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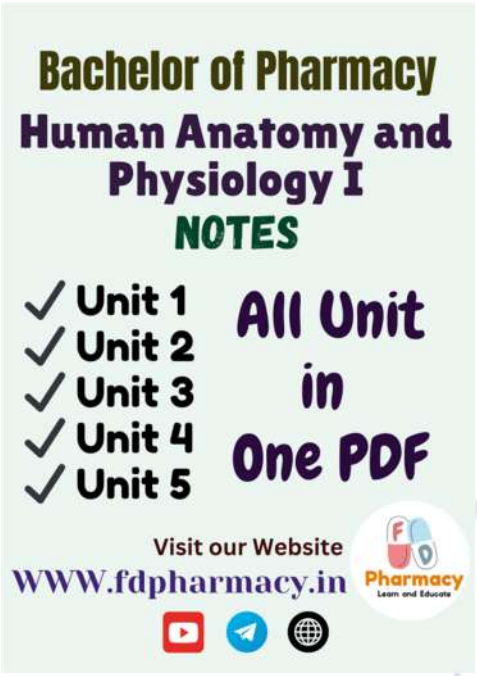
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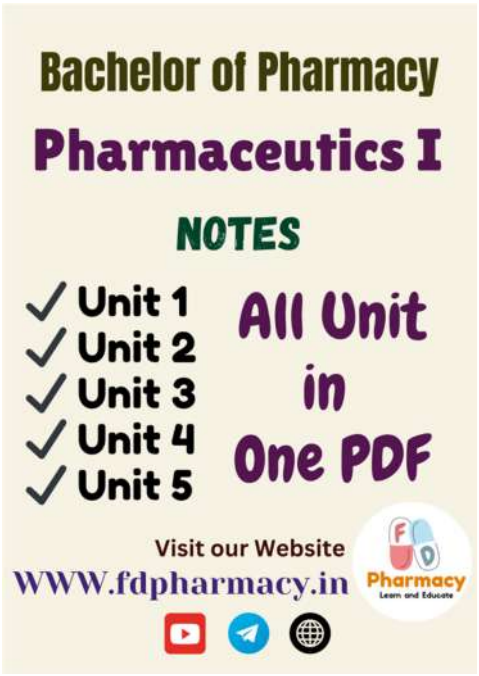
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Unit 3
Unit 4
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Unit 3
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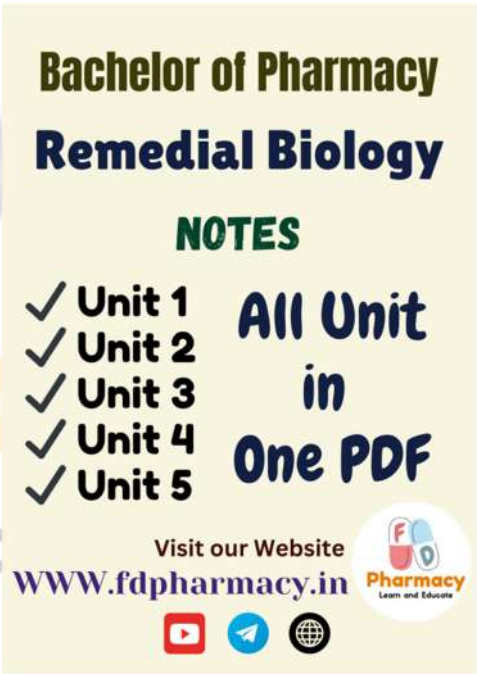
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Unit 1
Unit 2
Unit 3
Unit 4
Unit 5
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REMEDIAL BIOLOGY

UNIT 1

TOPIC :

- **Morphology of Flowering plants**

  Morphology of different parts of flowering plants– Root, stem, inflorescence, flower, leaf, fruit, seed.

  General Anatomyof Root, stem, leaf of monocotyledons & Dicotylidones

Morphology of Flowering Plants

Morphology refers to the **study of external form and structure** of organisms. In flowering plants (*angiosperms*), the body is divided into two main systems:

1. **Root system** – the part that lies below the ground
2. **Shoot system** – the aerial part including stem, leaves, flowers, fruits, and seeds

Root

- The root is the underground, non-green part of the plant that anchors the plant, absorbs water and minerals, and sometimes stores food.

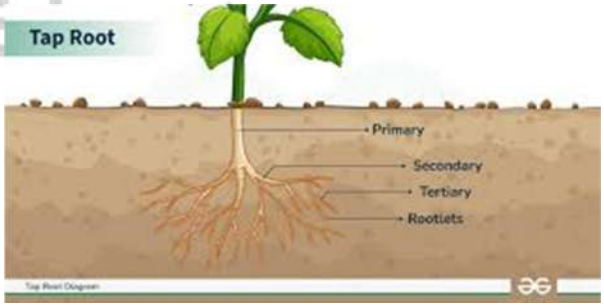
Types of Root Systems

1. Tap Root System

- A root system where a single primary root (taproot) grows directly downward and gives rise to lateral (secondary and tertiary) roots.
- Origin: Develops from the radicle.
- Common in: Dicotyledonous plants (Dicots)
- Structure: One long, central root with smaller side branches.

Functions

- Provides strong anchorage
- Penetrates deep into the soil
- Can store food (e.g., carrot, radish)



Examples

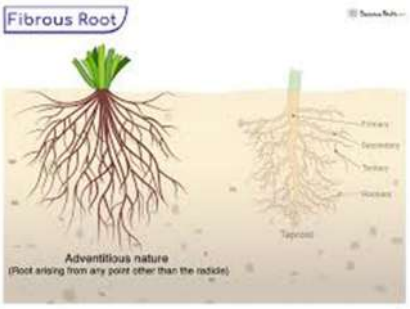
- Mustard, Pea, Mango, Carrot, Radish

2. Fibrous Root System

- A root system where the radicle dies early, and a cluster of similar-sized roots arise from the base of the stem.
- Origin: Arises from the stem (not radicle).
- Common in: Monocotyledonous plants (Monocots)
- Structure: Many thin, thread-like roots that spread out.

