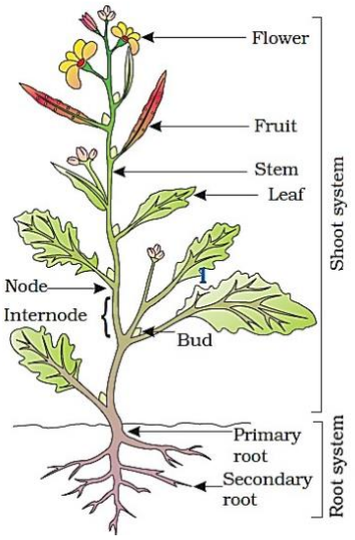
MORPHOLOGY OF FLOWERING PLANTS

- **Morphology** is the study of external forms of organisms.
- A flowering plant (Angiosperm) has 2 parts: **Root system** (underground part) & **Shoot system** (portion above the ground).

THE ROOT

It is the underground part formed from **radicle** of embryo.

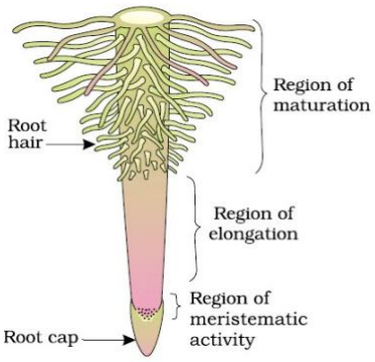
Root systems are 3 types:



- **Tap root system:** It consists of **primary roots (tap root)** and its branches (lateral roots such as **secondary roots, tertiary roots)**. Seen in dicots. Primary root is elongated from **radicle.** E.g. Mustard plant.
- **Fibrous root system:** In monocots, primary root is short lived and is replaced by many roots. They originate from the base of stem to form fibrous root system**.** E.g. Wheat.
- **Adventitious root system:** Roots that arise from parts other than radicle. E.g. Grass, *Monstera* and banyan tree.

Regions of the Root

- **Root cap:** It is the covering at the apex of root. It protects the tender apex of the root.
- **Region of meristematic activity:** Seen above the root cap. Here, the cells are very small, thin-walled and with dense protoplasm. They divide repeatedly.
- **Region of elongation:** Region just above the meristematic region. Here, cells undergo rapid elongation and enlargement. Helps in growth of the root in length.
- **Region of maturation:** It is proximal to elongation zone. Here, the cells differentiate and mature.
- **Root hairs:** Very fine, delicate, thread-like structures formed from epidermal cells in region behind region of elongation. They absorb water and minerals from the soil.



Modifications of Root

In some plants, roots are modified to perform functions other than absorption and conduction. E.g.

- **Swollen roots for food storage:** E.g. Tap roots of carrot, turnips and adventitious roots of sweet potato.
- **Prop roots**: Hanging structures that support banyan tree.
- **Stilt roots:** The supporting roots coming out of the lower nodes of the stem. E.g. maize & sugarcane.
- **Pneumatophores:** The roots that come out of the ground and grow vertically upwards to get oxygen for respiration. E.g. *Rhizophora* growing in swampy areas.

Functions of root

☺ Absorption of water and minerals from the soil.
☺ Provide a proper anchorage to the plant parts.
☺ Storage of reserve food material.
☺ Synthesis of plant growth regulators.

THE STEM

- It is the ascending part of the axis that develops from the **plumule** of the embryo of a germinating seed.
- It bears branches, leaves, flowers, fruits, buds (terminal or axillary), nodes and internodes.
- **Nodes** are the regions of the stem where leaves are born. **Internodes** are the portions between two nodes.
- Young stem is generally green and later often become woody and dark brown.

Functions of stem:

☺ Spreading out branches bearing leaves, flowers and fruits.
☺ It conducts water, minerals and photosynthates.
☺ Food storage, support, protection & vegetative propagation.

