Morphology of Flowering Plants

The Root

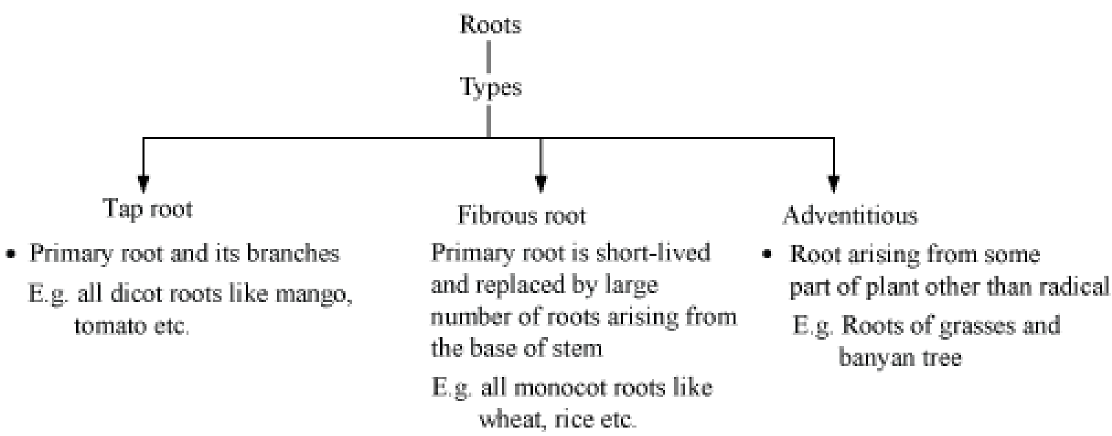
Angiosperms have diverse morphology, still they have the following structures in common:

- Roots
- Stem
- Leaves
- Flowers
- Fruits

The Root

- Primary root − direct elongation of radical which grows inside the soil

- Primary root bears several lateral roots termed as secondary roots, tertiary roots, etc.



Functions of Root

- Absorption of water and minerals from the soil

- Provision of anchorage to the plant

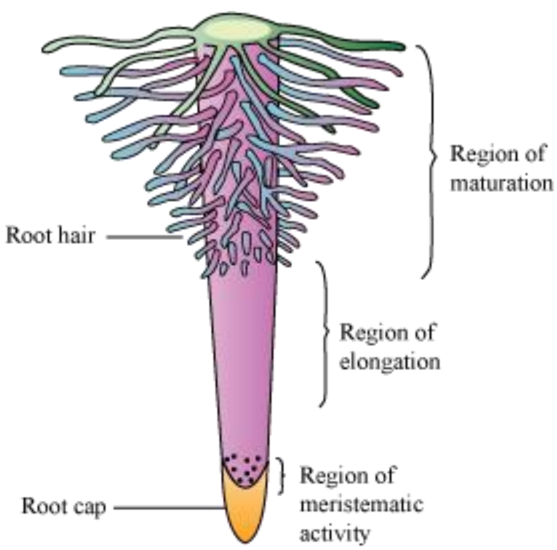
- Storage of reserve food materials

- Synthesis of plant growth regulators

Region of the Root

A root has following regions:

- **Root cap −** thimble-like structure that covers the root at apex, thereby protecting it
- **Region of meristematic activity −** Lies above the root cap
- Cells in this region are small, thin-walled, and have dense protoplasm.
- These cells divide repeatedly.
- **Region of elongation −** Lies above region of meristematic activity
- Cells in this region undergo rapid elongation and enlargement.
- These cells are responsible for growth of root.
- **Region of maturation −** Lies above region of elongation
- Cells in this region are differentiated and mature.
- Epidermal cells of this region form delicate thread-like root hair.
- These root hair help in the absorption of water and minerals from the soil.



Characteristics of Root for Absorbing Water

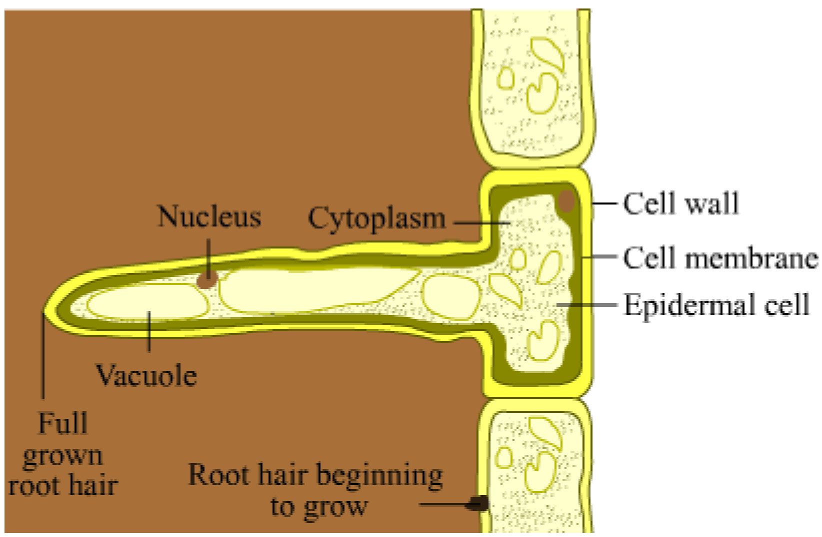
The nature of roots to draw water deep down from the soil depends on three main characteristics:

1. **Enormous Surface Area**: The surface area of the roots of all higher plants is very large. Larger the area covered by the roots, more water will be absorbed by them.

2. **Highly Concentrated Cell Sap**: The cells of root hairs contain salt-rich cell sap, that makes its concentration higher than that of the surrounding water. This helps in the occurrence of osmosis in the root hair, so that it can draw maximum water from outside.

