Morphology of Vegetative Organs

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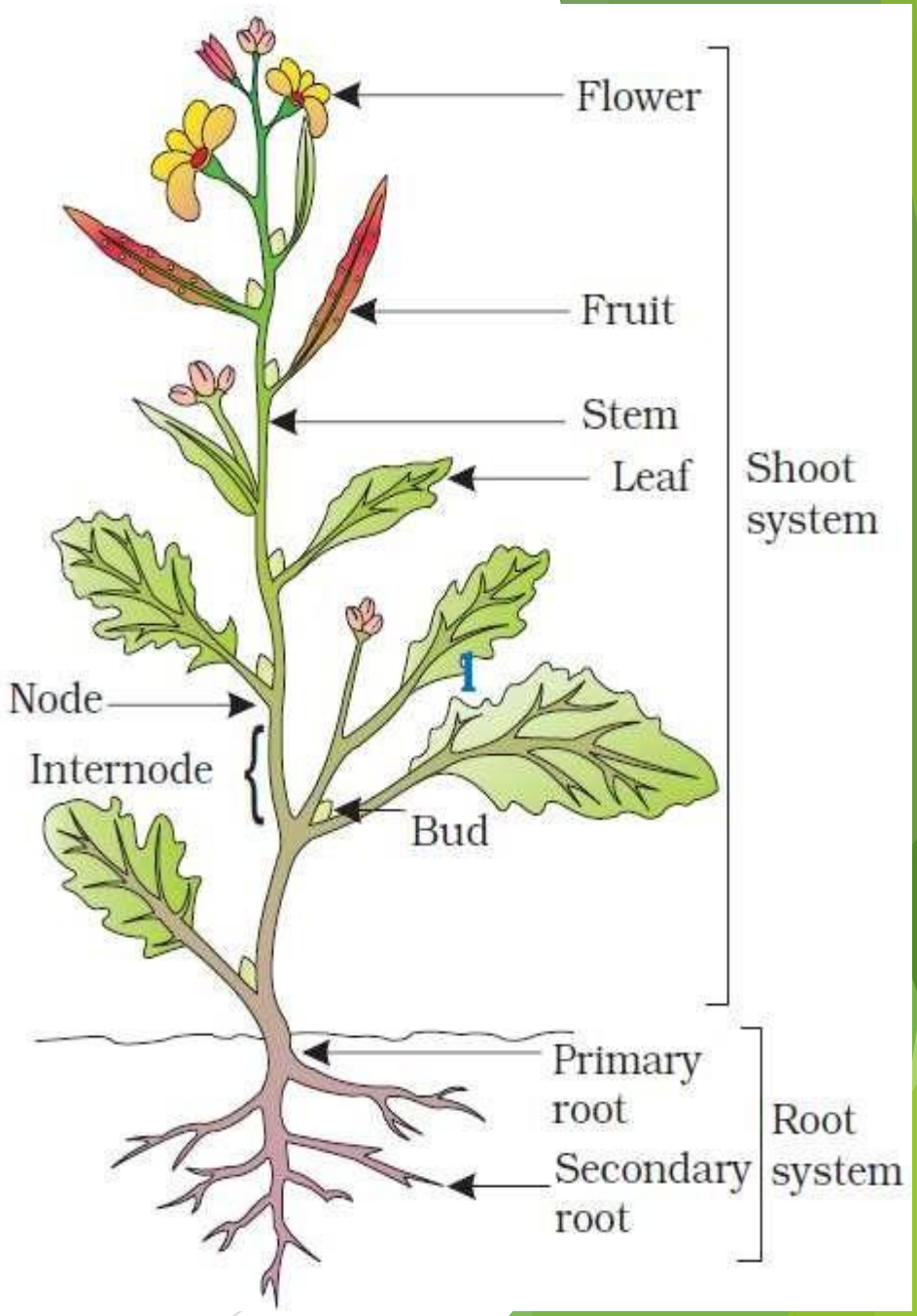
MORPHOLOGY OF FLOWERING PLANTS

- Root
- Stem
- Leaf
- Flower
- Fruit
- Seed



Morphology of Root

Characteristics :

1. Root is defined as the descending part of the plant axis.
2. It is **positively geotropic.**
3. It is **positively hydrotropic**
4. It is **negatively phototropic.**
5. It develops from the **radicle** of the embryo during seed germination.
6. Roots are generally non green and cylindrical.
7. They produce only similar organs i.e. secondary and tertiary roots
8. They do not show nodes and internodes

Morphology of Root

1. REGION OF ROOT CAP

-The tender apex of the root is protected with a multicellular cap like structure called root cap.

-The cells of the root cap secrete mucilage for lubricating the passage of root through the soil.

-In many hydrophytes like *Pistia* and *Eichhornia*, root cap is replaced by root pocket.

2. REGION OF CELL DIVISION OR MERISTEMATIC REGION

-It is a small region about 1mm in length.

-This is the growing part of the root and is protected by the root cap.

-It is made up of thin walled, compactly arranged meristematic cells which have the power of division.

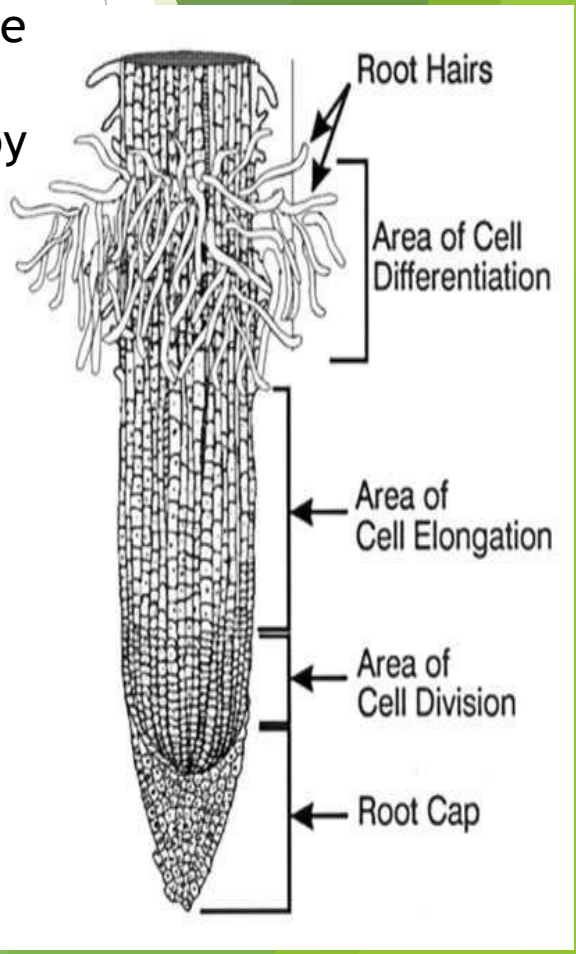
-This region helps in longitudinal growth by the addition of new cells

3. REGION OF ELONGATION

-It lies just above the meristematic region.

-The cells of this region are newly formed and they elongate rapidly. This increases the length of the root.

-The cells of this region help in the absorption of mineral salts



Morphology of Root

4. REGION OF ROOT HAIR OR ROOT ABSORPTION

-Surface of this area is covered with numerous root hairs. The cells of the outer layer known as piliferous layer or epiblema produce root hair.

-The root hairs are elongated, single celled, tubular structures which remain in contact with soil particles.

-The root hairs increase the surface area of absorption.They are short lived and are replaced by new root hairs after every 10 to 15 days and is responsible for absorption of water.

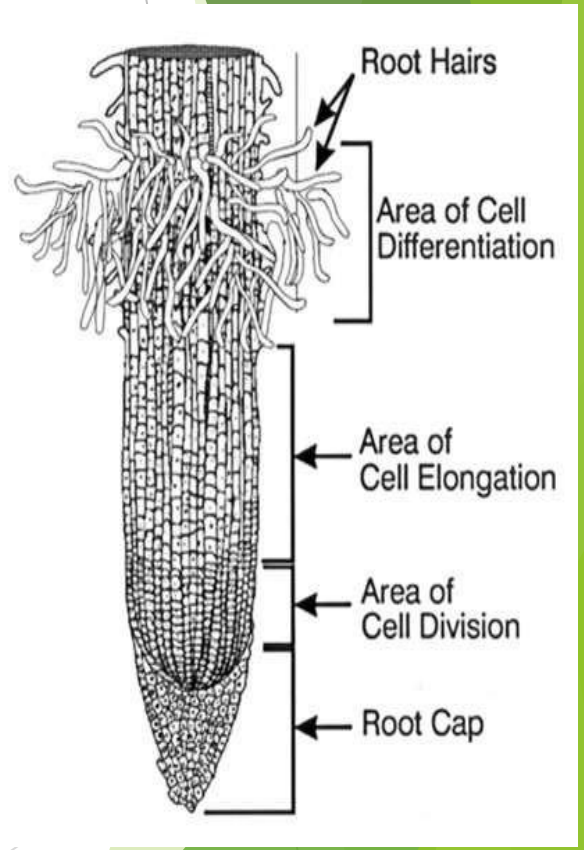
5. REGION OF MATURATION OR CELL DIFFERENTIATION

-It forms the major part of the root.

-The outermost layer of this region has thick walled impermeable cells.

-The enlarged cells undergo differentiation to form different types of primary root tissue like cortex, endodermis, xylem, phloem, etc. This region helps in fixation of plant body into the soil and also in conduction of absorbed substances.

-Lateral roots also develop from this region of the root.



Morphology of Root

FUNCTIONS OF THE ROOT:

PRIMARY

- The normal functions of the roots are fixation or **anchorage** of the plant body into the soil (substratum), **absorption** of water and minerals from the soil and **conduction** of absorbed materials up to the base of the stem.

