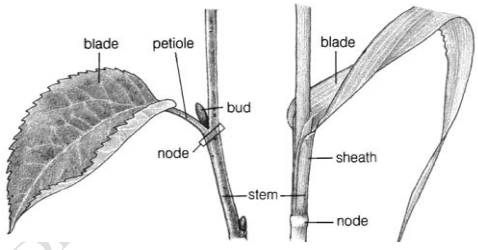
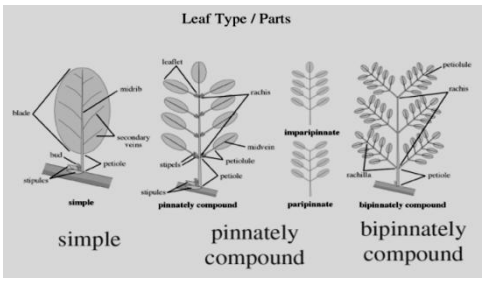
LEAF

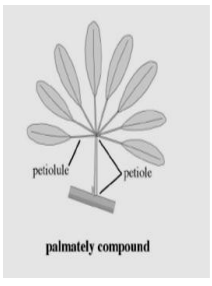
1. Petiolate – Leaves with a stalk called petiole below the lamina.
2. Sessile – Leaves without petiole
3. Stipulate – Small, leaf-like lateral outgrowths at the base of the leaves where the leaf attaches to the stem are called stipules. Leaves with stipules are called stipulate
4. Exstipulate – Leaves where stipules are absent

Leaf types

1. Simple leaf – leaf with single lamina. Eg. *Hibiscus*
2. Compound leaf- leaf having a number of distinct units or leaflets arranged on a common stalk called rachis. Two types – pinnately compound and palmately compound
    a. Pinnately compound – the leaflets are arranged on either sides of the rachis. If the leaflets are all paired, it is said to be paripinnate –eg. *Tamarindus*. If there is an odd member at the tip of the rachis, it is called imparipinnate –eg. *Rose*
    b. Palmately compound- the leaflets are borne at the tip of the rachis like the fingers on the palm – eg. *Bombax*







Venation

The mode of arrangement of veins on the lamina is known as venation. In dicots the veins are repeatedly branched to form a network or reticulum. Such a venation is called **reticulate.** Eg. *Hibiscus.* In monocots the veins run parallel to one another and is known as **parallel venation.** Eg. *Oryza.*

Phyllotaxy

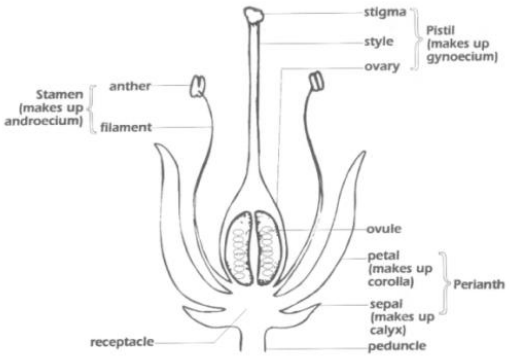
The mode of arrangement of leaves on the stem is known as phyllotaxy. There are three main types of phyllotaxy

1. **Alternate** – there is only a single leaf at a node and the arrangement of that leaf relative to the other is alternate. The alternate laves may be spirally arranged on the stem and is called **alternate spiral** e.g. *Hibiscus* or they may be developed one above the other and is called **alternate distichous** e.g. *Annona*

2. **Opposite** – in opposite phyllotaxy two leaves develop at a node. If the successive pairs are placed at right angles to each other it is called **opposite decussate** eg. *Calotropis.* If the successive pairs are placed exactly on top of the other it is called **opposite superposed** eg. *Quisqualis*

3. **Whorled** – if there are three or more leaves at a node the phyllotaxy is whorled eg. *Nerium, Alstonia* etc.

FLORAL MORPHOLOGY



- **Thalamus** – the axis of the flower where the floral members are arranged like leaves on a stem.

- **Whorls of a flower** – a typical flower has four whorls – (1) **calyx** composed of sepals, (2) **corolla** composed of petals, (3) **Androecium** composed of stamens and (4) **Gyoecium** or pistil composed of carpels.

  Calyx and corolla are called the **accessory or non-essential whorls** since they have secondary functions like protection and making flower attractive. Androecium and gynoecium are called **essential whorls** as they are the male and female sex organs.

- **Perianth** – in some flowers calyx and corolla cannot be distinguished then the accessory whorl is termed perianth.

- When all the four whorls (calyx, corolla, androecium and gynoecium) are present in a flower, it is termed **complete.** If any of the four whorls is absent, the flower is termed **incomplete.**

- When both the essential whorls (androecium and gynoecium) are present in a flower, it is called **perfect or bisexual or hermaphrodite.** A flower lacking either stamens or carpels is termed **imperfect or unisexual or diclinous.** Unisexual fowers are either **staminate** (male) or **pistillate** (female).

- If male and femal flowers develop on the same plant, the plant is called **monoecious** eg. *Cucurbita.* If separate male and female plants are present it is called **dioecious** eg. *Carica papaya.*

- A flower which is not having both sepals and petals is termed **achlamydeous.** Flower having only one accessory whorl (calyx or corolla or perianth) is called **monochlamydeous** eg. *Mirabilis*. Flowers with both calyx and corolla are called **dichlamydeous** eg. *Hibiscus.*

- A flower having no functional stamen or carpel is called **neuter or sterile.**

- If the floral whorls are similar in size and are arranged proportionally on the thalamus, the flower can be cut into two equal halves along any plane passing through the axis. Such a flower is called regular or **actinomorphic** eg. *Hibiscus*. If the floral members are dissimilar and not arranged uniformly, the flower can be cut into two equal halves only along a particular plane. Such a flower is called irregular or **zygomorphic** eg. *Crotalaria.* If a flower can not be cut into two equal halves along any vertical plane, the flower is said to be **assymetrical** eg. *Canna.*

- A flower arises from the axil of a small leaf like structure called bract. A flower subtended by a bract is called **bracteate** while a flower without bract is **Ebracteate.**

