PERIYAR ARTS COLLEGE, CUDDALORE -1

PG & RESEARCH DEPARTMENT OF BOTANY

AFFILIATED TO THIRUVALLUVAR UNIVERSITY

STUDY MATERIAL

COURSE:	**III B.Sc BOTANY**	**YEAR:2020-2021**	**SEMESTER-V**
SUBJECT PAPER	**MORPHOLOGY AND EMBRYOLOGY OF ANGIOSPERMS**		**PAPER CODE BBO51**
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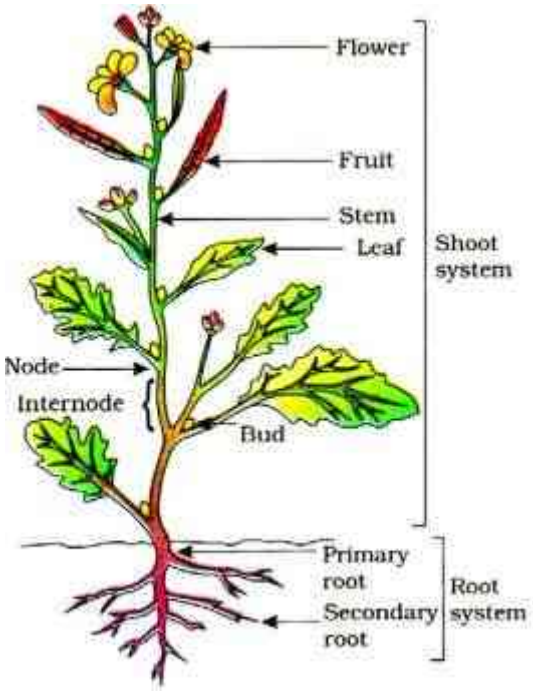
DESIGNATION	**Assistant Professor**		

UNIT I	Morphology – Root System, Modification of Roots, Shoot System, Modification of Stem, The leaf – Structure of a Leaf, Stipules, Phyllotaxy, Leaf shape, leaf margin, leaf apex, leaf surface, leaf texture, leaf venation, types of leaves, modification of leaves. Buds. Prefoliation, Vernation.
UNIT II	Inflorescence – Types of inflorescence, Flower parts, symmetry, form, position of the ovary, perianth, calyx, corolla, forms of corolla, Aestivation. Androeciuam – attachment of anthers, dehiscence of anthers, union of Stamens, length of stamens, nature of Stamens and Pollen.
UNIT III	Gynoecium – Types, fusion of carpels, Placentation, Ovule types. Types of Pollination. Fruits types, Dispersal of Fruits and seeds.

UNIT-I
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.

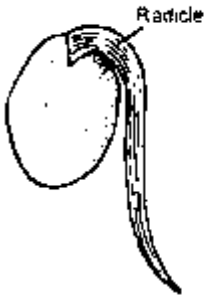
✔ TYPES OF ROOTS

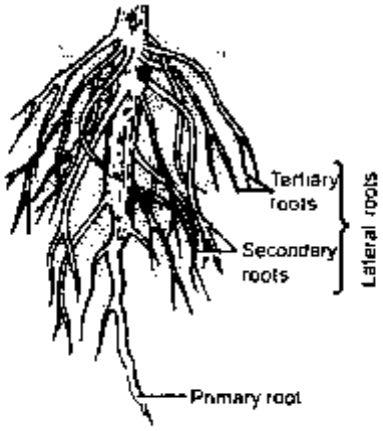
Roots are of two types :

✧ 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.





Tap root system

Adventitious root
Fibrous root system

✔ REGIONS OF ROOTS

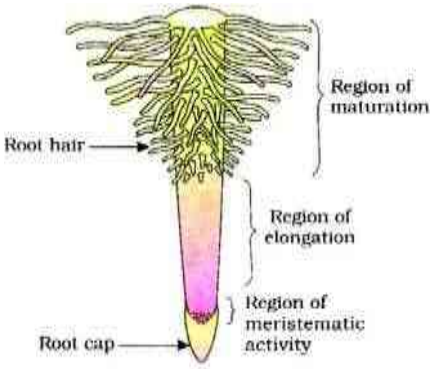
Morphologically four distinct regions are present in roots.

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.



The regions of the root-tip

✔MODIFICATION OF ROOTS

1. **Modified tap root for storage :**

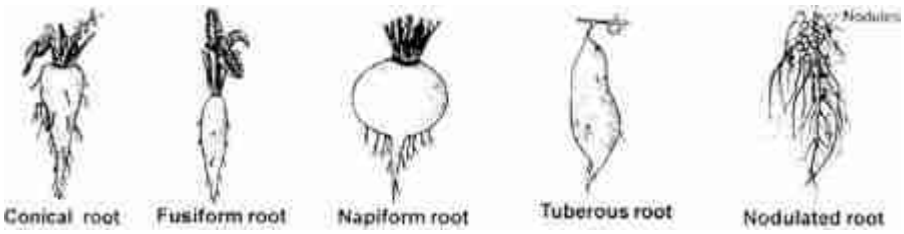
   Fusiform roots : These root are thicker in the middle and tappered on both ends. In this type of roots both hypocotyl and root help in storage of food. **eg. Radish**.

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

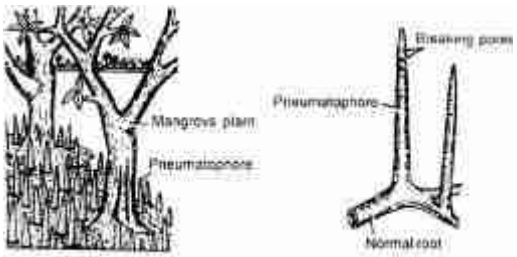
   Napiform : These roots become swollen and spherical at upper end and tappered like a thread at their lower end. **eg. Turnip (*Brassica rapa*), Sugarbeet**

   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, Sonaratia* and other mangrove plant.**

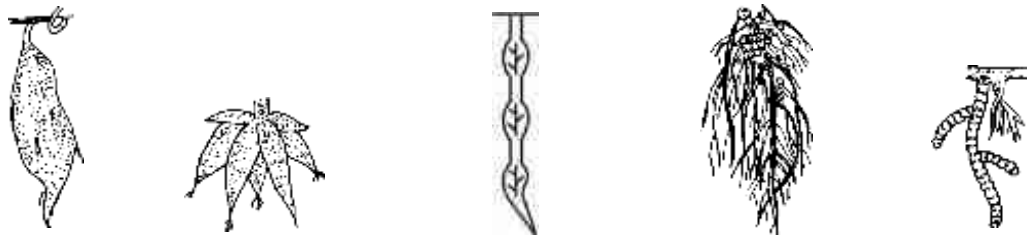


Respiratory roots (Pneumatophores) of Rhizophora

Modification of adventitious roots :

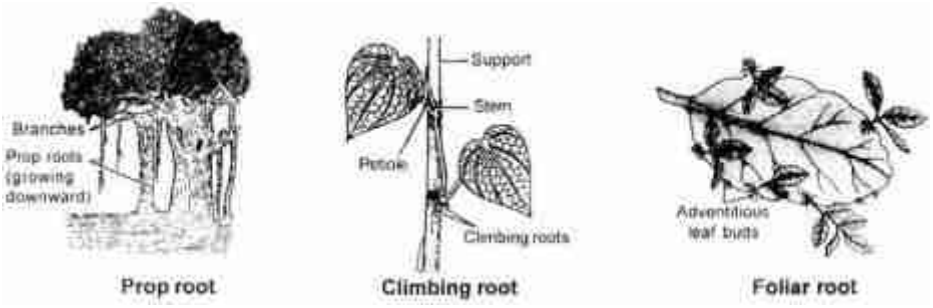
1. **Storage adventitious roots**

- ✧ **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* (screwpine)**
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***).

✔ TYPES & MODIFICATION OF STEM

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.
- **Tendril 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 :

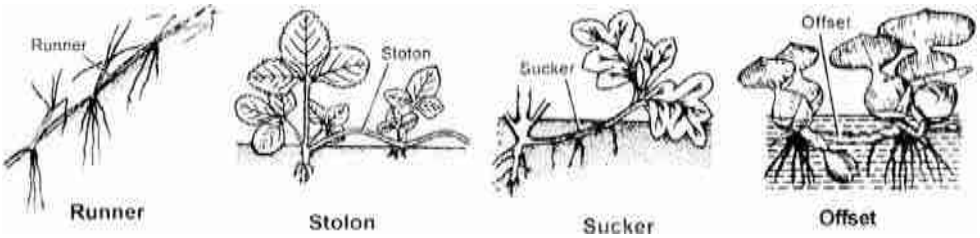
Runner – When stem grows and spread on the surface of soil. Roots are developed at lower side and leaves from upper side from node eg. ***Cynodon dactylon*** **(Doob grass),** ***Oxalis*****.**

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 rossette of leaves and tuft of roots at base. eg. ***Pistia, Eichhornea.***

These modification are also involved in vegetative reproduction.



