CHAPTER 5

MORPHOLOGY OF FLOWERING PLANTS

- Angiosperms are characterized by presence of roots, stems, leaves, flowers and fruits.
- The underground part of the flowering plant is the root system while the portion above the ground forms the shoot system.

THE ROOT

- Roots are developed from Radicle of the embryo of a germinating seed.
- In majority of the dicotyledonous plants, the direct elongation of the radicle leads to the formation of primary root which grows inside the soil. It bears lateral roots of several orders that are referred to as secondary, tertiary, etc. roots. The primary roots and its branches constitute the tap root system. e.g., mustard plant.
- In monocotyledonous plants, the primary root is short lived and is replaced by a large number of roots. These roots originate from the base of the stem and constitute the fibrous root system. e.g., wheat plant.
- In some plants, like grass, Monstera and the banyan tree, roots arise from parts of the plant other than the radicle and are called adventitious roots.
- The main functions of the root system are –
  - Absorption of water and minerals from the soil,
  - providing a proper anchorage to the plant parts,
  - storing reserve food material and
  - synthesis of plant growth regulators.
Regions of the Root

1. **Root cap** – The root apex is covered by a thimble-like structure called the root cap. It protects the tender apex of the root as it makes its way through the soil.

2. **Region of meristematic tissue** – It is present a few millimeters above the root cap. The cells of this region are very small, thin-walled and with dense protoplasm. They divide repeatedly.

3. **Region of root elongation** – The cells of this region undergo rapid elongation and enlargement and are responsible for the growth of the root in length.

4. **Region of maturation** – The cells of this zone gradually differentiate and mature. From this region some of the epidermal cells form very fine and delicate, thread-like structures called root hairs. These root hairs absorb water and minerals from the soil.

Modifications of Root

Roots in some plants change their shape and structure and become modified to perform functions other than absorption and conduction of water and minerals.

- **Modification for food storage** – Tap roots of carrot, turnips and adventitious roots of sweet potato, get swollen and store food.

- **Modification for support** –
  
  - *Prop roots* – vertically downward roots originates from heavy branches to support them.
    
    e.g., banyan tree.
  
  - *Stilt roots* – oblique downward roots coming out of the lower nodes of the stem to support weak stem.
    
    e.g., Maize, sugarcane.

- **Modification for respiration** –
  
  In some plants growing in swampy areas, many roots come out of the ground and grow vertically upwards. Such roots, called **pneumatophores**, help to get oxygen for respiration.
  
  e.g, Rhizophora.

THE STEM
• The stem is the ascending part of the axis bearing branches, leaves, flowers and fruits.
• It develops from the plumule of the embryo of a germinating seed.
• The stem bears nodes and internodes. The region of the stem where leaves are born are called nodes while internodes are the portions between two nodes.
• The stem bears buds, which may be terminal or axillary.
• The main functions of the stem are –
  – spreading out branches bearing leaves, flowers and fruits.
  – conducts water, minerals and photosynthates.
  – Some stems perform the function of storage of food, support, protection and of vegetative propagation.

Modifications of Stem
• **Modification for food storage** –
  Underground stems of potato, ginger, turmeric, zaminkand, Colocasia are modified to store food in them. They also act as organs of perenation to tide over conditions unfavourable for growth.
• **Modification for support** –
  Stem tendrils which develop from axillary buds, are slender and spirally coiled and help plants to climb such as in gourds (cucumber, pumpkins, watermelon) and grapevines.
• **Modification for defense** –
  Axillary buds of stems may also get modified into woody, straight and pointed thorns. Thorns are found in many plants such as Citrus, Bougainvillea. They protect plants from browsing animals.
• **Modification for photosynthesis** –
  Some plants of arid regions modify their stems into flattened (Opuntia), or fleshy cylindrical (Euphorbia) structures. They contain chlorophyll and carry out photosynthesis.
• **Modification for vegetative propagation** –
  **Runner** – Underground stems of some plants spread to new niches and when older parts die new plants are formed. e.g., grass and strawberry
  **Stolon** – In these plants a slender lateral branch arises from the base of the main axis and after growing aerially for some time arch downwards to touch the ground. e.g., mint and jasmine
  **Offset** – A lateral branch with short internodes and each node bearing a rosette of leaves and a tuft of roots is found in aquatic plants. e.g., Pistia and Eichhornia.
  **Sucker** – in these, the lateral branches originate from the basal and underground portion of the main stem, grow horizontally beneath the soil and then come out obliquely upward giving rise to leafy shoots. e.g., banana, pineapple and Chrysanthemum.

![Fig: Modifications of stem for: (a) storage (b) support (c) protection (d) vegetative propagation](image-url)
THE LEAF
- The leaf is a lateral, generally flattened structure borne on the stem.
- It develops exogenously at the node and bears a bud in its axil - the axillary bud, which later develops into a branch.
- Leaves originate from shoot apical meristems and are arranged in an acropetal order.
- They are the most important vegetative organs for photosynthesis.