SECONDARY

- In some plants roots perform certain special functions and such roots undergo necessary modifications. Some roots become fleshy or swollen for the **storage** of food materials e.g. *carrot, radish, asparagus, sweet potato, Dahlia*, etc.
- After becoming green some roots manufacture food by **photosynthesis** e.g. *Tinospora, Trapa, Orchids etc.*
- Some roots help in exchange of gases (**respiration**) e.g. *Rhizopora, Sonneratia* etc.
- In parasitic plants like *Cuscuta*, adventitious roots **penetrate the host stem** to obtain food and water.
- Sometimes roots also take part in **vegetative reproduction** e.g. *Sweet potato.*
- Aerial roots absorb **moisture** from the air e.g. *Orchids*. Thus modified roots perform different functions.

Morphology of Root

TAP ROOTS OR TRUE ROOTS

- develops from the **radicle** of an embryo during seed germination is called a **true root** or **tap root**.
- The main root is called **primary root.**
- Its branches of first order are called **secondary roots** and branches of secondary order are called **tertiary roots** and so on.
- The main root along with its branches forms a tap root system e.g. *Mustard (Brassica), Sunflower (Helianthus) etc*.
- Presence of a tap root system is a characteristic feature of **dicotyledonous** plants. The **tap** root normally grows **vertically** downwards to a lesser or greater depth, while **secondary** and **tertiary** roots grow **obliquely** downwards or some grow horizontally outwards.
- All lateral branches are produced in **acropetal** succession, i.e., the older and longer branches are near the base and the younger and shorter ones are near the apex of the main root.

Morphology of Root

ADVENTITIOUS ROOT SYSTEM

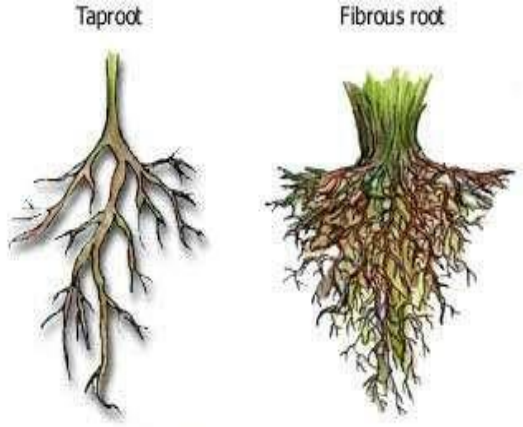
- A root that develops from **any other part** other than the radicle is known as **adventitious root.**
- Such roots may develop from the base of the **stem**, **nodes** or from **leaves**.
- In **monocots**, radicle is short lived and from the base of the stem a thick **cluster** of all equal sized roots arises. This is known as the adventitious root system e.g. *Maize*, *wheat*, *sugarcane*, *etc*.
- It is also known as **fibrous** root system as the adventitious roots of grasses (monocots) look like fibres.
- Fibrous roots do **not** grow very **deep** into the soil

Morphology of Root

Modifications

Tap

1. Storage of food
2. Respiration



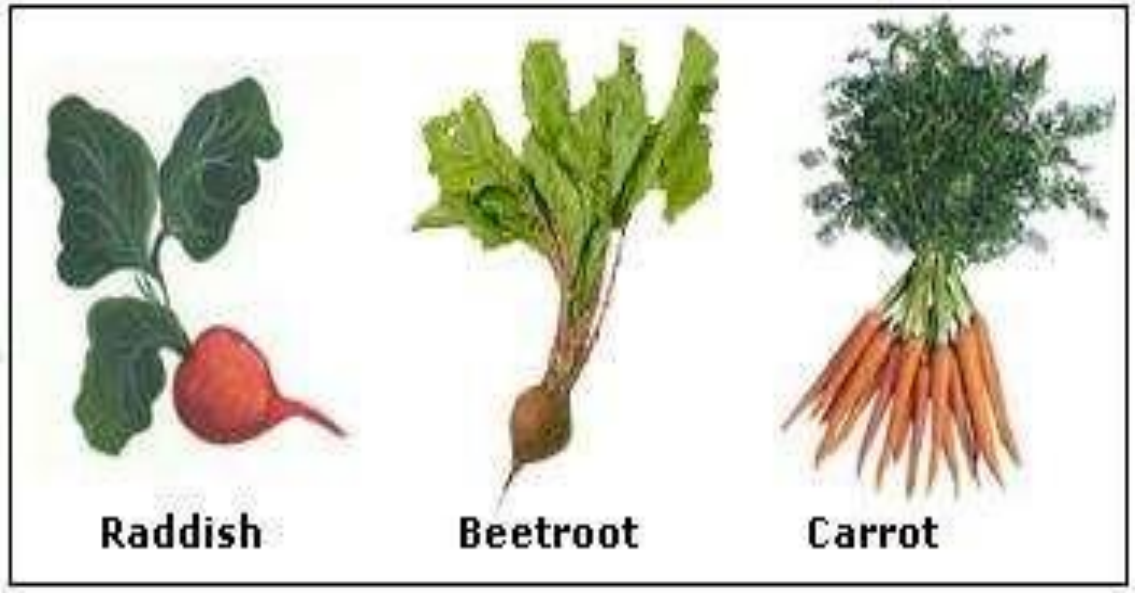
Adventitious

1. Storage of food
2. Support
3. Special functions

Morphology of Root

MODIFICATIONS OF TAP ROOT : 1. **Storage of food**

- The tap root (**primary**) becomes **fleshy** and swollen due to the stored food.
- The secondary roots remain thin.
- **Hypocotyl** (embryonic region between cotyledons and radicle) may also join the tap in storing food.
- Stem is reduced and discoid in the beginning and bears radical leaves.
- The swollen tap root acquires some typical **shape** and is accordingly classified into the following three types



Morphology of Root

MODIFICATIONS OF TAP ROOT :

1. Storage of food

FUSIFORM ROOT

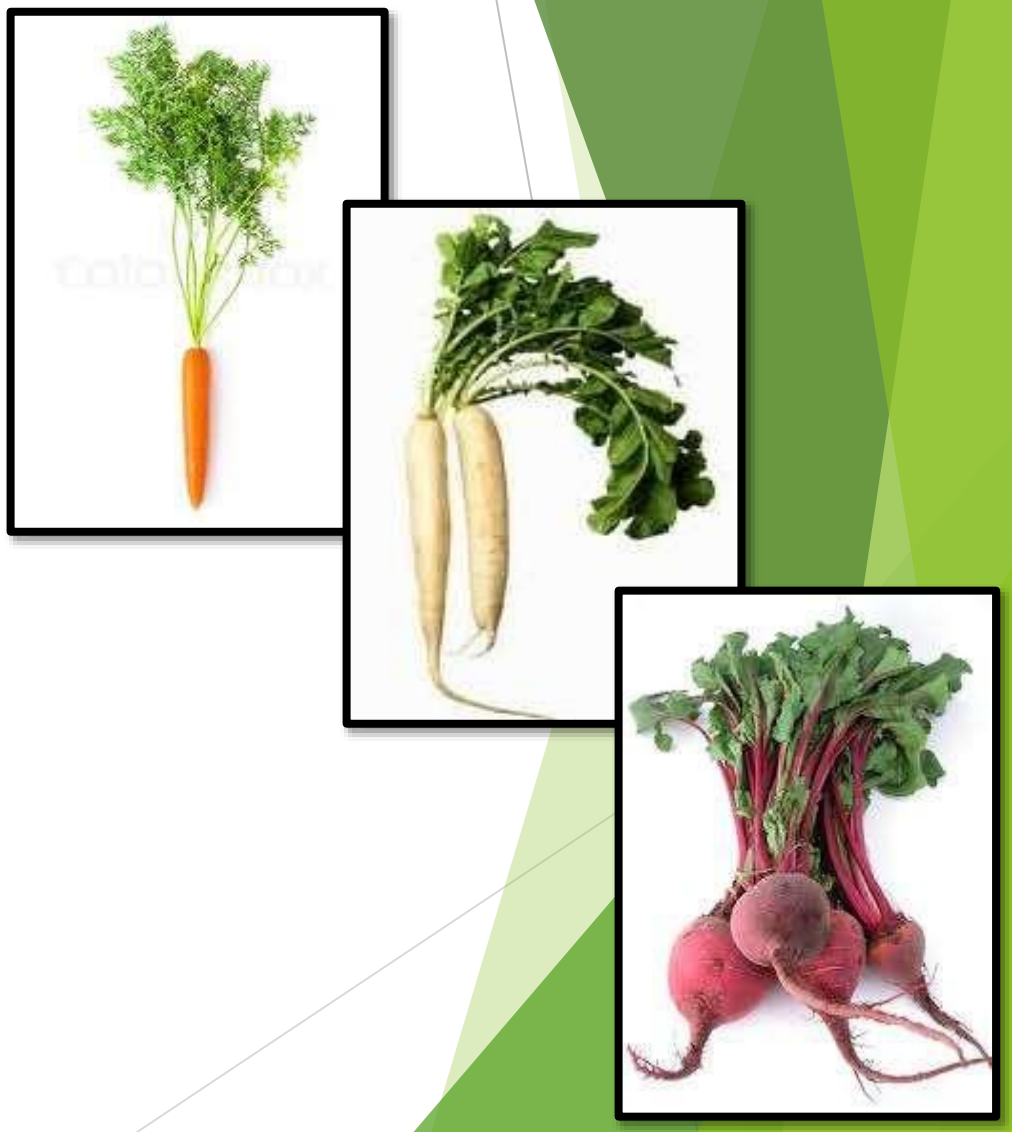
The storage root which is **swollen** in the **middle** part and **tapers** towards the **base** and **apex** is called Fusiform root e.g. *radish* (Raphanus sativus).

