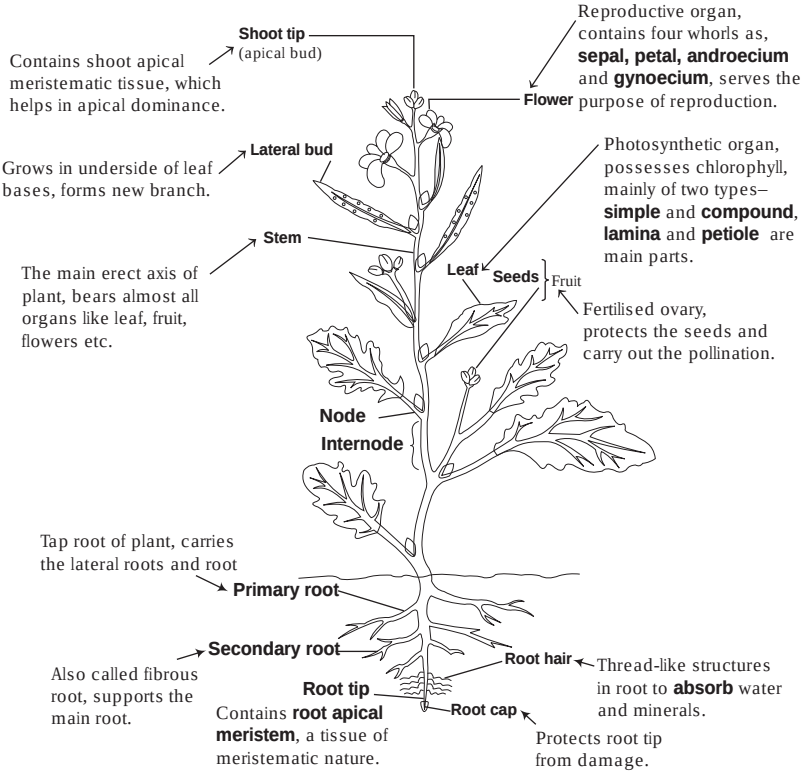
5

Morphology of Flowering Plants

Plant Morphology : An Overview

Flowering plants or angiosperms show large diversity in external structures or morphology. **A generalised morphology of these plants is as follows**



A typical flowering plant

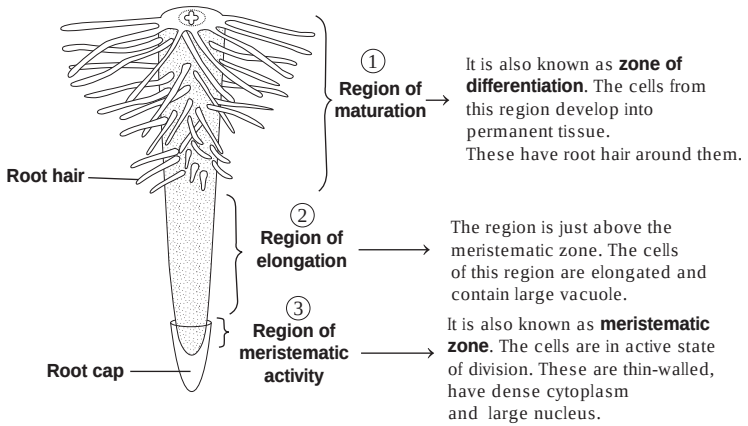
Various components of plant's morphology and their structures are discussed here.

Root

It is generally a non-green, underground, positively geotropic, positively hydrotropic and negatively phototropic, descending cylindrical axis of the plant body which develops from the radicle of the embryo. It is without node, internode, leaves, buds, flowers and fruits. Its main function includes anchorage to the plant along with water and mineral absorption.

Structure of Root

Generally, the root in plants is divided into three main regions. **These are**



The regions of the root-tip

Root cap A smooth cap-shaped structure to provide protection to the young apical cells against soil particles is called root cap.

Types of Root

There are two types of root

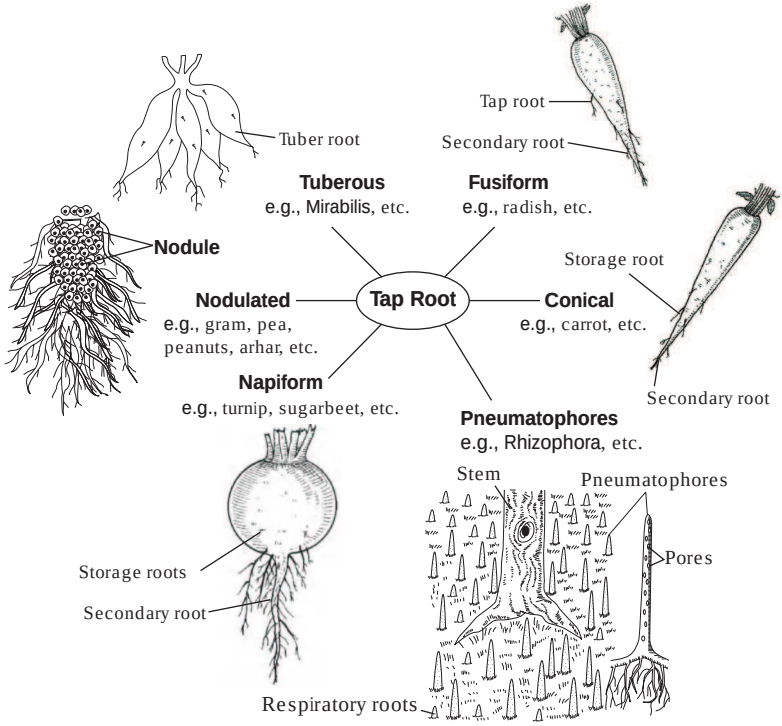
(i) **Tap root** Primary root further branches into secondary and tertiary roots, **e.g.,** dicotyledonous root.

(ii) **Adventitious root** In this, the radicle dies immediately after germination, hence these roots arise from different portions of the plant, **e.g.,** monocotyledonous root.

Modifications of Roots

Both, tap roots and fibrous roots are modified, according to their need.