Functions

- Quick absorption of water and minerals
- Prevents soil erosion
- Provides moderate anchorage

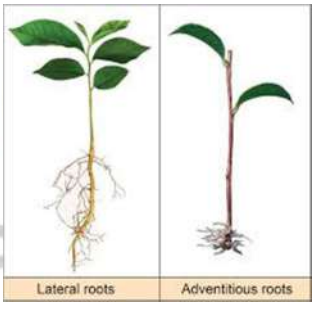


Examples

- Wheat, Rice, Maize, Grass, Sugarcane

3. Adventitious Root System

- A root system that develops from parts of the plant other than the radicle, like stem nodes, leaves, or old roots.
- Origin: From any part of the plant other than radicle.
- Common in: Both monocots and dicots



Types of Adventitious Roots

1. **Storage roots** – *Sweet potato*
2. **Prop roots** – *Banyan tree*
3. **Stilt roots** – *Maize*
4. **Climbing roots** – *Betel*
5. **Respiratory roots (pneumatophores)** – *Mangroves*

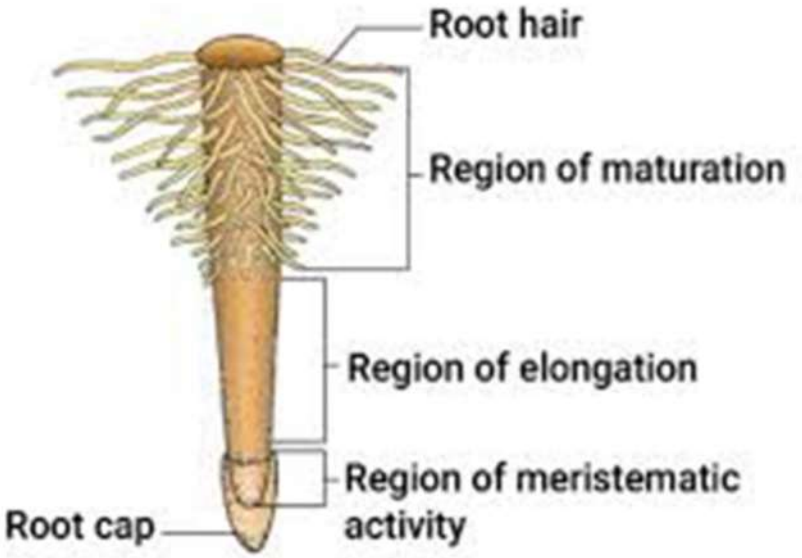
Functions

- Provide extra support, aeration, or storage
- Help in vegetative propagation
- Adapt to specific habitats (like swampy areas)

Examples

- Sweet Potato, Maize, Banyan, Money plant, Ivy

Regions of the Root



1. Root Cap Region

- The root cap is a small cap-like structure present at the very tip of the root. It is the outermost protective region.

Structure and Functions

- Made of parenchyma cells
- Protects the delicate apical meristem (growing tip) from injury
- Secretes mucilage to ease movement through the soil
- Constantly worn away and regenerated

2. Region of Cell Division (Meristematic Region)

- This region lies just behind the root cap and contains actively dividing cells of the apical meristem.

Structure and Functions

- Cells are small, cubical, thin-walled, and have dense cytoplasm
- Responsible for the continuous production of new cells
- Increases the length of the root
- Site of primary growth

3. Region of Elongation

➢ This is the region just above the meristematic zone where cells elongate and enlarge.

Structure and Functions

- Cells are larger, vacuolated, and elongated
- Cell walls become flexible and expand
- This region is responsible for increasing the length of the root
- Pushes the root deeper into the soil

4. Region of Maturation (or Differentiation)

➢ The uppermost region of the growing root, where cells mature and differentiate into specialized tissues.

Structure and Functions

- Cells differentiate into xylem, phloem, cortex, and epidermis
- Root hairs are present here — thin-walled extensions of epidermal cells
- Root hairs absorb water and minerals from the soil
- This is the functional region of absorption

Modification of Roots

1. Storage Roots

→ To store food and nutrients for future use (especially during unfavorable conditions).

Characteristics

- Become thick and fleshy
- Contain starch, sugars, or other nutrients

Types & Examples

Type	Description	Example
Conical	Cone-shaped (wide at top, narrow at base)	**Carrot** (*Daucus carota*)
Fusiform	Spindle-shaped (tapering at both ends)	**Radish** (*Raphanus sativus*)
Napiform	Spherical upper part, thin lower part	**Turnip**, **Beetroot**
Tuberous	Irregular, swollen root	**Sweet potato** (*Ipomoea batatas*)

2. Supportive Roots (Mechanical Support)

- These roots provide additional support to heavy stems or to plants growing in specific conditions.

Types & Examples

Type	Description	Example
Prop roots	Arise from horizontal branches and grow downward like pillars	**Banyan tree** (*Ficus benghalensis*)
Stilt roots	Arise from lower nodes of stem and enter the soil obliquely	**Maize**, **Sugarcane**
Buttress roots	Thick, wide roots at the base of tall trees for support	**Bombax** (Silk Cotton tree)

3. Respiratory Roots (Pneumatophores)

- Help in aeration and respiration in water-logged or marshy soils.

Characteristics

- Grow upward (negatively geotropic) from underground roots
- Have pores/lenticels for gas exchange

Examples

- Mangrove trees like *Rhizophora*, *Avicennia*

4. Photosynthetic Roots

➢ Perform photosynthesis in some aerial plants (epiphytes).