Parts of leaf
A typical leaf consists of three main parts:
1. **Leaf base** – The leaf is attached to the stem by the leaf base and may bear two lateral small leaf like structures called stipules.
   In monocotyledons, the leaf base expands into a sheath covering the stem partially or wholly – Sheathing leaf base.
   In some leguminous plants the leaf base may become swollen – Pulvinus leaf base.
2. **Petiole** – The petiole helps hold the blade to light.
   Long thin flexible petioles allow leaf blades to flutter in wind, thereby cooling the leaf and bringing fresh air to leaf surface.
3. **Lamina** – The lamina or the leaf blade is the green expanded part of the leaf with veins and veinlets. There is, usually, a middle prominent vein, which is known as the midrib. Veins provide rigidity to the leaf blade and act as channels of transport for water, minerals and food materials.

Venation
The arrangement of veins and the veinlets in the lamina of leaf is termed as venation.
1. **Reticulate venation** – When the veinlets form a network.
   e.g., Dicotyledons.
2. **Parallel venation** – When the veins run parallel to each other within a lamina. e.g., Monocot.

Types of Leaves
1. **Simple leaf** – when lamina of a leaf is entire or when incised, the incisions do not touch the midrib.
2. **Compound leaf** – When the incisions of the lamina reach up to the midrib breaking it into a number of leaflets, the leaf is called compound.
   A bud is present in the axil of petiole in both simple and compound leaves, but not in the axil of leaflets of the compound leaf.
   The compound leaves may be of two types –
   i) **Pinnately compound leaf** – a number of leaflets are present on a common axis, the rachis, which represents the midrib of the leaf.
      e.g., neem.
   ii) **Palmately compound leaves** – the leaflets are attached at a common point, i.e., at the tip of petiole.
      e.g., Silk cotton.
Phyllotaxy:
Phyllotaxy is the pattern of arrangement of leaves on the stem or branch. This is usually of three types –

1. **Alternate type** – a single leaf arises at each node in alternate manner. e.g., China rose, Mustard and Sunflower.
2. **Opposite type** – a pair of leaves arise at each node and lie opposite to each other. e.g., Calotropis and Guava.
3. **Whorled type** – If more than two leaves arise at a node and form a whorl. e.g., Alstonia.

Modifications of Leaves

1. **For support** - converted into tendrils for climbing. e.g., peas.
2. **For defense** - converted into spines. e.g., cactus.
3. **For food storage** - The fleshy leaves of onion and garlic.
4. **For photosynthesis** - In some plants the leaves are small and short-lived. The petioles in these plants expand, become green and synthesise food. e.g., Australian acacia.
5. **For insectivory** - pitcher plant, venus-fly trap.
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 always solitary.
- The arrangement of flowers on the floral axis is termed as inflorescence.
- Depending on whether the apex gets converted into a flower or continues to grow, two major types of inflorescences are defined –
  1. **Racemose inflorescence** – the main axis continues to grow, the flowers are borne laterally in an acropetal succession
  2. **Cymose inflorescence** – the main axis terminates in a flower, hence is limited in growth. The flowers are borne in a basipetal order

![Inflorescence: (a) Racemose (b) Cymose](image)

THE FLOWER

- The flower is the reproductive unit in the angiosperms. It is meant for sexual reproduction.
- A typical flower has four different kinds of whors arranged successively on the swollen end of the stalk or pedicel, called thalamus or receptacle.
  These are calyx, corolla, androecium and gynoecium.
  Calyx and corolla are accessory organs, while androecium and gynoecium are reproductive organs.
- **Perianth** : In some flowers like lily, the calyx and corolla are not distinct and are termed as perianth.

**Parts of a Flower**
Each flower normally has four floral whors, viz., calyx, corolla, androecium and gynoecium.

1. **Calyx (Sepals)** –
   - outermost whorl of the flower.
   - 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).

2. **Corolla (Petals)** –
   - Petals are usually brightly coloured to attract insects for pollination.
   - corolla may be also free (gamopetalous) or united (polypetalous).
   - The shape and colour of corolla vary greatly in plants. Corolla may be tubular, bell-shaped, funnel-shaped or wheel-shaped.

3. **Androecium (Stamens)** –
   - Represents the male reproductive organ.
   - Each stamen consists of a stalk or a filament and an anther.
   - Each anther is usually bilobed and each lobe has two chambers, the pollen-sacs.
- The pollen grains are produced in pollen-sacs.
- A sterile stamen is called staminode.
- When stamens are attached to the petals, they are called epipetalous. e.g., brinjal.
- When stamens are attached to the perianth, they are called epiphyllous. e.g., lily.
- Fusion of stamen –
  If the stamens in a flower remain free – Polyandrous.
  If the stamens are united into one bundle – monadelphous. e.g., china rose.
  If the stamens are united into two bundles – diadelphous. e.g., pea.
  If the stamens are united into more than two bundles – Polyadelphous. e.g., citrus.
- There may be a variation in the length of filaments within a flower, as in Salvia and mustard.