- The flower with a stalk called pedicel is called **Pedicellate**, while a flower without stalk is called **Sessile.**

- Based on the arrangement of floral leaves on the thalamus, flower may be cyclic, hemicyclic or spiral. In **cyclic flower**, calyx, corolla, androeciumm and gynoecium are arranged in definite whorls/ concentric circles. In **hemicyclic** flower, floral members are arranged partly in spirals and partly in whorls eg. *Annona* where calyx and corolla are in whorls while androecium and gynoecium are spirals. In **acyclic flower** the floral members are arranged in spirals on the thalamus eg. *Michelia.*

- When the whorls have equal number of members or in multiples, the flower is termed **isomerous**. When the members in different whorls are neither the same nor its multiples, the flower is termed **heteromerous.**

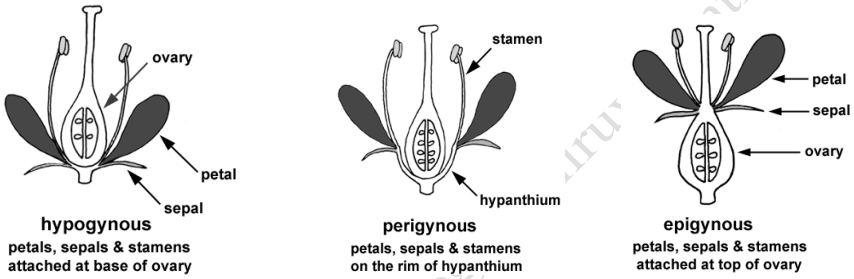
- Based on the nature of thalamus and the relative position of floral members, flowers are of 3 types:

    1. **Hypogynous flower** – the thalamus is flat, conical or convex and the floral parts are arranged in the sequence calyx, corolla, androecium and gynoecium

from below upwards. The ovary is placed on top of the thalamus and all other members arise from below the ovary. Such an ovary is **superior** and the flower is **hypogynous** eg. *Hibiscus.*

2. **Perigynous flower –** the thalamus is cup shaped or concave and the ovary is placed at the bottom of the cup. The other floral parts arise from the rim of the cup. The ovary is **half inferior** and the flower is termed **perigynous** eg. *Crotalaria.*

3. **Epigynous flower –** the torus is cup shaped and the ovary wall is fused with the thalamus. All other floral members arise from above the ovary. Thus the ovary is **inferior** and the flower is termed **epigynous** eg. *Ixora.*



Calyx

- Outermost whorl of flower made of members called sepals. If the sepals are free calyx is termed **polysepalous** and if they are united to form a cup it is termed **gamosepalous.** Calyx is said to be **caducous** if the sepals fall off as soon as the flower opens. It is called **desiduous** if the sepals fall off about the same time as the corolla. The clayx is **persistent** when the sepals remain adherent to the fruit eg. Brinjal. An **accrescent** calyx is persistent calyx which grows in size along with the fruit eg. *Physalis.*

Corolla

- It is made up of petals. Corolla may be **polypetalous** (petals are free) or **gamopetalous** (petals are fused). Small appendages or outgrowths present in corolla is termed **corona.**

Aestivation

- Aestivation is the arrangement of sepals or petals in a flower bud with relation to one another. It may be of following types:

1. **Valvate -** Aestivation is said to be valvate, when the petals or the sepals just touch one another by the edges and do not overlap. e.g. sepals and petals in *Annona*

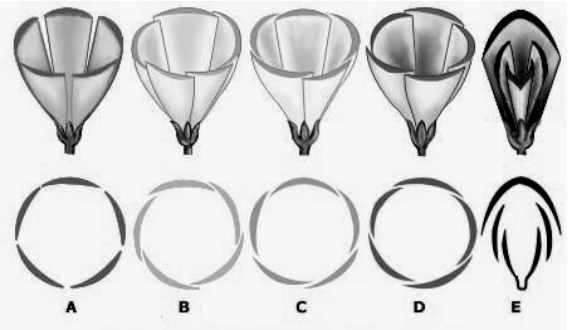
2. **Twisted or contorted -** In this type, each petal or sepal overlaps on one side and is overlapped on the other side. Thus the parts overlap one another in a regular manner. e.g. petals in *Hibiscus*.

3. **Imbricate -** Here overlapping is in an irreular way. One petal or sepal is outside (external) and one is inside (internal) and remaining three petals are partly in and partly out. There are 2 types of imbricate aestivation.

    i. **Ascendingly imbricated:** The posterior petal or sepal is internal and one is external, the remaining three are regularly overlapping. e.g. petals of *Caesalpinia*.

    ii. **Descendingly imbricate (vexillary):** This is seen in papilionaceous corolla e.g. *Crotalaria*. Here the standard petal (or vexilum which is posterior) is outermost. This overlaps the two wing petals (ale) which in turn overlap the two petals which are fused to form keel or carinate.

4. **Quincuncial:** Here two petals or sepals are completely external (or outside) and two are completely internal (or inside) and the remaining one is partly external and partly internal. Eg. Petals of *Psidium*



Different types of aestivation of calyx and corolla
A, Valvate, B, Twisted, C. Imbricate, D.Quincuncial, E. Vexillary

Androecium

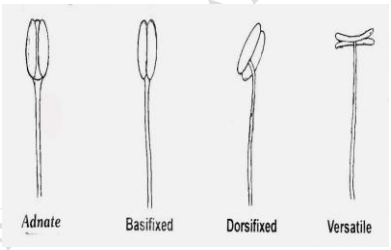
- Made up of stamens. Each stamen has a stalk called filament and fertile part called anther. The anther lobes are connected to the filament by a tissue called connective. The fleshy or attractive appendages on the stamen is termed **staminal corona.**

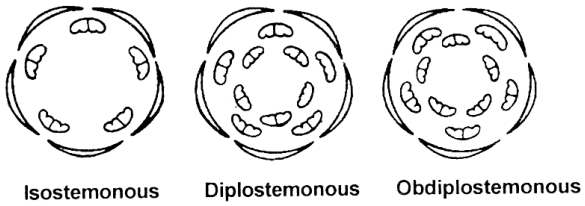
- **Basifixed** – Filament attached to the base of the anther eg. mustard; **dorsifixed** – filament attached to the back of the anther eg. *Sesbania*; **adnate** – Filament attached to the anther throughout its length eg. *Annona*; **versatile -** filament attached to the middle of the anther at its back in a single point so that the anther lobes swings freely eg. grasses.