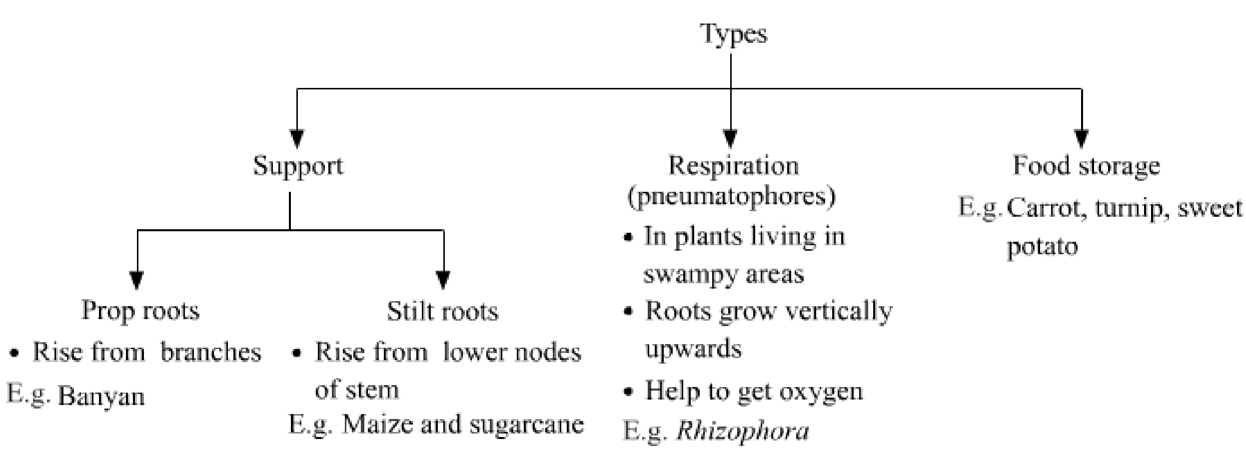
3. **Thin-walled Root Hairs**: Root hairs have very thin and semi-permeable walls that allow maximum water to pass through.

Structure of a Full Grown Root Hair



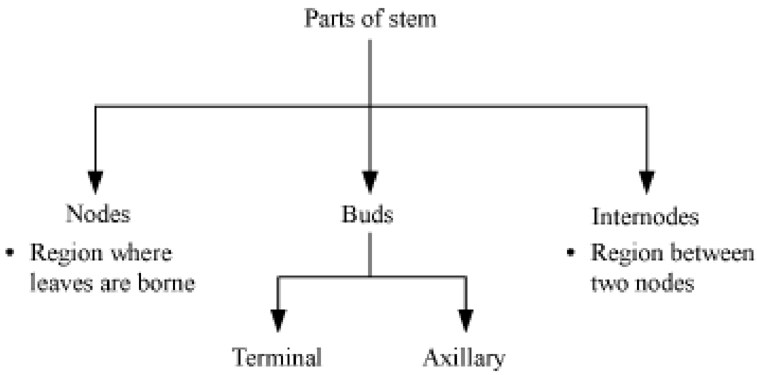
Modification of Root

- Roots of some plants modify their structure, shape, etc.
- These modifications are performing functions, other than absorption and conduction of water and minerals.
- Modified roots may perform functions such as support, respiration, and storage.



The Stem

- Stem is the ascending part of the axis growing above the soil bearing leaves, fruits, and flowers.
- Develops from the plumule of the embryo of a germinating seed



- In growing plants, stem is green in colour, but later it becomes woody and dark-coloured in trees.

Functions of Stem

- Conduction of water and minerals from the roots and food from the leaves
- Spreading out of branches to bear leaves, fruits, and flowers
- Storage of food
- Provision of protection and support to the plant
- Used in vegetative propagation

Modifications of stem

- **Underground stems −** For storage of food in potato, ginger, turmeric, etc. These structures also act as organs of perennation to help the plants survive in unfavourable conditions.
- **Tendrils −** Develop from axillary bud and are spirally coiled to help the plant to climb (E.g. Present in gourds and in grapevines)
- **Thorns −** Pointed, straight, and woody modifications of axillary buds, which arise to provide protection to plant from grazing animals. They are present in *Citrus, Bougainvillea.*

- **Photosynthetic stems −** Modification of stems into flattened or fleshy structures shown by some plants of arid regions to carry out photosynthesis (shown by *Opuntia and Euphorbia*)
- Underground stems of strawberry and grass spread to new niche to give rise to new plants when older ones die.
- In banana, pineapple, and *Chrysanthemum*, lateral branches originate from basal underground portion of main stem. They grow horizontally below the soil and then come out giving rise to leafy shoots.

The Leaf

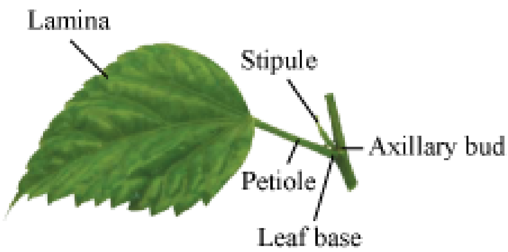
- The leaf is a lateral, flattened photosynthetic structure originating from the shoot apical meristems.
- It bears a bud in its axil and axillary bud develops into branches later.
- Leaves are arranged in an acropetal order.
- Important for photosynthesis

Parts of a leaf

A typical leaf consists of:

- **Leaf base**
- It attaches the leaf with the base of stem.
- Bears two stipules (lateral, small leaf-like structure)
- In monocots, leaf base expands to form a sheath that covers the stem totally or partially.
- In some leguminous plants, leaf base is swollen and called pulvinus.
- **Petiole**
- Holds the leaf base to light
- Allows the leaves to flutter and thus, bringing fresh air to the leaf surface
- **Lamina or leaf blade**
- Green expanded part with midrib and veins

- Veins provide rigidity to the leaf and also help in the transport of water, minerals, and food.



Venation

- Arrangement of veins and veinlets on the lamina of leaf

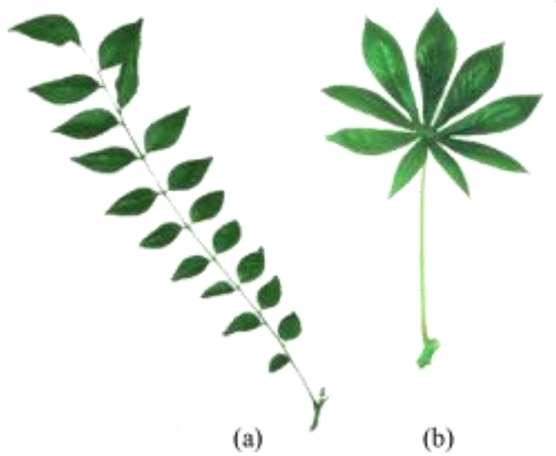
Types of Venation

Reticulate
- Veinlets form a network
- Generally all dicots like mango, rose etc.

Parallel
- Veins parallel to each other
- Generally all monocots like rice, wheat, sugarcane etc.