CONICAL ROOT

The storage root which is **broader** at the **base** and gradually **tapers** towards the **apex** is called Conical root e.g. *carrot* (Daucus carota).

NAPIFORM ROOT

The storage root which is much swollen, almost **spherical** and abruptly **tapers** around the **apex** is called Napiform root e.g. *beet* (Beta vulgaris).



Morphology of Root

MODIFICATIONS OF TAP ROOT : 2. Respiration

- Plants growing in saline **swamps**, **marshy** places and **salt** lakes are called **halophytes.**
- Many halophytes develop special kinds of roots called respiratory roots or **pneumatophores**.
- Roots of these plants do not get air for respiration as the soil is water logged. As a result, absorption of minerals is affected.
- Such plants produce **special roots** from the underground roots of the plant near the soil, which grow vertically **upwards** i.e. **negatively geotropic** and come out of the soil in the form of conical **spikes**.
- They occur in large number around the tree trunk and are provided with pores called **lenticels**.
- The lenticels help in **gaseous exchange** required for respiration
- e.g. *Rhizopora, Avicennia, Sonneratia, Heritiera (vern or sundri) etc.*

Morphology of Root

MODIFICATIONS OF ADVENTITIOUS ROOT :

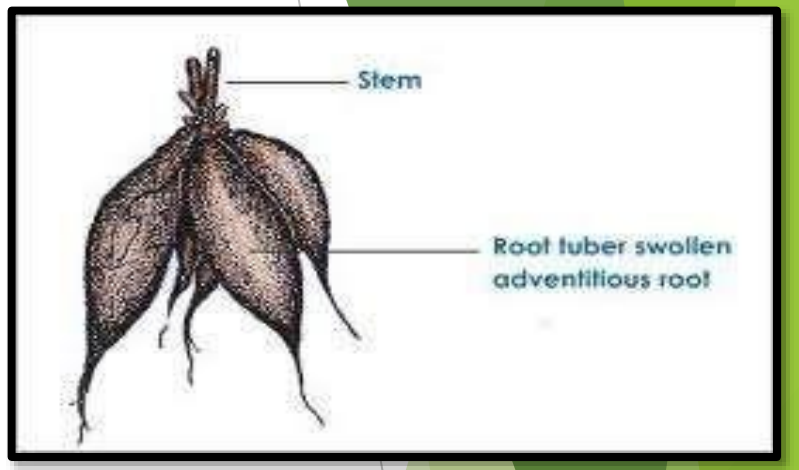
1. Storage of food

SIMPLE TUBEROUS ROOTS:

- These roots become **swollen** and do not assume a definite shape.
- They are always borne **singly**.
- These roots arise from the **nodes** of the stem and enter in the soil e.g. *sweet potato or shakarkand* (Ipomoea batatas).

FASCICULATED TUBEROUS ROOTS:

- A **cluster** of adventitious roots of some plants become **thick** and fleshy due to the storage of food.
- These are known as fasciculated tuberous roots, as there are many tuberous roots at the base of the stem. E.g. *Dahlia and Asparagus*.



Morphology of Root

MODIFICATIONS OF ADVENTITIOUS ROOT :

2. Mechanical Support

PROP ROOTS

- These roots arise **from** horizontal **branches** of trees like *Banyan* tree (Ficus benghalensis) and grow **vertically downward** till they penetrate the soil.
- **Secondary growth** occurs in these roots, so that they become thick and act like **pillars** to provide mechanical support to the heavy branches.

CLIMBING ROOTS

- Climbing plants like piper produce roots from their **nodes**, by means of which they **attach** themselves to some **support** or **climb** over it.
- e.g. *money plant (Pothos), kali mirch (Piper nigrum), pan (Piper betel).*

Morphology of Root

MODIFICATIONS OF ADVENTITIOUS ROOT :

2. Mechanical Support

STILT ROOTS:

- These roots normally arise from a few **lower nodes** of a weak stem in some monocots, shrubs and small trees.
- They grow **obliquely downwards** and penetrate the soil and provide mechanical support to the plant.
- In plants like *maize, sugarcane, bajra and jowar*, the roots grow in **whorls**.
- After penetrating the soil they provide support to the plant.
- In *screwpine or Pandanus*, these roots arise only from the lower surface of the **obliquely growing stem** to provide support.
- These roots bear much folded multiple **root caps**.

Morphology of Root

MODIFICATIONS OF ADVENTITIOUS ROOT

3. Special Functions

EPIPHYTIC ROOTS

- Some plants like *orchid* grow perched on the horizontal **branches** of big **trees** in forest to get **sunlight**. Such plants have green leaves and can **photosynthesize**. These plants are called epiphytes.
- Epiphytes develop special **aerial, hanging roots** called epiphytic roots. These roots are **spongy** due to presence of a special tissue called **velamen**, which is situated outside the cortex.
- The cells of velamen tissue are **hygroscopic**, have porous walls and with the help of velamen tissue these roots absorb **moisture** from the atmosphere e.g. *Venda*, *Dendrobium*, *etc*. These roots **fulfill the need of water** in epiphytes as they **do not have normal roots** penetrating the soil to absorb water. These roots are also called **assimilatory** roots as they are greenish white in colour, have chloroplast and can **photosynthesize** up to a certain extent.

Morphology of Root

MODIFICATIONS OF ADVENTITIOUS ROOT

3. Special Functions

SUCKING ROOTS OR HAUSTORIA:

- These are highly specialized and microscopic roots, developed by **parasites** to absorb **nourishment** from the **host**.
- In partial parasites like *Viscum album*, they penetrate only **xylem** elements of the host to absorb **water** and minerals.
- In total parasites like *Dodder or Cuscuta* (Amarvel), they establish a connection with the vascular strand of host and suck **food** directly from **phloem** and **water** and minerals from the **xylem**.
- Such roots are called parasitic roots, sucking roots or Haustoria.

Morphology of Stem

CHARACTERISTICS

- The aerial part of the plant body is collectively described as shoot system.
- Main axis of this shoot system is called the stem.
- Stem can be defined as the **ascending part** of the plant axis, which develops from the **plumule**,
- It is usually **negatively hydrotropic, negatively geotropic and positively phototropic.**
- It bears a **terminal bud and axillary buds** in the axils of leaves, for growth.
- It is differentiated into **nodes and internodes**.
- At the nodes, it produces dissimilar organs such as leaves and flowers and similar organs such as branches, exogenously i.e. originate from outer tissue.
- The young stem is green and is capable of performing photosynthesis.

Morphology of Stem

BUDS

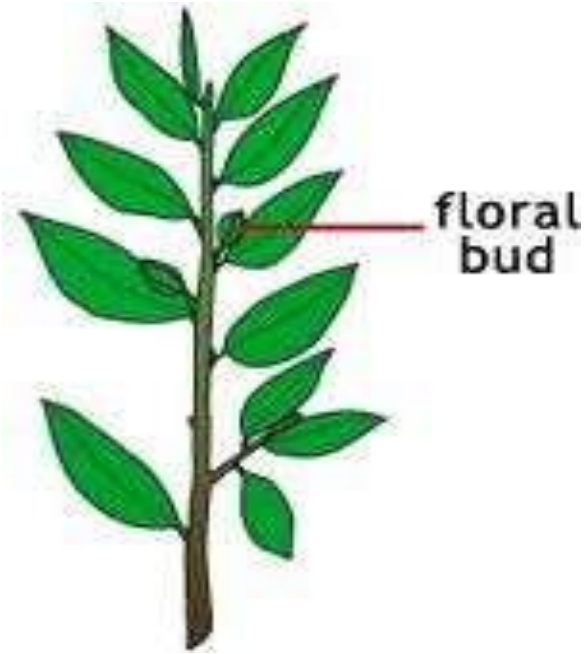
Vegetative

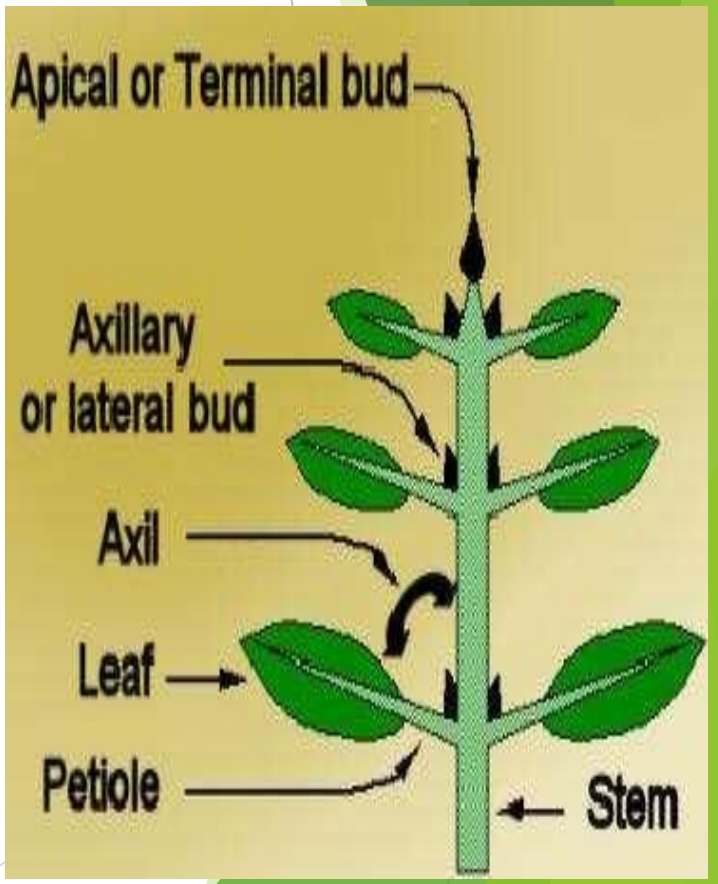
The buds which develop into **branches** are called vegetative buds

- **Apical buds** : located at the apex of stem
- **Axillary buds** : located in the axils of leaves
- **Accessory buds** : located on the sides or above the axillary buds
- **Adventitious buds** : located at areas other than nodes

Floral

The buds which develop into **Flowers** are called floral buds.





