary, the fruit is called as true fruit. eg. Mango, Coconut, *Zizyphus*

**FALSE FRUIT OR PSEUDOCARP :** In some fruits, in place of ovary, some other parts of flower like thalamus, inflorescence, calyx are modified to form a part of fruit. These types of fruit are called false fruits. eg. Apple, Strawberry, Pear.

## ✓ CLASSIFICATION OF FRUIT ::

Fruits are divided in three groups

- ✧ Simple
- ✧ Aggregate
- ✧ Composite

### **SIMPLE FRUIT :-**

These fruit develop from monocarpellary ovary or multicarpellary syncarpous ovary. Only one fruit is formed by the gynoecium. Simple fruits are of two types –

- ✧ Fleshy fruit
- ✧ Dry fruit

**Fleshy Fruit:-** These fruit develop from superior or inferior syncarpous gynoecium. These may be unilocular or multilocular. These fruits are indehiscent. Dispersal of seeds occur after pericarp is destroyed.

### **Fleshy fruits are of following types :**

- ✧ **Drupe fruit :-** These fruit develops from mono or multicarpellary, syncarpous, superior ovary. In these fruits endocarp is hard and stony so these fruits are also called stony fruits. eg. Mango, coconut almond, Peach walnut, plum. Brachysclereids are present in endocarp.

In mango edible fleshy part is mesocarp and the part where seed is protected is called as endocarp.

In ber, epicarp and mesocarp both are edible part.

The rind of Almond and walnut are endocarp and their edible part is seed.

In coconut epicarp is hard and thin while mesocarp is thick and consist of hard fibers The endocarp is hard and seed is protected in it. Endosperm is edible in coconut.

❖ **Berry** : These fruits develop from mono or multicarpellary syncarpous ovary. Ovary may be superior or inferior, Placentation is axile or parietal. In these epicarp is thin and seeds are embedded in fleshy part. Initially seeds are attached with placenta of fruit but after maturation these seeds are detached with placenta and are spread randomly in fleshy part.

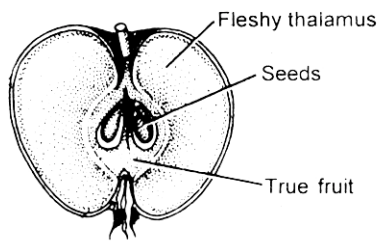
- Plants with superior ovary = Tomato, Grapes, Brinjal.
- Plants with inferior ovary = Guava, Banana

**Date palm** is one seeded berry. In it pericarp is divided into epicarp, mesocarp and endocarp. Epicarp is thin and soft while mesocarp is thick and fleshy and endocarp is thin like a membrane. Which is attached with seed.

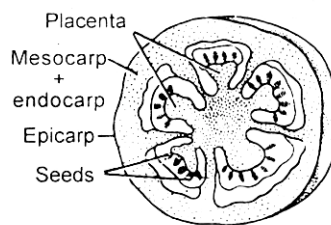
**Arecanut** is one seeded fibrous fruit berry. When its thick fibrous layer is removed then seed comes out which is hard.

❖ **Pepo** - These fruit develops from tricarpellary, syncarpous and inferior ovary. This fruit is unilocular and have parietal placentation. These fruits are fleshy and spongy. sometime fruits are bitter in taste due to presence of tetracyclic triterpine in flashy pulp. eg. fruits of cucurbitaceae family.

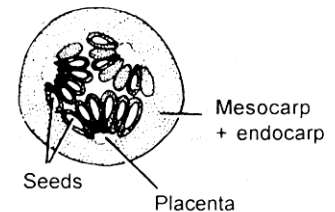
❖ **Pome** - This fruit develops from bi or multicarpellary syncarpous inferior ovary. The rind and fleshy pulp are made up of thalamus. The main part of ovary is hard and dry and remain inside the fruit. Seeds are present in it. eg. Apple, Pear.