Characteristics

- Green in color
- Exposed to sunlight

Example

- Taeniophyllum (an orchid)

5. Sucking or Parasitic Roots (Haustoria)

➢ Absorb nutrients and water from host plants in parasitic species.

Characteristics

- Penetrate into the host plant's tissue
- Also called haustorial roots

Examples

- Cuscuta (dodder)
- Viscum (mistletoe)

STEM

→ The stem is the aerial part of the plant that arises from the plumule of the embryo. It generally grows upward (negatively geotropic) and toward the light (positively phototropic). It bears nodes and internodes, and gives rise to branches, leaves, flowers, buds, and fruits.

Characteristics of Stem

- Arises from plumule of the embryo.
- Grows above the ground.
- Shows nodes (leaf-bearing regions) and internodes (regions between two nodes).
- Bears axillary and terminal buds.
- Usually green when young and can photosynthesize.
- Lacks root caps and root hairs.

➢ Depending upon the presence of mechanical tissues, the stems may be weak, herbaceous or woody.

1. Weak stems : When the stems are thin and long, they are unable to stand erect, and hence may be one of the following types:

(a) Creepers or Prostate stem: When they grow flat on the ground with or without roots. Examples are grasses, gokharu etc.
(b) Climbers: These are too weak to stand alone. They climb on the support with the help of tendrils, hooks, prickles or roots. For examples: vitis, piper betel, piper longum.
(c) Twinners: These coil the support and grow further. They are thin and wiry i.e. Ipomoea and phaseolus.

2. Herbaceous and woody stems : These are the normal stems and may be soft or hard and woody i.e. sunflower, sugarcane, mango etc.

- Produces leaves and exposes them properly to sunlight for carrying out photosynthesis.
- Conducts water and minerals from roots to leaves and buds.
- Foods produced by leaves are transported to non-green parts of the plant.
- Produces flowers and fruits for pollination and seal dispersal.
- Depending upon the environment it gets suitably modified to perform specjal functions like storage of foods, means of propagation etc.

Modifications of Stems

Classification of Stem Modifications

- Stem modifications are classified into three main types based on their growth location and function:

1. Underground Stem Modifications
2. Subaerial Stem Modifications
3. Aerial Stem Modifications

(i) Underground Modifications of Stems

- Underground modifications of stems are of the following types:
  - Rhizome
  - Tuber
  - Bulb
  - Corm.

1. Rhizome: Grow horizontal under the soil. They are thick and are characterised by the presence of nodes, inter-nodes and scale leaves. They also possess bud in the axil of the scaly leaves. Examples are: Ginger, turmeric, rhubarb, male-fern etc.

2. Tuber: Tubers are characterised by the presence of 'eyes' from the vegetative buds which grow further and develop into a new plant. Tubers are the swollen underground structure of the plant. The examples of tubers are Potato, Jalap, Aconite etc.

3. Bulb: In this case, the food material is stored in fleshy scales which overlap the stem. They are present in the axils of the scales and few of them develop into new plant in the spring season at the expense of stored food material in the bulb. Adventitious roots are present at the base of the bulb. The reserve food material formed by the leaves is stored at their bases and the new bulbs are produced next year. Examples are Garlic, Squill, Onion and Gloriosa.

4. Corm: Corms are generally, stout and grow in vertical direction. They bear bud in the axil of the scaly leaves and these buds then develop further to form the new plant. Adventitious roots are present at the base of the corm. Examples of the corm are Saffron, Colchicum, Dioscorea

(ii) Sub-aerial Modifications of Stems:

- These includes
  - Runner,
  - Stolon,
  - Offset
  - Sucker.

1. Runners: These creep on the ground and root at the nodes. Axillary buds are present, Strawberry, Pennywort are examples.

2. Stolons: These are lateral branches arising from the base of the stems which grow horizontally. They are characterised by the presence of nodes and inter-nodes. Few branches growing above the ground develop into a new plant. Examples are Glycyrrhiza, Arro-root, Jasmine.

3. Offsets: These originate from the axil of the leaf as short thick horizontal branches and also characterised by the presence of rosette type leaves and a cluster of roots at their bottom. Examples are Aloe, Valerian.

4. Suckers: These are lateral branches developed from under-ground stems. Suckers grow obliquely upwards, give rise to a shoot which develop further into a new plant. Examples are Mentha species, Chrysanthemum, Pineapple, Banana etc.

(iii) Aerial Modifications of Stems

- As the name indicates they grow into the air above the soil to a certain height. They are as under:

(a) Phylloclades: At times, the stem becomes green and performs the function of leaves. Normally, this is found in the plants growing in the desert (xerophytes). Phylloclades are characterised by the presence of small leaves or pointed spines. Examples are Opuntia, Ruscus, Euphorbia.

(b) Thorns and prickles: This is another type of aerial modification meant for protection. Thorns are hard, pointed, straight structures, such as Duranta, Lemon. Prickles and thorns are identical in function. Prickles get originated from outer tissues of the stem. Thus, they are superficial outgrowths. Prickles are sharp, pointed and curved structures. They are scattered all over the stem. Rose, Smilax can be quoted as examples of the same.

(c) Stem-tendrils: In certain plants, the buds develop into tendrils for the purpose of support. Terminal bud in case of vitis, axillary bud in case of passiflora are suitable examples.

(d) Bulbils: These are modifications of floral buds meant for vegetative propagation. Such as Dioscorea and Agave.

Uses of Stems

- Depending upon the structural and chemical contents, stems are used for various purposes:
  - Underground stems in their various forms are either used as food spices or for culinary purposes like, Potato, amorphophalus, colocasia, garlic, ginger and onion.
  - Jowar, rice and other stems are used as fodder.
  - Stems of Jute, Hemp and Lax as sources of industrial fibres used for various purposes.
  - Sugar Cane stems are used as source of sucrose while latex from stems of Hevea-brazilansis is used as Rubber.
  - Woods from stems of several plants are used as drugs like Quassia, Guaicum, Sandal Wood etc.
  - The stems of several plants are injured to produce gums for their multiple industrial uses like Gum-acacia, Gum-tragacanth, Gum-sturculia etc.