Underground modification :

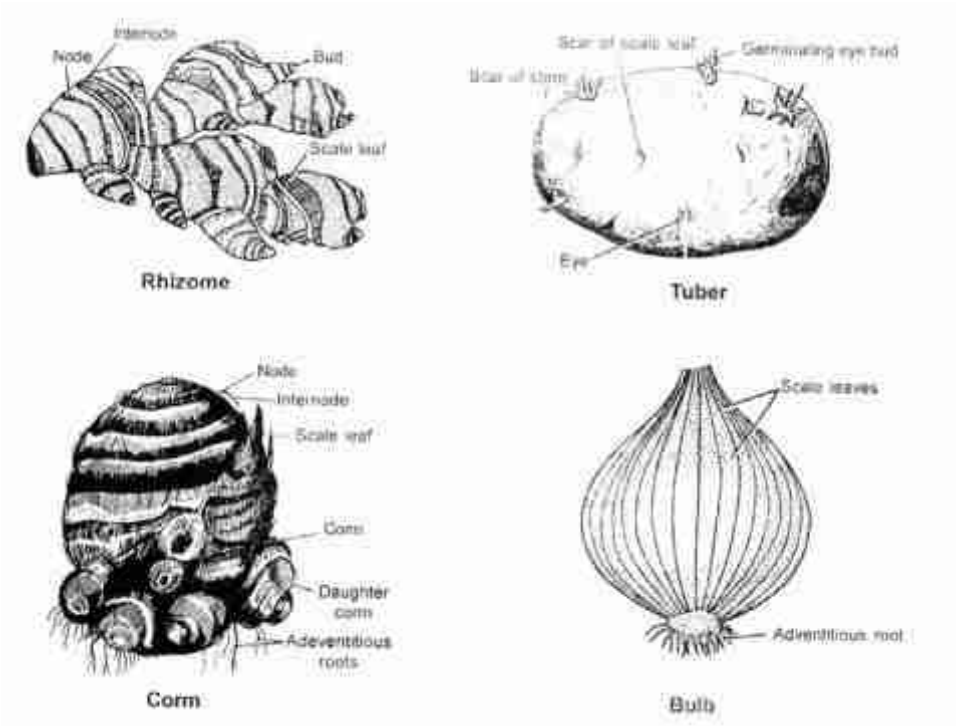
This type of modification occurs generally for food storage and vegetative propagation.

Tuber – The tips of underground branches become swollen in the soil. Eyes are found on then 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 fleshly scaly leaves. Many roots arise from its base. Food is stored in flashy leaves. They show apical growth eg. Onion, Garlic.

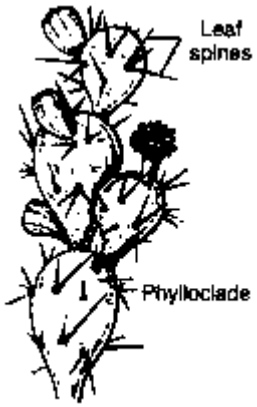


Special stem modification :

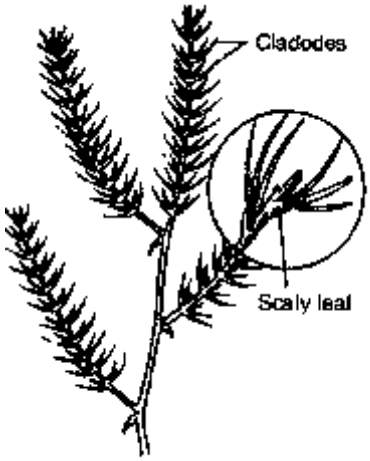
Phylloclade – It is green photosynthetic flattened or rounded succulent stem with leaves either feebly developed or modified into spines e.g., ***Opuntia, Casuarina***, ***Euphorbia, Cactus***.

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***.



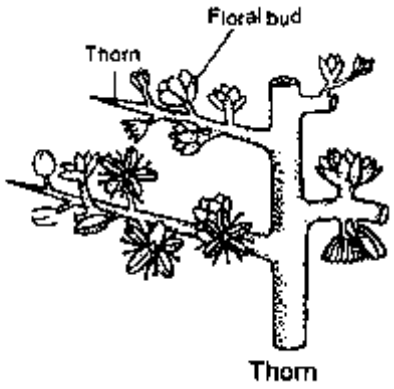
Phylloclade of *Opunita*



Cladode of *Asperagus*

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) –

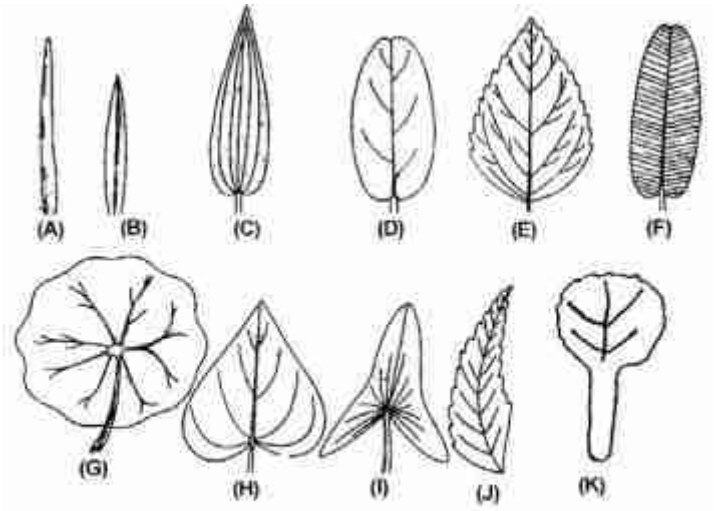
✧ The part of leaf connecting the lamina with the branch of stem. Petiole help to hold the blade to light.

- ✧ 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.

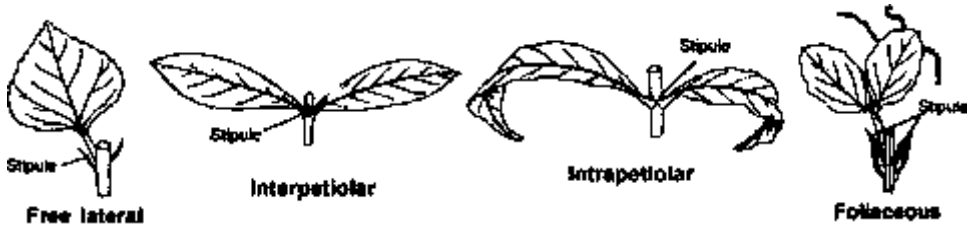
Stipules are of various types –

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

Interpetioler – 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.***

Intrapetioler – 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***

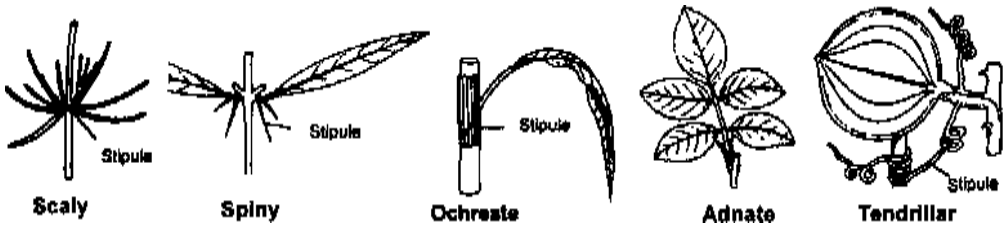
Spiny – Stipules modified into spine. eg. ***Zizyphus*** (Beri), ***Acacia***.

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**

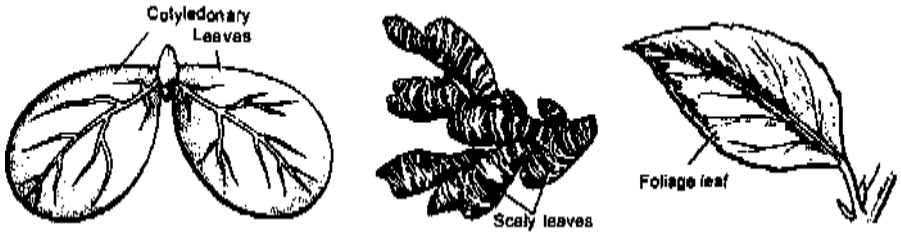


✔ TYPES OF LEAVES

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

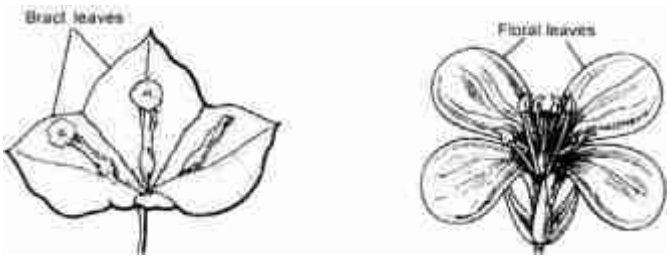


Bract (Hypsophyll) – Bract are the leaves which is present in flower axis.

Bracteole – These are leaf like structure found on pedical.

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 diverage from one another in middle part and converge towards the apex of leaf. eg. Camphor, ***Zizyphus***, Tejpat, Chinarose, plum.