L.S. of Apple



L.S. of Tomato



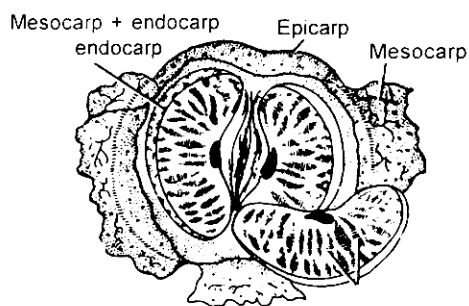
T.S. of Cucumber

❖ **Hesperidium** : This fruit develops from multicarpellary, syncarpous, superior ovary. This fruit is specially found in plants of Rutaceae family. eg. Orange, Lemon, Citrus fruit.

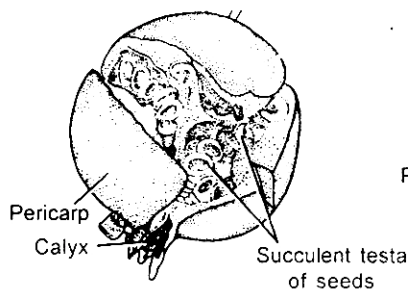
Epicarp of these is made up of thick rind which is leathery and many oil glands are found in it. Mesocarp is white fibrous structure which is attached with epicarp. Membranous endocarp projects inward and form many chambers. Many glandular hairs are present on the inner side of endocarp. These glandular hairs are only edible parts.

❖ **Balausta** : It is a multilocular multiseeded fruit, which develops from inferior ovary. Its pericarp is hard. Persistent calyx is arranged in the form of crown. Seeds are irregularly arranged on placenta. Endocarp is hard. Testa is fleshy. This is the edible part of fruit. eg. Pomegranate (*Punica granatum*).

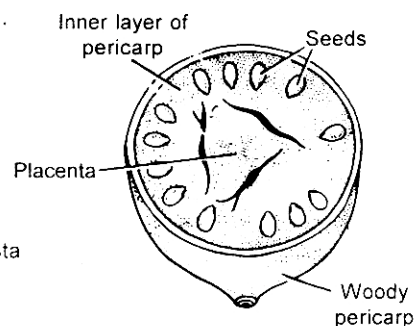
- ❖ **Amphisarca** : This fruit is multicarpellary and multichambered which develops from superior ovary. Pericarp is hard and fleshy placenta is found in them. The inner part of pericarp and placenta is edible part of fruit. Testa of seed is mucilegenous eg. wood apple (*Aegle marmelos*), elephant apple.



**Hesperidium of orange**



**Balausta of pomegranate**



**Amphisarca of wood apple**

**Simple Dry Fruit** - Pericarp of simple dry fruit is hard and dry and not differentiated into epicarp, mesocarp and endocarp. Such fruits are called dry fruit.

Simple dry fruits can be divided into following three groups :

- ❖ Indehiscent
- ❖ Dehiscent
- ❖ Schizocarpic

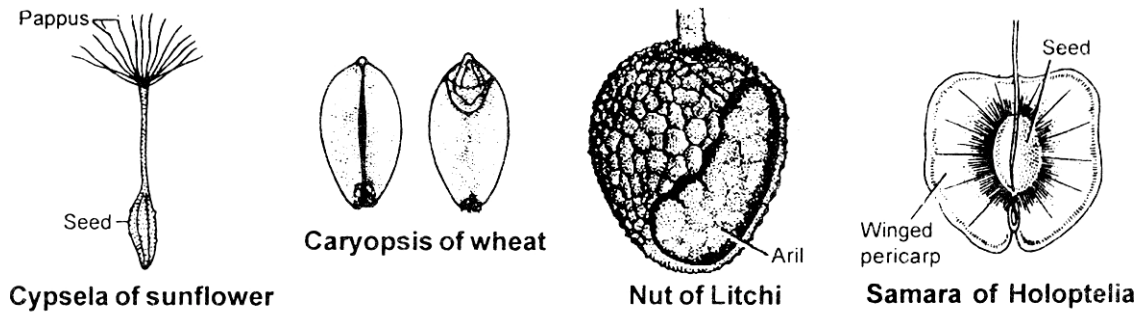
**Indehiscent fruits** : These simple dry fruits are generally of small size and single seeded pericarp does not rupture even after maturity.