Morphology of Stem

FUNCTIONS OF STEM

- The primary functions of stem are to produce and support lateral appendages such as **branches, leaves, flowers** and **fruits**, conduction of **water** and **minerals** to different parts of shoots and transport **food** to all plant parts.

- Stem may, however, get modified to perform additional or functions such as
- **storage** of food and water,
- proliferation and **propagation**,
- procuring **support** for climbing,
- **perennation** i.e. to tide over unfavorable conditions
- synthesis of food **(photosynthesis).**

Morphology of Stem

MODIFICATIONS OF STEM

- Underground
  1. Rhizome
  2. Tuber
  3. Corm
  4. Bulb
- Sub-aerial
  1. Runner
  2. Stolon
  3. Offset
  4. Sucker
- Aerial
  1. Tendril
  2. Thorn
  3. Phylloclade
  4. Cladode
  5. Bulbil

Morphology of Stem

UNDERGROUND MODIFICATIONS

- In many herbaceous plants, stem develops below the soil and is called underground stem.
- Such stem remains dormant during unfavorable conditions and gives off aerial shoots under favorable conditions.
- These underground stems often store food and become fleshy.
- Underground stem perform three functions-
- storage of food, perennation and vegetative propagation.

They can be differentiated from roots by

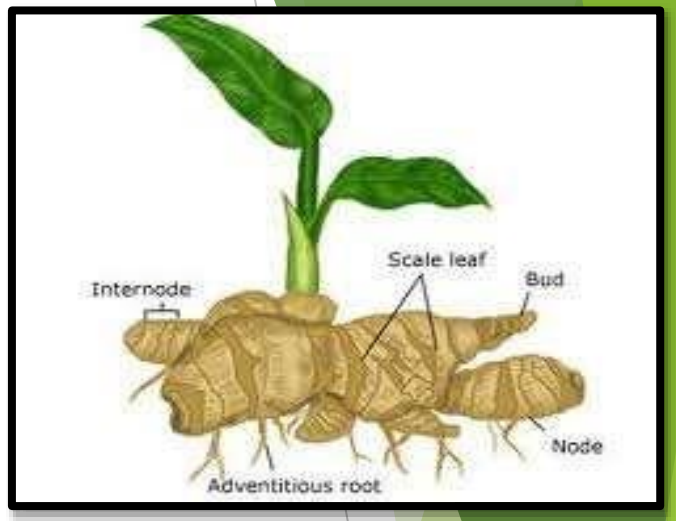
- stem like internal structure, exogenous branching,
- presence of nodes and internodes,
- occurrence of foliage leaves or scale leaves at the nodes with axillary buds
- absence of root cap

Morphology of Stem

UNDERGROUND MODIFICATIONS

RHIZOME

- **prostrate**, **dorsiventral** thickened **brownish** stem, which grows horizontally **under** the surface of the soil.
- It shows distinct **nodes** and **internodes**. It possesses a **terminal** bud and **axillary** buds in the axil of each **scale leaf** present at the node.
- Rhizome remains **dormant** under the soil and at the onset of favorable conditions; the **terminal** bud grows into the aerial shoot which **dies** at the end of the favorable season.



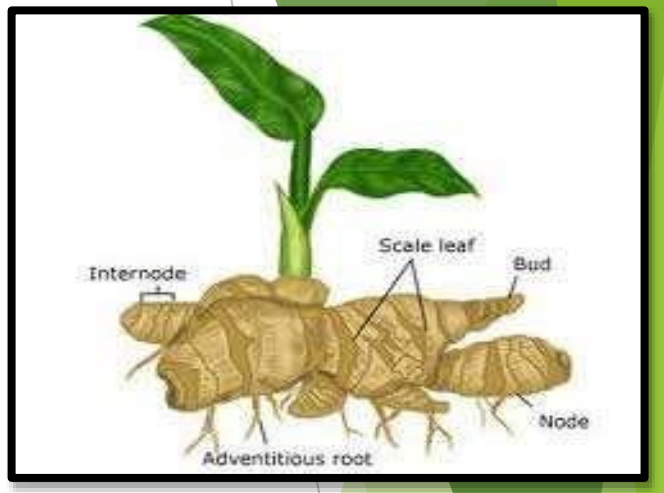
Morphology of Stem

UNDERGROUND MODIFICATIONS

RHIZOME:

- Growth of rhizome takes place horizontally with the help of the **lateral bud**
- . This type of rhizome is called **sympodial rhizome**
- e.g. *ginger (Zingiber officinale), turmeric (Curcuma domestica), Canna etc.*

- In some plants, growth of rhizome occurs with the help of **terminal bud.**
- These are called **monopodial rhizomes**
- e.g. *Lotus, Pteris (a fern) etc.*

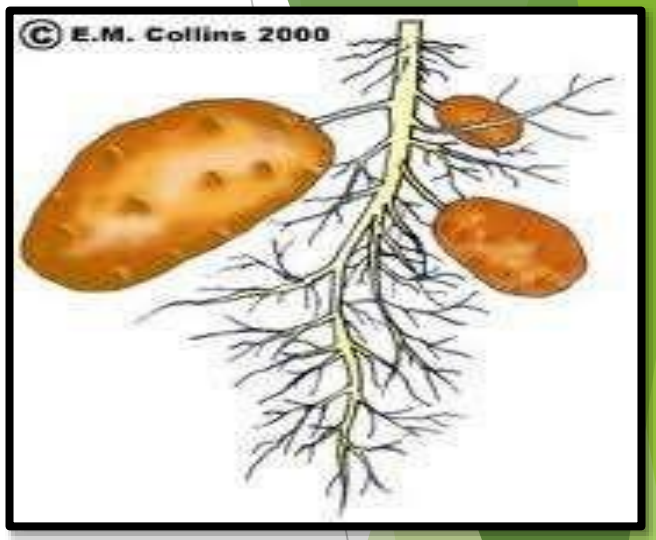


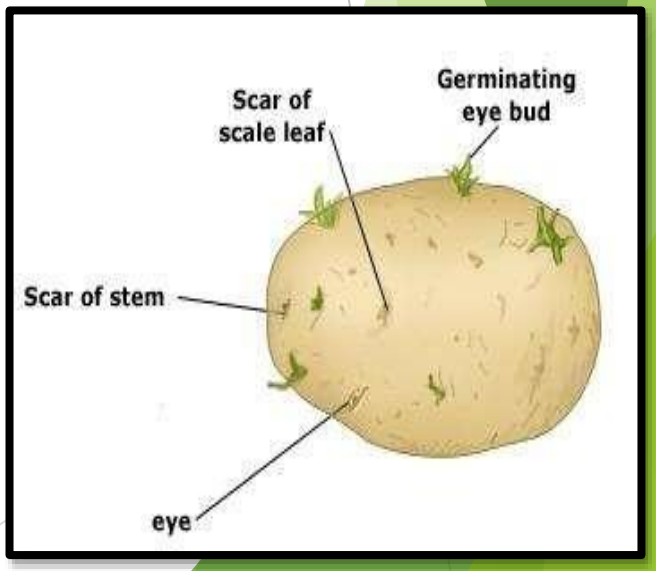
Morphology of Stem

UNDERGROUND MODIFICATIONS

TUBER :

- Tubers are actually the swollen ends or tips of **special swollen underground branches**, due to the storage of food (carbohydrate like starch).
- The tubers show nodes and internodes bear scale leaves with axillary buds, commonly called as **eyes**.
- Under favorable conditions these eyes sprout and produce aerial shoots.
- Thus tubers helps in **vegetative propagation.** Tubers do not produce adventitious roots, thus they differ from rhizomes e.g. ***potato (Solanum tuberosum)***



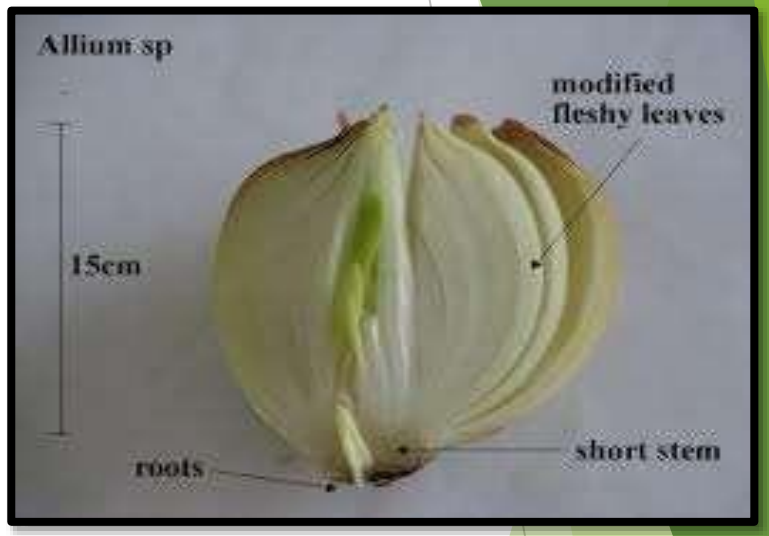


Morphology of Stem

UNDERGROUND MODIFICATIONS

BULB :

- It is a condensed; **disc** like underground stem, which itself **does not store food** material.
- The **upper** surface of disc like stem is slightly conical and bears centrally placed apical bud and many concentrically arranged overlapping scale leaves.
- **Inner scale leaves** or leaf bases **store food** and are thick and fleshy, while **outer** few **scaly** leaves remain thin and dry and are **protective** in function.
- **Lower** surface of disc-like stem produces **adventitious roots**.