4. **Gynoecium (Carpels/Pistils) –**
   - Gynoecium is the female reproductive part of the flower.
   - A carpel consists of three parts – stigma, style and ovary.
     - **Ovary** is the enlarged basal part, on which lies the elongated tube, the style.
     - The **style** connects the ovary to the stigma.
     - The **stigma** is usually at the tip of the style and is the receptive surface for pollen grains.
   - Each ovary bears one or more ovules attached to a flattened, cushion-like **placenta**.
   - **Types of gynoecium** –
     - **Monocarpellary** – when only one carpel is present.
     - **Multicarpellary** – When more than one carpel is present.
       - **Apocarpous** – if carpels are free. e.g., lotus and rose.
       - **Syncarpous** – when carpels are fused. e.g., mustard and tomato.
   - After fertilisation, the ovules develop into seeds and the ovary matures into a fruit.

**Aestivation**
The mode of arrangement of sepals or petals in floral bud with respect to the other members of the same whorl is known as aestivation.

1. **Valvate** – When sepals or petals in a whorl just touch one another at the margin, without overlapping. e.g., Calotropis.
2. **Twisted** – If one margin of the appendage overlaps that of the next one and so on. e.g., china rose, lady’s finger and cotton.
3. **Imbricate** – If the margins of sepals or petals overlap one another but not in any particular direction. e.g., Cassia and gulmohur.
4. **Vexillary (papilionaceous)** – it’s special type of aestivation. It has 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.

![Fig: Types of aestivation: (a) Valvate (b) Twisted (c) Imbricate (d) Vexillary](image)
Placentation
The arrangement of ovules within the ovary is known as placentation.

1. **Marginal** – 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.
2. **Axile** – When the placenta is axial and the ovules are attached to it in a multilocular ovary. e.g., china rose, tomato and lemon.
3. **Parietal** – 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 (Replum) e.g., mustard and Argemone.
4. **Basal** – the placenta develops at the base of ovary and a single ovule is attached to it. e.g., sunflower, marigold.
5. **Free Central** – When the ovules are borne on central axis and septa are absent. e.g., Dianthus, Primrose.

Fig: Placentation: (a) Marginal (b) Axile (c) Parietal (d) Free central (e) Basal

Types of flower
1. **Reproductive organs** –
   a. **Unisexual** – when either only stamens or only carpels is present.
   b. **Bisexual** – When both androecium and gynoecium are present.
2. **Symmetry** –
   a. **Actinomorphic (radial symmetry)** – When a flower can be divided into two equal radial halves in any radial plane passing through the centre. e.g., mustard, datura, chilli.
   b. **Zygomorphic (bilateral symmetry)** – When a flower can be divided into two similar halves only in one particular vertical plane. e.g., pea, gulmohur, bean, Cassia.
   c. **Asymmetric (irregular)** – if a flower cannot be divided into two similar halves by any vertical plane passing through the centre. e.g., canna.
3. A flower may be trimerous, tetramerous or pentamerous when the floral appendages are in multiple of 3, 4 or 5, respectively.
4. **Bracts** –
   a. **Bracteate** – Flowers with bracts (reduced leaf found at the base of the pedicel) are called bracteates.
   b. **Ebracteate** – Flowers without bracts are called ebracteate.
5. Based on the position of calyx, corolla and androecium in respect of the ovary on thalamus –
   a. **Hypogynous** – the gynoecium occupies the highest position while the other parts are situated below it. The ovary in such flowers is said to be superior. e.g., mustard, china rose and brinjal.
b. **Perigynous** – If gynoecium is situated in the centre and other parts of the flower are located on the rim of the thalamus almost at the same level, it is called perigynous. The ovary here is said to be half inferior. e.g., plum, rose, peach.

c. **Epigynous** – the margin of thalamus grows upward enclosing the ovary completely and getting fused with it, the other parts of flower arise above the ovary. Hence, the ovary is said to be inferior. e.g., guava and cucumber, and the ray florets of sunflower.