- ❖ **Cypsela** : It is a small, single seeded dry fruit which develops from bicarpellary, syncarpous inferior ovary. Pericarp and seed coat are free from each other. In these fruits a bunch of hair is attached with the fruit which is known as Pappus. Pappus helps in fruit dispersal. eg. Compositae family Plants.
- ❖ **Caryopsis** : These are small, single seeded dry fruits. It develop from monocarpellary, superior ovary. Pericarp of these fruits is fused with the seed coat and form a joint surface. These fruits are present in family gramineae. Wheat grain or rice grain is a fruit.
- ❖ **Achene** : These are single seeded fruit which develops from monocarpellary superior ovary. In it, pericarp is free from the seed coat eg. *Clematis*, *Mirabilis*, *Boerhaavia*
- ❖ **Nut** : This is a single seeded fruit which develop from monocarpellary syncarpous superior ovary. In it pericarp is hard eg. *Quercus* (oak), *Anacardium occidentale* (Cashewnut) *Trapa*, (Water chest-nut), Litchi.

In Litchi epicarp and mesocarp is fused and give leathery apperence. Endocarp is membrane like thin. Outer seed coat grows forward and forms an additional coat around the seed which is called as aril. In mature fruit, this aril is fleshy and is only edible part.



- ✧ **Samara** : These are dry indehiscent one seeded feathery fruit. It develops from bi or tri carpellary, syncarpous and superior ovary. The main character of these fruits is wing like structure develops from its pericarp which helps in dispersal. eg. *Holoptelia*.



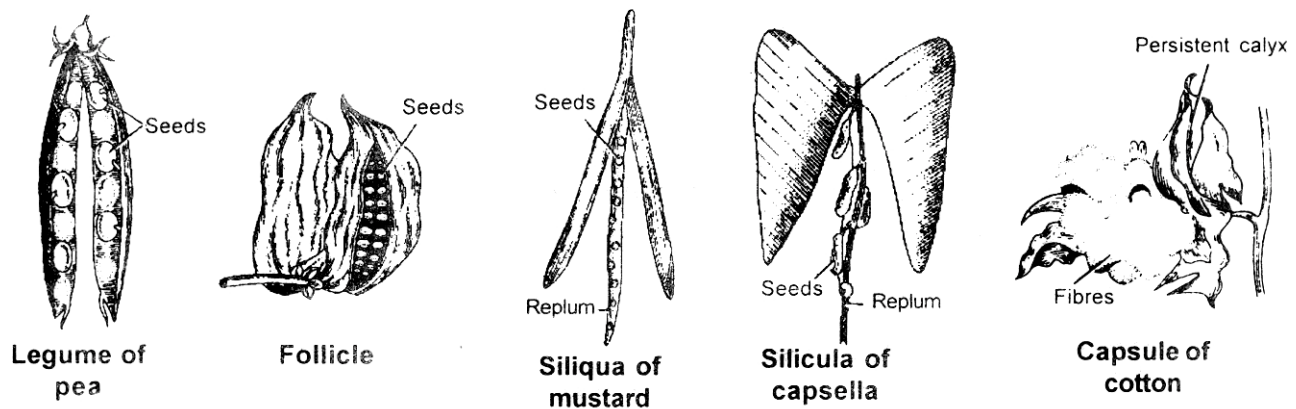
In *Shorea robusta* wing develops from calyx instead pericarp and these fruit are called samaroid.

**Dehiscent Fruits** : After ripening pericarp are ruptured and seeds are dispersed outside.

- ✧ **Legume or pods** : These fruits develop from monocarpellary, unilocular, superior ovary. It is generally long and multiseeded fruit. Dehiscence of fruit occurs at both sutures i.e. Dorsal and ventral side. Dehiscence start from apex and reaches to basal part. eg. Pea, Beans.

When only one or two seeds are present in fruit, then it is also called as pod.