Modifications of Stem

- **For food storage:** E.g. underground stems of potato, ginger, turmeric, *zaminkand*, *Colocasia* etc. They also act as organs of perennation to tide over conditions unfavourable for growth.
- **Stem tendrils:** Slender and spirally coiled structures formed from axillary buds. They help plants to climb. E.g. Gourds (cucumber, pumpkins, watermelon) & grapevines.
- **Thorns:** Woody, straight and pointed structures developed from axillary buds. They protect plants from browsing animals. E.g. *Citrus*, *Bougainvillea*.
- **Phylloclade:** It is a green, flattened or fleshy cylindrical stem containing chlorophyll for photosynthesis. Found in some plants of arid regions. E.g. *Opuntia* (flattened stem), *Euphorbia* (cylindrical stem).
- **Stolon:** Slender lateral branch that arises from the base of the main axis and after growing aerially for some time arch downwards to touch the ground. E.g. mint & jasmine.
- **Offset:** It is a lateral branch with short internodes and each node bearing a rosette of leaves and a tuft of roots. E.g. aquatic plants like *Pistia* and *Eichhornia*.
- **Sucker:** The lateral branches that originate from the basal underground part of the main stem. It grows horizontally beneath the soil and come out obliquely upward giving rise to leafy shoots. E.g. Banana, Pineapple & *Chrysanthemum.*

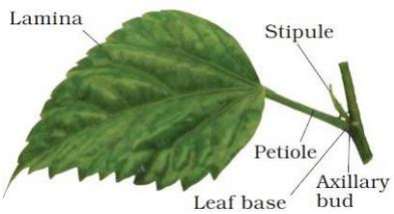
Underground stems of grass, strawberry etc. spread to new niches. When older parts die, new plants are formed.

THE LEAF

- It is a lateral, flattened structure borne on the stem.
- It develops at the node and bears a bud in its axil.
- The **axillary bud** later develops into a branch.
- Leaves originate from shoot apical meristems and are arranged in an acropetal order.
- They are important vegetative organs for photosynthesis.

A typical leaf has 3 main parts:

- **Leaf base:** With this, the leaf is attached to stem. It may bear two lateral small leaf-like structures called **stipules.** In monocots, the leaf base expands into a sheath covering the stem partially or wholly. In some leguminous plants, the leaf base may be swollen. It is called **pulvinus**.
- **Petiole:** It helps to hold the leaf blade to light. Long thin flexible petioles allow leaf blades to flutter in wind, thereby cooling leaf and bringing fresh air to leaf surface.
- **Lamina (leaf blade):** The green expanded part with veins & veinlets. The middle prominent vein is called **midrib.** Veins provide rigidity to lamina and act as channels of transport for water, minerals & food materials.



Venation

- It is the arrangement of veins and veinlets in leaf lamina.
- It is 2 types:
  - **Reticulate venation:** Here, the veinlets form a network. It is seen in dicotyledons.
  - **Parallel venation:** Here, the veins run parallel to each other within a lamina. It is seen in monocotyledons.

Types of Leaves

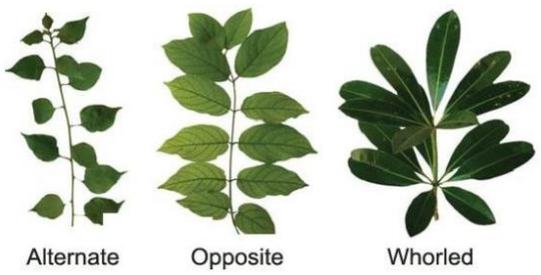
- **Simple leaf:** Here, leaf lamina is entire or when incised, the incisions do not touch the midrib.
- **Compound leaf:** Here, the incisions of the lamina reach up to the midrib breaking it into several leaflets.
  A bud is seen in the axil of petiole in simple & compound leaves, but not in the axil of leaflets of the compound leaf. The compound leaves are 2 types.
  - **Pinnately compound leaf:** In this, many leaflets are present on a common axis, the **rachis**, which represents the midrib of the leaf. E.g. neem.
  - **Palmately compound leaf:** In this, leaflets are attached at a common point (at the tip of petiole). E.g. silk cotton.