THE FRUIT

- The fruit is a characteristic feature of the flowering (Angiospermic) plants.
- It is a mature or ripened ovary, developed after fertilisation.
- If a fruit is formed without fertilisation of the ovary, it is called a **parthenocarpic fruit**.
- Generally, the fruit consists of a wall or pericarp and seeds.
- The pericarp may be dry or fleshy.
- When pericarp is thick and fleshy, it is differentiated into the outer epicarp, the middle mesocarp and the inner endocarp.
- **Drupe Fruit** - In mango and coconut. They develop from monocarpellary superior ovaries and are one seeded. In mango the pericarp is well differentiated into an outer thin epicarp, a middle fleshy edible mesocarp and an inner stony hard endocarp. In coconut the mesocarp is fibrous.
THE SEED
- The ovules after fertilisation, develop into seeds.
- A seed is made up of a seed coat and an embryo.
- The embryo is made up of a radicle, an embryonal axis and one (wheat, maize) or two cotyledons (gram and pea).

Structure of a Dicotyledonous Seed
- **Seed coat** – The outermost covering of a seed.
  The seed coat has two layers, the outer **testa** and the inner **tegmen**.
- **Hilum** – The hilum is a scar on the seed coat through which the developing seeds were attached to the fruit.
- **Micropyle** – It is a small pore present above the hilum.
- **Embryo** – It consists of an embryonal axis and two cotyledons.
- **Cotyledons** – These are often fleshy and full of reserve food materials.
- **Radicle and plumule** – They are present at the two ends of the embryonal axis.
- **Endosperm** – In some seeds such as castor, the endosperm formed as a result of double fertilisation, is a food storing tissue. In plants such as bean, gram and pea, the endosperm is not present in mature seeds and such seeds are called non-endospermous.

Structure of Monocotyledonous Seed
- **Seed Coat** – In the seeds of cereals such as maize, the seed coat is membranous and generally fused with the fruit wall, called Hull.
- **Endosperm** – The endosperm is bulky and stores food. Generally, monocotyledonous seeds are endospermic but some as in orchids are non-endospermic.
- **Aleuron layer** – The outer covering of endosperm separates the embryo by a **proteinous** layer called aleurone layer.
- **Embryo** – The embryo is small and situated in a groove at one end of the endosperm.
- **Scutellum** – One large and shield shaped cotyledon known as scutellum.
- **Embryonal axis** – Ends are known as plumule and radicle.
- **Coleoptile and coleorhiza** – The plumule and radicle are enclosed in sheaths which are called coleoptile and coleorhiza respectively.
### SEMI-TECHNICAL DESCRIPTION OF A TYPICAL FLOWERING PLANT

Symbols used in Floral Formula –

<table>
<thead>
<tr>
<th>Plant Part</th>
<th>Symbol/Abbreviation</th>
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<tbody>
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<td>Bracteate</td>
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<tr>
<td>Calyx, Sepals united</td>
<td>K(number)</td>
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<tr>
<td>Corolla, Petals free</td>
<td>C(number)</td>
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<tr>
<td>Corolla, Petals united</td>
<td>C(number)</td>
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<tr>
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<tr>
<td>Gynoecium, carpels free</td>
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<tr>
<td>Gynoecium, carpels united</td>
<td>G(number)</td>
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<td>Ovary superior (Hypogynous flower)</td>
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<td>Ovary Inferior (Epigynous flower)</td>
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<tr>
<td>Ovary Half–inferior (Perigynous flower)</td>
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<tr>
<td>Epipetalous</td>
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Floral formula also shows cohesion and adhesion within parts of whorls and in between whorls. (Brassicaceae).
DESCRIPTION OF SOME IMPORTANT FAMILIES

Fabaceae

- This family was earlier called Papilonoideae, a subfamily of family Leguminosae.
- **Habitat** – 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; 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** –
  \[ K_{50} C_{1+2+3} A_{10+1+1} \]
- **Economic importance** –
  - pulses (gram, arhar, sem, moong, soyabean)
  - edible oil (soyabean, groundnut)
  - dye (indigofera)
  - fibres (sunhemp)
  - fodder (Sesbania, Trifolium),
  - ornamentals (lupin, sweet pea);
  - medicine (mulithi).

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

- It is a large family, commonly called as the ‘potato family’.
- **Habitat** – It is widely distributed in tropics, sub-tropics 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, syncarpous; ovary superior, bilocular, placenta swollen with many ovules
- **Fruits** – berry or capsule
- **Seeds** – many, endospermous
- **Floral Formula** – \( \text{Floral Diagram} \)
- **Economic Importance** –
  - source of food (tomato, brinjal, potato),
  - spice (chilli);
  - medicine (belladonna, ashwagandha);
  - fumigatory (tobacco);
  - ornamentals (petunia).

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

- Commonly called the ‘Lily family’.
- It is a characteristic representative of monocotyledonous plants.
- **Habitat** – 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** – $\odot P_{2-3} A_{2-3} G_3$
- **Economic Importance** –
  - ornamentals (tulip, Gloriosa),
  - medicine (Aloe),
  - vegetables (Asparagus)
  - colchicine (Colchicum autumnale).

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