Types of leaves

- **Simple** − When lamina is entire, or when incised, the incisions do not touch the midrib
- **Compound** − When incisions reach the midrib and break it into number of leaflets (bud is not present in the axil of leaflets)
  Two types of compound leaves may exist:
- *Pinnately compound leaf* − Leaflets are present on a common axis called rachis (equivalent to the midrib of leaf as in neem).
- *Palmately compound leaf* − Leaflets are attached at a common point (at tip of petiole as in silk cotton).



Phyllotaxy

- Pattern of arrangement of leaves on stem or branch

Types of Phyllotaxy

Alternate
- Single leaf arises at each node
- Leaves are alternate to each other

Eg. China rose

Opposite
- A pair of leaves arise at each node and lie opposite to each other

Eg. Guava, *Calotropis*

Whorled
- More than two leaves arise at each node forming a whorl

Eg. *Alstonia*

Modifications of Leaves

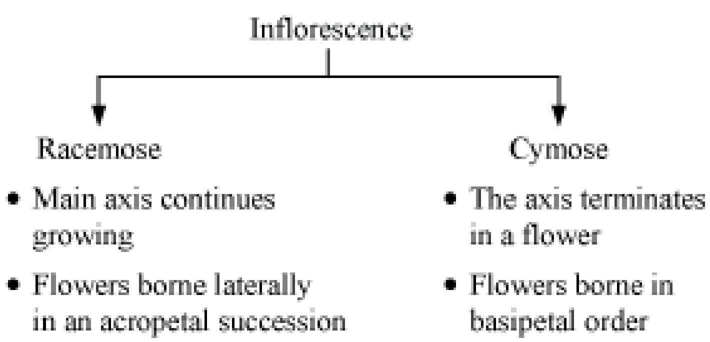
- To perform function other than photosynthesis
- Tendrils are used for support and climbing (eg. Peas).
- Spines are used for reducing water loss and defence.
- In insectivorous plants, leaves are modified to trap insects as in pitcher plant.
- Leaves are modified for storage of food in onion and garlic.

- In some plants such as Australian acacia, leaves are small and short-lived and petiole performs the function of leaves.

Inflorescence

The Inflorescence

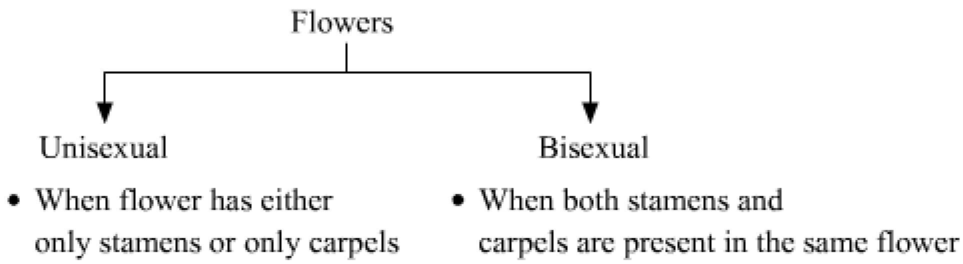
- The arrangement of flowers on floral axis is termed as inflorescence.
- Flower is a modified shoot. Modifications that occur in shoot to give rise to inflorescence are as follows:
- Apical meristem changes into floral meristem.
- Internodes do not elongate and axis gets condensed.
- Different kinds of floral appendages are produced at nodes in place of leaves.
- When shoot tip is modified into flowers, the flower is always solitary.
- Based on arrangement on the floral axis, inflorescence is of two types:



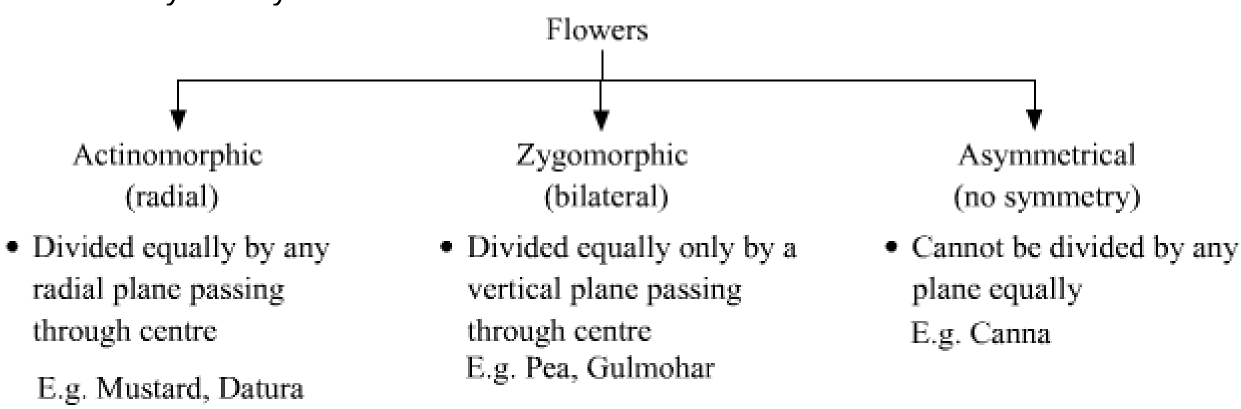
Flower

- Reproductive unit in angiosperms
- Thalamus (receptacle) is the swollen end of stalk (pedicel). On the thalamus, 4 different kinds of whorls are arranged:
- Androecium (reproductive organ)
- Gynoecium (reproductive organ)
- Calyx (accessory organ)

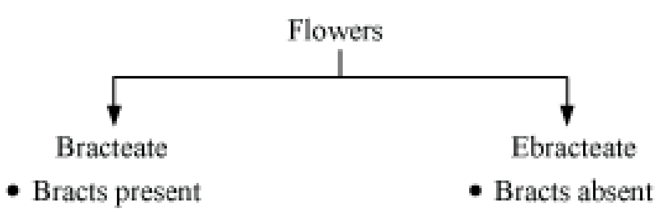
- Corolla (accessory organ)
- Perianth − When calyx and corolla are not distinct, together they are called perianth.
- Based on sexuality, flowers can be divided into:



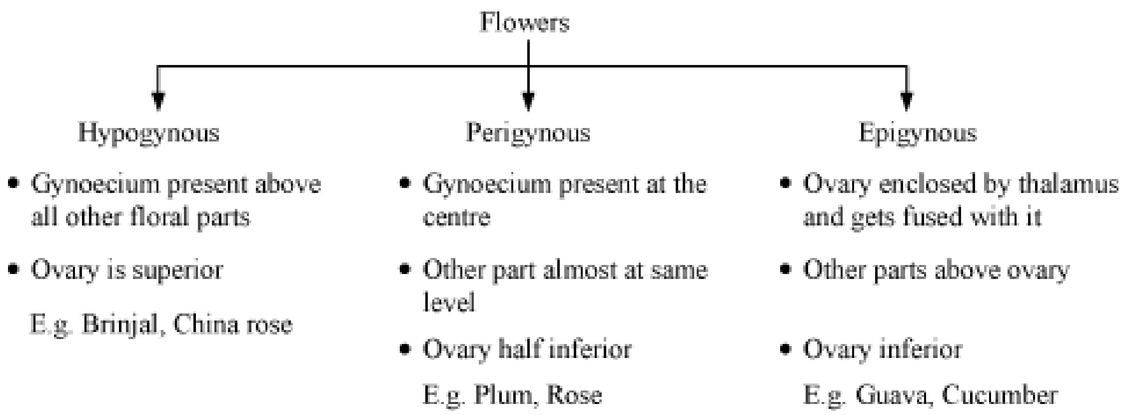
- Based on symmetry:



- A flower may be trimerous, tetramerous, or pentamerous based on the number of floral appendages (multiples of 3, 4 or 5 respectively).
- Based on presence or absence of bracts − reduced leaf found at the pedicel base

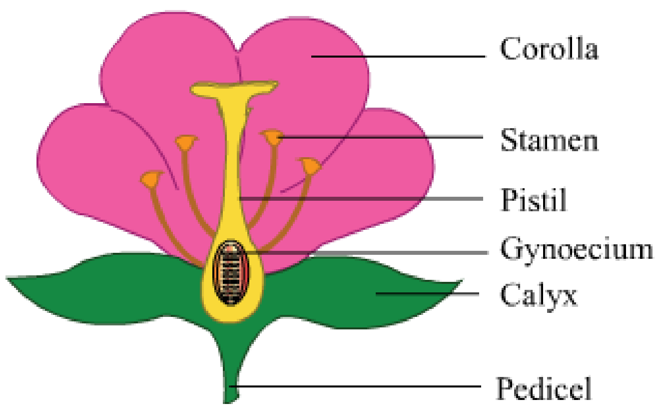


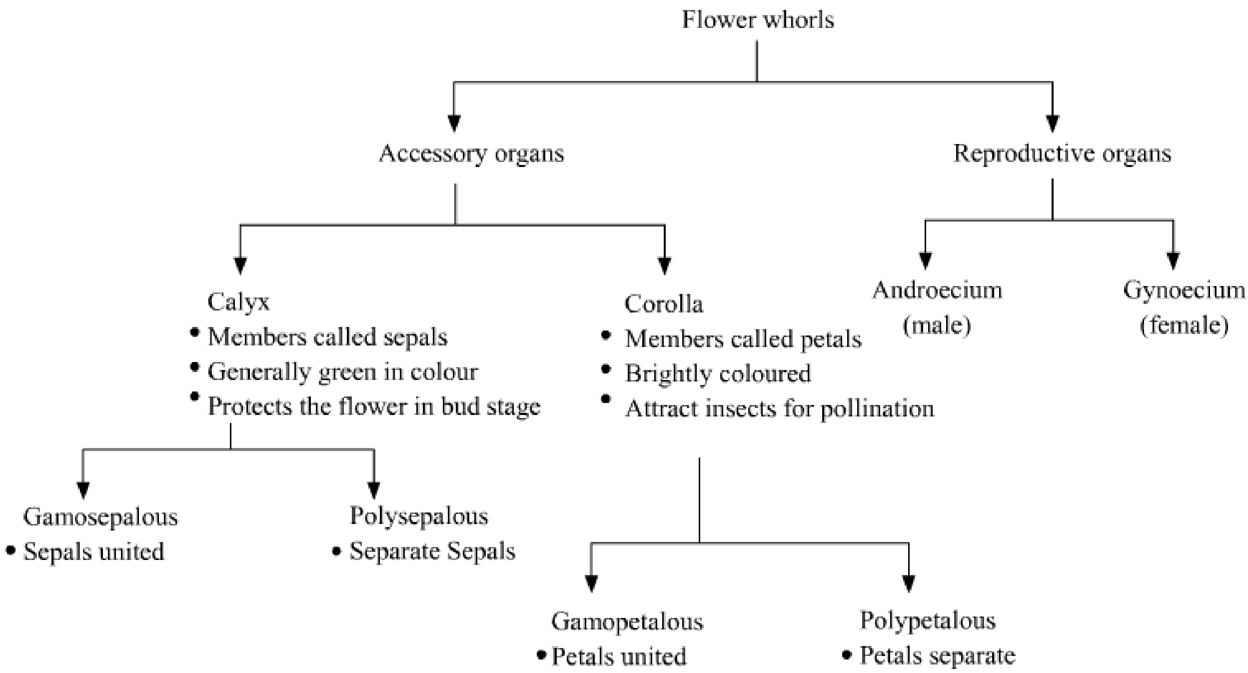
- Based on position of sex organs on the thalamus:



Details of Whorls of a Flower

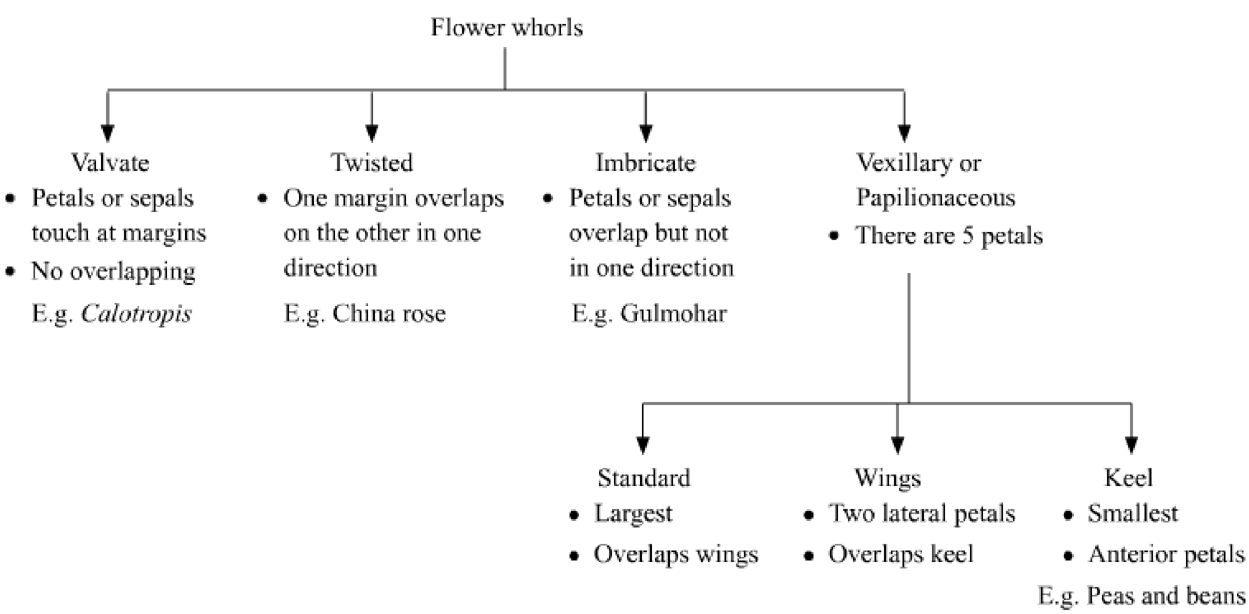
- Whorls are arranged on thalamus or receptacle (swollen ends of pedicel).
- A typical flower has 4 whorls.



- 

Aestivation

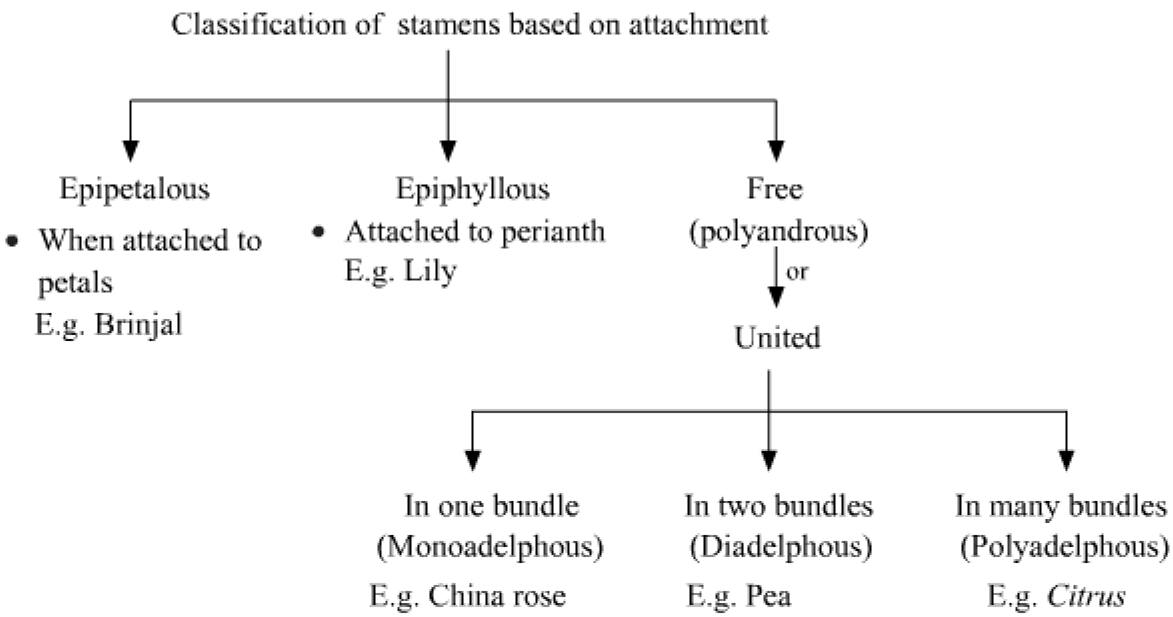
- Mode of arrangement of sepals or petals with respect to other members of the same whorl:



Androecium

- Male reproductive part composed of stamens

- Each stamen consists of a filament and an anther.
- Anther is bilobed; each lobe has 2 chambers called pollen sacs where pollen grains are produced.
- Sterile stamen is called a staminode.

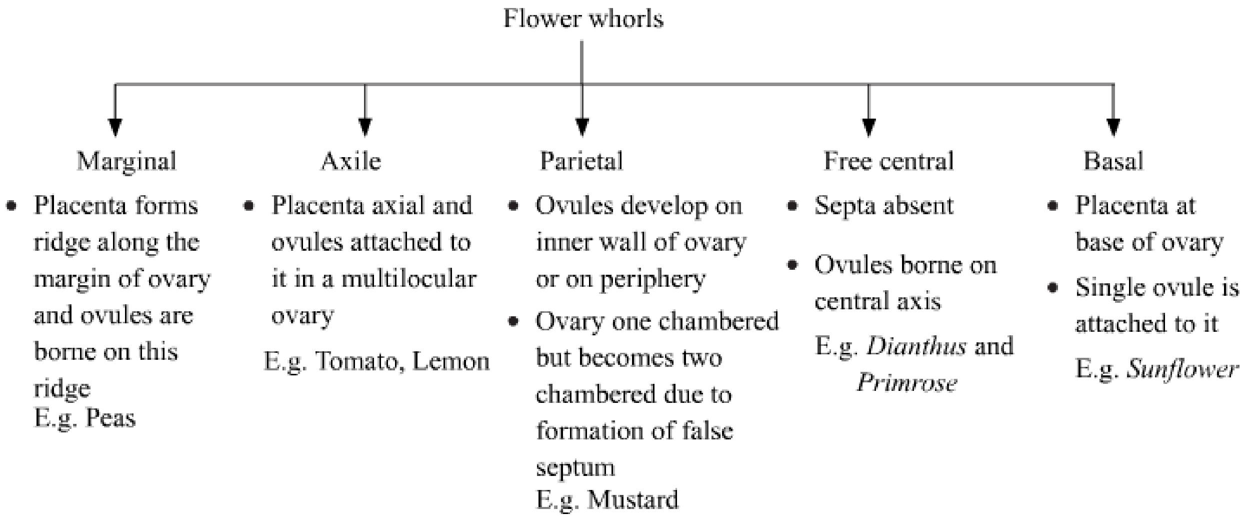


Gynoecium

- Female reproductive part made up of carpels
- Carpel is made up of:
- Style − connects stigma to the ovary
- Stigma − receptacle for pollen grains
- Ovary − enlarged basal part on which style lies
- Each ovary bears one or more ovules attached to cushion-like placenta.
- After fertilization, ovules develop into seeds and ovary into fruit.