1. Modifications of Tap Roots



Various modifications of tap root

- **Pneumatophores** are present in plants of coastal habitat. These roots absorb oxygen.
- **Nodulated roots** in leguminous plants form nodules after combining with nitrogen-fixing bacteria. They are meant for nitrogen-fixation.

2. Modifications of Adventitious Roots

(i) **Tuberous** From the nodes of the stem, **e.g.,** sweet potato.
(ii) **Fasciculated** Arise in bunches, **e.g., Asparagus**, **Dahlia**.
(iii) **Beaded root** Swell at different places, **e.g., Vitis**,. bitter gourd, etc.
(iv) **Nodulose** Apical portion swells up, **e.g., Curcuma**, maranta etc.

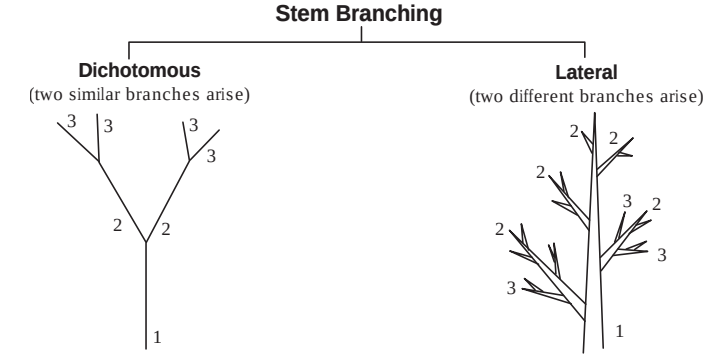
(v) **Annular** Ring structure formed, **e.g., Psychortia, cephaelis.**
(vi) **Prop roots** Roots hang from branches and penetrate into soil, **e.g.**, **Ficus**, banyan.
(vii) **Stilt Roots** They arise from stem and enter into soil, **e. g.**, maize, sugarcane, etc.
(viii) **Climbing roots** Arise from nodes, **e.g., Pothos**, piper bettle.
(ix) **Buttress roots** Arise from basal part of main stem, **e.g., Bombax.**
(x) **Contractile roots** Underground and fleshy, **e.g.**, onion, etc.
(xi) **Sucking roots** In parasites, **e.g., Cuscuta**.
(xii) **Epiphytic roots** Found in epiphytes, **e.g.,** orchids.
(xiii) **Floating roots** Arise from nodes, help in floating, **e.g., Jussiaea**.
(xiv) **Photosynthetic roots** Have chlorophyll, **e.g., Trapa**, **Tinospora**.
(xv) **Reproductive roots** Develop vegetative buds, **e.g.**, **Trichosanthes dioica.**
(xvi) **Mycorrhizal roots** With fungal hyphae, **e.g., Pinus**.
(xvii) **Thorn roots** Serves as protective organ, **e.g., Pothos**.
(xviii) **Clinging roots** Arise from node and pierce into host plant, **e.g.,** Orchid, **Ivy** etc.
(xix) **Leaf roots** From margin of leaves, **e.g., Bryophyllum**.

Stem

It is the ascending cylindrical axis of plant body which develops from the plumule of the embryo and grows by means of terminal bud. This is usually negatively geotropic and positively phototropic. Its major function is to conduct water, minerals and photosynthates and to support the plant body.

Stem Branching

There are two types of branching



Branching patterns in stem

Types of Stem

Stems are of three types

1. Aerial 2. Sub-aerial 3. Underground

Different types of stems, actually are the modified stem. The modifications are to serve various purposes like **perennation**, **vegetative reproduction** and **storage of food**.

1. Aerial/Epiterranean Stem Modifications

These are of following types

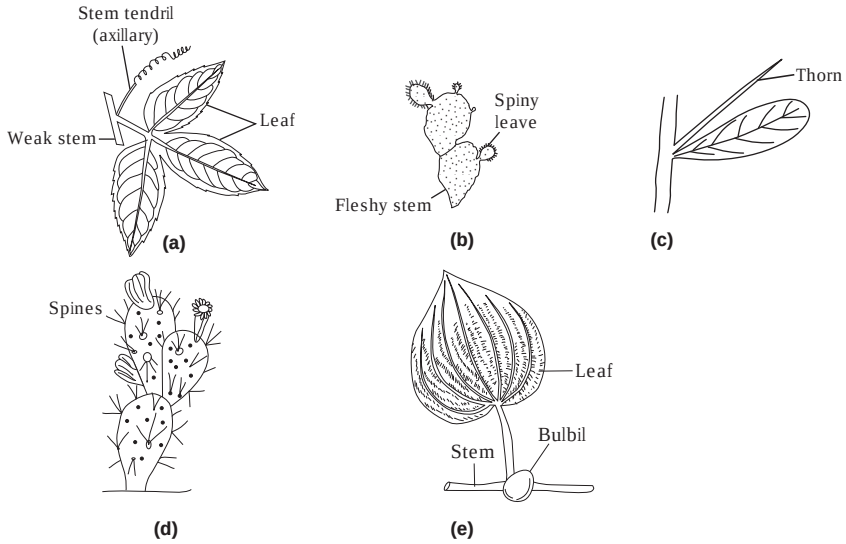
(i) **Stem tendril** In weak plants with weak stem, the apical bud is modified into tendril for climbing, **e.g., Vitis, Passiflora**, etc.

(ii) **Phylloclade** In this, the stem is modified into flat, fleshy and green leaf-like structure, **e.g., Opuntia**, **Cocoloba**, **Ruscus**, etc.

(iii) **Stem thorn** Axil of the leaf or apex of the branch is modified into pointed structure called thorn, **e.g., Citrus**, **Bougainvillea**, etc.

(iv) **Cladode** Stem is modified into leaf-like structure, **e.g., Asparagus**.