Parallel venation :

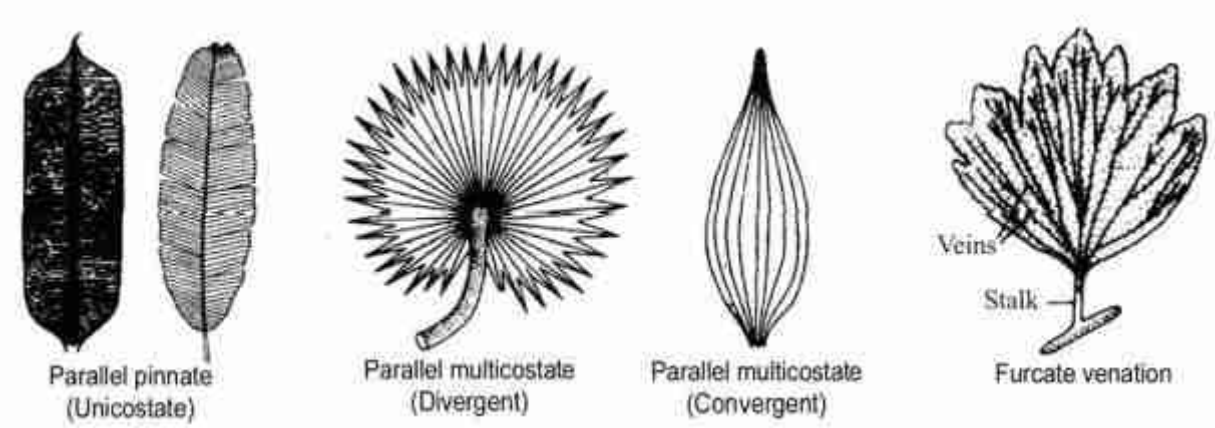
In this type of venation, all veins run parallel to each other and they do not from network. They are of 2 types.

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 donot 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 donot divide into veinlets and do not form 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, Chinarose, 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.

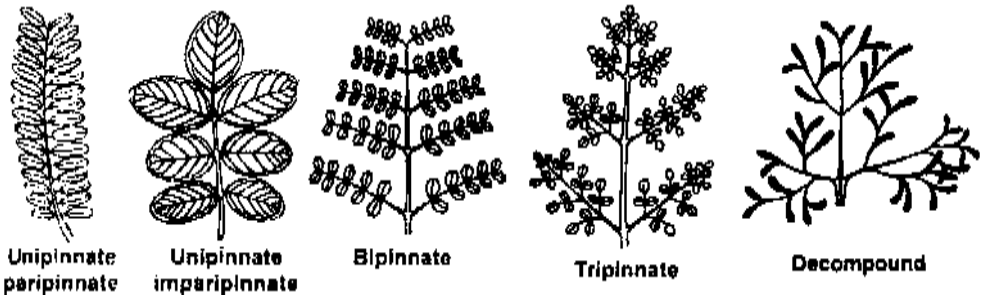
It is of two types –

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.

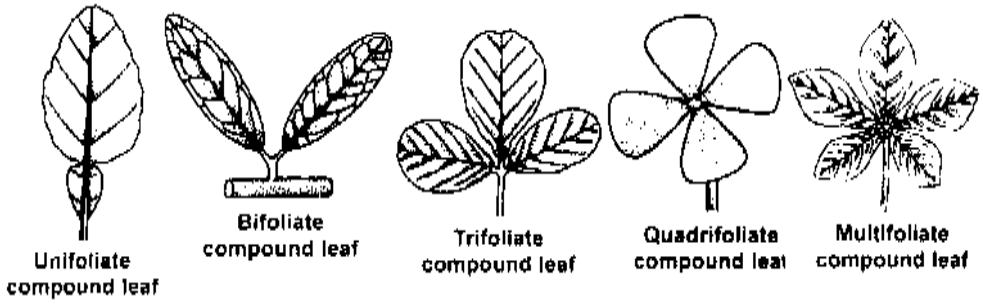
- ✧ If the number of leaflet is even, then leaf is known as paripinnate. eg. ***Cassia fistula, Sesbania***
- ✧ If the number of leaflet is odd, it is known as imparipinnate. eg. **Rose, Neem.**
- ✧ **Bipinnate –** A twice pinnate compound leaf eg. ***Acacia,* Gulmohar*, Mimosa*.**
- ✧ **Tripinnate –**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

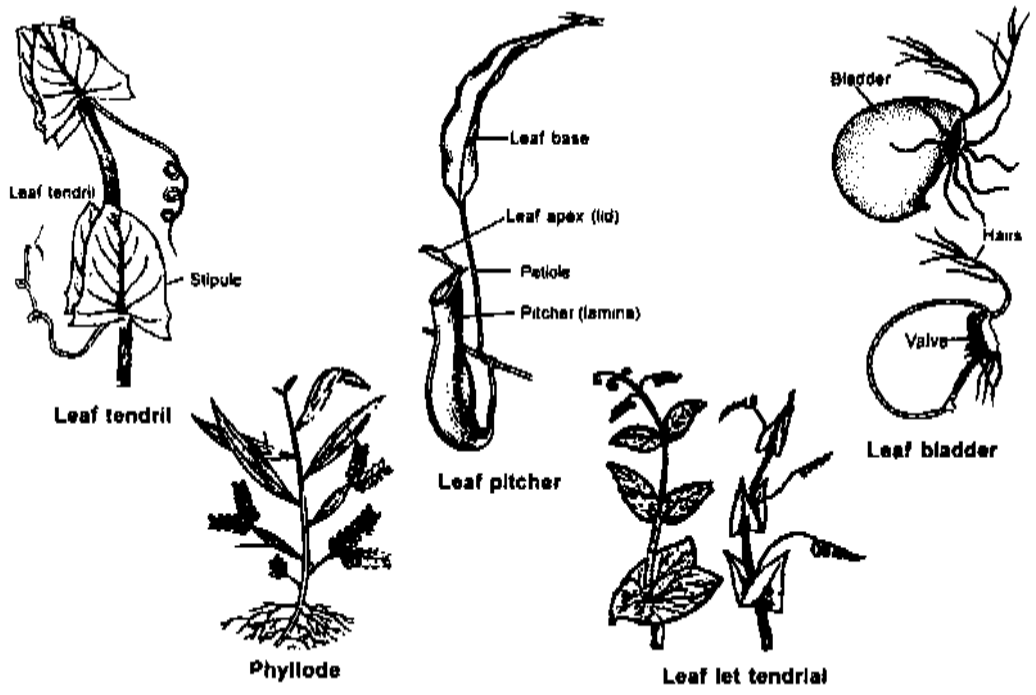
Leaf pitcher – Leaves of some plants are modified to pitcher shape. eg. ***Nepenthes, Dischidia.***

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 flashy leaves are present.



UNIT-II

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 inflorescene 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,***

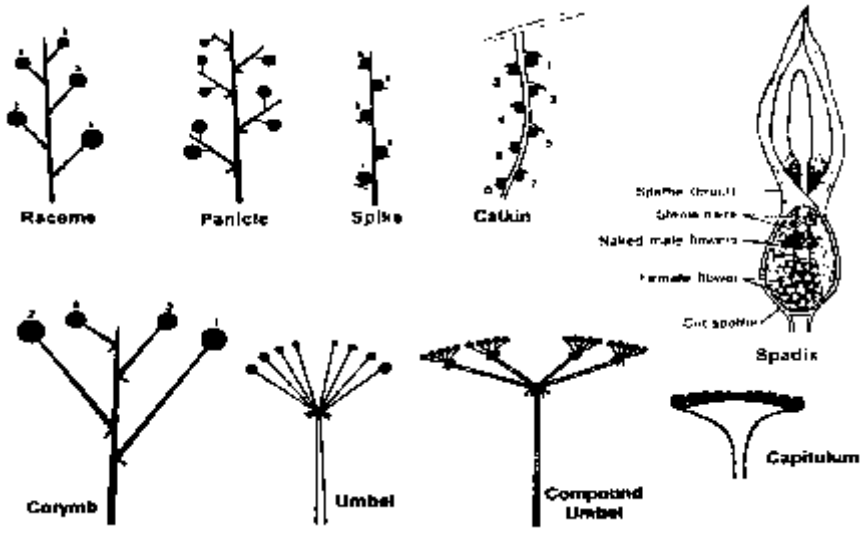
Cuminum. Characteristic feature of

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.***

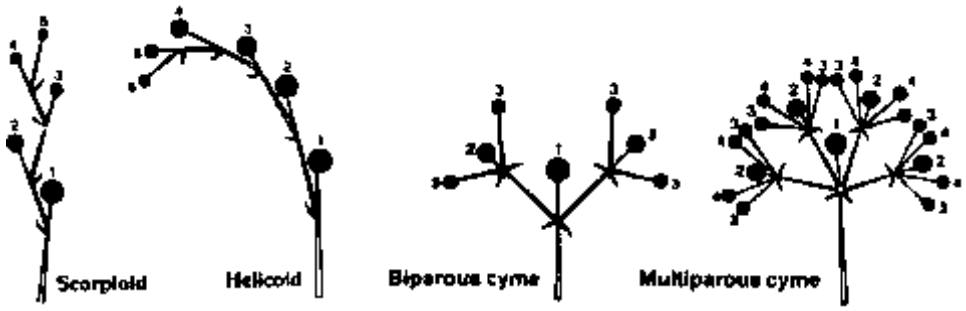
Scorpioid cyme – In it the lateral branch is alternately develop on left and right side. eg. ***Bignonia***,

Riphidium – 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***.