- ✧ **Follicle** : It is also multiseeded fruit which develops from superior unilocular, monocarpellary ovary but the dehiscence of it occur only at ventral suture. eg. *Asclepias*, *Rauwolfia*, *Vinca*, *Michelia* (Champa), *Delphinium*.
- ✧ **Siliqua** : This fruit develops from bicarpellary, syncarpous superior ovary with parietal placentation. Dehiscence occurs at both dorsal and ventral suture and starts from lower part and proceeds upward. Due to formation of false septum ovary become bilocular. On false septum, seeds are attached, This type of fruit is found in Cruciferae family. eg. Mustard.
- ✧ **Silicula** : A short broad siliqua is known as Silicula. It is also found in Cruciferae family. eg. Candytuft (*Iberis amara*), Capsella,
- ✧ **Capsule** : This is dry multichambered and multiseeded fruit and develop from multicarpellary syncarpus, superior ovary. In it, Axile placentation is found and dehiscence occurs by various methods. Poricidal (Poppy), loculicidal (cotton), septifragal (Datura), septicidal (Lineseed).



**Schizocarpic fruit :** It is a multiseeded fruit. After ripening, it is divided into mericarp and seeds come out after destruction of pericarp. The fruits develop from mono or bi or multicarpellary superior or inferior ovary. The mericarp contains one or two seeds.

❖ **Lomentum :** It develops like legume. Fruits are constricted or divided in one seeded mericarp, after maturity these are separated with each other. Eg *Tamarind*, *Cassia fistula*, *Mimosa pudica*, *Archis hypogea*, *Desmodium*.

❖ **Cremocarp :** It is a double seeded fruit and develops from bicarpellary, syncarpous, inferior ovary. On maturation, it dehisces from apex to base in such a way that two mericarp forms and each contain one seed. These mericarp are attached with carpophore. Carpophore is the extended part of receptacle. eg. **Coriander, Cuminum, Foeniculum.**

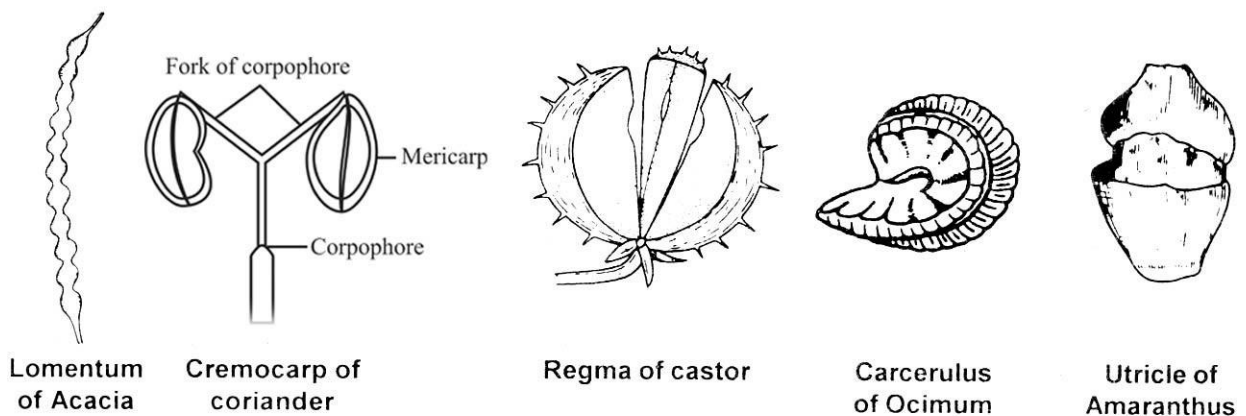
❖ **Regma :** This fruit develops from tri to pentacarpellary, syncarpous superior ovary. In it three locules are present and its fruit is breaks into three one seeded part. Each part is known as coccus. At the outer end of pericarp, spines are found. eg. Euphorbiaceae family, Castor has three cocci Geranium has 5 cocci.

❖ **Carcerulus :** It is a dry fruit which develops from multi carpellary or bicarpellary, syncarpous, superior ovary. Number of mericarp is more than locules because of formation of false septum. It divides into four one seeded locules. eg. *Ocimum* (Basil), *Salvia*.

In hollyhock and abutilon (family malvaceae), the no. of locules is more than four

❖ **Utricle :** It is a single seeded fruit which has thin membrane. It dehiscence generally from cap. It develops from bicarpellary, unilocular, syncarpous, superior ovary. eg. *Achyranthes*, *Amaranthus*.