Morphology of Stem

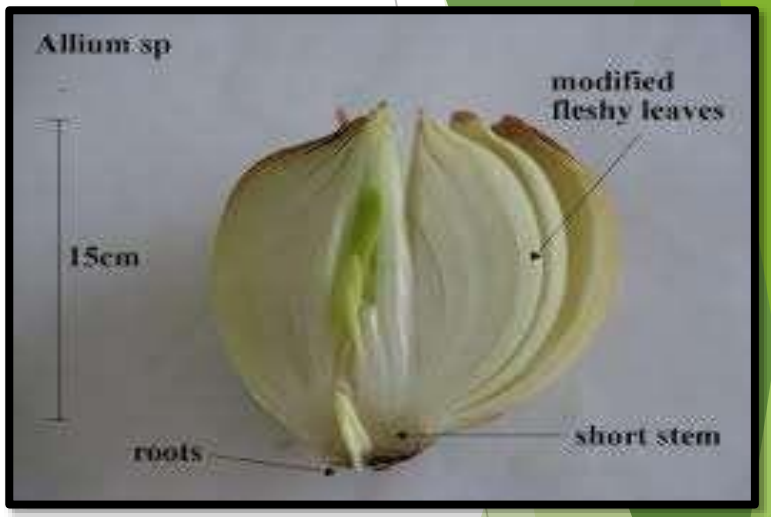
UNDERGROUND MODIFICATIONS

BULB

- The discoid stem with compactly arranged fleshy **leaves above** and fibrous **roots below** is commonly called bulb. It is almost spherical.

- When the fleshy scale leaves surround the apical bud in the form of **concentric rings**, it is called **tunicated bulb** e.g. *onion*.

- Sometimes they may **partially** overlap each other by their **margins** only, such bulbs are called **scaly bulbs** e.g. *garlic*.

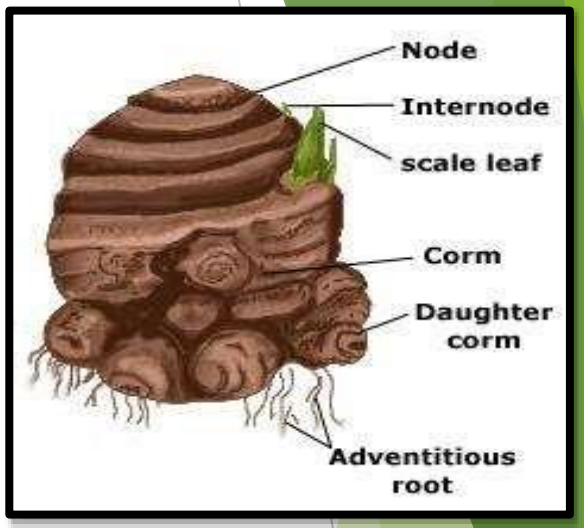


Morphology of Stem

UNDERGROUND MODIFICATIONS

CORM :

- Corm is a short, stout, fleshy, upright and thickened underground stem.
- It bears many **buds** in the axils of **scale** leaves which develop into **daughter** corms.
- At the bases or even from sides of stem **adventitious roots** develop.
- Corm is a condensed form of **rhizome growing vertically**,
- e.g., *Arbi (Colocasia), zaminkand (Amorphophallus etc.)*

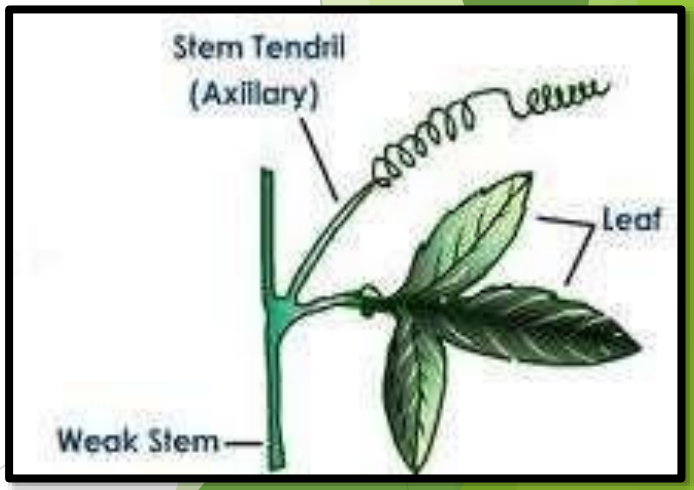


Morphology of Stem

AERIAL MODIFICATIONS

STEM TENDRIL:

- It is a modification of stem in which **axillary bud** modifies to form a **thin, wiry**, and highly **sensitive** structure called tendril.
- Tendrils help the plant to attach itself to the **support** and **climb**. They are found in plants with weak stem. The tendrils are **leafless, coiled** structures with sensitive **adhesive glands** for fixation.
- An example of axillary tendril is *Passiflora (Passion flower)*.
- In *Vitis* **apical bud** is modified into tendril and further growth is resumed by axillary bud.
- In *Cucurbita*, extra **axillary bud** is modified into tendril, while in *Antigonon*, **floral bud** is tendrillar.

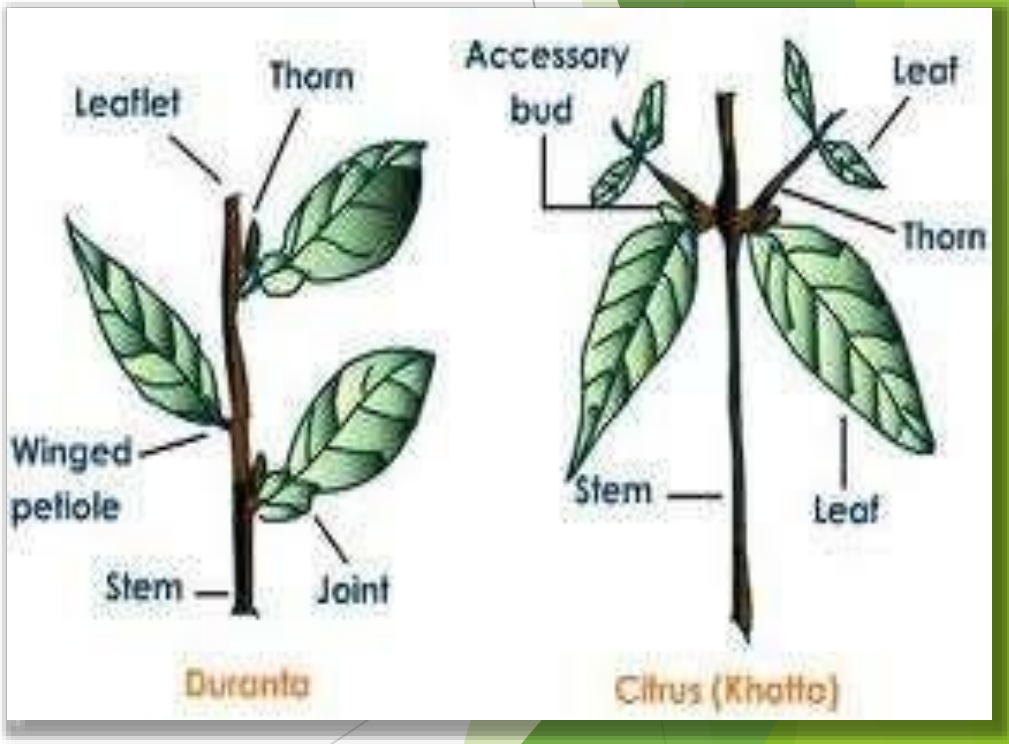


Morphology of Stem

AERIAL MODIFICATIONS

THORN:

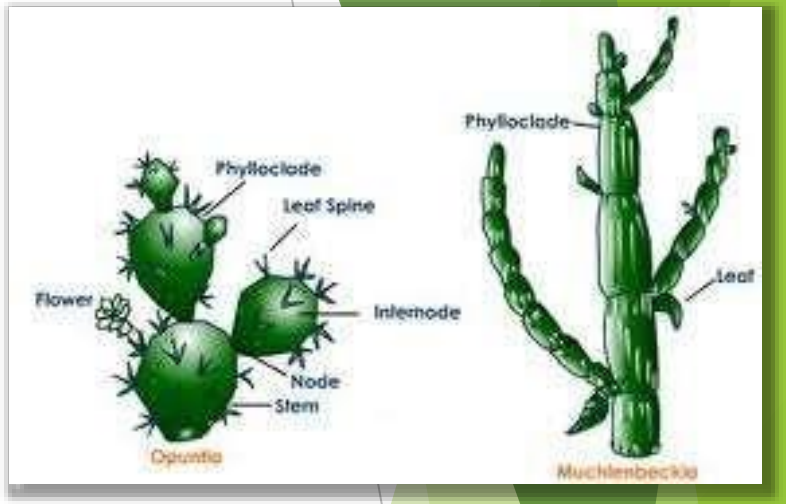
- Thorn is a **hard, pointed** usually straight structure produced by modification of **axillary bud**.
- Leaves, branches and flowers are developed on thorns at the nodes, indicating that it is a modified stem.
- It provides **protection** against **browsing animals**,
- e.g. *Citrus*, *Bougainvillea*, *Duranta* etc.
- In *Carrisa*, **apical bud** is modified into thorn.