- Sometimes the connective broadens out and the anther lobes get separated from each other, then the stamen is termed **divergent or divaricate** eg. *Justicia*

- The grooved ventral side of the anther faces gynoecium – **Introrse;** The grooved ventral side of the anther faces petals – **extrorse**

- When the stamens form a single whorl and the number of stamens is the same as the sepals and petals, the flower is **isostemonous.** In some flowers there are two whorls of stamens and the outer whorl alternates with the petals. Such a flower is called **diplostemonous.** When there are two whorls of stamens and the outer whorl is opposite to petals, the condition is termed **obdiplostemonous.**





- When there are 4 stamens out of which 2 are long and 2 short, the condition is termed d**idynamous** eg. *Leucas.* In mustard and radish there are 6 stamens of which 4 are long and 2 short. This condition is called **tetradynamous.**

- **Union of stamens**

  Stamens may unite among themselves (cohesion) or with other members (adhesion).

i. **Adelphous –** Cohesion of stamens where they are united by filaments alone. Anthers are free. **Monadelphous** condition is when filaments of all the stamens are united to form a single bundle eg. *Hibiscus.* **Diadelphous** condition is when filaments of the stamens are united to form two bundles eg. *Clitoria*. **Polyadelphous** condition is when filaments of the stamens are united to form more than two bundles eg. Citrus.

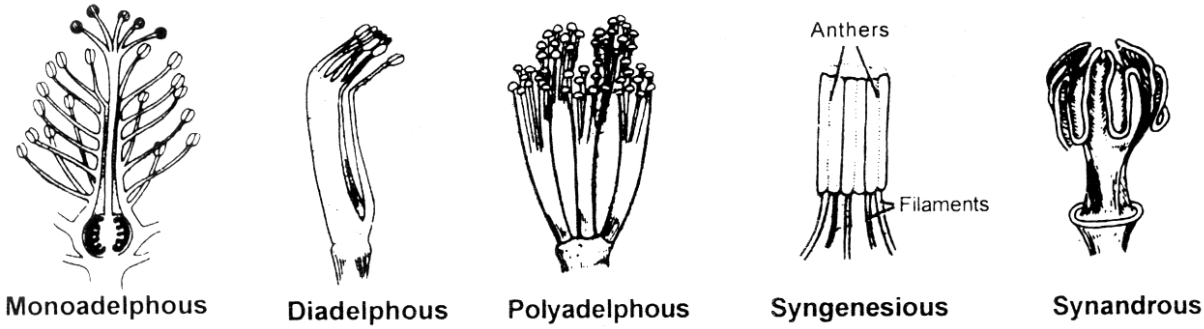
ii. **Syngenesious** – Cohesion of stamens where they are united by anthers while filaments remain free eg. *Tridax*

iii. **Synandrous** - Cohesion of stamens where they are united by both anthers and filaments eg. *Cucurbita*

iv. **Epipetalous stamens -** Adhesion where stamens are attached to the corolla by their filaments eg. *Vinca*

v. **Epiphyllous stamens -** Adhesion where stamens are attached to the perianth by their filaments eg. monocots

vi. **Gynandrous –** Adhesion where stamens are united with gynoecium as in orchids, *Calotropis* etc. In orchids there is complete fusion of the stamens with gynoecium to form structure called **gynostemium.** In *Calotropis* only the anthers are fused to the stigma of gynoecium to form structure called **gynostegium.**



Gynoecium

- Made up of carpels. Each carpel has 3 parts – ovary, style and stigma. Inside the ovary, ovules are attached to the thick tissue called placenta

- **Apocarpous pistil** – Carpels free; **Syncarpous pistil** – carpels united.

- **Monocarpellary** – only one carpel present in the flower; **Multicarpellary** – more than one carpel. Multicarpellary may be –

  i. Bicarpellary – 2 carpels

  ii. Tricarpellary – 3 carpels

  iii. Tetracarpellary – 4 carpels

  iv. Pentacarpellary – 5 carpels and so on.

- Usually style is terminal in position. In plants of Labiatae, there is a central depression on the 4-lobed ovary and the style arises from the base of the ovary (from the depression). This is called **gynobasic style** eg. *Leucas.* In some plants style is seen arising from one side of ovary. This is called **lateral style** eg. *Mangifera.*

- **Placentation** – inside the ovary there is a special tissue called placenta from which ovules arise. The mode of arrangement of placenta within the ovary is called placentaion. It is of the following types:

  i. **Marginal** – it is seen in monocarpellary pistil and in carpels of apocarpous pistil. The placenta develops along the ventral suture only where the margins of the carpellary leaves fuse. Eg. Beans.

  ii. **Parietal –** it is seen n syncarpous pistils with unilocular ovary. Ovules are attached to the placenta which develop on the uneven wall of the ovary where the margins of the component carpels fuse. Here there are as many placentas as there are carpels. Eg. Cleome