Reticulate venation | **Parallel venation** | **Palmately compound** | **Pinnately compound**

Phyllotaxy

It is the pattern of arrangement of leaves on the stem or branch. It is 3 types:

- **Alternate:** In this, a single leaf arises at each node in alternate manner. E.g. China rose, mustard & sun flower.
- **Opposite:** In this, a pair of leaves arise at each node and lie opposite to each other. E.g. *Calotropis* and guava.
- **Whorled:** In this, more than two leaves arise at a node and form a whorl. E.g. *Alstonia.*



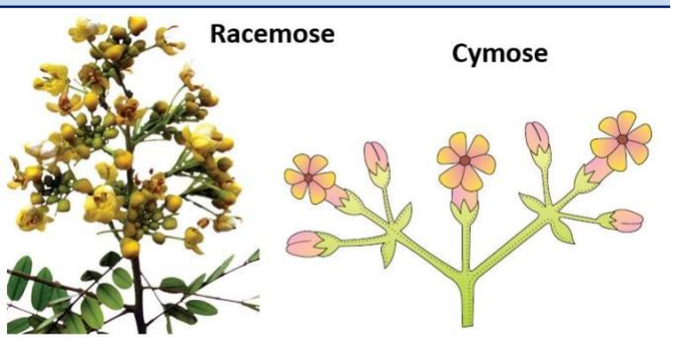
Alternate | Opposite | Whorled

Modifications of Leaves

- Leaves are modified to perform functions other than photosynthesis. E.g.
  - **Tendrils:** For climbing. E.g. peas.
  - **Spines:** For defense. E.g. cacti.
  - **Fleshy leaves:** To store food. E.g. onion and garlic.
- In plants such as Australian acacia, the leaves are small and short-lived. The petioles in these plants expand, become green and synthesise food.
- Leaves of some insectivorous plants (e.g. pitcher plant, Venus-fly trap) are also modified leaves.

THE FLOWER AND THE INFLORESCENCE

- A flower is a modified shoot wherein the shoot apical meristem changes to floral meristem.
- Internodes do not elongate and the axis gets condensed.
- The apex produces different kinds of floral appendages laterally at successive nodes instead of leaves.
- When a shoot tip transforms into a flower, it is solitary.
- The arrangement of cluster of flowers on the floral axis is called **inflorescence.**
- Based on whether the apex gets converted into a flower or continues to grow, inflorescences are 2 types: Racemose and Cymose.



- **Racemose:** In this, the main axis continues to grow. Flowers are borne laterally in an acropetal succession.

- **Cymose:** In this, main axis terminates in a flower, hence is limited in growth. Flowers are borne in a basipetal order.

THE FLOWER

- It is the **reproductive unit** in the angiosperms.
- It is meant for sexual reproduction.
- A flower has a **stalk (pedicel).** Its swollen end is called **thalamus (receptacle)**.
- Reduced leaf found at the base of the pedicel is called **bracts.** Flowers with bracts are called **bracteate** and those without bracts, **ebracteate**.
- A typical flower has 4 kinds of whorls arranged on thalamus- **calyx, corolla, androecium & gynoecium.**
- Calyx & corolla are accessory organs, while androecium and gynoecium are reproductive organs.
- In flowers like lily, the calyx and corolla are not distinct. It is termed as **perianth.**
- When a flower has both androecium and gynoecium, it is **bisexual**. A flower having either only androecium or only gynoecium is **unisexual.**

Based on symmetry, flowers are 3 types:

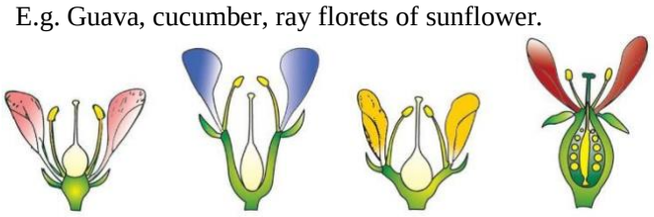
- **Actinomorphic** (radial symmetry): Here, a flower can be divided into 2 equal radial halves in any radial plane passing through the centre. E.g. mustard, *datura*, chilli.
- **Zygomorphic** (bilateral symmetry): Here, a flower can be divided into two similar halves only in a particular vertical plane. E.g. pea, gulmohur, bean, *Cassia*.
- **Asymmetric** (irregular): Here, a flower cannot be divided into two similar halves by any vertical plane passing through the centre. E.g. canna.