INFLORESCENCE

- Inflorescence is the arrangement or pattern of flowers on the floral axis (peduncle) of a plant. Instead of bearing a single flower, most plants bear a group or cluster of flowers, and this cluster is called an inflorescence.

Main Parts of an Inflorescence

1. **Peduncle** – Main stalk that supports the inflorescence.
2. **Rachis** – The central axis of the inflorescence (in compound forms).
3. **Flowers** – The reproductive units borne on the axis.
4. **Bract** – A leaf-like structure found at the base of a flower.
5. **Bracteole** – Smaller leaf-like structures on the flower stalk (pedicel).
6. **Pedicel** – Stalk of an individual flower.

Types of Inflorescence

- Inflorescence is broadly classified into two main types**:**

    1. Racemose Inflorescence

    2. Cymose Inflorescence

1. Racemose Inflorescence (Indeterminate)

→ The main axis continues to grow.

→ Flowers are borne in an acropetal succession (i.e., young flowers at the top, older ones at the base).

→ The growth is indeterminate, and no terminal flower is formed.

Type	Description	Examples
Raceme	Main axis is elongated; flowers have pedicels	*Radish, Mustard*
Spike	Main axis is elongated; flowers are **sessile**	*Achyranthes, Amaranthus*

Spikelet	Small spike, usually found in **grasses**	*Wheat, Rice, Grass*
Catkin	Long, hanging spike with unisexual flowers	*Mulberry, Willow*
Spadix	Thick, fleshy axis; flowers enclosed in a **spathe**	*Banana, Colocasia*
Corymb	Lower flowers have longer pedicels, forming flat top	*Iberis, Candytuft*
Umbel	All flowers arise from the same point on peduncle	*Coriander, Onion*
Head/Capitulum	Sessile flowers on flat receptacle, surrounded by bracts	*Sunflower, Marigold*

2. Cymose Inflorescence (Determinate)

→ The main axis terminates in a flower (growth stops).

→ Flowers are arranged in basipetal order (older flowers at top, younger ones below).

→ Growth is limited.

Type	Description	Examples
Uniparous/Monochasial Cyme	Only one lateral branch grows at a time	*Jasmine, Drosera*
- **Helicoid**	Branches develop on one side only	*Hamelia*
- **Scorpioid**	Branches develop alternately on both sides	*Heliotropium*
Biparous/Dichasial Cyme	Two lateral branches	*Bougainvillea,*

	develop from below terminal flower	*Ixora*
Multiparous/Polychasial Cyme	More than two branches develop from below the flower	*Calotropis, Nerium (Oleander)*

Importance of Inflorescence

- ✓ Facilitates effective pollination and reproduction.
- ✓ Enhances visibility to pollinators.
- ✓ Allows compact floral arrangements, saving space and resources.
- ✓ Helps in plant classification and identification.
- ✓ Some inflorescences (e.g., Sunflower) increase seed production.

FLOWER

- A flower is the reproductive part of angiospermic (flowering) plants. It is a modified shoot that bears reproductive organs (stamens and carpels), and in many species, it is colorful and scented to attract pollinators.

Functions of a Flower

- **Reproduction** (both sexual and asexual)
- **Pollination** (transfer of pollen)
- **Fertilization** (fusion of male and female gametes)
- **Fruit and seed formation**
- In some cases, **vegetative propagation** (e.g., *bulbil*)

Parts of a Flower

1. Calyx (Sepals)

- Outermost whorl
- Usually green, leaf-like
- Protects the flower when it is a bud
- Collectively called calyx
- Can be:
  - Polysepalous (sepals free)
  - Gamosepalous (sepals united)

2. Corolla (Petals)

- Brightly colored
- Attracts pollinators (insects, birds)
- Collectively called corolla
- Can be:
  - Polypetalous (free petals)
  - Gamopetalous (united petals)
  - May have nectaries at base

3. Androecium (Male Reproductive Part)

- Composed of stamens (each has a filament and anther)
- Anther produces pollen grains
- Stamens may be free or united:
  - Monadelphous: Filaments united (e.g., *China rose*)
  - Diadelphous: 9 + 1 arrangement (e.g., *Pea*)
  - Polyadelphous: Many groups (e.g., *Citrus*)

4. Gynoecium (Female Reproductive Part)

- Also called pistil
- Composed of one or more carpels
- Each carpel has:
  - Ovary (contains ovules)
  - Style (stalk)
  - Stigma (pollen receiving surface)
- Types:
  - Monocarpellary – Single carpel
  - Multicarpellary – More than one carpel
    - Syncarpous (fused carpels)
    - Apocarpous (free carpels)

Types of Flowers

Type	Proper Definition	Example
Complete Flower	A flower that has all **four floral whorls**: calyx, corolla, androecium, and gynoecium.	*Hibiscus*
Incomplete Flower	A flower that is **missing one or more floral whorls**, such as petals or sepals.	*Cucumber*
Bisexual (Perfect)	A flower that contains **both male (stamens)** and **female (carpels)** reproductive organs.	*Mustard, Rose*
Unisexual (Imperfect)	A flower that contains **either stamens or carpels**, but **not both**.	*Papaya, Corn*
Actinomorphic	A flower that can be divided into **two equal halves** through **multiple planes** (radial symmetry).	*Datura, Mustard*
Zygomorphic	A flower that can be divided into **two equal halves** through **only one plane** (bilateral symmetry).	*Pea, Bean*
Hypogynous	A flower in which the **ovary is superior**, and all other floral parts are attached **below it**.	*Mustard, China rose*
Perigynous	A flower in which the **ovary is partially inferior**, and floral parts are attached to the rim of a **cup-like thalamus**.	*Rose, Pea*
Epigynous	A flower in which the **ovary is completely inferior**, and other floral parts arise **above it**.	*Guava, Cucumber*

Placentation

→ Placentation refers to the arrangement of ovules (future seeds) within the ovary of a flower.