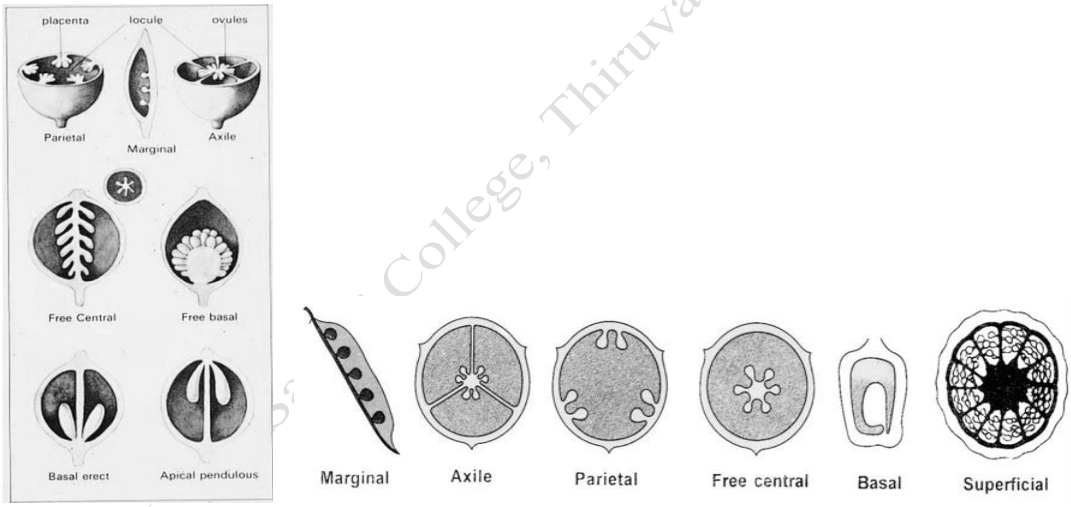
  iii. **Axile –** it is seen in syncarpous pistils with mltilocular ovary. The placenta develop at the inner angles of the locules. Eg. *Hibiscus.*

iv. **Free-central –** it is seen in syncarpous unilocular ovay. The placenta arises from the base of the ovary, projects into the cavity as a swollen central axis and bears ovules all over its surface. In the cross section, the placenta lies freely in the single chamber of the ovary. Eg. Portulaca

v. **Basal –** it is seen in unilocular ovaries. Placenta develops at the base of the ovary. Eg. *Tridax*

vi. **Superficial –** the ovary is many chambered and numerous ovules arise from the partition walls between the locules. Eg. *Nymphaea*

vii. **Pendulous –** it is seen in unilocular ovaies. Placenta develops on the roof of the vay. One or more ovules hang downwards to the locule from the roof. Eg. *Quisqualis.*



FLORAL FORMULAE AND FLORAL DIAGRAMS

Floral Diagram is a graphical representation of the parts and symmetry of a flower. It is a diagram showing the arrangement and number of parts in a flower, drawn in cross section. The different whorls such as calyx, corolla, androecium and gynoecium are represented in the form of concentric circles. The outermost circle will represent the calyx and the innermost one the carpel represented by an ovary drawn in the centre. If any parts such as the petals or sepals are fused, this is also indicated. Bracts and bracteoles are also shown.

The floral diagram consists of a plan view of the flower with the organs arranged on circles or spirals, showing the degree of overlapping, any fusion of parts or irregularity and the position relative to the main stem of the plant (indicated by a small circle). The floral diagram gives a general idea of the pattern of the flower, along with the number of parts in each whorl, their disposition to one another, their degree union and symmetry of the flower.

The first step in the construction of a floral diagram is to mark the posterior and anterior positions of the flower. The axis marked by a cross or well defined dot will represent the posterior side. The bract is represented by an arc drawn below and will represent the anterior part of the flower. All parts of the flower should fall within the axis and bract. Usually odd sepal occupies the posterior position of the flower (ie just below the axis) in dicots, while in monocots it occupies an anterior position.

The sepals and petals are represented in conformity with their aestivation, if united adjoining members are connected by a line. A fertile stamen is represented by showing the four loculi while a staminode is represented by a cross in the place where it is found. The carpels are represented by the c.s. of the ovary.

A **floral formula** is a way to represent the structure of a flower using specific letters, numbers, and symbols. It is not written alone but always accompanies a floral diagram. It supplements the information provided by the floral diagram. The following are the symbols used in floral diagram:

1. Floral Symmetry - actinomorphic ⊕ or zygomorphic ⊕
2. Sex - males (♂), females (♀) and bisexual flower ⚥
3. Calyx - Symbolized by the letter "K". The number of sepals in the calyx is given as subscript following the K. The degree of fusion of the sepals can be indicated by circling the sepal number. Thus, a flower with five separate sepals would be symbolized K_5. A flower with five united sepals would be $K_{(5)}$.
4. Corolla - Symbolized by the letter "C". The number of petals and degree of fusion is represented as above.
5. Androecium - Symbolized by the letter "A". The number of stamens and degree of fusion can be represented as described for the calyx. In addition, if the stamens are epipetalous, a line can be drawn connecting the K and A. For example, a petunia has five epipetalous stamens. This would be represented C_5 A_5.

6. Gynoecium - Symbolized by the letter "G". The number of carpels and degree of carpellary fusion is expressed in a similar fashion to sepals. The ovary insertion (inferior, superior) can be represented by a line drawn above or below the "G". A line under the carpel figure means that the flower is hypogynous. Above the figure it indicates epigyny. For example, a unicarpellate gynoecioum with a superior ovary would be symbolized $G_{\underline{1}}$. A syncarpous gynoecioum comprised of four carpels with an inferior ovary would be $G_{(4)}$. Eg. the floral formula for *Hibiscus* is as follows:

$$\oplus \; \underset{+}{\male} \; K_{(5)} \; C_5 A_{(\alpha)} G_{\underline{(5)}}$$

FLOWER AS A MODIFIED SHOOT

A flower is a modified shoot where the internodes have become condensed bringing the nodes very close to each other. Leaves of this modified shoot also become modified into different floral parts like sepals, petals, stamens and carpels. Flower parts are arranged in whorls on the expanded apex of the flower stalk or pedicel.

Evidences regarding flower as a modified shoot:

Generally, a shoot is characterized by the presence of nodes, internodes, leaves and buds. The axial stem bearing a flower is a thalamus.

It is very much condensed without showing distinct nodes and internodes. However, it bears floral leaves like calyx, corolla, androecium and gynoecium.

The internodes of the thalamus are very small so that all the floral leaves appear to arise from a single point. Following are some of the evidences to justify that flower is a modified shoot:

(i) Homology of the floral bud:

Both the floral and vegetative buds are similar in origin although the different in their outward appearance. It can be proved from the two aspects, viz., position and the fact that modification of floral buds, at times, into vegetative b bulbils.

(ii) Axis nature of the thalamus:

The thalamus on which different parts of a flower is placed is an axis W evident from the following facts:

(a) Development of internodes of the thalamus is marked in Cleome, Cap Pass flora, etc. In these cases thalamus is elongated and found with well develop nodes and internodes.