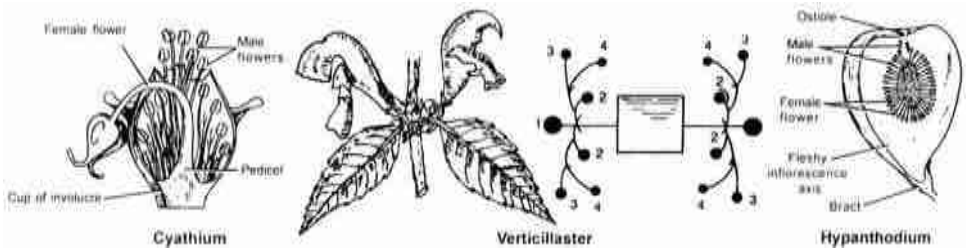
✔ SPECIAL TYPE OF INFLORESCENCE

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.

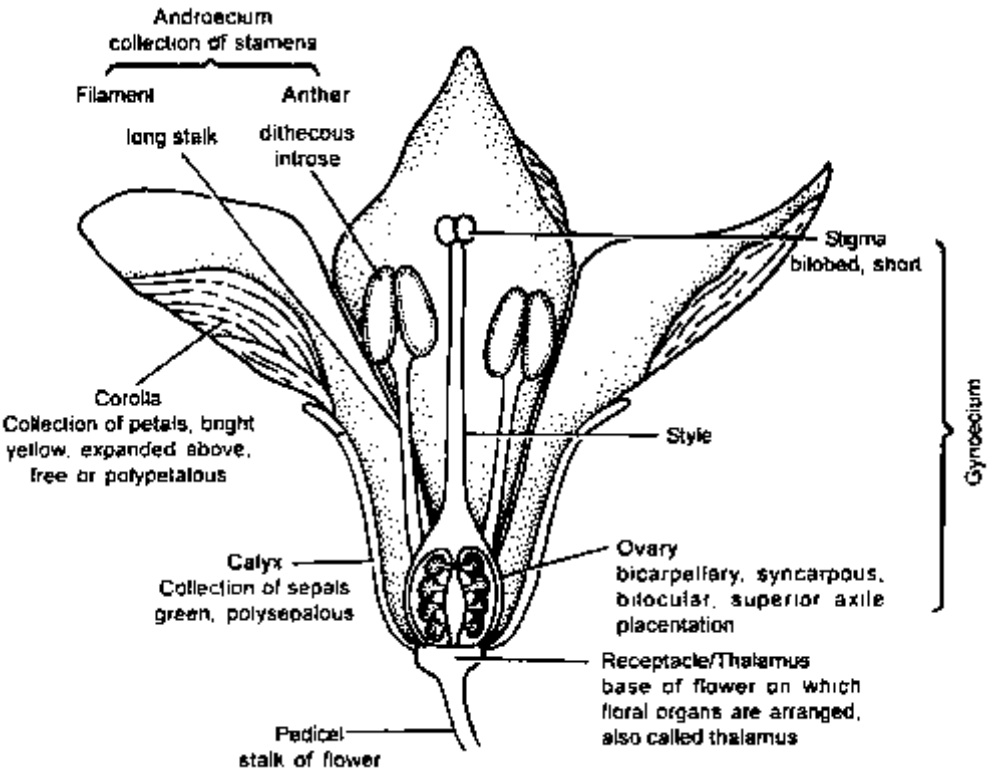
FLOWER

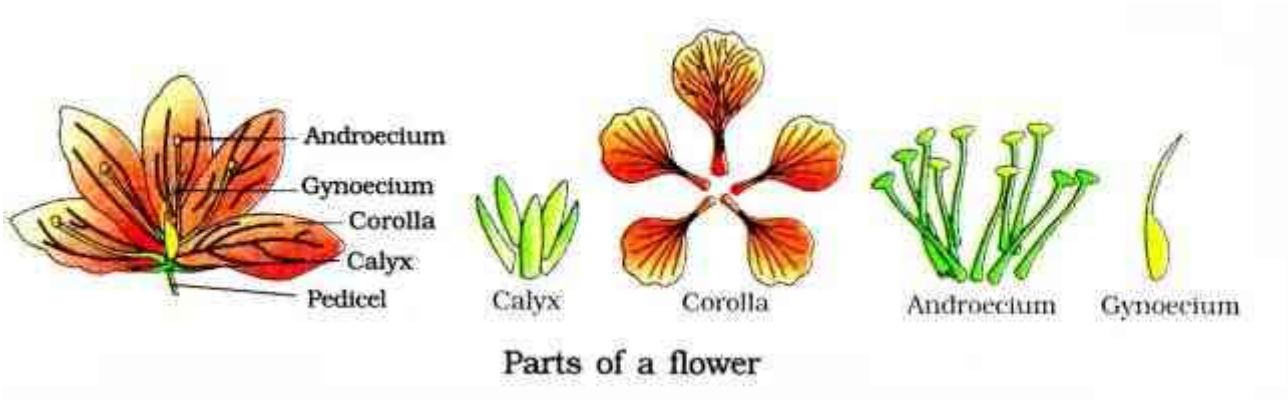
Flower is defined as highly condensed and modified reproductive shoot. The part from where flower arise is called bract. Flower has short or long flower stalk which is called pedicel. The upper part of pedicel is swollen, spherical shaped or conical which is called thalamus / Receptacle.

Floral leaves are present on it.

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

✧ Sepal ✧ Petal ✧ Stamen ✧ Carpel





Parts of a flower

✔ 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. ***Silane***

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**

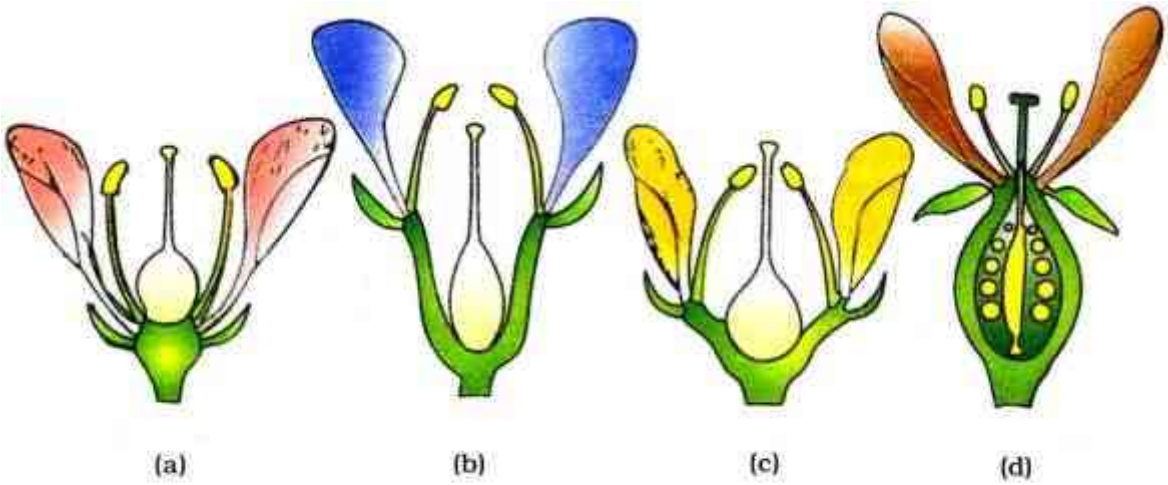
Note : - Part of flower which lies near to mother axis is posterior part while the part which is far from mother axis is anterior part of flower.

✔ 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, Chinarose, 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

Persistant – 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

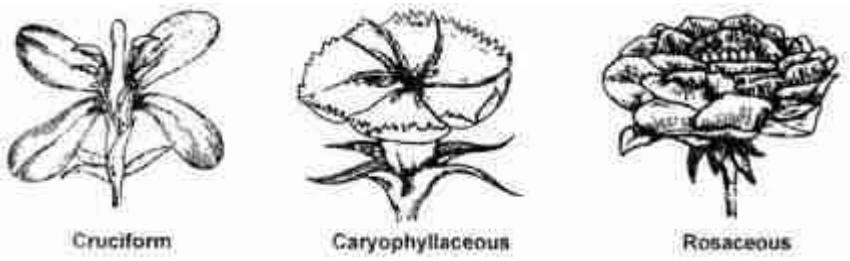
The second whorl of flower is called corolla and each member of it is called Petals. When the shape and size of petals are similar then it is called symmetrical while when they are not similar then they are asymmetrical. When all the petals are free, then it is called polypetalous while when petals are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

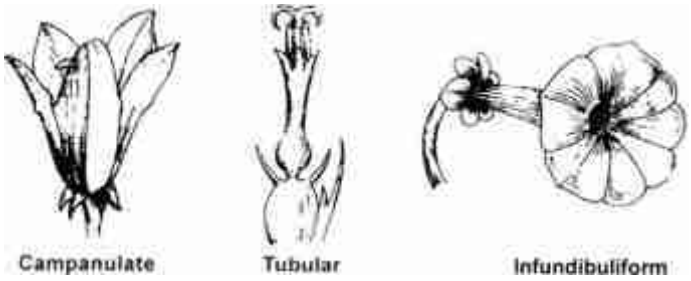


GAMOPETALOUS

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**.