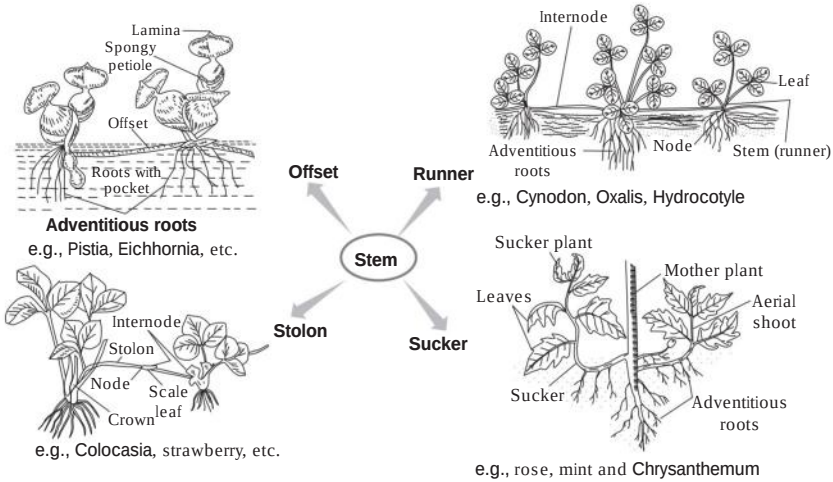
(v) **Bulbil** A multicellular structure functions as organ of vegetative reproduction, **e.g., Oxalis, Dioscorea**, etc.



Aerial stems : (a) Stem tendril in Vitis, (b) Phylloclade of Opuntia, (c) Stem thorn of Bougainvillea, (d) Cladode in Asparagus, (e) Bulbil in Dioscorea

2. Sub-Aerial/ Prostrate Stem

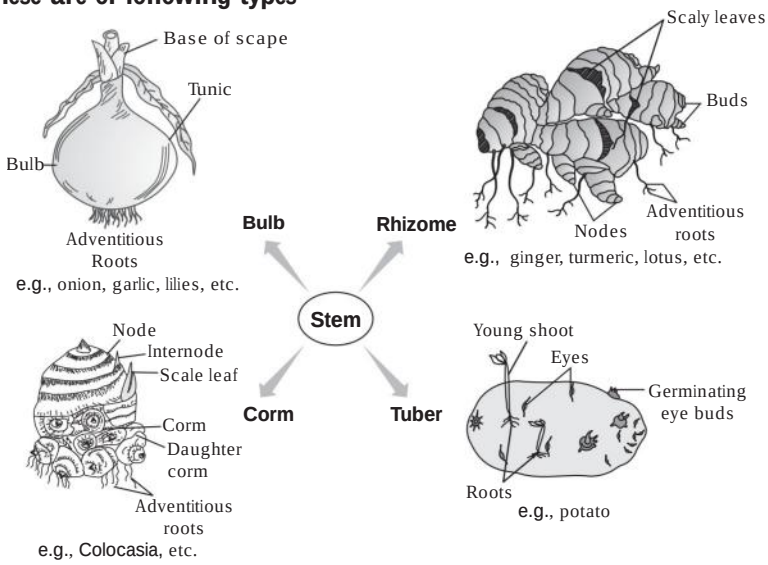
These are of following types



Sub-aerial modifications in stem

3. Underground/Subterrannean Stem

These are of following types



Underground modifications in stem

Leaf

It is an exogenous, lateral, generally flattened outgrowth that arises from the node of the stem and bears a bud in its axil. The leaves are the most important vegetative organs for photosynthesis and also perform gaseous exchange and transpiration.

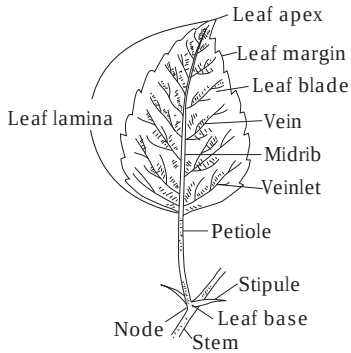
Parts of Leaves

A typical leaf has three main parts

(i) **Leaf base** Part of leaf attached to the stem by the leaf base.

(ii) **Petiole** Part of leaf that connects lamina to stem.

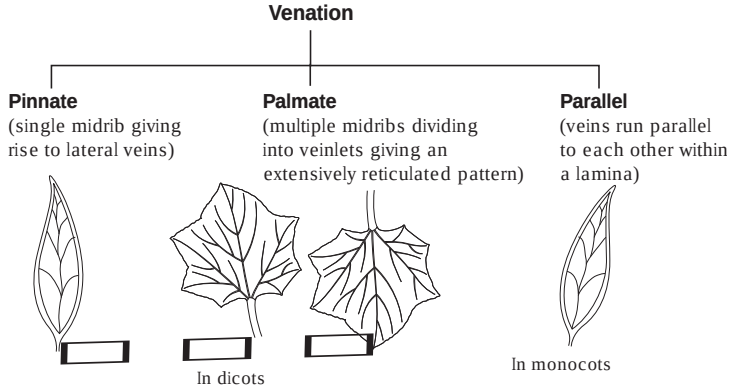
(iii) **Lamina or leaf blade** Flattened part of the leaves, which contains veins.



Typical leaf with its parts

Leaf Venation

The arrangement of veins in lamina is known as venation.



Different venation patterns in leaves

Types of Leaves

On the basis of incision of lamina, leaves may be of two types

1. Simple Leaves

In this, there is a single lamina, which is usually entire, **e.g.,** mango, guava, **Cucurbita**, etc. fig. (a).

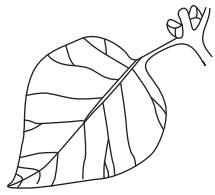
2. Compound Leaves

In this type of leaves, the incision of lamina, reaches up to midrib or petiole, **e.g.,** rose, neem, lemon, etc.

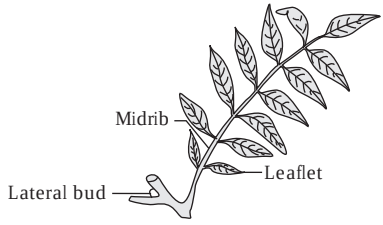
These are of two types

(i) Pinnately compound leaves (a number of leaflets present on rachis representing midrib of the leaf) fig. (b).