(b) As the calyx, corolla, androecium and gynoecium are placed on the thalamus sequence, it is evident that thalamus growth is limited by the carpel. In s cases, however, the thalamus grows beyond the gynoecium and bears a 1 shoot. It is known as monstrous development of thalamus a seen in rose.

(c) In Michelia champaca, the region of thalamus bearing carpels elongates like ordinary stem giving rise to an aggregate fruit.

(iii) Leaf nature of floral members:

The leaf like nature of the floral members such as calyx, corolla, stamens and carpel is evident from the following facts. Floral parts are modified foliage leaves and the characters that are marked in foliage leaves are also found in the floral members.

(a) The phyllotaxy or arrangement of floral leaves, i.e., sepals, petals, etc., on the thalamus (cyclic or spiral) - strongly resembles that of foliage leaves on stem.

(b) The floral leaves also show percolation as noticed in the foliage leaves. It is the arrangement of floral leaves with respect to each other (aestivation).

(c) In Mussaenda, one of the sepals becomes large and looks like an ordinary leaf. It shows the foliar nature of sepal.

(d) The transition of one type of floral leaves to another is also seen. In Nymphaea (water-lily), all forms of gradual transition, such as sepals to petals and petals to stamens, are found. In this case, there are a large number of floral leaves arranged spirally on the thalamus.

The sepals gradually merge into petals and petals gradually merge into stamens developing anthers on the top.

Presence of many petals in cultivated rose are really stamens, those have transformed into petals. In Hibiscus there are 'single' and 'double' varieties of flowers, it is thought that doubling is the transformation of some stamens into petals. In Canna, the stamens and the style have become petaloid.

INFLORESCENCE

Arrangement of flowers on floral axis is called **inflorescence**. The stem or its branch that bears flowers is called **peduncle**, while the stalks of individual flowers are called **pedicels.** If a single flower is borne at the apex of a branch or axil of a leaf, it is called **solitary** eg. *Hibiscus.*

The inflorescence may be of three types – racemose, cymose and special types of inflorescence.

A. **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 older flowers are arranged towards the base and younger flowers are at tip. When peduncle is broad then flowers are centripetally arranged. This is of following different types:

1. **Simple Raceme –** When peduncle (main axis) is elongated and flowers are pedicellate and are arranged in acropetalous manner. eg. *Crotalaria***.**

   When peduncle is branched and each branch bear pedicellated flowers like racemose and are arranged in acropetal manner, it is known as compound raceme or panicle. eg. Gulmohar, Neem.
2. **Spike –** In it peduncle is elongated but flowers are bisexual and sessile. eg. *Achyranthes, Quisqualis.*

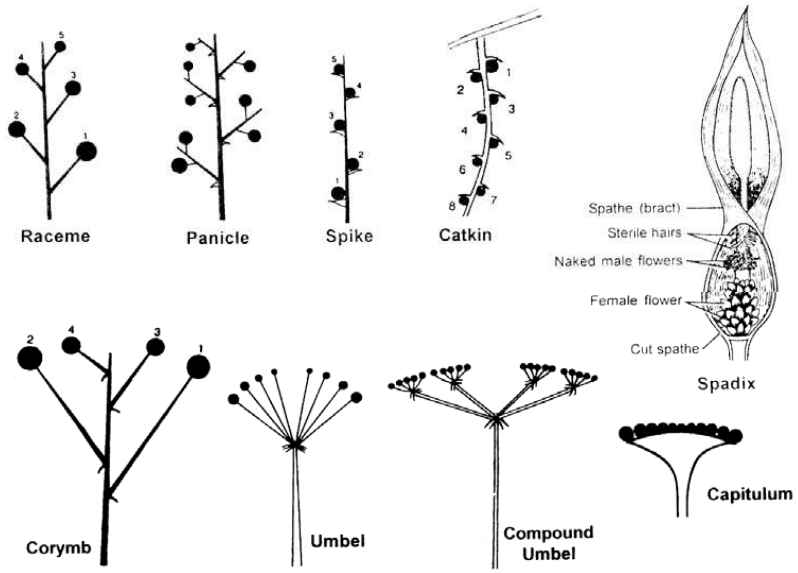
   When peduncle is branched and each branch bear spike like inflorescence then the small branch having flower is called **spikelet** and this arrangement is called as spike of spikelet. Characteristic inflorescence of family Gramineae.
3. **Catkin –** In it peduncle is thin, long and weak, and flowers are sessile and unisexual. Peduncle is pendulous. eg. *Acalypha hispida* (Cat's tail).
4. **Spadix –** it is a highly modified spike in which the peduncle is thick, long and fleshy and have small sessile and unisexual male and female flowers covered with one or more green or coloured bracts known as **spathe**. eg. *Colocasia, Anthurium*
5. **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. *Caesalpinia*

   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
6. **Umbel –** the peduncle is shortened to a point and the flower stalks of different flowers are of more or less equal length, arise from the same point. The younger flowers are in the

center and older flowers towards the periphery. At the base of flowers stalks, there is whorl of bracts forming the **involucre**. eg. *Centella, Biophytum*

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.

7. **Capitulum / Racemose head –** In it the growth of peduncle is retarded and it become broad, flattened concave or convex. On it small sessile flowers are found. These flowers are called **florets**. They are arranged in centripetal manner with younger flowers in the center and older flowers towards the periphery. Two kinds of florets may be seen – (1) **ray florets** that are usually arranged along the rim of the receptacle and are generally female or sterile and always zygomorphic, (2) **disc florets** that are grouped in the center and are bisexual and actinomorphic. This inflorescence is surrounded by one or more **involucre**. If all the florets of a capitulum are of same type (either ray or disc), then it is called **homogamous**. If both ray florets and disc florets are present in the same inflorescence then it is known as **heterogamous**. eg. *Sunflower, Zinnia, Tridax*. Characteristic feature of Asteraceae family.