The ovules are attached to the placenta, a specialized tissue inside the ovary wall, and their positioning varies among plant species.

Types of Placentation

Type	Definition	Diagram Description	Examples
1. Marginal	Ovules are arranged along one side (margin) of a unilocular ovary, on a single placenta.	Ovary has one chamber, ovules are lined along one inner edge.	*Pea, Gram*
2. Axile	Ovules are attached to a central axis in a multilocular ovary (with multiple chambers).	Ovary divided by septa into many chambers; ovules arranged at the center.	*Lemon, Tomato, China rose*
3. Parietal	Ovules are attached to the inner wall of a unilocular ovary, not in the center.	Ovary has one chamber; ovules attached to wall in two or more places.	*Mustard, Argemone, Cucumber*
4. Free Central	Ovules are borne on a central column in the ovary, but no septa (false or no chamber walls).	Ovules arise from a central axis in a single chamber; ovary looks empty around center.	*Dianthus, Primrose*
5. Basal	A single ovule is attached to the base of the ovary.	Small ovary with one ovule fixed at the very bottom.	*Sunflower, Marigold*
6. Superficial	Ovules are attached to the entire inner surface of a multilocular ovary.	Ovules found on all inner walls of the chambers.	*Water lily*

LEAF

→ A leaf is a green, flat, lateral outgrowth of a stem or branch, arising from the node and developed from the shoot apical meristem.
It is the main photosynthetic organ of the plant and typically consists of a leaf blade, petiole, and sometimes a stipule.

Parts of a Typical Leaf

1. Leaf Base (Hypopodium)

- It is the lowest part of the leaf that attaches the leaf to the stem or branch at the node.
- It may bear two small leaf-like structures called stipules.
- In monocots, the leaf base may sheath the stem (e.g., grass).
- Types of leaf base:
  - Pulvinus: Swollen leaf base (e.g., *legumes* like *bean*).
  - Sheathing base: Leaf base that wraps around the stem (e.g., *maize*).

2. Petiole (Mesopodium)

- It is the leaf stalk that connects the leaf blade (lamina) to the stem.
- It holds the leaf away from the stem for better sunlight exposure and air circulation.
- Flexible petiole allows movement (wind resistance).
- Leaves without petiole are called sessile (e.g., *wheat, rice*).
- Leaves with petiole are called petiolate (e.g., *guava, mango*).

3. Lamina (Leaf Blade or Epipodium)

- The broad, flat, green portion of the leaf where photosynthesis, transpiration, and gas exchange occur.
- Contains:
  - Midrib: The central prominent vein.
  - Veins and Veinlets: Network of vascular bundles used for transport of water, minerals, and food.

- Margin: The edge of the leaf – can be smooth, serrated, lobed, etc.
- Apex: Tip of the leaf – may be pointed, rounded, notched, etc.
- Surface: The upper and lower sides, often having stomata.

4. Stipules *(if present)*

- Small, leaf-like outgrowths present on either side of the leaf base.
- May protect the young leaf or have other functions.
- Plants with stipules are called stipulate (e.g., *pea*).
- Plants without stipules are called exstipulate (e.g., *mustard*).

Types of Leaves

1. Simple Leaf

- A leaf with single, undivided lamina (leaf blade), though it may have lobes.
- These lobes do not reach the midrib or petiole base, hence the leaf remains undivided.
- Has a single axillary bud at the base.

Examples :

- *Mango*
- *Guava*
- *Peepal*
- *China rose*

2. Compound Leaf

- A leaf in which the lamina is divided into two or more distinct leaflets.
- Each leaflet appears like a small leaf but does not bear axillary buds.
- The whole compound leaf has a single axillary bud at its base.

There are two main types of compound leaves :

A. Pinnately Compound Leaf

- Leaflets are arranged laterally on both sides of a common axis (called the rachis), resembling a feather.

Types of Pinnate Compound Leaves

Type	Description	Example
Unipinnate	Leaflets attached directly on the rachis.	*Neem, Rose*
Bipinnate	Leaflets are on **secondary rachis** (pinna).	*Tamarind*
Tripinnate	Leaflets are divided thrice	*Moringa (drumstick)*
Decompound	Leaflets are further and repeatedly divided	*Coriander*

B. Palmately Compound Leaf

- Leaflets arise from a common point at the tip of petiole, like fingers from a palm.

Types of Palmately Compound Leaves

Type	Description	Example
Unifoliate	Only one leaflet (appears compound)	*Citrus*
Bifoliate	Two leaflets	*Balanites*
Trifoliate	Three leaflets	*Clover, Bean*
Quadrifoliate	Four leaflets	*Marsilea*
Multifoliate	More than four leaflets	*Bombax (Silk cotton)*

Shapes of the Lamina (Leaf Blade)

Shape	Definition
1. Ovate	A leaf that is egg-shaped, with the broader part at the base and narrowing towards the tip (apex).
2. Obovate	A reverse ovate leaf; it is broader at the apex and tapers towards the base.
3. Lanceolate	A long, narrow leaf, shaped like a lance or spear, tapering at both ends.
4. Oblanceolate	A reverse lanceolate leaf; it is broader near the tip and tapers toward the base.
5. Elliptical	An oval-shaped leaf that is broadest at the center and tapering evenly towards both ends.
6. Linear	A very narrow, long leaf with parallel margins throughout its length.
7. Cordate	A heart-shaped leaf with a distinct notch at the base.
8. Obcordate	A reverse heart-shaped leaf with the notch at the apex instead of the base.
9. Sagittate	A leaf shaped like an arrowhead, with pointed lobes at the base that are directed downward.
10. Hastate	Similar to sagittate but the lobes spread outward like a spearhead.
11. Reniform	A kidney-shaped leaf with a broad, rounded base and a shallow notch.
12. Spathulate	A spoon-shaped leaf that is broad at the tip and narrows gradually towards the base.
13. Orbicular	A circular or nearly round leaf, with a uniform diameter.