Morphology of Stem

AERIAL MODIFICATIONS PHYLLOCLADE

- The phylloclade or **cladophyll** is a stem which gets transformed into **leaf** like structure.
- The phylloclade is **green**, flattened structure with distinct nodes and internodes.
- It is thick, fleshy and **succulent**, in *Opuntia* or *Nagphani*,
- cylindrical in *Casuarina* and *Euphorbia tirucalli* and
- ribbon like in *Muehlenbeckia*.
- In **xerophytes**, **leaves** get modified into **spines** or get reduced in size to check the loss of water due to transpiration and thus **stem** takes up the function of leaf, i.e. **photosynthesis**.

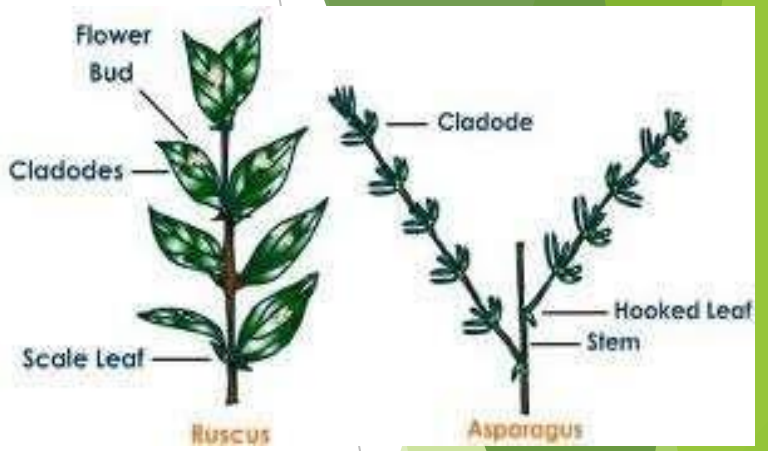


Morphology of Stem

AERIAL MODIFICATIONS

CLADODE

- These are **green branches** of limited growth (usually one internode long) which have taken up the function of photosynthesis.
- **True leaves** are reduced to **scales** or **spines**,e.g. *Asparagus*



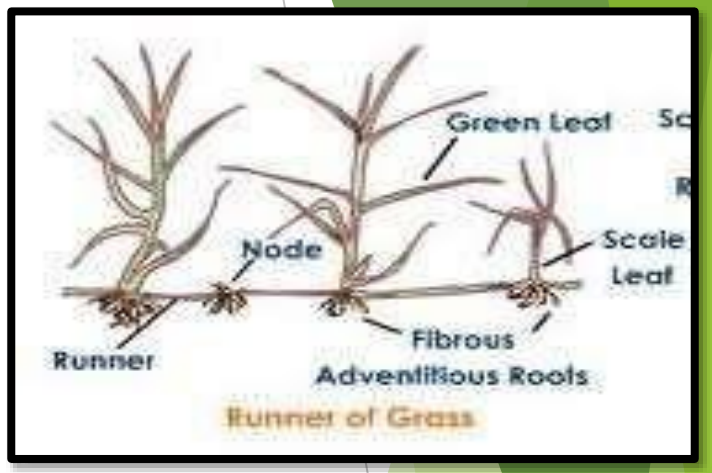
BULBILS:

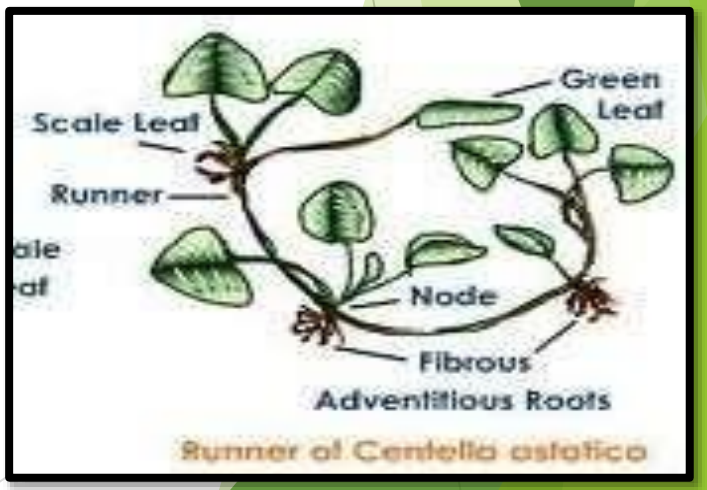
- When **axillary bud** becomes **fleshy** and rounded due to storage of food, it is called bulbils.
- It gets **detached** from the plant, **falls** on ground and develops into a **new plant**,
- e.g. *Dioscorea*

Morphology of Stem

SUB - AERIAL MODIFICATIONS RUNNER

- These are special, narrow, **green**, **horizontal** or prostrate branches which develop at the base of erect shoots called **crowns**.
- **Many** runners arise from each erect shoot. They spread in **different directions** and bear new **crowns above** and tufts of adventitious **roots below** at certain intervals.
- Each runner has one or more **nodes**. The nodes bear scale leaves and axillary buds,
- e.g., *Lawn grass (Cynodon dactylon)*,
- *Hydrocotyl (Centella asiatica)*,
- *Oxalis, etc.*



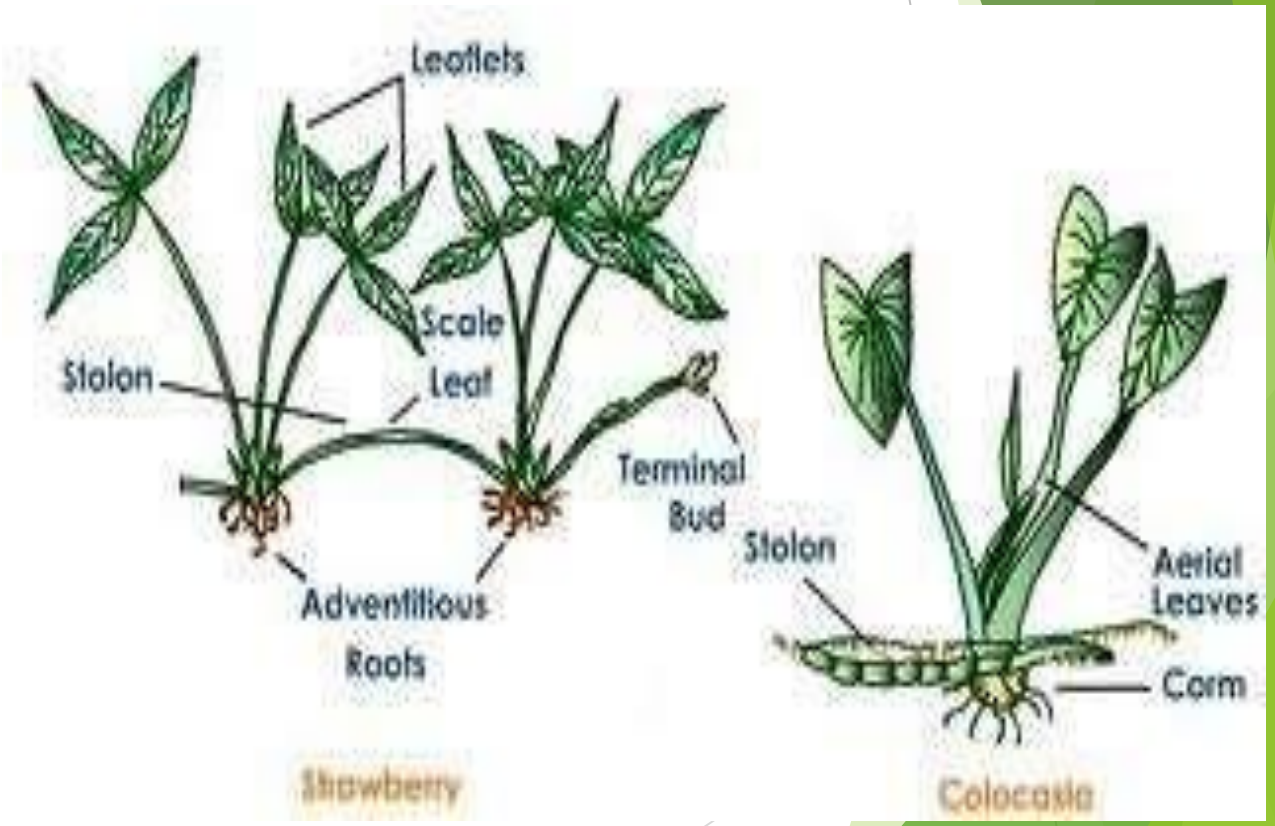


Morphology of Stem

SUB – AERIAL MODIFICATIONS

STOLON

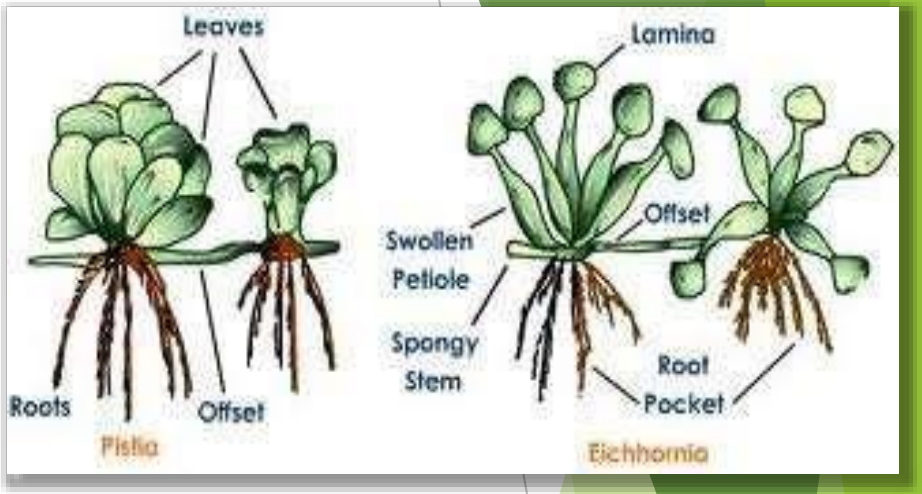
Stolon is a slender **lateral** branch that arises from the base of the main axis. Initially stolon **grows upwards** like an ordinary branch and then **bends down** and touches the soil where its **terminal bud** gives rise to a new **shoot** and adventitious **roots**, e.g., *jasmine, Mentha, strawberry and Colocasia.*