Based on number of floral appendages, flowers are classified as follows:

- **Trimerous:** Floral appendages are multiple of 3.
- **Tetramerous:** Floral appendages are multiple of 4.
- **Pentamerous:** Floral appendages are multiple of 5.

Based on the position of calyx, corolla and androecium in respect of the ovary on thalamus, the flowers are 3 types:

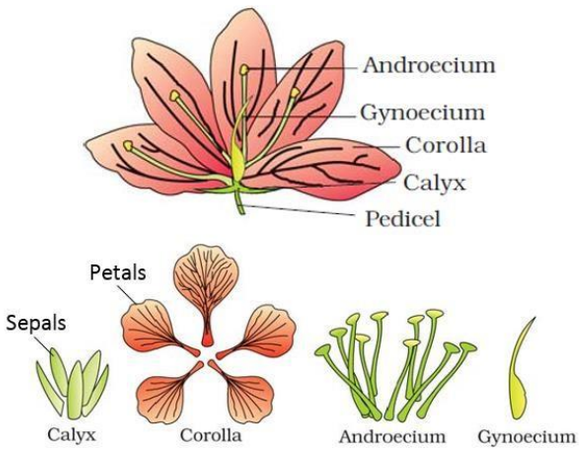
- **Hypogynous:** Here, gynoecium occupies the highest position while other parts are situated below it. The ovary is **superior.** E.g. mustard, China rose & brinjal.
- **Perigynous:** Here, gynoecium is situated in the centre and other parts are located on the rim of the thalamus at the same level. Ovary is **half inferior.** E.g. plum, rose, peach.
- **Epigynous:** Here, the margin of thalamus grows upward enclosing the ovary completely and getting fused with it. Other parts arise above the ovary. The ovary is **inferior.** E.g. Guava, cucumber, ray florets of sunflower.



Parts of a Flower

a) Calyx

- It is the outermost whorl of flower. It is made of **sepals.**
- Generally, sepals are green, leaf like and protect the flower in the bud stage.
- The calyx may be **gamosepalous** (sepals united) or **polysepalous** (sepals free).

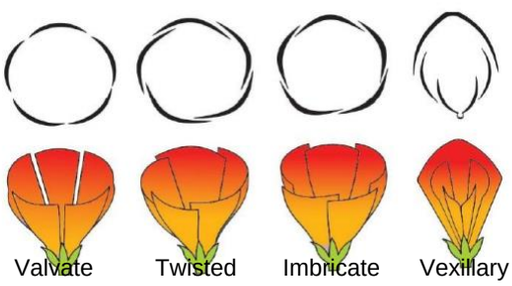


b) Corolla

- It is the whorl inner to calyx. It is composed of **petals.**
- Petals have bright colour to attract insects for pollination.
- Corolla may be **gamopetalous** (petals united) or **polypetalous** (petals free).
- Shape and colour of corolla vary in plants. Corolla may be tubular, bell-shaped, funnel-shaped or wheel-shaped.

Aestivation: It is the mode of arrangement of sepals and petals in floral bud. It is many types:

- **Valvate:** Sepals or petals in a whorl just touch one another at the margin, without overlapping. E.g. *Calotropis.*
- **Twisted:** One margin of the appendage overlaps that of the next one and so on. E.g. China rose, lady's finger & cotton.
- **Imbricate:** Margins of sepals or petals overlap one another but not in any particular direction. E.g. *Cassia* & gulmohur.
- **Vexillary (papilionaceous):** In this, there are five petals; the largest (standard) overlaps the two lateral petals (wings) which in turn overlap the two smallest anterior petals (keel). E.g. pea & bean.