Placentation

- Arrangement of ovules within ovary



Seed Germination

Germination is the process during which seed reserves present in the seed are broken down and the embryo starts to grow.

During germination, the seed absorbs water. Germination is irreversible i.e. once begun; the seed cannot be brought back to dormant state,

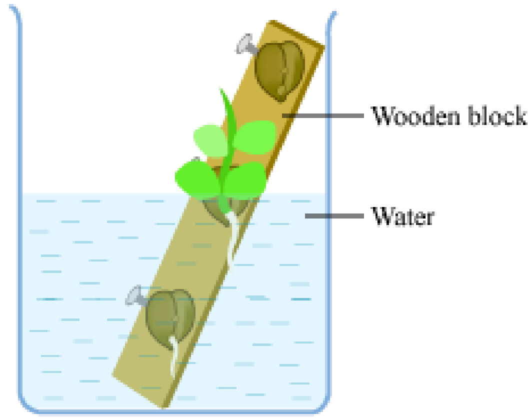
Seeds which do not germinate even after provided with all the conditions necessary for germination are called **dormant seeds** and the phenomenon is termed as **dormancy**.

Let us study what happens during germination

When a seed is germinating, the portion above the cotyledon that forms future shoots is called plumule and the portion below the cotyledon that forms the future roots is called radicle.

Conditions Necessary for Germination

Activity 1



- As shown in the figure, take a beaker with water and place it in, a glass slide with three bean seeds tied to it.
- The slide should be kept in such a way that the upper seed is completely out of water, lower seed is completely submerged in water and the middle seed is half submerged in water.
- The beaker is placed in warm temperature (25° C − 30° C) for few days.

Result

- Seed at top − Does not germinate
- Seed at middle − Germinates
- Seed at bottom − Does not germinates

Inference

- Seed at top gets only oxygen and no water. So it does not germinate.
- Seed at middle receives both oxygen and water. So it germinates.
- Seed at bottom gets only water and no oxygen. So it does not germinate.

Activity 2

- Take two petridishes with moist cotton placed in it.
- Place a few soaked seeds in both petridishes.
- Place the first petridish in refrigerator (4°C) and the second one at room temperature (30°C).

- Leave the petridishes for few days.

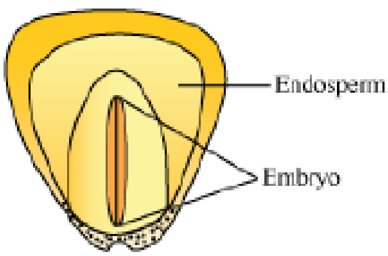
Result

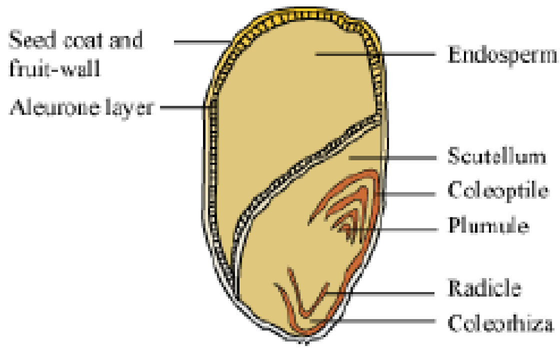
- No germination was seen in the petridish kept in refrigerator while the seed present in the petridish kept at room temperature germinates.

Inference

- Suitable temperature is necessary for germination.

Structure of Monocot Seed





- In seeds of cereals, seed coat is membranous and fused to the fruit wall.
- Generally, monocot seeds are endospermous. Endosperm is bulky and stores food.
- Aleurone layer - proteinous layer that separates embryo from outer covering of endosperm
- Embryo is situated in a groove in endosperm. Embryo consists of
- cotyledon known as scutellum
- embryonal axis (consisting of plumule and radical)
- Plumule is enclosed in a sheath called coleoptile and radical in coleorrhiza.

So what does you concluded about the necessary conditions for seed germination?

Seeds require water, suitable temperature, and oxygen for germination. Let us see how these factors affect germination one by one.

Water

- Helps in rupture of seed coat by swelling the seed, so as to allow the elongated radicle to come out during germination

- Necessary for various biochemical reactions occurring within the seed

Suitable Temperature

- Moderately warm temperature (25ºC - 35°C) is suitable for germination of most of the seeds.
- Very low or high temperature can destroy the delicate tissues of the seed.

Oxygen

- Necessary for providing energy (through respiration) required for rapid cell division and cell growth

Types of Germination

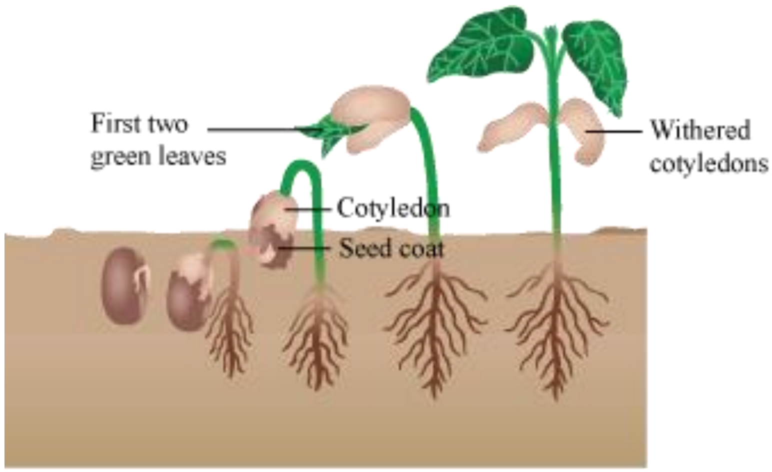
There are two types of germination patterns depending upon the behaviour of cotyledons during germination.

- Epigeal germination

- Hypogeal germination

Epigeal Germination

When the cotyledons are lifted above the ground as a result of rapid elongation of hypocotyls e.g. seeds of bean, castor, cotton, etc germinate in this manner.