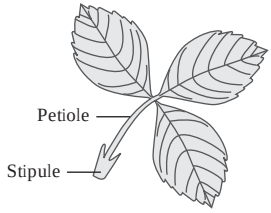
(ii) Palmately compound leaves (leaflets attached at a common point, **i.e.,** at the tip of petiole) fig. (c).



(a) Simple leaf of lilac



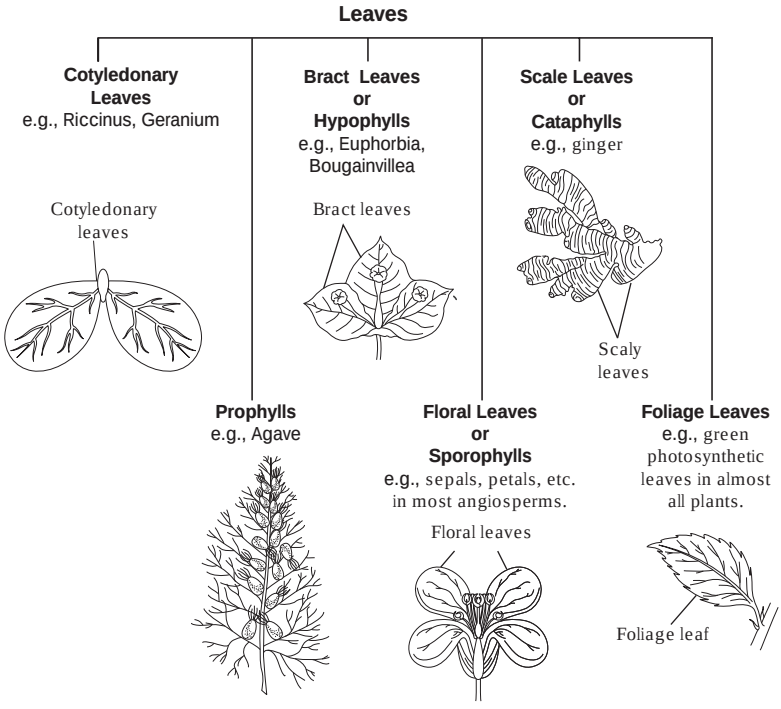
(b) Pinnately compound leaf of neem



(c) Palmately compound leaf of strawberry

Types of leaves

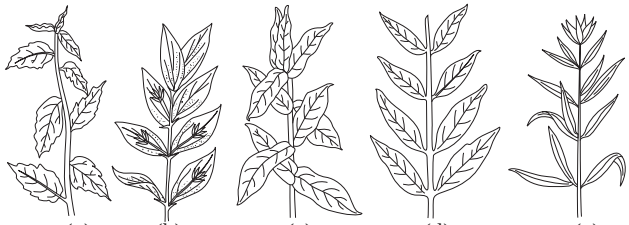
On the basis of origin and function, leaves are of the following types



Types of different functional leaves

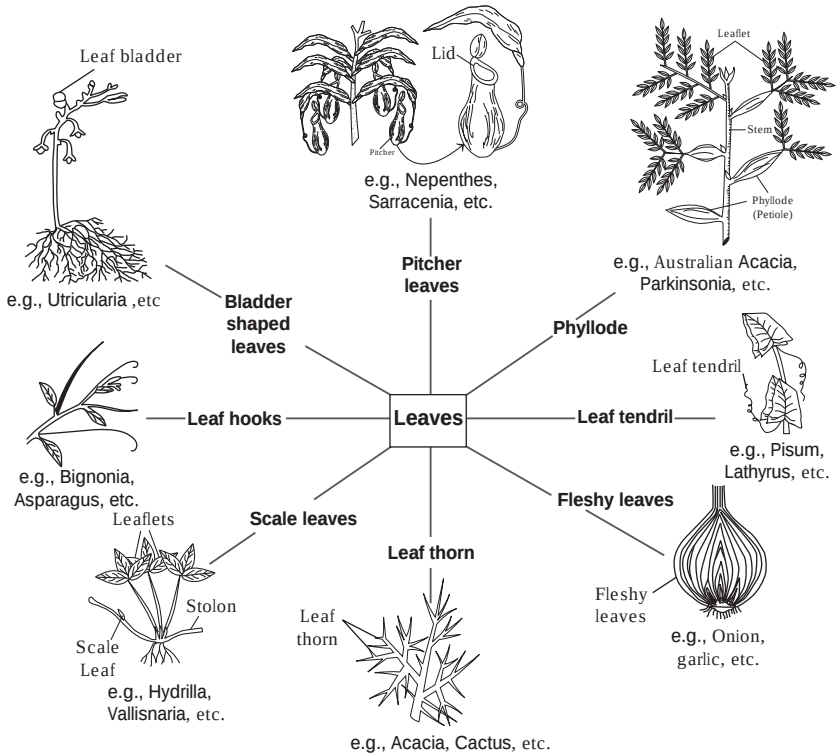
Phyllotaxy

Arrangement of leaves on main stem or branches is known as phyllotaxy. There are 5 main types of phyllotaxies, reported in plants. **The various phyllotaxies can be understood through following figures**



Types of phyllotaxy (a) Cyclic (b) Alternate (c) Opposite decussate, (d) Opposite superposed (e) Whorled or verticillate

Modifications of Leaves



Various leaf modifications

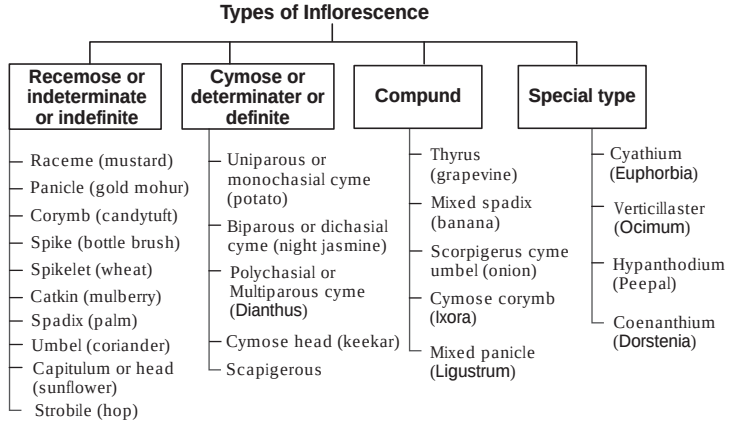
Inflorescence

The Shoot Apical Meristem (SAM) changes into floral meristem to form a flower and this flower bearing branch is called **peduncle**. The arrangement of flowers on floral axis is termed as **inflorescence**.