c) Androecium

- The male reproductive part composed of **stamens.**
- Each stamen represents the male reproductive organ. It consists of a **stalk (filament)** and an **anther.**
- Each anther is usually **bilobed.**
- Each lobe has 2 chambers called **pollen-sacs.**
- In pollen-sacs, **pollen grains** are produced.
- A sterile stamen is called **staminode**.
- When stamens are attached to petals, they are **epipetalous.** E.g. brinjal. When stamens are attached to perianth they are **epiphyllous.** E.g. lily.
- If the stamens are free, it is called **polyandrous.**

- If they are united, it is called **synandrous.** It is many types:
  - **Monadelphous:** Stamens are united into one bunch or one bundle. E.g. China rose.
  - **Diadelphous:** Stamens are united into two bundles. E.g. pea.
  - **Polyadelphous:** Stamens are united into more than two bundles. E.g. citrus.
- There may be a variation in the length of filaments within a flower. E.g. *Salvia* and mustard.

d) Gynoecium (Pistil)

The female reproductive part made up of one or more **carpels.** A carpel has 3 parts:

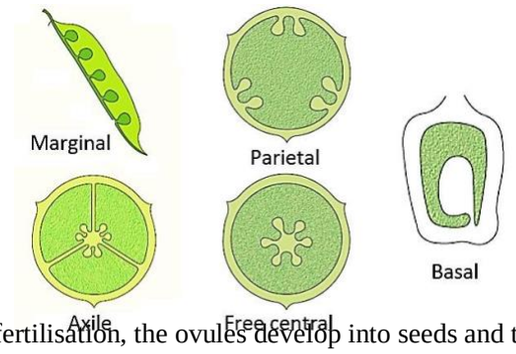
- **Stigma:** It is the receptive surface for pollen grains. It is usually at the tip of the **style.**
- **Style:** An elongated tube that connects ovary to stigma.
- **Ovary:** It is the enlarged basal part on which the style lies. Each ovary bears one or more **ovules** attached to a flattened, cushion-like **placenta**.

Polycarpellary pistils (pistil with many carpels) are 2 types:

- **Apocarpous:** Carpels are free. E.g. lotus and rose.
- **Syncarpous:** Carpels are fused. E.g. mustard and tomato.

Placentation: It is the arrangement of ovules on the placenta within the ovary. It is many types:

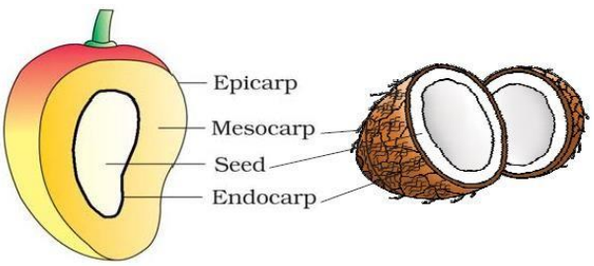
- **Marginal:** Here, the placenta forms a ridge along the ventral suture of the ovary and the ovules are borne on this ridge forming two rows. E.g. pea.
- **Axile:** Here, the placenta is axial and the ovules are attached to it in a multilocular ovary. E.g. China rose, tomato and lemon.
- **Parietal:** Here, the ovules develop on the inner wall of the ovary or on peripheral part. Ovary is one-chambered but it becomes two-chambered due to the formation of the false septum. E.g. mustard and *Argemone*.
- **Basal:** Here, placenta develops at the base of ovary and a single ovule is attached to it. E.g. sunflower, marigold.
- **Free central:** Here, ovules are borne on central axis and septa are absent. E.g. *Dianthus* and *Primrose*.



After fertilisation, the ovules develop into seeds and the ovary matures into a fruit.

THE FRUIT

- It is a **ripened ovary** developed after fertilisation.
- It is a characteristic feature of the flowering plants.
- A fruit formed without fertilisation of the ovary is called **parthenocarpic** fruit.
- In mango & coconut, fruit is called a **drupe.** They are one seeded and develop from monocarpellary superior ovaries.
- A fruit consists of
  - **Pericarp (fruit wall):** It may be dry or fleshy. Thick and fleshy pericarp is differentiated into outer **epicarp,** middle **mesocarp** and inner **endocarp**.
  - **Seeds**
- In mango, the pericarp is well differentiated into thin epicarp, fleshy edible mesocarp and stony hard endocarp.
- In coconut, the mesocarp is fibrous.