B. CYMOSE - In this type of inflorescence, the peduncle terminates in a flower. Here 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:

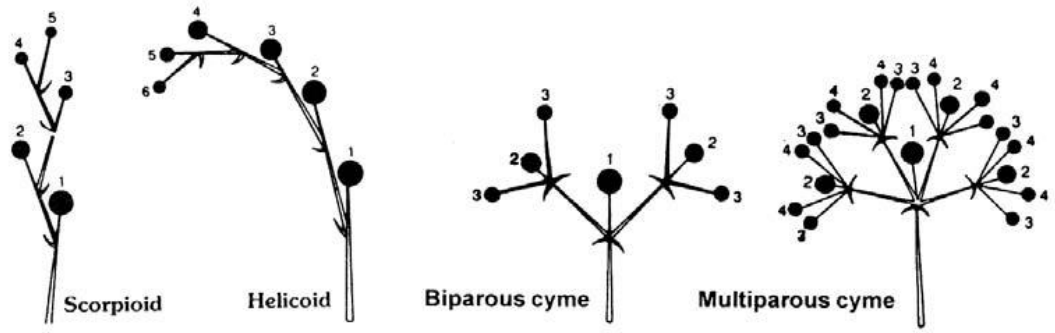
1**. Simple Cyme -** the peduncle terminates in a flower. Two lateral branches are formed which also terminates in flowers. There are three flowers, oldest in the center. Eg. *Jasminum*

2**. Uniparous cyme / Monochasial cyme -** The peduncle ending in a flower. Single lateral branch produced at a time**,** also ending in flower. It is of two types:

- **Helicoid cyme –** When all lateral branches are developed on the same side on peduncle, then it is called helicoid cyme. eg. *Heliotropium, Saraca, Atropa, Datura.*
- **Scorpioid cyme –** In this the lateral branches are alternately developed on left and right sides. eg. *Bignonia, Hamelia*

3. Dichasial or biparous cyme – In it the 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. *Clerodendron, Bougainvillea*

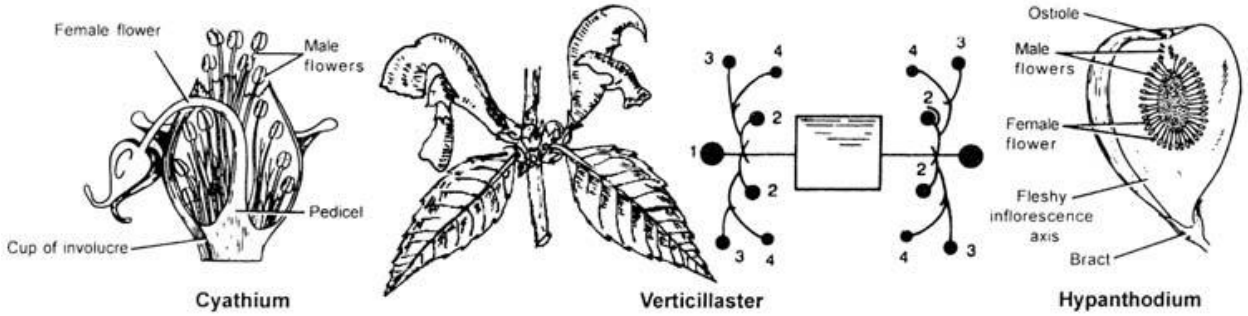
4. **Multiparous cyme / polychasial –** In it peduncle ends in a flower and from the base of it many lateral branches arise which also terminates in flower, this arrangement now also occur on these lateral branches. eg. *Nerium, Asclepias*



C. SPECIAL TYPES OF INFLORESCENCE

1. **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 flower is found, which is represented by an ovary raised above the cup by the growth of pedicel. Female flower is surrounded by large no. of small male flowers represented by stalked stamens arranged in scorpiod cymes. An extra-floral nectary is present on the outside of the involucre. This inflorescence is found in Euphorbiaceae members like *Euphorbia, Poinsettia, Pedilanthus.*

2. **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.
3. **Hypanthodium –** In it peduncle is modified into a narrow cup like structure with an opening called **ostiole**. At the base of the cup female flowers develop while towards the mouth male flowers develop. Neutral flowers are seen in the middle. eg. *Ficus*.
4. **Coenanthium:** In *Dorsitenia*, the receptacle becomes saucer shaped and its margins are slightly curved. Arrangement of florets are similar to hypanthodium.



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 by 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, and calyx are modified to form a part of fruit. These types of fruit are called false fruits. eg. Apple, Strawberry, Pear.

CLASSIFICATION OF FRUITS

Fruits are divided in three groups

✧ Simple ✧ Aggregate ✧ Composite/ Multiple

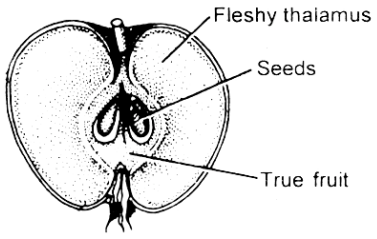
Simple Fruit - These fruit develop from monocarpellary ovary or multicarpellary syncarpous ovary. Only one fruit is formed by the gynoecium. Simple fruits are of two types ✧ Fleshy fruit ✧ Dry fruit

Simple Fleshy Fruit - These fruits 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 :

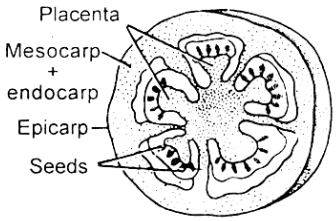
1. **Drupe -** These fruit develops from mono or multicarpellary, syncarpous, superior ovary. In these fruits endocarp is hard and stony so these fruits are also called stony fruits. eg. Mango, coconut almond, Peach walnut, plum. Brachysclereids are present in endocarp. In mango edible fleshy part is mesocarp and the part where seed is protected is called as endocarp. 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