It can also be defined as 'system of branches bearing flower.'

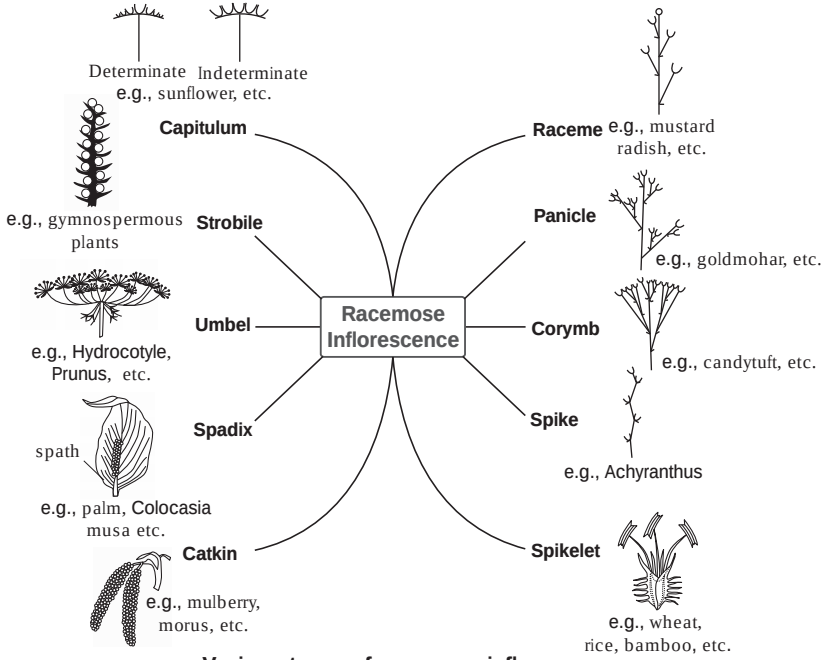
Types of Inflorescence

On the basis of the **mode of branching** and **modification of the peduncle**, **the inflorescence is of following types**



Racemose/Indeterminate/Indefinite Inflorescence

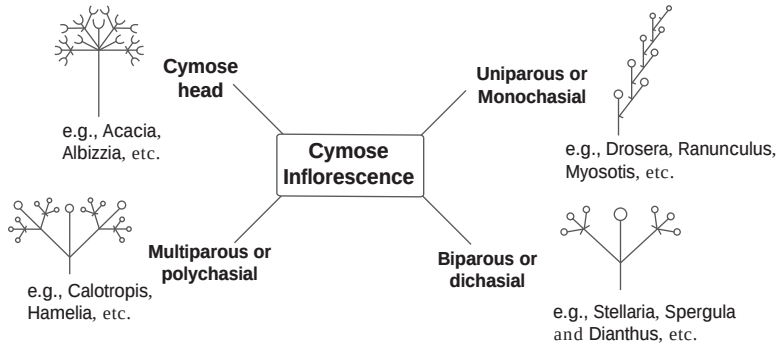
The peduncle continues to grow, forming new bracts and flowers in succession (acropetal manner). In this, the oldest flower is near to base and youngest is near the growing point.



Various types of racemose inflorescence

Cymose/Determinate/Definite Inflorescence

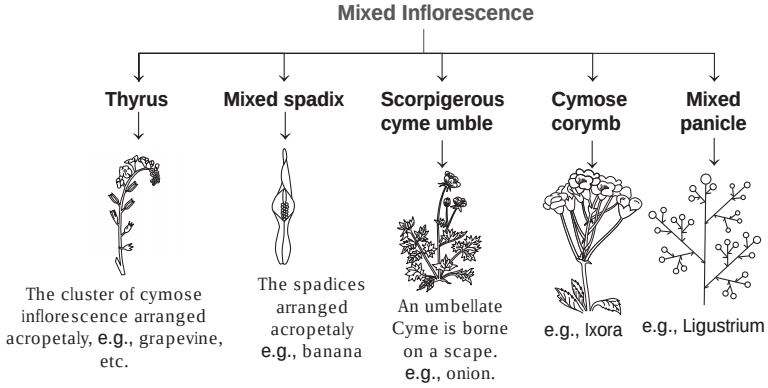
In this type of inflorescence, the apical meristem of peduncle produces the first flower while, the other flowers originate from lateral branches from the axis below. The oldest flower remains in centre and the youngest towards periphery, this arrangement is called centrifugal or basipetal sequence.



Various types of cymose inflorescences

Compound/Mixed Inflorescence

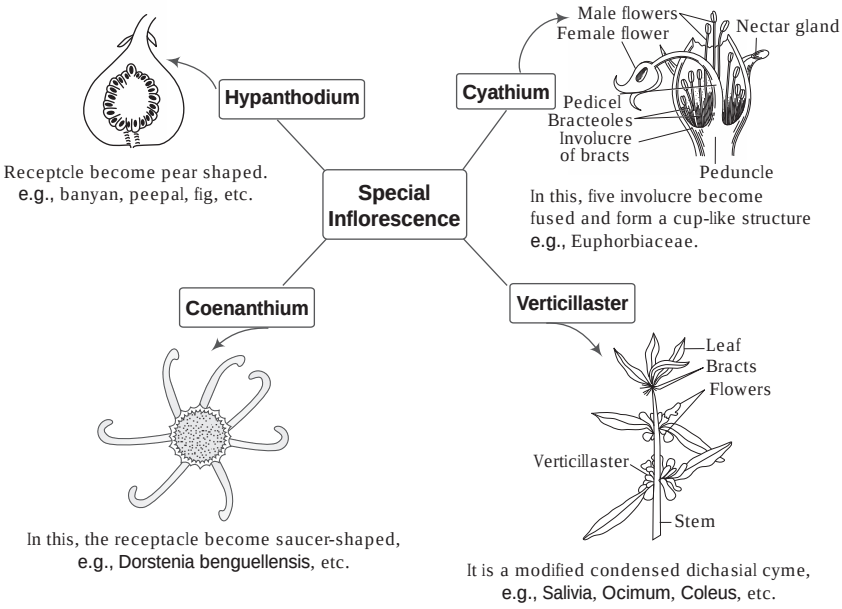
In this, the peduncle or main axis branches repeatedly once or twice in racemose or cymose manner.