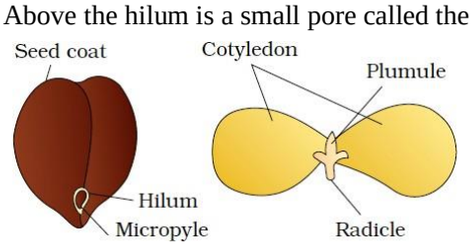


THE SEED

- It is the mature ovule developed after fertilisation.
- A seed is made up of a **seed coat** and an **embryo.**
- Embryo is made up of **a radicle, an embryonal axis** and **one** (e.g. wheat, maize) or **2 cotyledons** (e.g. gram & pea).

Structure of a Dicotyledonous Seed

- The outermost covering of a seed is the seed coat.
- Seed coat has 2 layers: outer **testa** and inner **tegmen**.
- On the seed coat, there is a scar called **hilum** through which the developing seeds are attached to the fruit.
- Above the hilum is a small pore called the **micropyle**.



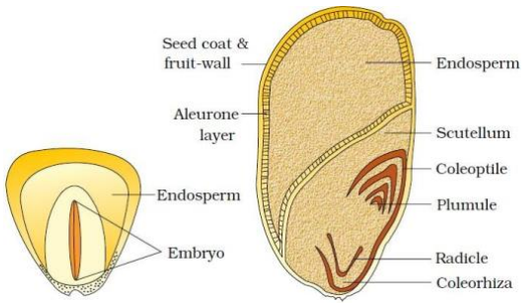
Structure of dicotyledonous seed

- Within the seed coat is the **embryo,** consisting of an **embryonal axis** and **two cotyledons.**
- The cotyledons are often fleshy and full of reserve food materials. At the two ends of the embryonal axis, the **radicle** and **plumule** are present.
- In some seeds such as castor, the **endosperm** is formed due to double fertilisation. It is a food storing tissue.
- In plants such as bean, gram and pea, the seeds are **non-endospermous** (endosperm is not seen in mature seeds).

Structure of Monocotyledonous Seed

- Generally, monocot seeds are **endospermic** but some are non-endospermic (e.g. orchids).
- In cereals such as maize, the seed coat is membranous and generally fused with the fruit wall.
- The endosperm is bulky and stores food.

- The outer covering of endosperm separates the embryo by a protein layer called **aleurone layer**.
- The embryo is small and situated in a groove at one end of the endosperm. It consists of one large and shield shaped cotyledon known as **scutellum** and a short axis with a **plumule** and a **radicle**.
- The plumule is protected in a sheath called **coleoptile** and radicle is protected in a sheath called **coleorhiza.**

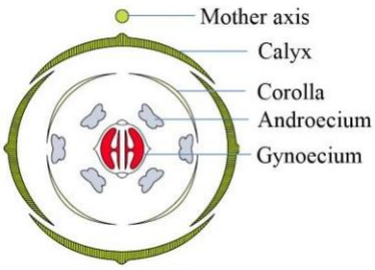


SEMI-TECHNICAL DESCRIPTION OF A TYPICAL FLOWERING PLANT

- The plant is described beginning with its habit, vegetative characters and then floral characters.
- Then a **floral diagram** and a **floral formula** are presented.
- Floral formula is represented by some symbols. They are

Br (bracteates)	**K** (calyx)	**C** (corolla)
P (perianth)	**A** (androecium)	**G** (Gynoecium)
$\underline{G}$ (superior ovary)	$\overline{G}$ (inferior ovary)	
♂ (male)	♀ (female)	⚥ (bisexual)
⊕ (actinomorphic)	% (zygomorphic)	

- Fusion is indicated by enclosing the figure within bracket and adhesion by a line drawn above the symbols of the floral parts.
- A floral diagram gives information about the number of parts of a flower, their arrangement and relation.



Floral formula

$\oplus ♂ K_{2+2}\, C_4\, A_{2+4}$

$\underline{G}_{(2)}$

Floral diagram of mustard plant (Family: *Brassicaceae*)

- Floral formula also shows cohesion and adhesion within parts of whorls and in between whorls.