Leaf Margins

- Leaf margin refers to the edge or border of the leaf blade (lamina). It plays an important role in plant identification and classification, and it may be smooth, lobed, toothed, or wavy, depending on the species.

Types of Leaf Margins

Type	Definition	Example
1. Entire	The margin is smooth with no teeth or lobes.	*Guava (Psidium), Mango*
2. Serrate	Edge has sharp teeth pointing forward (like a saw blade).	*Rose*
3. Dentate	Edge has sharp teeth pointing outward (not forward).	*China rose (Hibiscus)*
4. Crenate	Edge has rounded teeth or scalloped margins.	*Tulsi (Ocimum)*
5. Undulate	Margin is wavy or sinuous along the edge.	*Water lily, Bryophyllum*
6. Lobed	Margin has deep, rounded or pointed cuts (lobes), but not reaching midrib.	*Cotton, Castor*
7. Incised	Margin is deeply and irregularly cut towards the midrib.	*Chrysanthemum*
8. Spiny	Margin bears spine-like projections or prickles.	*Argemone, Holly*
9. Serrulate	Like serrate, but with very small, fine teeth.	*Neem*
10. Ciliate	Margins are fringed with fine hair-like projections.	*Paddy, Grasses*

Leaf Apices

- The leaf apex is the tip or terminal end of the lamina (leaf blade). It is an important morphological feature that helps in identifying plant species and reflects adaptations to the environment.

Types of Leaf Apices

Type	Definition	Example
1. Acute	Leaf apex ends in a sharp angle (<90°); pointed but not elongated.	*China rose (Hibiscus)*
2. Acuminate	Leaf tapers into a long, narrow, pointed tip.	*Peepal (Ficus religiosa)*
3. Obtuse	Leaf ends in a blunt or rounded tip with an angle >90°.	*Banyan (Ficus benghalensis)*
4. Truncate	Leaf appears cut straight across at the tip, as if abruptly ended.	*Bauhinia*
5. Retuse	Apex is slightly notched or indented (shallow depression).	*Clerodendrum*
6. Emarginate	A deeper notch or indentation at the apex.	*Butea monosperma*
7. Mucronate	Apex has a short, stiff, sharp point (tiny tip projection).	*Ixora, Jasmine*
8. Cuspidate	Leaf apex ends in a sharp, stiff, and abrupt point, longer than mucronate.	*Holly leaves*
9. Cirrhose	Apex forms a tendril-like structure (used for climbing).	*Gloriosa, Passiflora*

Venation

→ Venation is defined as the arrangement of veins and veinlets in the lamina (leaf blade) of a leaf.
Veins help in transport of water, minerals, and food, and provide mechanical support to the leaf.

Types of Venation

➢ Venation is mainly classified into two types :

1. Reticulate Venation

→ The veins form a net-like pattern in the lamina.
→ Common in dicotyledonous plants.

Sub-types

- Unicostate Reticulate – Only one main midrib from which lateral veins arise (e.g., Peepal).
- Multicostate Reticulate – More than one principal vein arises from the leaf base (e.g., Castor).

Examples

- *Peepal, Mango, Guava, China rose*

2. Parallel Venation

→ The veins run parallel to each other throughout the leaf blade.
→ Common in monocotyledonous plants.

Sub-types

- Unicostate Parallel – One main midrib with parallel veins (e.g., Banana).
- Multicostate Parallel – Many veins arise from base and run parallel (e.g., Grass, Wheat).

Examples

- *Maize, Grass, Banana, Wheat*

MODIFICATION OF LEAVES

- **Leaf tendril** – In it, whole leaf is modified into thin thread like structure which is called leaftendril. eg. Lathyrus aphaca (wild pea).
- **Leaflet tendril** – When leaflet is modified into tendril like structure than it is called leaflet tendril. eg. Pisum sativum (Garden pea), Lathyrus odoratus (sweet pea)
- **Leaf spine** – Leaves or any part of leaflet are modified into pointed spine. eg. Asparagus, Opuntia,Aloe, Argemone.
- **Leaf scale** – In it, leaves become thin, dry and form a membrane or paper like structure and serve to protect axillary buds as in Ficus and Tamarix, Ruscus, Casurina.
- **Leaf pitcher** – Leaves of some plants are modified to pitcher shape. eg. Nepenthes, Dischidia.
- **Leaf bladder** – In some plan , leaves are modified into bladder like structure eg. Utricularia.

Uses of Leaf

- ✓ **Photosynthesis**
  - Leaves are the main site for food production in plants.
  - They use sunlight, CO_2, and water to synthesize glucose using chlorophyll.
- ✓ **Transpiration**
  - Loss of water through stomata helps in cooling and mineral transport.
  - Maintains the water movement from roots to leaves.
- ✓ **Respiration**
  - Leaves exchange gases (O_2 and CO_2) for respiration through stomata.
- ✓ **Storage of Food**
  - Some leaves store food and water.
  - *Example*: Onion, Garlic, Aloe vera.
- ✓ **Vegetative Propagation**
  - Some leaves can develop new plantlets from margins.
  - *Example*: Bryophyllum, Begonia.
- ✓ **Protection**
  - Leaves can be modified into spines or scales to reduce water loss and protect from animals.
  - *Example*: Opuntia (spines), Ruscus (scale leaves).
- ✓ **Support and Climbing**
  - Tendrils or leaf parts help weak plants to climb.
  - *Example*: Pea, Gloriosa.
- ✓ **Medicinal Uses**
  - Used in traditional and modern medicines.
  - *Examples*: Tulsi (cough/cold), Neem (antiseptic), Aloe vera (skin).
- ✓ **Economic Uses**
  - Leaves are used for packaging, decoration, and products.
  - *Examples*: Banana (plates), Tea leaves, Tendu leaves (bidis), Curry leaves.
- ✓ **Aesthetic and Ornamental Uses**
  - Colorful leaves are used for decoration in gardens and homes.