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**

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**.

AESTIVATION -

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

Valvate – When the petal of a whorl lie adjacent to each other petal and just touches 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, Chinarose

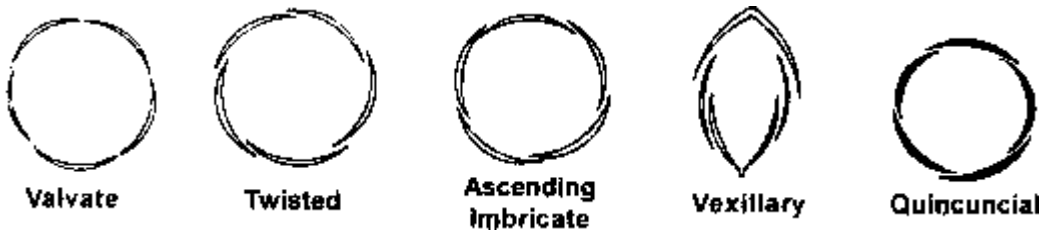
Imbricate – When both margin of the one petal are covered by the others two petals and both margin of another one, covers other, Rest are arranged in twisted manner.

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 consist 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 :

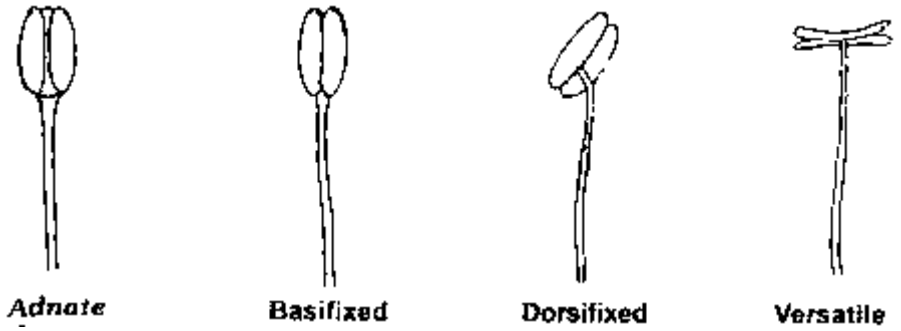
The attachment of filament to another lobe is of 4 type -

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 –

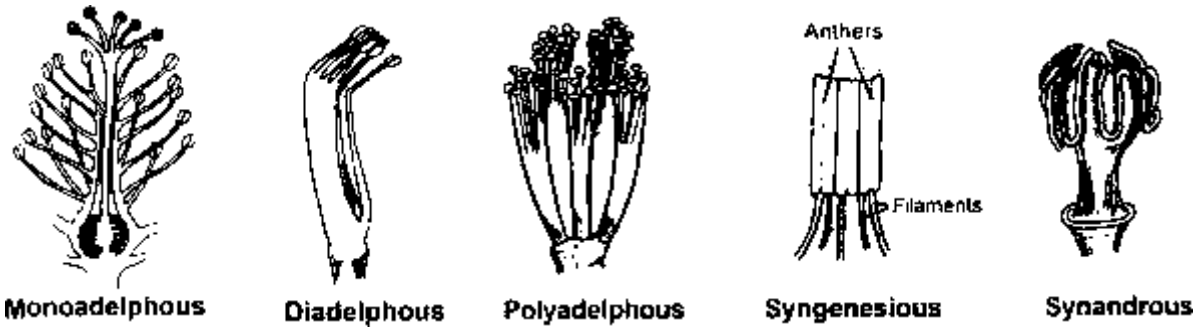
- ✧ **Monoadelphous** – When all the filaments are united into a single bundle but anthers are free from each other. In this type of cohesion a tube is formed around the gynoecium which is called staminal tube eg. Cotton, Hollyhock, Ladyfinger.
- ✧ **Diadelphous –** When the filaments are united in two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

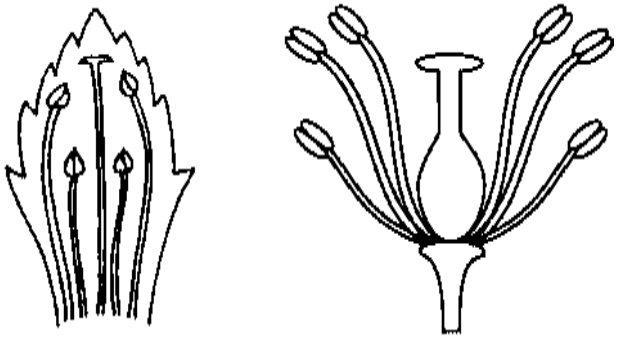
Epiphyllous – When stamens are attached to tepals. eg. Onion, Lily.

Gynandrous – When stamens are attached to gynonecium 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 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***.

Androecium

The androecium is the third set of floral organs composed of stamens or micro- sporophylls. Ordinarily, each stamen is composed of a slender stalk-like filament supporting a knob-like spore case or the anther .

Each anther consists of two lobes (anther lobes) connected by a connective which can be clearly seen on the dorsal side as an extension of the filament. Each anther lobe, again, has two pollen sacs or pollen

chambers placed longitudinally. There are longitudinal grooves or sutures along the ventral face of the anther demarcating the pollen chambers. Each pollen chamber re-presents a microsporangiur and contains innumerable microspores or pollens.

The stamen, therefore, is a microsporophyll bearing four microsporangia. While this is the normal case, there are some flowers where the anther possesses only two pollen chambers (i.e., bisporangiate) and in Malvaceae even these two pollen chambers fuse developing a mature unilocular anther.

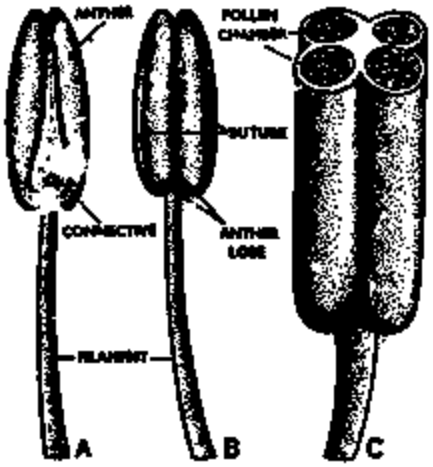


Fig. 336. Stamen showing parts. A. Dorsal view. B. Ventral view. C. Enlarged portion showing t.. of anther.

Filament:

In rare cases a stamen may be devoid of a filament or sessile as seen in the stamens of Arum maculatum . On the other extreme, a stamen may not develop any fertile anther when it is sterile and termed a staminode as seen in Cassia and Canna .

The filament may be white or coloured yellow, blue, black, etc., like petals. While the filament is ordinarily simple, in Ricinus communis it is found to be branched. When filaments are very long, stamens protrude out of the flower and are term-ed exserted. On the contrary, when stamens remain within the flower; they are termed inserted.

Connective:

Ordinarily, the connective is a patch of tissues connecting the two parallel anther lobes .It is a prolongation of the filament and contains the conducting strands.

The connective, however, may be (1) extremely small or altogether wanting as in some species of Euphorbia and in Adhatoda zeylanica (Acanthaceae) where the anther lobes are very close together. This condition is termed discrete.

(2) In the lime tree (Tilia) and in fusticia gendarussa (Acanthaceae) the connective is called divaricate as it develops in such a way that the two anther lobes are separated from one another.

(3) In Salvia (Labiatae) a pet liar condition called distractile is noticed where the connective is a long stalk-like body placed crosswise on the filament separating the two anther lobes.

Anther:

All Angiospermous anthers are bilobed and quadrilocular (i.e., formed of four micro- sporangia) at an early stage of development and this condition is seen in most mature stamens.

Rarely, however, the anther becomes unilocular or one-chambered either by the abortion of one lobe and destruction of the portion wall between the two chambers or the destruction of the entire partition tissue separating the four chambers.

This condition is seen in the family Malvaceae . The grooved ventral side of an anther usually faces the gynoecium or the centre of the flower and this condition is known as introrse; but, in a few cases as in Gloriosa superba, Iris, Colchicum, etc., the anther faces the petals when the condition is called extrorse.

Anthers may be linear (Acalypha), rounded (Mercurialis), sagittate (Vinca), sinuous (peculiar -shaped appearance as seen in the cucurbits), reniform (china-rose), etc. The anther also may be appendiculate like the connective as may be seen in Erica cinerea of Ericaceae

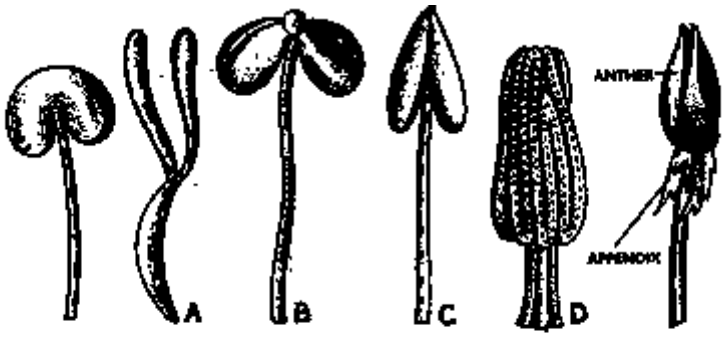


Fig. 347 Fig. 348 Fig. 349

Anther. Fig. 347. Unilocular and reniform in *Hibiscus rosa-sinensis*.- Fig. 348. A. Linear in *Acalypha*. B. Rounded in *Mercurialis*. C. Sagittate in *Vinca*. D. Sinuous in *Cucurbita maxima*. Fig 349. Appendiculate in *Erica cinerea*.