Various types of compound inflorescences

Special Inflorescence

These are of unique type of inflorescences.



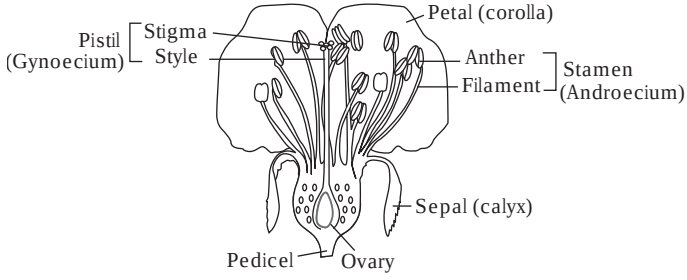
Various types of special inflorescences

Flower

It is the reproductive part of an angiospermic plant. It develops in the axis of a small leaf-like structure called **bract**.

Structure of a Flower

A complete flower is a modified condensed shoot, which is situated on receptacle (thalamus). It is a beautiful, reproductive organ that serves the purpose of attracting pollinators.



A flower showing detailed structure

Parts of a Typical Flower

Every flower normally has four floral whorls, **i.e, calyx, corolla, androecium** and **gynoecium**. All whorls are arranged on the swollen ends of the stalk, called **thalamus**.

The details of these parts are as follows

1. **Calyx** (Sepals)

It is the outermost whorl of floral leaves and the individual segment is called sepal. Mostly they are green in colour, but sometimes they are coloured like petals (petaloid).

- Sepals free from each other – Polysepalous
- Sepals fused with each other – Gamosepalous

Modifications of Sepals

Sepals undergo following modifications

(a) **Pappus** Hair-like modified sepals particularly for the dispersal of fruits, **e.g.,** sunflower, **Tagetes**, **Tridex**.

(b) **Spinous** Spine-like, **e.g., Trapa**.

(c) **Tubular** Tube-like, **e.g., Datura**.

(d) **Spurred** A tubular outgrowth called spur, arises at the base of one of the sepals, **e.g., Delphinium** (larkspur).

(e) **Campanulate** Bell-shaped, **e.g.,** China rose.

(f) **Leaf** One sepal becomes leaf-like, **e.g., Mussaenda**.

(g) **Hooded** One sepal becomes hood-like, **e.g., Aconitum**.

(h) **Cupulate** Cup-like, **e.g., Gossypium.**

(i) **Bilabiate** Like two lips of mouth, **e.g., Salvia, Ocimum**.

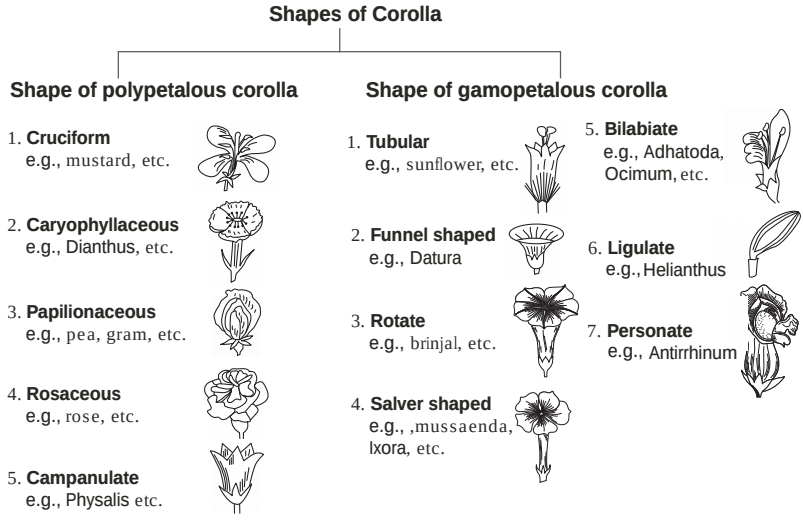
(j) **Infundibuliform** Like funnel-shapped, **e.g., Atropa**.

(k) Ureolate Urn-like, **e.g., Silene**.

2. **Corolla** (Petals)

This is the second whorl which arises inner to the calyx. The petal and sepal together form the floral envelope.

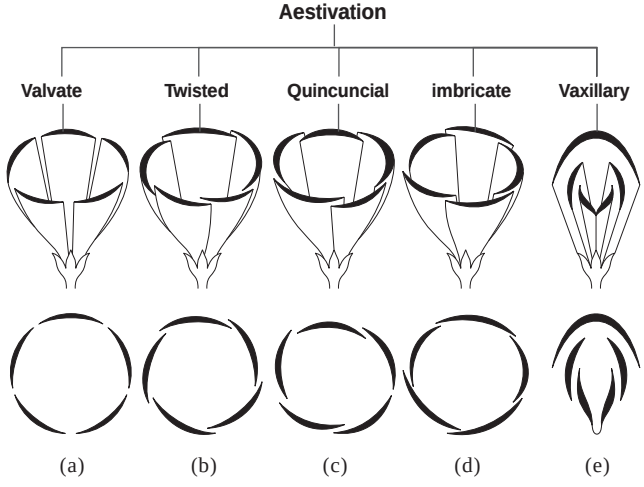
Note Both petals and sepals combinely called **perianth**. When petals and sepals are not differentiated clearly, it is called **tepal.**