SOME IMPORTANT FAMILIES

1. Fabaceae

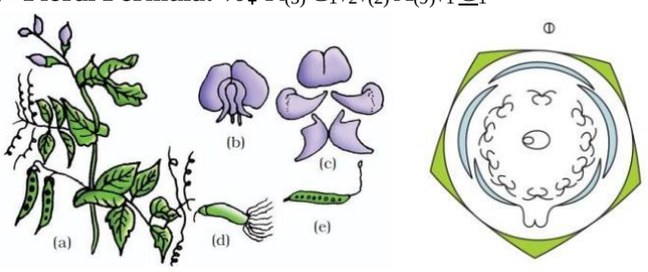
This family was earlier called **Papilonoideae,** a subfamily of family **Leguminosae.** It is distributed all over the world.

Vegetative Characters:

- Trees, shrubs, herbs; root with root nodules.
- **Stem:** erect or climber.
- **Leaves:** alternate, pinnately compound or simple; leaf base, pulvinate; stipulate; venation reticulate.

Floral characters:

- **Inflorescence:** racemose.
- **Flower:** bisexual, zygomorphic.
- **Calyx:** sepals five, gamosepalous; valvate/imbricate aestivation.
- **Corolla:** petals five, polypetalous, papilionaceous, consisting of a posterior standard, two lateral wings, two anterior ones forming a keel (enclosing stamens and pistil), vexillary aestivation.
- **Androecium:** ten, diadelphous, anther dithecous.
- **Gynoecium:** ovary superior, mono carpellary, unilocular with many ovules, style single.
- **Fruit:** legume; seed: one to many, non-endospermic.
- **Floral Formula:** $\%♂ K_{(5)}\, C_{1+2+(2)}\, A_{(9)+1}\, \underline{G}_1$



Pisum sativum (pea) plant: (a) Flowering twig (b) Flower (c) Petals (d) Reproductive parts (e) L.S.carpel (f) Floral diagram

Economic importance:

- Pulses: E.g. gram, *arhar*, *sem*, *moong*, soyabean.
- Edible oil: E.g. soyabean, groundnut.
- Dye: E.g. Indigofera.
- Fibres: E.g. sun hemp.
- Fodder: E.g. *Sesbania, Trifolium.*
- Ornamentals: E.g. lupin, sweet pea.
- Medicine: E.g. *muliathi.*

2. Solanaceae (Potato family)

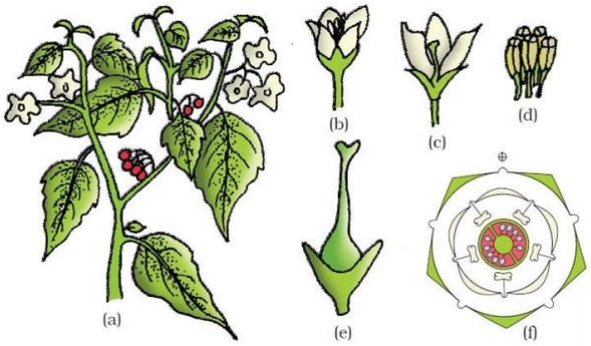
It is a large family. It is widely distributed in tropics, subtropics and even temperate zones.

Vegetative Characters:

- Plants mostly herbs, shrubs and small trees.
- **Stem:** herbaceous rarely woody, aerial; erect, cylindrical, branched, solid or hollow, hairy or glabrous, underground stem in potato (*Solanum tuberosum*).
- **Leaves:** alternate, simple, rarely pinnately compound, exstipulate; venation reticulate.