Attachment of the Anther to the Filament:

The mode of attachment of the anther to the filament varies . (1) It is adnate when the filament or its continuation, the connective, appears to be attached throughout the whole length of the back of the anther as seen in magnolia and water-lily.

(2) In mustard, Carex and other members of Cyperaceae, etc., the filament ends just at the base of the anther, the latter being firmly fixed on the top of the former. This condition is called basifixed or innate.

(3) The attach-ment is dorsifixed when the filament is firmly fixed to some position on the back of the an-ther as in passion-flower, Sesbania, etc.

(4) In most grasses and in many lilies the attachment is versatile where the filament, is attached merely at a point about the middle of the connective so that the anther can swing on it freely.

Dehiscence of Anthers:

When the anthers become ripe they burst discharging the dry pollens. This act is called dehiscence and the time when this takes place is called anthesis.

Dehiscence may be of different types:

(1) Longitudinal—this is the common type of dehiscence when the anther lobes burst along the longitudinal sutures (i.e., the lines of fusion of the two pollen chambers in the two anther lobes) as may be seen in Datura, etc.;

(2) Transverse —seen in some unilocular anthers as those of Malvaceae (it appears to be transverse as the suture .is placed that way); (3) Porous or apical—-the discharge of pollens is through apical processes seen in potato, brinjal, etc.;

(4) Valvular—when the whole or portions of the wall of the anther Open out like trap-doors releasing the pollens as seen in Berberis, Laurus, Cinnatnomum, etc.

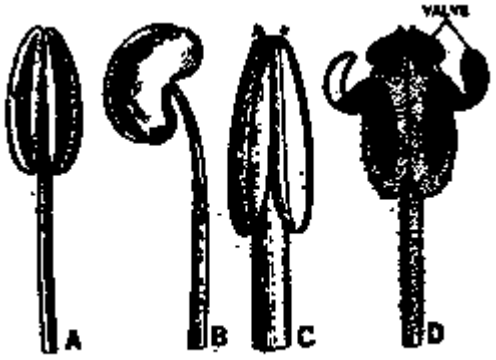


Fig. 351. Dehiscence of anthers. A. Longitudinal. B. Transverse. C. Porous. D. Valvular in *Laurus* sp.

Number and Insertion of Stamens:

A flower may be monandrous (Poinsettia), diandrous (Acanthaceae), triandrous (many monocots), tetrandrous (Labiatae), pentaindrous (most dicots), hexandrous (rice, bamboo, etc.) or polyandrous (Rosaceae) according as the usual number of stamens in the flower is 1, 2, 3, 4, 5, 6 or many. The number of stamens, however, may sometimes vary as discussed later.

When the stamens form a single whorl and the number of stamens is the same as that of the sepals and petals, the flower is isostemonous. In such a flower the stamens alternate with the petals, i.e.; they are antisepalous.

Occasionally, however, such stamens may be antipetalous as found in different members of Rhamnaceae, Portulacaceae, etc. Sometimes there are two whorls of stamens, the first whorl alternating with petals (antisepalous) and the second whorl alternating with sepals (antipetalous).

Union of Stamens:

Union of stamens may involve adhesion (union with other members, viz., petals, perianth leaves or gynoecium) or cohesion, i.e., among the stamens themselves.

When stamens adhere, to petals they are termed epipetalous—a condition found in many flowers. When the adherence is to perianth leaves, the condition is termed epiphyllous as seen in the tube-rose.

Another inteiesting adhesion is between stamens and carpels (gynandrous condidon) as seen in the gynostegiom of Asclepia- daceae and the gynostemium of Orchidaceae .

Cohesion usually involves either only the filaments (adelphy) or only the anthers (syngeny). In adelphy, all the stamens may unite by their filaments forming one bundle of stamens with all the anthers free.

This is the monadelphous condition. In the family Malvaceae and in many other flowers the united filamen's form a staminal lube through which the long style of the pistil passes.

Oxalis (Oxalidaceae) also show's a simi-lar staminal tube in which the few stamens are clearly unequal . In unisexual female flowers of Jatropha (Euphorbiaceac), the filaments unite to form a central column.

Diadelphy (two bundles) is very commonly seen in Papilionaceous flowers where rine stamens form one bundle and the tenth remains free as the second bundle .

In the silk-cotton tree (Salmalia or Bombax ceiba) the stamens form several separate groups with the filaments uniting to form several bundles or fascicles giving rise to the polyadelphous condition.

This is often seen in the families Guttiferae, Tilia- ceae, Bombacaceae, Rutaceae (e.g., orange), Myrtaceae (e.g., Melaleuca), etc. When the stamens unite only by the anthers leaving the filaments free, the condition is termed syngenesious.

Nature of Stamens and Pollen.

Stamen

Stamen, the male reproductive part of a flower. In all but a few extant angiosperms, the stamen consists of a long slender stalk, the filament, with a two-lobed anther at the tip. The anther consists of four saclike structures (microsporangia) that produce pollen for pollination. Small secretory structures, called nectaries, are often found at the base of the stamens; they provide food rewards for insect and bird pollinators. All the stamens of a flower are collectively called the androecium. For a discussion of the female reproductive parts of a flower, see pistil.

The number and arrangement of stamens, as well as the way in which the anthers release pollen, are important taxonomic characteristics for many flowering plants. The number of stamens is often the same as the number of petals. The presence of numerous stamens is common in many plant families (e.g., Cactaceae, Ranunculaceae, and Rosaceae); most orchids possess only one stamen. In plants with imperfect (unisexual) flowers, the staminate flowers may be borne individually, as in most squash species, or arranged in long clusters known as catkins, as is characteristic of oaks and willows. While the anthers of most angiosperms release pollen through a rupture along one side of each sac, the anthers belonging to members of the heath family (Ericaceae) release pollen through small pores at the anther tip. Some flowers produce sterile stamens, known as staminodes, which may be showy (e.g., on the cannonball tree) or inconspicuous (e.g., in Penstemon species).

Pollen

- Transfer of pollen grains from anther to stigma is termed as Pollination. This transfer of pollen grains occurs with the help of pollinating agents like wind, water, insects, birds etc.
- There are 2 types of pollination:
- Autogamy
- Transfer of pollen grains from anther to stigma of the same flower
- Seen in plants which produce Chasmogamous & Cleistogamous flowers
- Chasmogamous flowers
- Exposed anther & stigma
- Cleistogamous flowers

- Closed flower
- Anther & stigma lie very close to each other
- Example: Viola, polygala
- Geitonogamy
- Transfer of pollen grains from anther to stigma of another flower of same plant
- It is functionally cross-pollination, but genetically self-pollination
- Xenogamy
- Transfer of pollen grains from anther to stigma of a different plant
- Genetically as well as functionally cross-pollination
- Pollinating agents
- Agents which carry pollen grains from anther to stigma of same/different plant are termed as Pollinating agents. They are of **2** types:
- Biotic agents
- Living organisms which act as agents of pollination
- Insects, Birds
- Abiotic agents
- Non-living objects which act as agents of pollination
- Pollination occurs by chance
- Wind, water
- Pollination by Wind
- Pollen grains are carried by wind from anther to stigma. Wind pollination is very commonly seen in grasses. Characteristics of a plant pollinated by wind are:
- Light pollen grains
- Non-sticky pollen grains
- Well-exposed stamens
- Large, feathery stigma

UNIT – III

Gynoecium – Types, fusion of carpels, Placentation, Ovule types. Types of Pollination. Fruits types, Dispersal of Fruits and seeds.

Gynoecium

Gynoecium:

The gynoecium (also spelt gynaeceum) or pistil is the central or the topmost whorl of the flower usually terminating the thalamus. It is composed of one or more carpels or megasporophylls.

When there is a single carpel the pistil is called simple or monocarpellary which is not very common although it is a characteristic of the large families of Leguminosae and Gramaneae

A typical carpel has three parts—ovary, style and stigma. The lowermost swollen part is the ovary containing one or more swollen bodies called ovules which are the rudiments of seeds.

Above the ovary the carpel is protruded into a long or short style which ends in a somewhat rounded and usually sticky stigma on which the pollens are deposited during pollinatior. A sterile pistil devoid of fertile ovules is called a pistillode.

Compound or polycarpellary gynoeciums are much more common than the simple type. In such a gynoecium, the different carpels may remain completely free from one another when it is termed apocarpous (apocarpous multiple, as opposed to simple, as there are multiple carpels) or the carpels may unite with each other, wholly or partially, forming syncarpous gynoeciums.