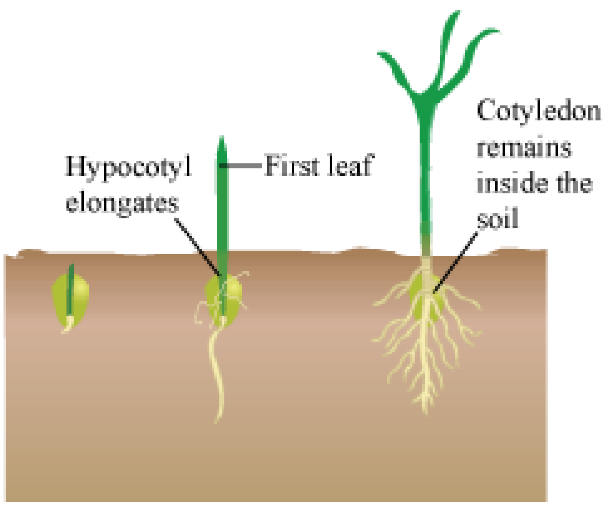


Epigeal germination in a bean seed

Hypogeal Germination

When the epicotyls elongates quickly and pushes the plumule up, and cotyledons are left on the ground only, the germination is hypogeal.

e.g. Gram, pea, maize, etc germinate in this manner.



Hypogeal germination in a maize grain

Viviparous Germination
A special mode of germination in which seed starts germinating inside the fruit while it is still attached to the parent plant. Once germinated, the seedling is dropped into the soil where it fixes itself by developing roots.

Seedling: A very young plant that grows from a seed after germination. It consists of roots, that fix it in the soil and absorb water and minerals, and small young leaves which manufacture food for it.

Floral Diagrams

Floral Diagrams

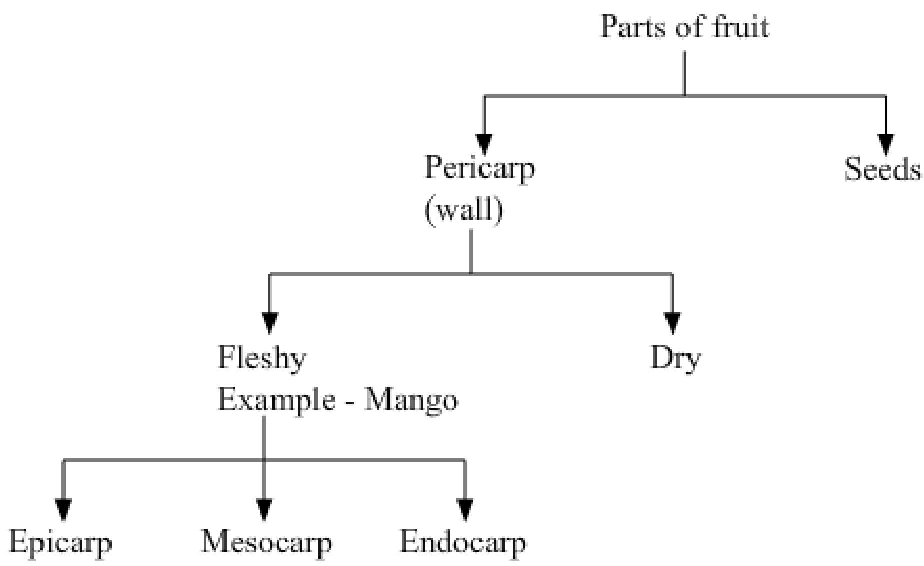
- Information provided by a floral diagram is as follows:
- Number of parts of a flower
- Arrangement of the parts of a flower with respect to each other
- Relation of the parts of a flower with each other
- Position of the mother axis with respect to the flower (represented by a dot on the top of the floral diagram)
- Calyx, corolla, androecium and gynoecium are drawn in successive whorls, with the calyx being the outermost and gynoecium being the innermost.
- Also shows cohesion and adhesion of the parts of whorls and between whorls.
- Floral formulae are represented by symbols; some of them are as follows:

Br	Bracteate
K	Calyx
C	Corolla
P	Perianth
A	Androecium
G	Gynoecium
$\underline{G}$	Superior ovary

$\overline{G}$	Inferior ovary
♂	Male
♀	Female
⚥	Bisexual
⊕	Actinomorphic
%	Zygomrphic
Enclosing figure within brackets	Fusion
Line drawn over symbols of floral parts	Adhesion

The Fruit

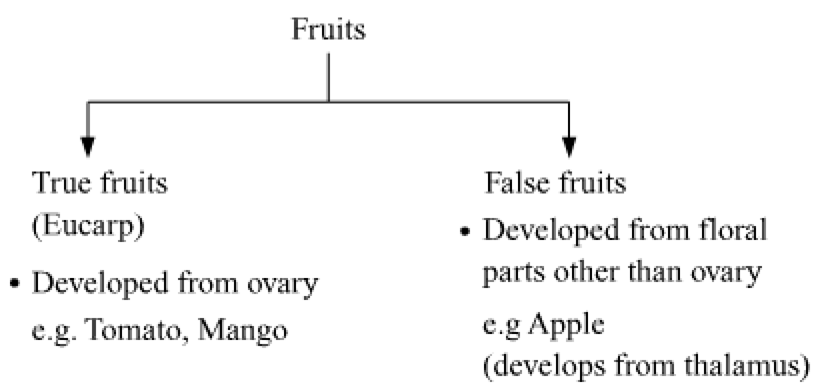
- It is the matured ovary developed after fertilization.
- Fruits formed without fertilization of ovary are called parthenocarpic fruits.
- Generally a fruit has the following parts:



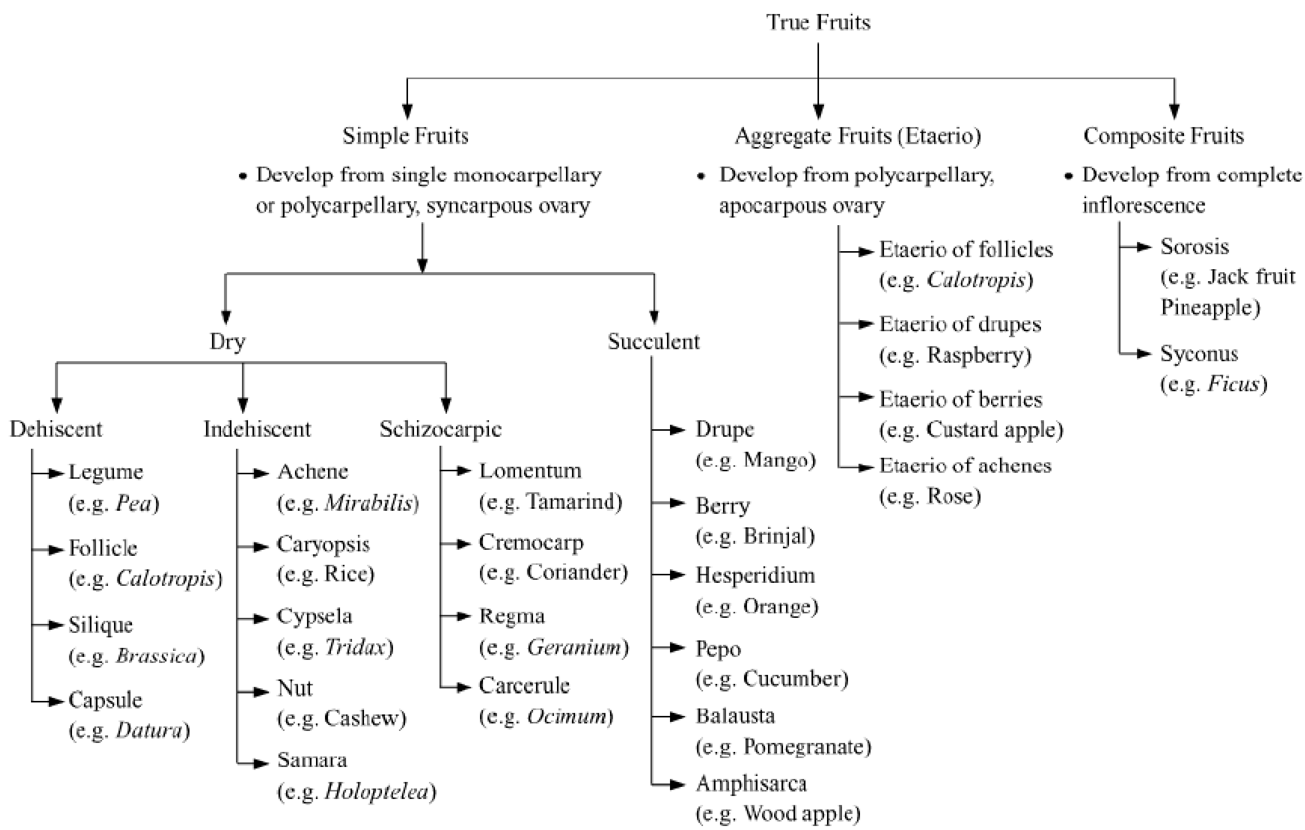
- In mango and coconut, the fruit is known as drupe (developing from monocarpellary superior ovaries). In mango, the mesocarp is edible while in coconut, the mesocarp is represented by the fibrous part.

- **Geocarpic fruits** : The fruit that ripens below the surface of ground are known as geocarpic fruits. For example, groundnut.

Fruits can be classified on the basis of their origin



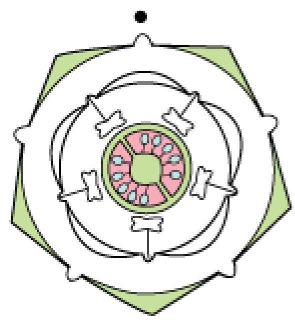
- Based on the floral origins, true fruits can be further classified as simple, aggregate and composite.



Family Solanaceae

Family Solanaceae

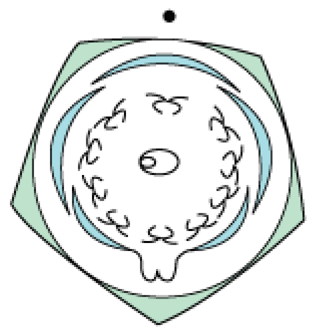
		Solanaceae (potato family)
Vegetative Characters	Stem	Herbaceous, aerial, erect, branched, hairy, underground stem (potato)
	Leaf	Alternate, simple, rarely pinnately compound, reticulate venation
	Plant	Mostly herbs, shrubs and rarely small trees
Floral Characters	Inflorescence	Solitary, axillary or cymose
	Flower	Bisexual, actinomorphic
	Calyx	Five sepals, gamosepalous, valvate aestivation
	Corolla	Five petals, gamopetalous, valvate

	Androecium	Five, epipetalous
	Gynoecium	Bicarpellary, syncarpous, superior ovary, bilocular, many ovules
	Fruit	Berry or capsule
Floral Formula		$\oplus$ ⚥ $K_{(5)}\ \widehat{C_{(5)}\ A_5}\ \underline{G}_{(2)}$
Floral Diagram		

Family Fabaceae

Family Fabaceae

		Fabaceae (bean family)
Vegetative Characters	Stem	Erect or climber
	Leaf	Alternate, pinnately compound or simple, reticulate venation
	Plant	Trees, shrubs, herbs, root with nodules
Floral Characters	Inflorescence	Racemose
	Flower	Bisexual, zygomorphic
	Calyx	Five sepals, gamosepalous, imbricate aestivation
	Corolla	Five petals, polypetalous, 1 posterior standard, 2 lateral wings, 2 anterior ones forming a keel, Vexillary aestivation.

	Androecium	Ten, diadelphous, anther dithecous
	Gynoecium	Ovary superior, monocarpellary, unilocular ovary, many ovules, single style
	Fruit	Legume, one to many seeds, non-endospermic
Floral Formula	% ⚥ $K_{(5)}\ C_{1+2+(2)}\ A_{(9)+1}\ \underline{G}_1$	
Floral Diagram		

Family Liliaceae

Family Liliaceae

		Liliaceae (lily family)
Vegetative Characters	Stem	Underground bulb, corm or rhizome
	Leaf	Mostly basal, alternate, linear, parallel venation
	Plant	Perennial herbs
Floral Characters	Inflorescence	Solitary/ cymose
	Flower	Bisexual, actinomorphic
	Perianth	Six tepals (3 + 3), united into tube, valvate aestivation
	Androecium	Six stamens (3 + 3)

	Gynoecium	Tricarpellary, syncarpous, superior ovary, trilocular with many ovules, axile placentation
	Fruit	Capsule, rarely berry; endospermous seed
Floral Formula	Br $\oplus$ ⚥ $P_{(3+3)}$ A_{3+3} $\underline{G}_{(3)}$	
Floral Diagram