Different shapes of corolla

Aestivation of Petals

The arrangement of petals or sepals on the thalamus is called aestivation. **On the basis of its arrangement / pattern, aestivation can be of following types**

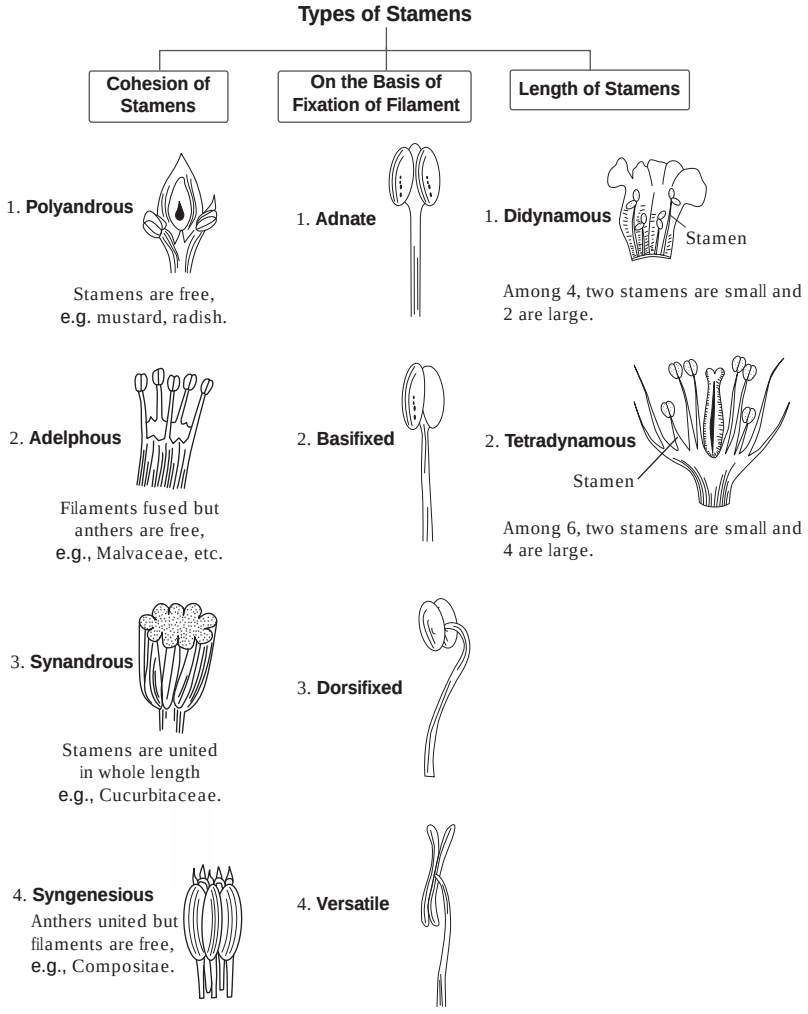


Various aestivations in flowering plants

3. **Androecium** (Male Reproductive Organ)

This is the third whorl of floral appendages, that arises inner to corolla. Individual appendage is called **stamen** which represents the male reproductive organ.

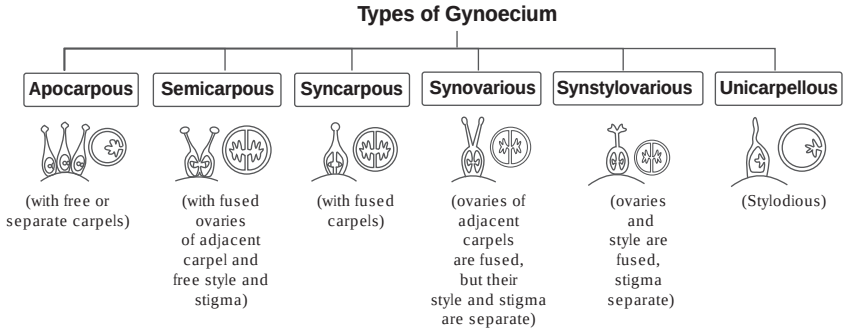
There are different types of stamens, on the basis of various criteria



Various types of stamens

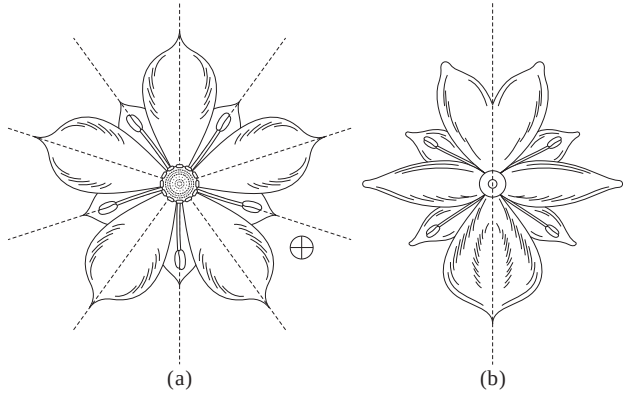
4. **Gynoecium** (Female Reproductive Organ)

It is the innermost floral whorl which acts as female reproductive organ of the flower. On the basis of number of carpels and their arrangement, **the gynoecium is of following types**



Terms Related to Flower Structure

1. **Actinomorphic flower** When the flower is regular and radially symmetrical, it is termed as actinomorphic, **e.g.,** mustard (Cruciferae), onion (Liliaceae), brinjal (Solanaceae).
2. **Asymmetric flower** Flowers, which cannot be divided into two equal halves by any vertical division, **e.g., Canna**.
3. **Zygomorphic flower** When the flower is bilaterally symmetrical, **i.e.,** divisible into only two equal halves by a single vertical plane, it is termed as zygomorphic, **e.g., Adhatoda**, pea, larkspur, **Ocimum**.