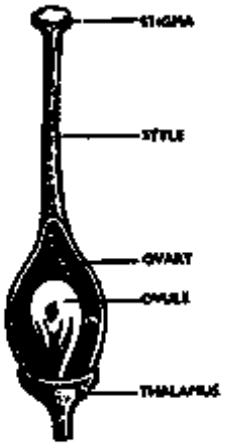


FIG. 362. A typical carpel.

Gynoeciumtypes.

Monocarpellate (also called **unicarpellate**) - if made from one carpel; **apocarpous** - made from more

than one separate carpels; **syncarpous** - formed from more than one fused carpels. The term **pistil** is used to refer to the structure made of stigma, style and ovary. A simple pistil - comprised of a single carpel; compound pistil - made of more than one fused carpels. Botanists generally avoid the term pistil preferring to use "carpel(s)". If you do use pistil, spell it correctly - it's not a weapon!

2. Evolution.

The gynoecium was formed by the fusion of carpels. The carpel folded in middle (**dorsal suture**) and fused along the margins (**ventral suture**). At the point of fusion the **placenta** develops and gives rise to ovules. The **locule** is inside.

Placentation:

Placentation.

This term refers to the arrangement of ovules in ovary; indicates the pattern of carpellary fusion. There are several types including:

- **marginal** (single carpel, ovules along margin, characteristic of a monocarpellate gynoecium (or each carpel of an apocarpous gynoecium), single locule),
- **axile** (syncarpous gynoecium, ovules in center, divided by septa, multiple locules);
- **parietal** (syncarpous, margin, one locule);
- **free central** (syncarpous, one locule, ovules on short axis at base);
- **basal/apical** (single ovule at base/apex).

Carpel

Carpel has 3 important parts in a flower

Ovary

- Basal enclosed part of carpel
- Ovarian cavity is termed as Locule
- Encloses ovule (megasporangium) in it
- Ovules are attached to cushion-like structure called Placenta

Style

- Tube like structure that connects the Ovary & Stigma

Stigma

- Located at the exposed end of Style
- Acts as the receptive surface for pollen grains

It has already been seen that the placental tissue develops along the margin of the megasporophyll so that, when the latter closes to form a chamber, the placenta is located along the ventral suture.

But, ma-gin is not the only place where placenta develops. Placenta may also develop on a direct prolongation of the thalamus at the base of the carpel. As a result, we get different types of placentation, i.e., distribution of placenta, in different ovaries.

As this placenta is the tissue on which the ovules or the future seeds develop, a study of placentation is of importance in the study of the fruit and the flower.

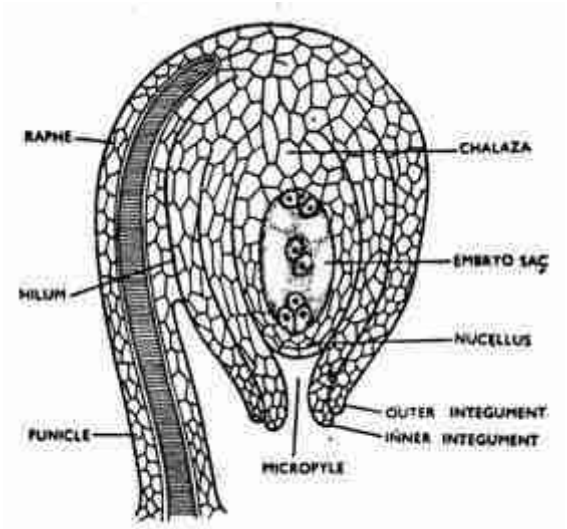


FIG. 384. Longitudinal section of a typical ovule (anatropous).

The Ovule:

The ovule is the megasporangium contained within the ovary. There may be one or more ovules inside an ovary and these are destined to be the seeds.

When fully formed, the tissues in a typical ovule are as follows: The ovule is attached to the placenta by the funicle or funiculus which meets the ovule at the hilum.

An ovule devoid of any funicle and directly attached to the placenta is termed sessile. Raphe is an extension of the funicle and may extend up to the chalaza which is the base of the ovule. (The ovule commonly remains reversed).

The general tissue of the ovule is called nucellus and the embryosac (the female gametophyte within the megaspore—its development is described) is in the top part of it.

The ovule is enveloped by two integuments (inner and outer) which leave an opening called micropyle at the top. Abnormally, there may be a single integument as in some Compositae while in some parasites like Loranthus, Viscum album, etc., there may be no integument at all

It is amphitropous when placed transversely at right angles to the funicle . This condition is not common but is met with in Ranunculus, Lemna and poppy.

Sometimes, a transverse ovule may be bent like a horse-shoe so that the micropyle is brought nearer to the chalaza . This is the campylotropous (kampylos— curved) condition found in many plants of Cruciferae, Chenopodiaceae, Caryophyliaceae, etc., and some other plants like Mirabilis (Nyctaginaceae).

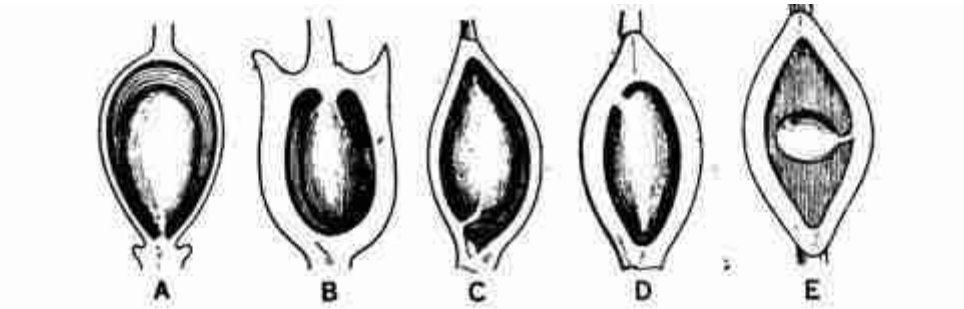


Fig. 386. Position of ovules. A. Erect. B. Pendulous. C. Ascending. D. Suspended. E. Horizontal.

Pollination

Pollination is the transfer of pollen grains from the anther of one flower to the stigma of the same or another flower. It is said to be the first process of sexual fertilization in flowering plants. Pollen grains contain the male gamete and are present in the anthers of the flower.

Types of Pollination

Pollination can be of two types:

1. Self- Pollination
2. Cross-Pollination

Let us understand more about each type of pollination a little in detail.

Self- Pollination

When the pollen is transferred from the anthers of a flower to the stigma of the same flower, it is called as self- pollination. This form of pollination is common in hermaphrodite or dioecious plants which contain both male and female sexual parts on the same flower.

In self-pollinating plants, there is less dependence on the external factors to cause pollination. These plants depend on wind or other smaller insects that visit the flower regularly. In self- pollinating

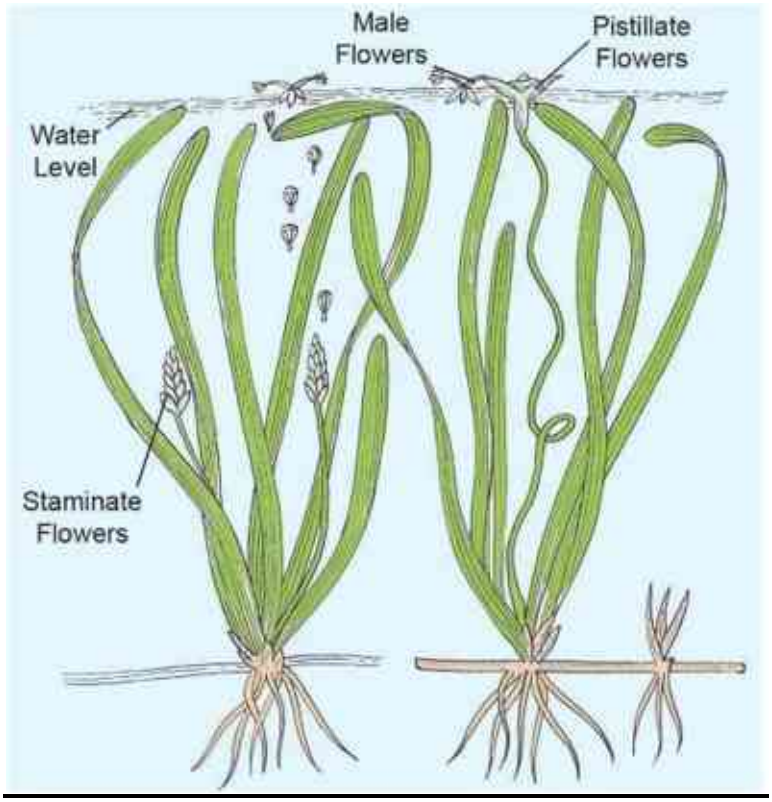
flowers, the anthers, and stigma are of similar lengths to facilitate the transfer of pollen. Self – pollination can be further divided into two types:

- *Autogamy*– In this type of self-pollination, the pollen is transferred from the anthers of one flower to the stigma of the same flower.
- *Geitonogamy*– In this type of self- pollination, the anthers are transferred from the anthers of one flower to the stigma of another flower but on the same plant.