Floral Characters:

- **Inflorescence:** Solitary, axillary or cymose as in *Solanum.*
- **Flower**: bisexual, actinomorphic.
- **Calyx:** sepals five, united, persistent, valvate aestivation.
- **Corolla:** petals five, united; valvate aestivation.
- **Androecium:** stamens five, epipetalous.
- **Gynoecium:** bicarpellary obligately placed, syncarpous; ovary superior, bilocular, placenta swollen with many ovules, axile.
- **Fruits:** berry or capsule.
- **Seeds:** many, endospermous
- **Floral Formula:** $\oplus ♂ K_{(5)}\, C_{(5)} A_{(5)} \underline{G}_{(2)}$



Solanum nigrum (makoi) plant: (a) Flowering twig (b) Flower (c) L.S. of flower (d) Stamens (e) Carpel (f) Floral diagram

Economic Importance:

- Food: E.g. tomato, brinjal, potato
- Spice: E.g. chilli
- Medicine: E.g. belladonna, *ashwagandha*.
- Fumigatory: E.g. tobacco.
- Ornamentals: E.g. petunia.

3. Lilaceae (Lily family)

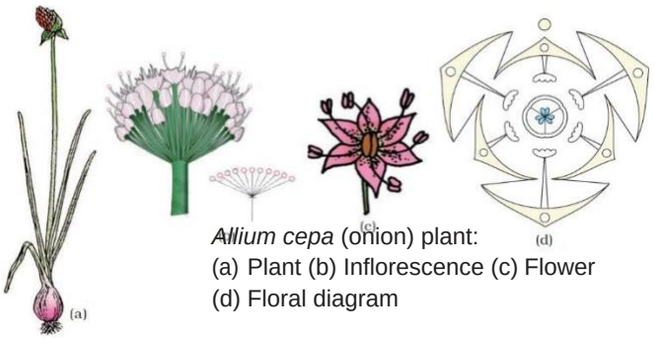
A characteristic representative of monocotyledonous plants. It is distributed worldwide.

Vegetative characters:

- Perennial herbs with underground bulbs/corms/ rhizomes.
- **Leaves** mostly basal, alternate, linear, exstipulate with parallel venation.

Floral characters:

- **Inflorescence:** solitary / cymose; often umbellate clusters.
- **Flower:** bisexual; actinomorphic.
- **Perianth** tepal six (3+3), often united into tube; valvate aestivation.
- **Androecium:** stamen six, (3+3).
- **Gynoecium**: tricarpellary, syncarpous, ovary superior, trilocular with many ovules; axile placentation.
- **Fruit:** capsule, rarely berry.
- **Seed**: endospermous
- **Floral Formula:** $\oplus \varnothing \, P_{(3+3)} \, A_{3+3} \, \underline{G}_{(3)}$



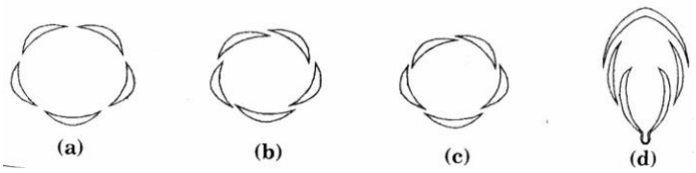
Allium cepa (onion) plant:
(a) Plant (b) Inflorescence (c) Flower
(d) Floral diagram

Economic Importance:

- Ornamentals: E.g. tulip, *Gloriosa*
- Medicine: E.g. *Aloe*
- Vegetables: E.g. *Asparagus*
- Colchicines: E.g. *Colchicum autumnale*

MODEL QUESTIONS

1. Even though Ginger is seen under the soil, it is not a root, but a stem.
   a. Give reason. b. Write its functions.
2. While examining a flower, Geetha noticed in its corolla a large outer standard petal, two small wing-like petals and two innermost petals united in to a keel. The aestivation was of vexillary type.
   a. Identify the family of the plant which produced the above flower.
   b. Write the floral formula of the family.
3. Identify the types of the arrangement of petals shown in the following diagrams.



4. Pick out the whorled arrangement of leaves from the group given below and write why it is said so?
   Neem, Nerium, Nepenthes
5. From the following terms relating a flower write its floral formula and family.
   Bisexual, sepals 5 united, petals 5 united, stamens 5 epipetalous, Carpels 2 superior.
6. Plants growing in swampy areas have special type of roots. Name the roots and their function?
7. From the following group of plants choose the best examples for root, stem and leaf modification.
   Hibiscus, Nepenthes, Rice, Carrot, Ginger, Calotropis