FRUIT

- Fertilized and ripened ovary is fruit. A Fruit consist of
  (i) Pericarp (fruit wall),
  (ii) Seed.
- The seeds are protected inside fruit. But in some fruits. seeds are not found like in grapes, banana and such type of fruits are seedless fruit
- If a fruit is formed without fertilization of the ovary it is known as parthenocarpic fruit.
- Pericarp : After ripening, the ovary wall change into pericarp. This pericarp may by thick and fleshy or thick and hard or thin and soft.
- Pericarp is differentiated in 3 layers
  - **Epicarp :-** It is the outermost layer, which is also called rind
  - **Mesocarp :-** It is the middle layer.
  - **Endocarp :-** It forms the innermost layer.

➲ **TRUE FRUIT :** When the fruit is developed only from the ovary, the fruit is called as true fruit. eg. Mango,Coconut, Zizyphus

➲ **FALSE FRUIT OR PSEUDOCARP :** In some fruits, in place of ovary, some other parts of flower like thalamus, inflorescence, calyx are modified to form a part of fruit. These types of fruit are called false fruits.eg. Apple, Strawberry, Pear.

Classification of Fruits

1. Simple Fruits

→ Simple fruits develop from a single ovary of a single flower, which may be either monocarpellary or syncarpous.

Types of Simple Fruits

- Simple fruits are further divided based on the texture of the pericarp:

A. **Fleshy Fruits** (Pericarp is thick and soft at maturity):

Type	Description	Example
Drupe	One-seeded, pericarp differentiated into layers; endocarp is hard	Mango, Coconut, Peach
Berry	Entire pericarp is soft and edible	Tomato, Grapes
Pome	Edible part is thalamus, not ovary	Apple, Pear
Hesperidium	Leathery rind and juicy hairs	Orange, Lemon
Pepo	Hard rind, develops from inferior ovary	Cucumber, Watermelon

B. **Dry Fruits** (Pericarp becomes dry at maturity):

i. **Dehiscent Dry Fruits** (Split open to release seeds):

Type	Description	Example
Legume	Splits on both sutures	Pea, Bean
Capsule	Splits in various ways (pores, slits)	Datura, Cotton
Siliqua	Long fruit splitting from both sutures	Mustard

ii. **Indehiscent Dry Fruits** (Do not split open at maturity):

Type	Description	Example
Achene	Single seed not fused with pericarp	Sunflower, Mirabilis
Caryopsis	Seed coat fused with pericarp	Maize, Wheat, Rice
Nut	Hard, woody pericarp	Litchi, Chestnut

iii. **Schizocarpic Fruits** (Split into one-seeded segments):

Type	Description	Example
Lomentum	Breaks into one-seeded segments	Acacia
Cremocarp	Splits into two mericarps	Coriander
Regma	Splits into 3 one-seeded cocci	Castor

2. Aggregate Fruits

- Aggregate fruits develop from a single flower having multiple free ovaries (apocarpous gynoecium).
- Each ovary develops into a fruitlet, and the group of fruitlets together forms the aggregate fruit.

Type	Description	Example
Etaerio of Achenes	Multiple achenes	Strawberry
Etaerio of Follicles	Multiple follicles	Michelia
Etaerio of Drupes	Multiple small drupes	Raspberry
Etaerio of Berries	Multiple small berries	Custard Apple (Annona)

3. Multiple or Composite Fruits

- Multiple (composite) fruits develop from a complete inflorescence (i.e., multiple flowers).
  The fruits from each flower combine to form a single, large structure.

Type	Description	Example
Sorosis	Develops from spike/spadix inflorescence	Pineapple, Jackfruit
Syconus	Develops from hypanthodium inflorescence	Fig (Ficus)

Functions and Importance of Fruits

- ✓ Protect seeds until they mature.
- ✓ Aid in seed dispersal by wind, water, animals, or humans.
- ✓ Store food (especially in fleshy fruits).
- ✓ Have economic importance (used as food, juice, jam, oil, fiber, medicine).
- ✓ Used in agriculture and horticulture for commercial purposes.

Seed

→ A seed is the mature ovule formed after fertilization in flowering plants.

It contains an embryo, stored food, and a protective seed coat, and it gives rise to a new plant on germination.

→ The Seeds are characterised by the presence of the three parts known as Sead-coat, Embryo, Endosperm.

- **Seed coat:** It is the outermost layer of the seeds providing necessary protection to the embryo laying inside the seed.
- **Embryo:** It is the main part of the seed. It consists of an axis having apical meristem for plumule, radicle the origin or root and adhered to it are one or two cotyledons, differentiating the plants as monocot or dicot.
- **Endosperm:** It is the nutritive tissue nourishing the embryo. It may be present or may not be present in the seed. Depending upon the presence or absence of the seeds are classified as under.
    - Endospermic or albuminous seeds.
    - Non-endospermic or exalbuminous seeds.
    - Perispermic seeds.

Special Features of Seeds

→ Sometimes apart from the regular growth of seeds additional growth is visible in the form of appendages which attribute to their special features. They are described as under.