Symmetries in flowers (a) Actinomorphic (b) Zygomorphic

4. **Hermaphrodite or intersexual or bisexual or monoclinous flower** A flower is called bisexual when it contains both male and female reproductive organs, **e.g.,** China rose, mustard, etc.
5. **Unisexual or dioecious flowers** A flower is called unisexual when it has only one essential floral whorl, either androecium (staminate or pistalloide) or gynoecium (pistillate or staminoide), **e.g., Morus alba**, papaya, **Cucurbita**, etc.
6. **Complete and incomplete flowers** A flower is called complete when it contains all the floral whorls, **i.e.,** calyx, corolla, androecium and gynoecium, **e.g., Solanum**, mustard. While the flower in the absence of any one of these four floral whorls, is called incomplete flower, **e.g., Cucurbita**.
7. **Regular and irregular flowers** When the flowers of a plant have same size, shape, colour and arrangement of various floral whorls/organs, then the flowers are called **regular**. If flower of a plant shows dissimilarity in any of its part or trait, then the flowers are called **irregular**.
8. **Cyclic and acyclic flowers** When the floral parts of a flower are arranged in a whorl, the flower is called **cyclic**, **e.g.**, **Solanum**. If the floral part of a flower are arranged spirally and not in whorls, the flower is called **acyclic**, **e.g., Ranunculus, Opuntia, Nymphaea.**
9. **Achlamydeous, monochlamydeous and dichlamydeous flowers** In achlamydeous flowers, the accessory floral whorls (calyx and corolla) are absent, **e.g., Piper** sp. (Piperaceae).

   When a flower contains only one accessory whorl (either calyx or corolla) or **perianth** (a collective term given to a group of undifferentiated calyx and corolla), it is called **monochlamydeous**, **e.g., Polygonum** (Polygonaceae), onion (Liliaceae).

   The condition **dichlamydeous** is used when both the accessory whorls (calyx and corolla) are present, **e.g.,** in most of the flowers.
10. **Isomerous and heteromerous flowers** When the parts of a floral whorl are found in a particular basic number or its multiple, the situation is called **isomery** and the flower is **isomerous**.

An isomerous flower may be **dimerous** (2 or multiple of 2), **e.g.**, poppy or **trimerous** (3 or multiple of it), **e.g., Argemone** or **tetramerous** (4 or multiple of 4), **e.g., Solanum**. A flower is called **heteromerous**, when different parts of different floral whorls have different basic number of its multiple.

11. **Hypogynous, perigynous and epigynous ovary** A flower is called **hypogynous,** when the innermost floral whorl (gynoecium) occupies the highest position (superior) while corolla and calyx successively arise below it (inferior). **e.g., Brassica**, China rose, **Papaver, Citrus, Solanum**, cotton, etc.

    In **perigynous** flower, all the floral whorls occurred at the same level of height on the thalamus so, they are called half superior or half inferior, **e.g.,** rose, peach, **Prunus.**

    In an **epigynous** flower, the innermost whorl, **i.e.,** gynoecium is covered by the elongated margins of thalamus.

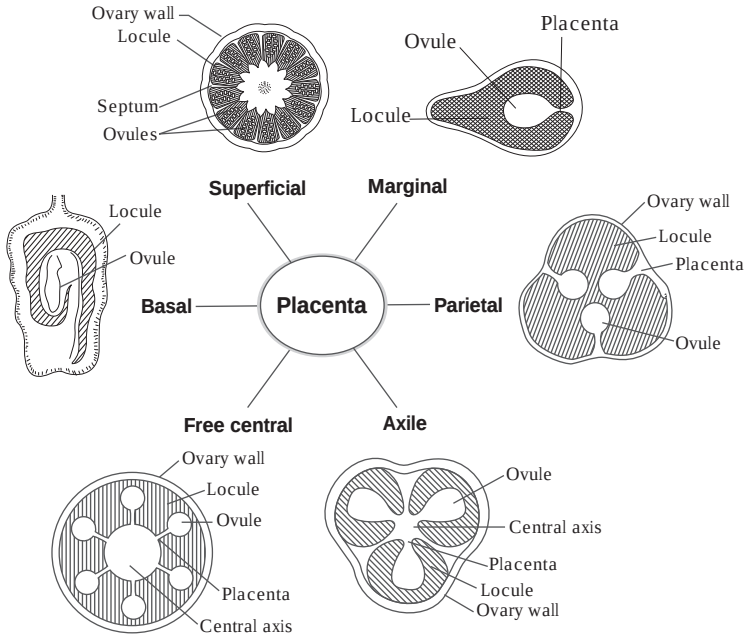
    Thus, its position is inferior in relation to other floral whorls, which arise above the ovary and thus superior, **e.g.,** sunflower, **Cucurbita,** coriander, etc

12. **Bracteate and ebracteate flowers** Bract is a small leaf-like structure, whose axil bears a pedicel (flower stalk). A flower containing bract is called bracteate, **e.g., Adhatoda** and without bract it is called ebracteate, **e.g., Solanum.**
13. **Bracteolate and ebracteolate** A pedicel sometimes bears a pair of bracteoles, which are often green, sepal-like structures. A flower with bracteoles, is called **bracteolate** and without bracteoles, it is termed as **ebracteolate**.
14. **Epicalyx** It is an additional whorl of bracteole-like structures, which are found exterior to the sepals, **e.g.,** China rose, cotton (Malvaceae).

Placentation

The arrangement of ovules within the ovary is called placentation. The placenta is a tissue which develops along the inner wall of the ovary. The ovule remains attached to the placenta.

It is of following types



Types of placentations in flowering plants

Fruit

After fertilisation of ovary, ovule is changed into seed and ovary into fruit. The fruit is a characteristic feature of the flowering plants. A true fruit is a ripened ovary. At this stage, the perianth and stamens fall off, the gynoecium is rearranged and ovary becomes extended.

Generally the fruit consists of a **wall or pericarp** and **seeds. Sometimes this pericarp is differentiated into three layers**

1. Outer – Epicarp 2. Middle – Mesocarp 3. Inner – Endocarp

On the basis of their development, the fruits are of two types

1. **True Fruits** These fruits develop from the ovary of flower, **e.g.,** mango, orange, etc.
2. **False Fruits** The floral parts other than ovary develop into fruit, **e.g.,** apple and pears, etc.