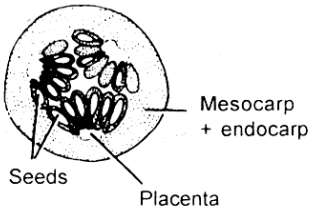
2. **Berry -** These fruits develop from mono or multicarpellary syncarpous ovary. Ovary may be superior or inferior, Placentation is axile or parietal. In these epicarp is thin and seeds are embedded in fleshy part. Initially seeds are attached with placenta of fruit but after maturation these seeds 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 a one seeded fibrous fruit berry. When its thick fibrous layer is removed then seed comes out which is hard.
3. **Pepo -** These fruits develop from tricarpellary, syncarpous and inferior ovary. This fruit is unilocular and have parietal placentation. These fruits are fleshy and spongy. Sometimes fruits are bitter in taste due to presence of tetracyclic triterpine in flashy pulp. eg. Fruits of Cucurbitaceae family.
4. **Pome -** This fruit develops from bi- or multicarpellary syncarpous inferior ovary. The rind and fleshy pulp are made up of thalamus and forms psuedofruit. The true fruit is hard and dry and remain inside the false fruit. Seeds are present in it. eg. Apple, Pear.
5. **Hesperidium -** This fruit develops from multicarpellary, syncarpous, superior ovary. This fruit is specialy 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.
6. **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*).
7. **Amphisarca -** This fruit is multicarpellary and multichambered which develops from superior ovary. Pericarp is hard and woody 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*).



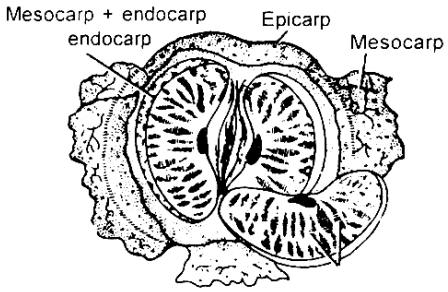
L.s. of Apple



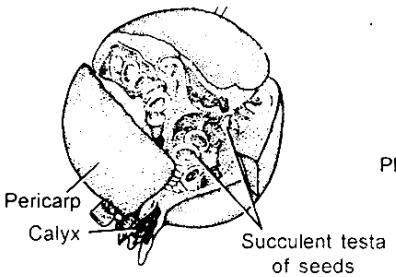
L.s. of Tomato



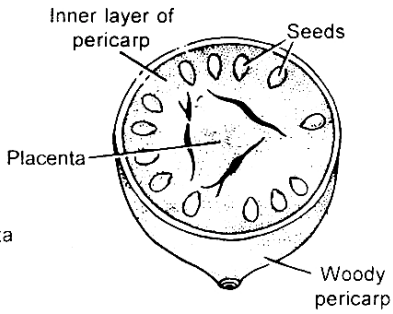
T.s. of Cucumber



Hesperidium of orange



Balausta of pomegranate



Amphisarca of wood apple

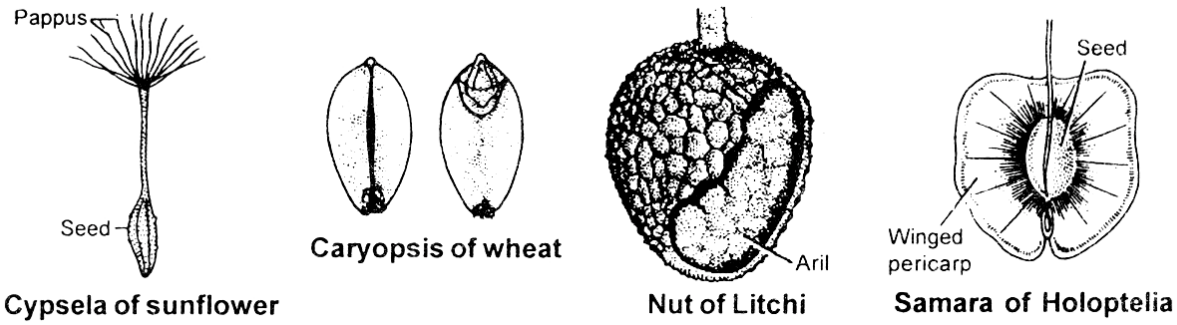
Simple Dry Fruit - Pericarp of simple dry fruit is hard and dry and not differentiated into epicarp, mesocarp and endocarp. Such fruits are called dry fruit. Simple dry fruits can be divided into following three groups: ✧ Indehiscent ✧ Dehiscent ✧ Schizocarpic

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

1. **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.
2. **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.
3. **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*
4. **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.

5. **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.



Cypsela of sunflower | Nut of Litchi | Samara of Holoptelia

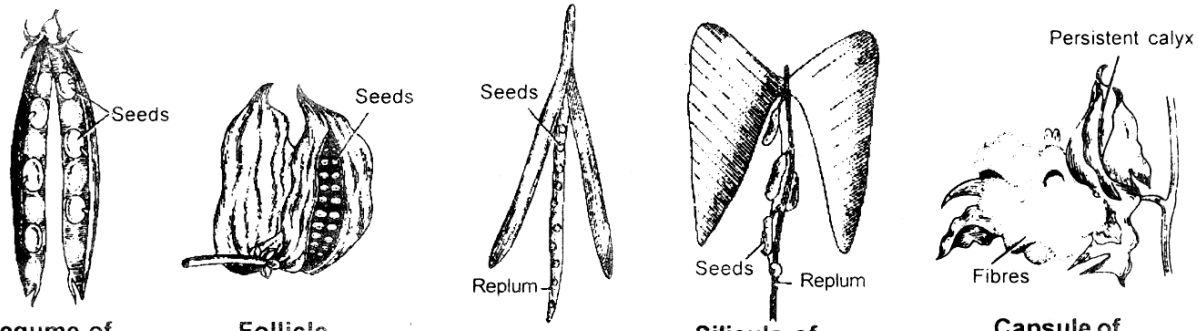
B. **Dehiscent Fruits:** After ripening the pericarp is ruptured and seeds are dispersed outside.