❖ **Double Samara :** It develop from bicarpellary syncarpous superior ovary. Pericarp develops into two wings. On maturation it divides in two single seeded mericarp eg . samara , acer.



**AGGREGATE FRUIT :-**

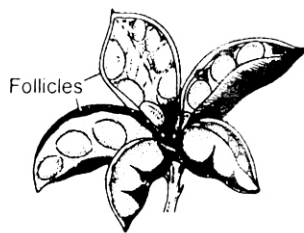
These fruits develop from multicarpellary apocarpous ovary. Because in apocarpous ovary, each carpel is separated from one another, therefore it forms a fruitlet. These fruits are made up of bunch of fruitlets which is known as etaerio.

**Etaerio of follicles :** Each fruitlet is a follicle. eg. *Calotropis, Catharanthus, Magnolia.*

**Etaerio of achenes :** In this aggregate fruit, each fruitlet is an achene. eg. *Ranunculus*, Strawberry, Rose, Lotus

**Etaerio of berries :** It is an aggregate of small berries. eg. *polyalthia, Annona squamosa* (Custard-apple). In etaerio of Anona all the berries are arranged densely on thalamus.

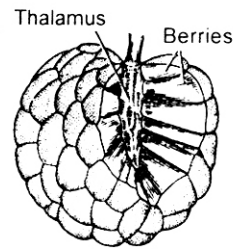
**Etaerio of drupes :** In this type of fruit, many small drupes develop from different carpels. eg. Raspberry



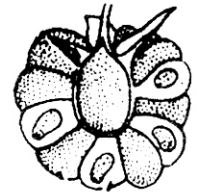
**Etaerio of Follicles**



**Etaerio of Achenes**



**Etaerio of Berries**



**Etaerio of Drupes**

**COMPOSITE FRUIT :-**

All composite fruits are false fruits.

This type of fruit differ from aggregate fruit that in place of single ovary many ovaries and other floral parts combine together to form fruit. In composite fruits, generally whole inflorescence is modified into fruit. These are of two types.

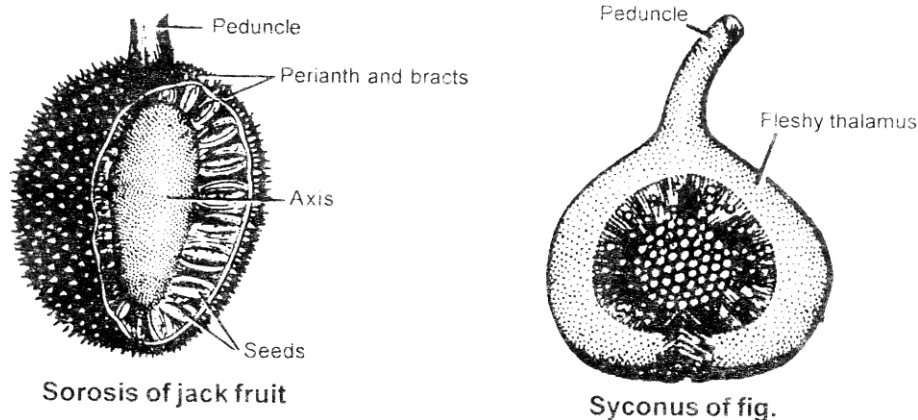
**Sorosis :** This fruit develops from spike, spadix or cartkin inflorescence. Peduncle become thick spongy and woody. eg. Jack fruit, *Pandanus (screwpine)*, Pineapple

In jack fruit (Kathal) pistillate flowers are developed around the peduncle. In fruit formation pericarp become spongy and fused.

In Pine apple peduncle bracts and perianth become fleshy. Due to the fusion of perianths of flower a composite fruit is formed.

In mulberry perianth become fleshy and calyx of every flower becomes thick, sweet and fleshy and are edible.

**Syconus** : This fruit develops from hypanthodium inflorescence. eg. **Ficus** species like fig, Peepal



**Geocarpic fruit** : When fruit development occurs inside soil e.g. **ground nut**

### ✓ DISPERSAL OF FRUITS AND SEED ::

The seeds falling directly under the mother plant have to germinate and develop under limited food supply and space. To overcome this problem, the fruits and seeds have developed several special devices for wide dispersal.