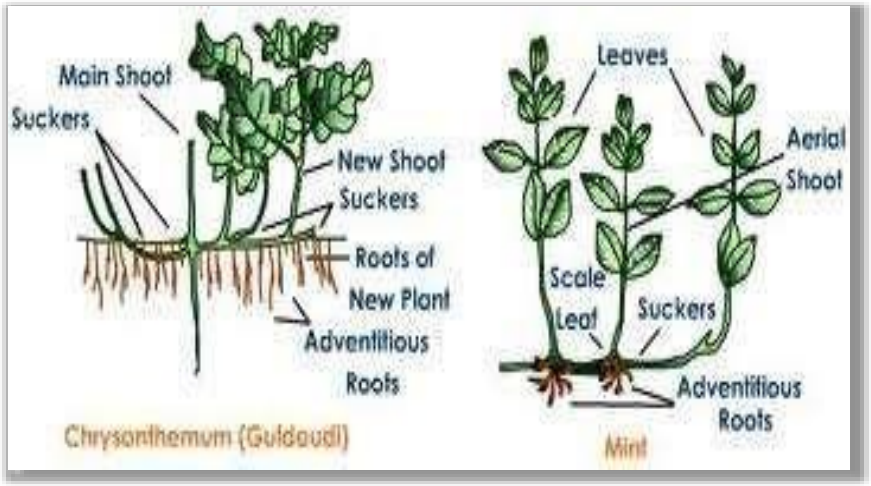


Morphology of Stem

SUB - AERIAL MODIFICATIONS OFFSET:

- It is commonly called the **runner of aquatic plants**.
- It is shorter and thicker than runner.
- It helps in the **vegetative propagation** in aquatic plants,
- e.g. *water hyacinth or jalkumbhi (Eichhornia) and Pistia*.





SUCKER

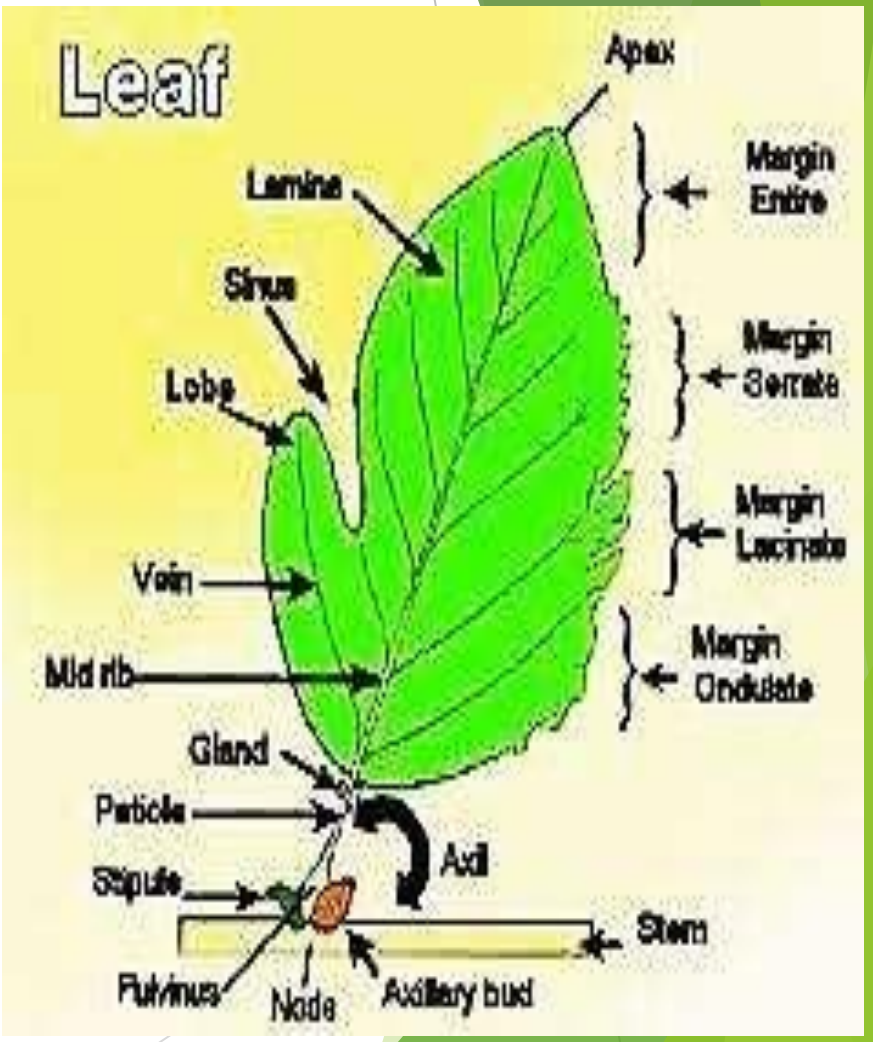
- Sucker is a runner like non-green branch which develops from the **axil of scale leaf** in the underground part of stem.
- It grows horizontally **below the soil** for some distance and comes **above** the soil obliquely and produces **green leaves** to form aerial shoots.
- The sucker can, therefore, be called **underground runner**,
- e.g., *Chrysanthemum, mint (Pudina)*.

Morphology of Leaf

A **dorsi-ventrally** compressed, **lateral appendage** of stem produced at the **nodes** and is specialized to perform photosynthesis

CHARACTERISTICS OF LEAF:

- Leaf is a **thin, expanded, green** structure.
- The green colour of the leaf is due to the presence of chlorophyll pigment.
- It is **exogenous** in origin.
- It is borne on the stem **at the node.**
- An **axillary bud** is often present in the **axil** of each leaf.
- It has **limited growth.**
- It does not possess apical bud or a regular growing point.



Morphology of Leaf

PARTS OF A TYPICAL LEAF

LEAF BASE OR HYPOPODIUM

- The part of leaf **attached** to the stem or branch is known as leaf base.
- It may assume different shapes in different plants.
- In some leguminous plants, the leaf blade may become swollen which is called **pulvinus**.
- In monocots, the leaf base expands into a sheath **covering** the stem partially or completely.
- Leaves of some plants possess a pair of lateral outgrowths at the base, on either sides of axillary bud. These outgrowths are called **stipules** and such leaves are called **stipulate** leaves.
- The leaves without stipules are called **ex- stipulate** leaves. Stipules are usually **green**.
- The main functions of stipules are to **protect** the **bud** and carry out **photosynthesis**.

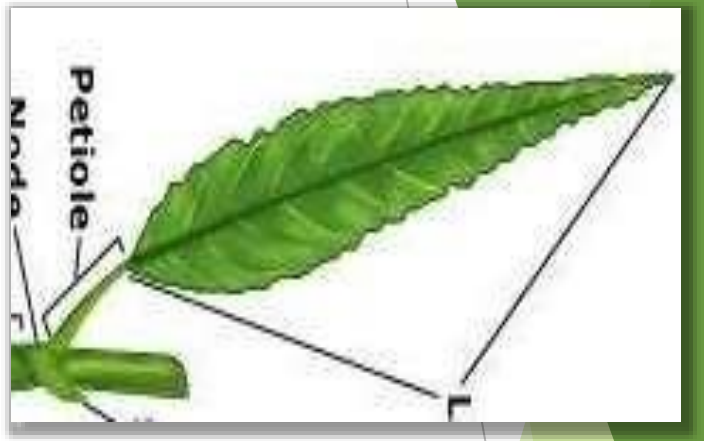
STIPULES

Morphology of Leaf

PARTS OF A TYPICAL LEAF

PETIOLE OR MESOPODIUM

- Petiole is the part of leaf connecting the **lamina** with the branch or stem.
- Leaves that possess petiole are called **petiolate** and leaves without petiole are called non-petiolate or **sessile** leaves.
- Petiole is usually **cylindrical**, but may be hollow *(Papaya)*, tubular or flattened.
- Function of petiole is to **raise** the lamina to expose it to more **light** and **air** and to help in conduction.



Morphology of Leaf

PARTS OF A TYPICAL LEAF

LAMINA OR EPIPODIUM

- This is the **largest**, most important, **green** and flattened part of the leaf.
- It plays a vital role in **photosynthesis, gaseous exchange** and **transpiration.**
- The leaf is known as **dorsiventral** when its ventral surface is structurally different from dorsal surface, e.g. *dicotyledonous* leaves.
- The leaves having both similar surfaces are called **isobilateral**. Such leaves are found in *monocot* plants

Morphology of Leaf

LEAF VENATION

- The **arrangement of veins and veinlets** in the lamina is known as venation.
- The veins are in fact conducting strands of lamina.
- They are concerned with the **conduction** of water, mineral salts and food and form the **structural framework** of the lamina.