(i) Aril: Succulent growth from hilum covering the entire seeds as in nutmeg (Mace) and yew seeds.

(ii) Arillode: Outgrowth originating from micropyle and covering the seeds as in cardamam.

(iii) Arista (awn): Stiff-bristle-like appendage with many flowering glumes of grasses and found in strophanthus.

(iv) Caruncle: A warty outgrowth from micropyle i.e. castor, croton, viola moringa

(v) Hairs: Gossypium and calotropis are examples of this type of outgrowth.

Functions of Seeds

- ✓ Most important function of the seeds is reproduction i.e. it germinates into new plant.
- ✓ Seeds are meant for the spread of the species.
- ✓ Species and varieties do not come to an end by successive formation of seeds by plant. Thus, seeds are means of perennation
- ✓ Seeds are 'means of perpetuation of species.

Uses of Seeds

- Due to high protein and fixed oil contents seeds are the essential part of the food. Sunflower, safflower, sesame and groundnuts are used for edible oil, while Soyabean, cotton-seed are used for isolation of proteins also
- Cotton seeds are used as source of cotton fibres.
- Guar seeds, Isapgol, psyllum are used for the isolation of mucilage

ANATOMY OF ROOT

A. Dicot Root (e.g., Sunflower)

→ A dicot root originates from the radicle and shows radial vascular bundles with limited xylem groups. It undergoes secondary growth.

Anatomical Features

1. **Epiblema / Piliferous Layer**:
   Outermost layer with root hairs for absorption of water and minerals. No cuticle.
2. **Cortex**:
   Several layers of parenchyma without chloroplasts. Stores food and helps in water movement.
3. **Endodermis**:
   Innermost layer of cortex with Casparian strips (suberin bands), regulates entry of water into vascular cylinder.
4. **Pericycle**:
   Just below endodermis; gives rise to lateral roots, vascular cambium, and cork cambium during secondary growth.
5. **Vascular bundles**:
   - **Radial** arrangement (xylem and phloem alternate in a circle).
   - **Tetrarch or Pentarch** (4 or 5 xylem groups).
   - Xylem is **exarch** (protoxylem at periphery).
6. **Pith**:
   Very small or absent in dicot roots.

B. Monocot Root (e.g., Maize)

→ A monocot root also originates from the radicle, shows polyarch vascular bundles (many xylem groups), and does not show secondary growth.

Anatomical Features

1. **Epiblema**:
   Similar to dicot root; has root hairs.
2. **Cortex**:
   Multilayered, made of parenchyma.
3. **Endodermis**:
   Well-developed with Casparian strips.
4. **Pericycle**:
   Gives rise to lateral roots only (no cambium).
5. **Vascular Bundles**:
   - **Radial and polyarch** (6 or more xylem groups).
   - **Xylem is exarch**.
6. **Pith**:
   Large and well-developed (unlike dicot).
7. **Secondary Growth**:
   Absent due to lack of vascular cambium.

ANATOMY OF STEM

A. Dicot Stem (e.g., Sunflower)

→ A dicot stem shows vascular bundles in a ring, has cambium, and undergoes secondary growth.

Anatomical Features:

1. **Epidermis**:
   Outermost layer, covered with cuticle; may bear trichomes.
2. **Hypodermis**:
   Made of **collenchyma** (provides mechanical strength).
3. **Cortex**:
   Parenchymatous tissue that stores food.
4. **Endodermis**:
   Inner boundary of cortex with starch grains (called **starch sheath**).
5. **Pericycle**:
   Made of sclerenchyma or parenchyma, lies below endodermis.
6. **Vascular Bundles**:
   - **Conjoint, collateral, open**, arranged in a **ring**.
   - **Cambium** present between xylem and phloem.
7. **Pith**:
   Large and centrally located, stores nutrients.
8. **Secondary Growth**:
   Present due to cambium activity.

B. Monocot Stem (e.g., Maize)

→ A monocot stem has scattered vascular bundles, closed bundles (no cambium), and no secondary growth.

Anatomical Features

1. **Epidermis**:
   Covered with a thick cuticle for protection.
2. **Hypodermis**:
   Made of **sclerenchyma** for support.
3. **Ground Tissue**:
   Undifferentiated, no separate cortex or pith.
4. **Vascular Bundles**:
   - **Scattered** throughout ground tissue.
   - **Conjoint, collateral, closed** (no cambium).
   - Surrounded by **bundle sheath** (sclerenchymatous).
5. **Secondary Growth**:
   Absent due to lack of cambium.

ANATOMY OF LEAF

A. Dicot Leaf (Dorsiventral Leaf, e.g., Mango)

→ A dicot leaf shows differentiation of mesophyll, reticulate venation, and is mostly hypostomatic (stomata on lower side).

Anatomical Features

1. **Upper Epidermis**:
   Single-layered with cuticle; stomata absent.
2. **Mesophyll**:
   - Differentiated into:
     a. **Palisade parenchyma** (upper side, photosynthetic).
     b. **Spongy parenchyma** (lower side, with air spaces).
3. **Vascular Bundles**:
   Embedded in mesophyll; enclosed by **bundle sheath**.
4. **Lower Epidermis**:
   Contains **stomata** (gas exchange).

B. Monocot Leaf (Isobilateral Leaf, e.g., Maize)

→ A monocot leaf has undifferentiated mesophyll, parallel venation, and stomata on both surfaces.

Anatomical Features

1. **Epidermis**:
   Both upper and lower epidermis have **stomata** and **cuticle**.
2. **Bulliform Cells**:
   Large, thin-walled cells in upper epidermis that help in **leaf folding** during water stress.
3. **Mesophyll**:
   Not differentiated into palisade and spongy layers.
4. **Vascular Bundles**:
   Arranged parallel; surrounded by **bundle sheath**.