The natural agents like wind, water, animals and even mechanism of dehiscence in some fruits, help the seeds and fruits to disperse from one place to another, and to long distances from the parent plant.

#### **WIND (Anemochory) :**

In the species where the seeds are light in weight or have some accessory part to help dissemination, are dispersed by the air current.

The seeds of Drum-stick and Cinchona, and fruits of yam, maple and sal tree, are having appendages in the form of thin, flat and membranous wings, which help them to float in the air and be carried away to long distances.

In the members of Asteraceae, the calyx is modified into hair like structures called pappus. They persist in fruit and open out like umbrella, helping the seeds to float in the air.

In poppy and prickly poppy (Argemone), the fruit dehisces and seeds are thrown out to a distance away from the parent plant. (Censor mechanism)

The seeds of Calotropis, Alstonia and cotton are provided with hair and cover sufficient distances along with the wind.

The seeds of orchids and some grasses are very small and light in weight and may be easily carried away by wind to far off places.

In fruits of physalis swollen persistent calyx is present and fruit can easily be carried out by air.

Some plants like chenopodium, amaranthus etc. are uprooted after drying and carried away by wind and seeds are dispersed distantly. These plants are known as tumbler weed.



On aerial parts of *Equisetum* and members of grass family silica or silicon oxide is found which protect them from grazing animal.

On epidermis of some plants wax, oil, resin crystallized salts, silica, lignified substances etc. are deposited.

In woody plants periderm is present which is a secondary epidermal tissue and is formed by activity of the phellogen. Here the cork is a protective layer.

Bark is the tertiary epidermal tissue found in woody plants. Its main function is to protect the internal tissues from mechanical injury.

### **Trichomes, Hairs and spines :**

Leafy epidermal hairs regulate atmospheric humidity,

Covering hairs protect plants from disease causing insects

Glandular epidermal hairs secrete some chemical substances to protect them from animals.

Stinging hairs pierce the skin of animals and secrete poisonous substances which cause irritation and protect the plants from animals. eg. *Urtica diocea*.

Spiny stipules and spines found in xerophytes protect these plants from grazing animals. eg. *Zizypus*, *Acacia*.

Spines of *Euphorbia* act as defensive devices against grazing animals.

Prickles of *Capparis*, *Bombax* and rose and needle like hairs of cacti save these plants from animals.

### **Laticiferous glands or Ducts :**

Woody plants of arid and semi arid areas secrete a white milky fluid which is called latex.

It is a viscous fluid which contains various substances like water, hydrocarbons, resins, oils, proteins, acids, salts, sugars and rubber in suspended form. It is found in members of family Moraceae, Euphorbiaceae, Apocyanaceae etc. Latex help in protection of these plants from animals. The latex secreted by plants of *Calotropis* is poisonous.

### **Secretory glands or cells :**

They are filled with different types of excretory or secretory substances such as oils, tannins, gums, mucilage and different type crystals

Smell of oily substances secreted by oil glands present in the leaves and bark of **Eucalyptus** and pericarp of lemon fruit protect these plants from animals.

### **Taste of different plant parts :**

Aerial parts like fruits, seeds leaves, branches and bark of some plants contain different type of alkaloids or excretory substances which are repulsive or bitter in taste and are disliked by animals e.g. *Azadirachta indica*, *Momordica charantia*, *Trigonella*, *Ocimum sanctum*, *Datura stramonium*, *Papaver somniferum*, *Mentha arvensis*, *Nicotiana tabacum*, *Carica papaya*, *Cinchona officinalie* etc.

## Underground plants :

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In some plants, plant parts remain under the soil i.e. out of reach of grazing animals e.g. underground modified roots of radish (*Raphanus sativus*), carrot (*Daucus carota*), turnip (*Brassica rapa*), chukandar (*Beta vulgaris*), heeng (*Ferula asafoetida*) etc. underground modified stems of potato (*Solanum tuberosum*), arbi (*Colocasia antiquorum*), onion (*Allium cepa*), garlic (*Allium sativum*), ginger (*Zingiber officinale*), turmeric (*Cucrcuma domestica*) etc. and underground fruits of ground nut (*Arachis hypogea*).