Cross-Pollination

In this type of pollination, the pollen is transferred from the anthers of one flower to the stigma of another flower. In this case, the two flowers are genetically different from each other. Cross-pollination is always dependant on another agent to cause the transfer of pollen. The agents of pollination include birds, animals, water, wind, and insects. Based on the agent of pollination, cross-pollination can be of different types:

- **Hydrophilous Flowers**-These flowers are pollinated by water means. The flowers are often very small and inconspicuous to other agents. They do not have any fragrance or too much color on their petals. The pollen is adapted to be able to float in water.



- **Zoophilous flowers**– In this type of pollination, the pollinating agents are animals like human beings, bats, birds etc. The zoophilous flowers have pollen that is designed to stick on to the body of the animal so that they can be easily carried from one flower to another.

- **Anemophilous flowers**– These flowers are pollinated by the agency of wind. These flowers, like zoophilous flowers, are small and inconspicuous. Another important feature of flowers that are wind pollinated is that they are very light so that they are easily carried by the wind. The pollen grains are very light, non-sticky and sometimes winged.

- **Entomophilic flowers**– These flowers are pollinated by insects. These flowers are often attractive to look at with bright petals and are fragrant to attract the insect visitors to them. They often have broad stigmas or anthers to allow the insect to perch on it. Many of the insect-pollinated flowers also secrete nectar which attracts bees, butterflies or other similar insects to the flowers. The pollen grains in these flowers are often spiny or have extensions that help them to stick on to the body of the insects.

Fruit

Almost all of us love all types of fruits! However, have you ever thought about how complex the fruits can be? Yes! Fruits are of various types, with different characteristics and each one with a distinct scientific name! So, what's your favorite fruit? Mango? But, how much do you know about it, apart from the fact that it is tasty! In this topic, we will read more about the various types and characteristics of fruits.

Types of fruit

- Apples and pears.
- Citrus – oranges, grapefruits, mandarins and limes.
- Stone **fruit** – nectarines, apricots, peaches and plums.
- Tropical and exotic – bananas and mangoes.
- Berries – strawberries, raspberries, blueberries, kiwifruit and passionfruit.
- Melons – watermelons, rockmelons and honeydew melons.

Classification of Fruits

There are two criteria for the classification of fruits:

- Whether the carpels present in gynoecium are free or in a fused state.

- One or more flower takes part in the formation of fruit.

According to the above points, we can classify fruits into types of fruits

Types of Fruits

- Simple
- Aggregate
- Composite

Simple fruit

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

- **Fleshy Fruits:** In fleshy fruits, the fruit wall is differentiated into epicarp, mesocarp, and endocarp. These fruits develop from superior or inferior syncarpous gynoecium.
- **Dry Fruits:** The pericarp of simple dry fruits is usually quite dry and hard. It is not differentiated into the three layers of epicarp, mesocarp and endocarp. In some dry fruits, this pericarp is broken down and the seeds are scattered or dispersed. These fruits are dehiscent fruits.

Aggregate Fruits

These are the fruits that develop from the multicarpellary apocarpous ovary. It becomes a fruitlet because each carpel is separated from one another in the apocarpous ovary. These fruits make a bunch of fruitlets which is known as etaerio.

- **Etaerio of follicles:** Each fruit or etaerio is a follicle. Eg. Calotropis, Catharanthus, Magnolia -e. In calotropis, the stigma is fused or joined in carpellary ovary and ovaries of ovules are separated. It means only two follicles are present in etaerio.
- **Etaerio of achenes:** In this aggregate fruit, each fruit is an achene. Eg. Ranunculus, Strawberry, Rose, Lotus. In lotus, the thalamus becomes spongy and some achenes are embedded in it. In strawberry, the thalamus is fleshy and we can find small achenes on its surface.
- **Etaerio of berries:** It is an aggregate of small berries. Eg. Polyalthia, Annona squamosa (Custard-apple). In the etaerio of Annona, all the berries are arranged densely on the thalamus.
- **Etaerio of drupes:** In this type of fruit, many small drupes develop from different carpels. Eg. Raspberry. In this type carpel of apocarpous ovary form drupe fruit.

Composite Fruits

All composite fruits are false fruits. In these fruits, generally, there are many ovaries and other floral parts combining to form the fruit. These are of two types:

- **Sorosis:** These fruits develop from spike, spadix or catkin inflorescence. Examples inJackfruit fruit, Kevda (screwpine). In jackfruit (Kathal) pistillate flowers are developed around the peduncle. In fruit formation, the pericarp becomes spongy and fused.

- **Sycosis:** These fruits develop from hypanthodium inflorescence. Receptacle becomes hollow and has a pore. Numerous small scales surround the pore. Eg. Ficus species Peepal

Dispersal of Fruits and seeds.

Some fruits rind seeds are so small and light that they may be easily carried by wind. Many of them develop crowns of hairy outgrowths and winged expansions often acting like parachutes, which help them in distribution. Hairy outgrowths are present on the seeds of cotton, Calotropis (B. Akanda), Nerium (B. Karabi).

Many small fruits of sunflower family have modified hairy sepals. Persistent hairy styles are found in Naravelia (B. Chagalbati). Winged expansions on the seeds are common in Moringa (B. Sajina), mahogany Fruits of Hiplage. (B. Madhabilata). Dipterocarpus (B. Garjan) have winged outgrowths for the same purpose.

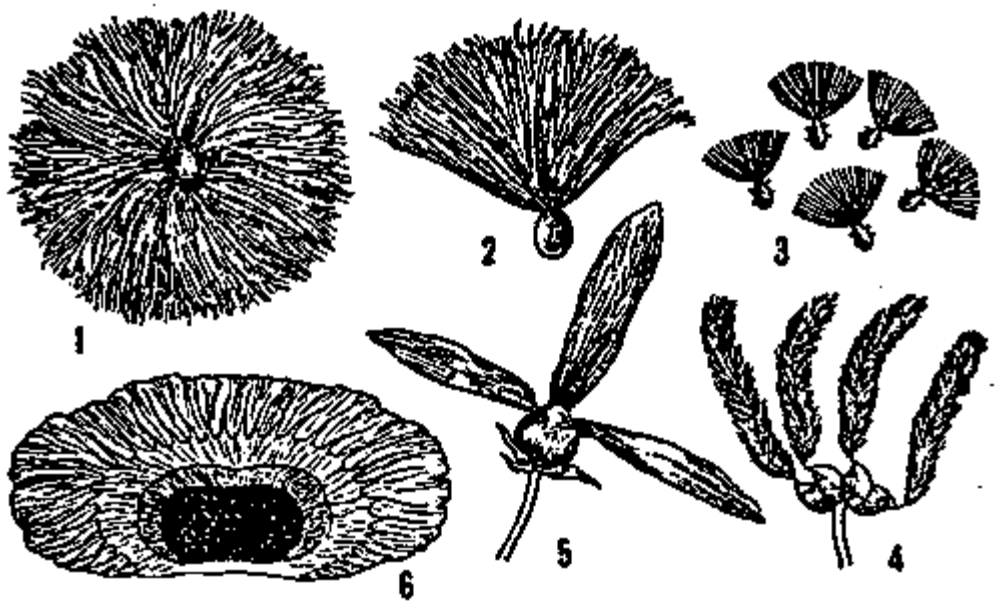


Fig. 113. Seeds and fruits with hairy and winged outgrowths. 1—seed of cotton; 2—seed of *Calotropis*; 3—fruits (cypsela) of sunflower family; 4—achenes of *Naravelia*; 5—samara of *Hiptage*; 6—winged seed of *Oroxylon*.

Dispersal by Animals:

Many fruits and seeds are provided with spiny projections or sticky glands to adhere to the animal bodies, and are thus scattered. Andropogon (B. Chore Kanta), Achyranthes (B. Apang) have stiff hairs on the pericarp; curved hooks and barbs are present in Martynia (B. Bagnak. Fig. 114); Xanthium (B. Okra), Plumbago (B. Chita) have glands by which they stick to the animal bodies.

Fleshy fruits like tomato, figs, develop beautiful colours to attract animals like birds, squirrels and bats. The small seeds are carried by those animals from place to place. Some of the fruits are eaten up by animals and seeds remain uninjured even when they pass through their alimentary canals. The excreta of the animals rather forms a more congenial soil for the germination of the seeds.

Dispersal by Explosive Mechanism:

Certain fruits burst with a bit of force to scatter the seeds away from the mother plant. Familiar examples are Balsam (B. Dopati), Oxalis (B. Amrul), castor. Fruits of Rvellia (B. Chatpati), Andrographis (B. Kalomegh), burst suddenly when they come into contact with moisture. Legumes of Clitoria (B. Aparajita), dehisce by both the sutures and the two halves twist just to scatter the seeds.

Dispersal by Water:

Aquatic plants and plants growing on river banks and sea-shore have fruits and seeds which are dispersed through water. They have usually fibrous tissue for floating on water surface, and protective devices so that the embryo may not be damaged.

Fruits of cocoanut, Nipa (B. Golpata) are common examples. Lotus fruits remain embedded in the spongy thalamus. The seeds of water-lily contain air-spaces in the testa for ready dispersal by water.