1. **Legume or pods -** These fruits develop from monocarpellary, unilocular, superior ovary. It is generally long and multiseeded fruit. Dehiscense 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.
2. **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*.
3. **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.
4. **Silicula -** A short broad siliqua is known as Silicula. It is also found in Cruciferae family. eg. Candytuft (*Iberis amara*), Capsella,
5. **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:
   a. Loculicidal capsule: Here, the pericarp dehisces longitudinally along the middle of each locule into as many valves as there are carpels. e.g., Lady's finger, Cotton

b. Speticidal capsule: Here, the pericarp splits longitudinally along the Septa and hence the fruit is called septicidal capsule. All the carpels get separated from one another but still the seeds are exposed as in loculicidal capsule. e.g. Aristolochia.

c. Septifragal capsule: Here, the pericarp breaks away completely from the septa and further the dehiscence may be of septicidal or loculicidal type. e.g. Datura.

d. Poricidal (Poppy),

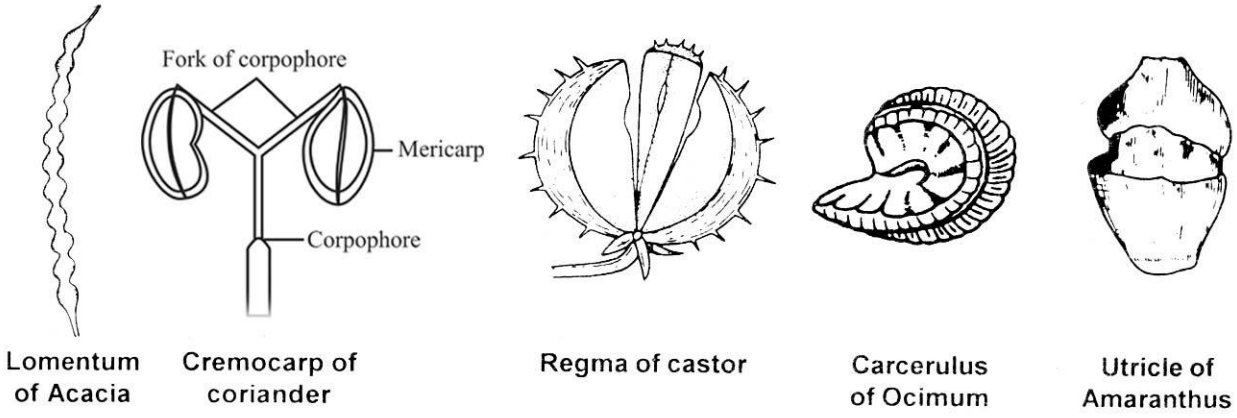


Legume of pea | Follicle | Siliqua of mustard | Silicula of capsella | Capsule of cotton

C. **Schizocarpic fruit** - It is a multiseeded fruit. After ripening, it is devided 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.

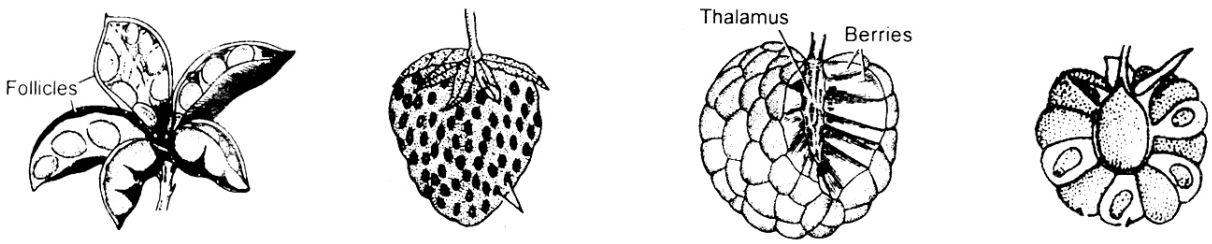
1. **Lomentum** - It develops like legume. Fruits are constricted or divided in one seeded mericarp, after maturity these are separated with each other. Eg *Tamarind, Cassia fistula, Mimosa pudica, Archis hypogea, Desmodium.*
2. **Cremocarp** - It is a double seeded fruit and develops from bicarpellary, 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
3. **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.
4. **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

5. **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.*
6. **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.

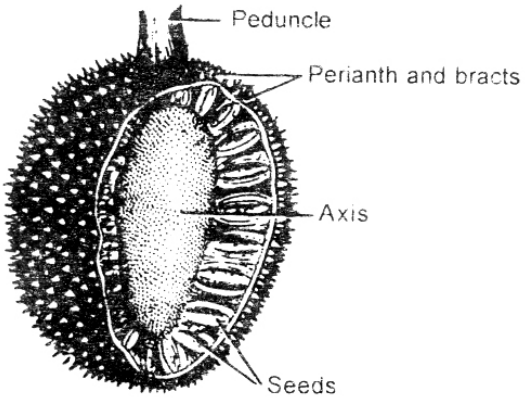
1. **Etaerio of follicles -** Each fruitlet is a follicle. eg. *Calotropis, Catharanthus, Magnolia***.**
2. **Etaerio of achenes -** In this aggregate fruit, each fruitlet is an achene. eg. *Rananculus,* Strawberry, Rose, Lotus
3. **Etaerio of berries** - It is an aggregate of small berries. eg. *Polyalthia, Annona squamosa* (Custardapple). In etaerio of Anona all the berries are arranged densly on thalamus.
4. **Etaerio of drupes -** In this type of fruit, many small drupes develop from different carpels. eg. Raspberry



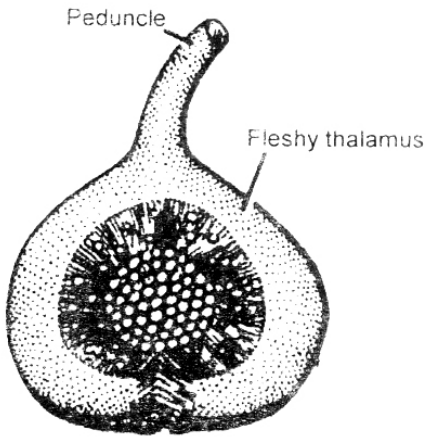
Etaerio of Follicles **Etaerio of Achenes** **Etaerio of Berries** **Etaerio of Drupes**

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.

1. **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 pistillate flowers are developed around the peduncle. In fruit formation the 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.
2. **Syconus** - This fruit develops from hypanthodium inflorescence. eg. Ficus



Sorosis of jack fruit



Syconus of fig.

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