## Myrmecophily :

Gauva (*Psidium guajava*), mango (*Mangifera indica*), litchi (*Litchi chinensis*), mulberry (*Morus alba*) etc. secrete some substances which attracts some ants. These ants take their abode on these plants and act as bodyguards against any animal attack. This relationship is called myrmecophily.

## Colour, shape and structure of plants :

Certain plants strikingly resemble some dreaded animals so that they are carefully avoided by other animals. This is known as mimicry e.g. plants of *Caladium* and *Sensviria* resemble spotted serpents.

## Some fruit & their edible part :

S.No.	Fruit	Type of fruit	Edible part
(i)	<i>Abelmoschus esculentus</i> /Lady's Finger	Capsule	Whole fruit (vegetable)
(ii)	<i>Achrus sapota</i> /Cheeku	Berry	Mesocarp and endocarp
(iii)	<i>Aegle marmelos</i> /Wood Apple	Amphisarca	Pulpy endocarp (inner pericarp) and placentae.
(iv)	<i>Anacardium occidentale</i> /Cashewnut	Nut	Cotyledons and Peduncle
(v)	<i>Ananas comosus</i> = Pineapple	Sorosis	Outer fleshy axis, bracts fused perianth & Pericarp
(vi)	<i>Annona squamosa</i> /Custard Apple	Etario of Berries	Mesocarp (Pericarp)
(vii)	<i>Arachis hypogea</i> /Ground nut/Peanut	Lomentum	Seeds/Cotyledons
(viii)	<i>Areca catechu</i> /Betel or Areca Nut	Berry	Seed/Endosperm
(ix)	<i>Artocarpus integrifolia</i> /Jack Fruit	Sorosis	Bracts, perianth and seeds
(x)	<i>Carica papaya</i> /Papaya	Berry	Mesocarp and Endocarp



(xi)	Cereals, <i>Avena sterilis</i> (Oat), <i>Oryza sativa</i> (Rice), <i>Hordeum vulgare</i> (Barley), <i>Triticum durum</i> (Durum Wheat), <i>Triticum aestivum</i> (Bread Wheat), <i>Zea mays</i> (Maize)	Caryopsis	Whole fruit
(xii)	<i>Citrus reticulata</i> /Orange, <i>Citrus sinensis</i> /Sweet Orange, <i>Citrus aurantifolia</i> /Lime	Hesperidium	Glandular hair
(xiii)	<i>Cocos nucifera</i> /Coconut	Drupe	Endosperm
(xiv)	<i>Cucumis melo</i> /Musk Melon	Pepo	Mesocarp, Endocarp & seeds
(xv)	<i>Cucumis vulgaris</i> /Water melon	Pepo	Mesocarp, Endocarp & seeds
(xvi)	<i>Cucumis sativus</i> /Cucumber	Pepo	Mesocarp, Endocarp and Young seed
(xvii)	<i>Ficus carica</i> /Fig/Anjeer	Syconus	Fleshy receptacle
(xviii)	<i>Fragaria vesca</i> /Strawberry	Etaerio of achenes	Fleshy thalamus
(xix)	<i>Grewia asiatica</i> /Dhamin/Phalsa	Drupe	Mesocarp
(xx)	<i>Juglans regia</i> /Walnut	Drupe	Lobed cotyledons
(xxi)	<i>Litchi chinensis</i> /Litchi	Nut	Aril
(xxii)	<i>Lycopersicon esculentum</i> /Tomato	Berry	Pericarp and placenta
(xxiii)	<i>Pyrus malus</i> (M. sylvestris)/Apple	Pome	Thalamus
(xxiv)	<i>Mangifera indica</i> /Mango	Drupe	Mesocarp
(xxv)	<i>Morus alba</i> , <i>M. nigra</i> /Mulberry	Sorosis	Fleshy perianth, Fleshy axis
(xxvi)	<i>Phoenix dactylifera</i> /Date	Berry	Pericarp
(xxvii)	<i>Prunus amygdalus</i> /Almond	Drupe	Seed (Cotyledons and embryo)
(xxviii)	<i>Musa paradisiaca</i> /Banana	Berry	Less developed Mesocarp and well developed endocarp
(xxix)	<i>Psidium guajava</i> /Guava	Berry	Thalamus, pericarp and placenta



(xxx)	Pulses	Pod/Legume	Seed
(xxxix)	<i>Punica granatum</i> , Pomegranate/Anar	Balausta	Testa
(xxxixii)	<i>Pyrus comunis</i> /Pear	Pome	Fleshy thalamus
(xxxixiii)	<i>Solanum melongena</i> /Brinjal	Berry	Pericarp & Placenta
(xxxixiv)	<i>Tamarindus indica</i> /Tamarind	Lomentum	Pericarp (Mesocarp)
(xxxixv)	<i>Trapa bispinosa</i> /Water Chestnut/Singhara	Nut	Seed
(xxxixvi)	<i>Vitis vinifera</i> /Grape	Berry	Pericarp and placenta
(xxxixvii)	<i>Zizyphus mauritiana</i> /Jujube/ Chinese Dates/Ber	Drupe	Epicarp and mesocarp

### ✓ MORPHOLOGY OF ANGIOSPERM (Point to be remembered always) ::

Arrangement of flowers on peduncle and study of flowers is called **Anthology**.

**National flower** of India is **Lotus** (*Nelumbo nucifera*)

**Longest styles** are found in **maize**.

**Longest inflorescence** is in **Agave** (12m),

In **Mussanda**, One (odd) sepal is enlarged to form a leafy structure called **Advertisement Flag**.

**National fruit** of India is **Mango** (*Mangifera Indica*)

**Largest fruit** and **largest seed** is of *Lodoicea maldivica* (double coconut, weight is 18 Kgs.)

**False nuts** are **Coconut** (drupe), **Areca nut** (Berry), **Pea nut or Ground nut** (Lomentum), **Walnut** (drupe) and **Chilgoza** (seed)

Dispersal of fruits and seeds by ants is called **myrmechory** eg. *Ulex* and *Trillium* (seeds).

*Monophyllea* is a plant with **single leaf**.

*Welwitschia* (a gymnosperm) is a plant with **two leaves** throughout the life.

*Victoria regia* has **broadest** leaves each with a diameter of 1.5–1.8m.

Leaves are **longest** in *Raphia vinifera* (10–15m)

Small protein rich glands called *Belt's corpuscles* are present at the tip of leaflets in *Acacia sphaerocephola*.

In *Musca* the suckers are called **sword suckers**.

In **knol-khol** (Ganth Gobhi) the entire stem becomes tuberous.

**Largest bud** is cabbage.

**Pseudostem** is a trunk formed by leaf bases in Banana.

A plant with reduced stem is called as **Acaulescent**.

*Ulex* possesses both **stem thorns** as well as **leaf spines**.

Shrubby climbers which climb with the help of hooks are called **Stragglers** eg. *Bougainvillea*, *Artobotrys*.

**Marine** angiosperm is *Zostera*.

**Pseudobulb** is swollen part of stem in orchids for storing water and food reserve.

Annuals and biennials are **monocarpic**. The perennials are **polycarpic** as they bear fruits every year. Some perennial plants such as *Agave*, Bamboo are **monocarpic** as they flower and fruit only once in their **life** after a long period of vegetative growth.

**Smallest** angiosperm is *Wolffia* (less than 0.1 mm) and **largest** or **tallest** angiosperm is *Eucalyptus regnans* (height more than 114 m or 375 ft)

Plants with **roots only** are *podostemon*, *Arceuthobium*, *Rafflesia* and *Sapria*.

Hypocotyl develops into a large tuber in *Myrmecodia enchinata* family Rubiaceae. In the cavities of tuber many ant live. So it is an example of **myrmecophily**.

Gynostagium : It is formed due to the fusion of crowned stamens with the carpels. It forms a protective covering around the carpels, thus protects the gynoecium. Presence of Gynostagium is the characteristic feature of family Asclepediaceae.

Maize (*Zea mays*) has largest stigma and style.

The sterile pistil is called pistalloide.

State tree of Rajasthan → *Prosopis cineraria*.

State flower of Rajasthan → Rohira (*Tecomela undulate*)

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