RETICULATE

PARALLEL

Morphology of Leaf

RETICULATE VENATION

- When the veins and veinlets form a **network**, it is called reticulate venation.
- Here the midrib is **centrally** placed and veins and veinlets remain distributed **laterally**.
- It is found in *dicotyledonous* plants.

On the basis of number of mid-veins,

1. **Unicostate** - with a *single* mid-vein *(e.g. Mango)*
2. **Multicostate** - with *two* or more prominent veins *(e.g. Zizyphus)*. It may be *convergent* or *divergent*.

Morphology of Leaf

PARALLEL VENATION

- In this type of venation, **veins** in lamina run almost **parallel** to one another.
- It is found commonly in *monocotyledonous* plants.
- It is of the following two types:

1.Unicostate e.g., *Banana*, *Canna*.

2. Multicostate e.g., *Grass*, *rice*, *bamboo*, etc

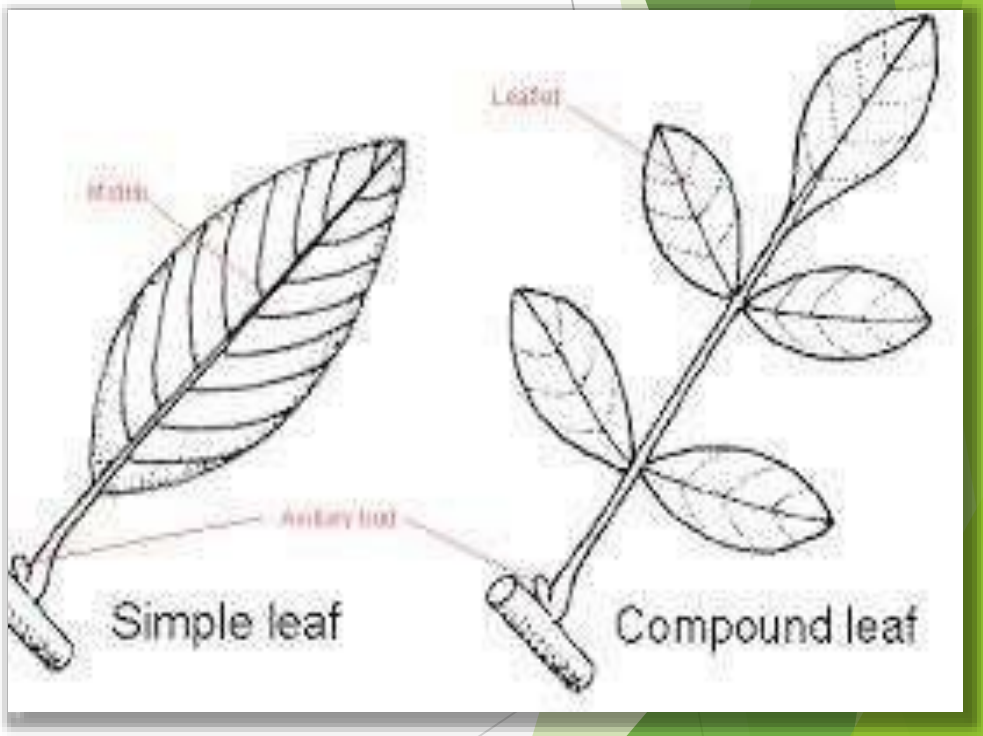
Morphology of Leaf

SIMPLE LEAF

- Simple leaves are those in which **single** leaf blade or **lamina** is present,
- e.g., *Mango, Peepal, Papaya,etc.*

COMPOUND LEAF

- Compound leaves are those in which the leaf blade or lamina is divided into number of segments known as **leaflets** or **pinnae.**
- The leaflets never bear axillary buds in their axil.



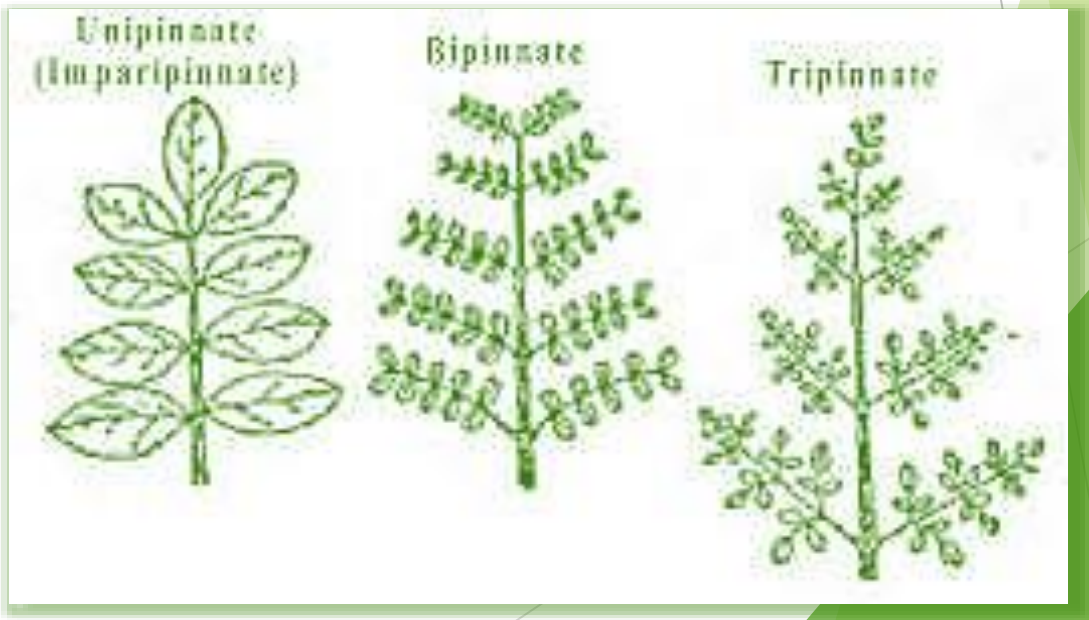
Morphology of Leaf

COMPOUND LEAF :

a) Pinnately compound leaves:

- In this type the leaflets are present laterally on a common axis called **rachis**, which represents the **midrib** of the leaf
- *(e.g. Gold mohur, Cassia)*
- There are of four kinds of pinnately compound leaves as

i) Unipinnate
ii) Bipinnate
iii) Tripinnate
iv) Decompound



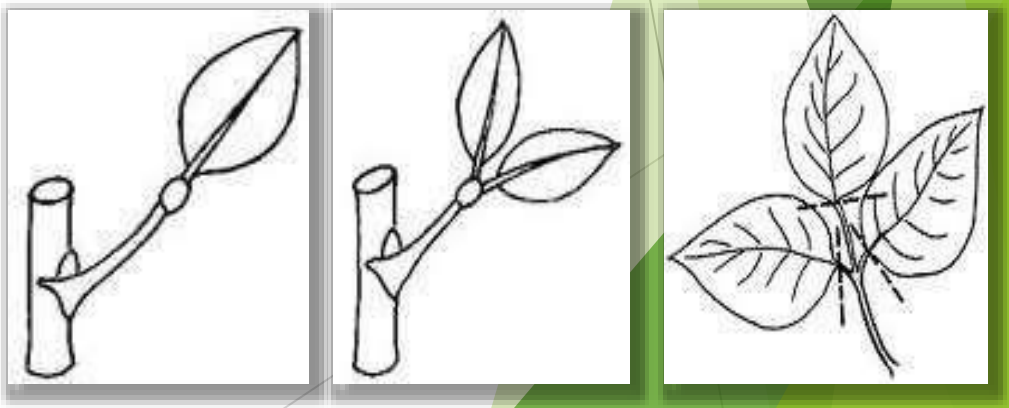
Morphology of Leaf

COMPOUND LEAF :

b) Palmately compound leaves:

- All the **leaflets** of the palmately compound leaves are attached at a **common point**, i.e. at the tip of petiole, like fingers of the palm.
- There are five types of palmately compound leaves as:

1. Unifoliate
2. Bifoliate
3. Trifoliate
4. Quadrifoliate
5. Multifoliate.



Morphology of Leaf

PHYLLOTAXY:

Phyllotaxy is the **arrangement of leaves** on the stem and branches

ALTERNATE PHYLLOTAXY:

- In this type, **single leaf** arises at each node.
- The leaves arise **laterally** on the stem or branches,
- e.g., *Sunflower, Mango, China rose, Mustard etc.*

OPPOSITE PHYLLOTAXY

In this type, **two leaves** arise from each node in opposite direction. It is of two types:

DECUSSATE : When **one pair** of leaf is placed at **right angle** to next or **lower pair** of leaf, it is said to be opposite decussate phyllotaxy. e.g., *Calotropis, Ocimum*, etc.

SUPERPOSED: In this type, **all the pairs** of leaves on the stem are arranged **one above** the other, e.g., *Jamun, Guava, etc.*

WHORLED OR VERTICILLATE PHYLLOTAXY

- In this type **more than two leaves** arise from **each node** and form a **whorl** around it.
- e.g., *Nerium, Alstonia*

Morphology of Leaf

MODIFICATIONS OF LEAVES

LEAF SPINES

In some **xerophytic** plants like *Opuntia*, the entire leaf gets modified into a small, stiff, pointed structure called **spine** to check transpiration.

Sometimes only a part of leaf such as **stipules**, get modified into **spines**, to protect plants from grazing animals, e.g., *Zizyphus* and *Acacia*.

Morphology of Leaf

MODIFICATIONS OF LEAVES

LEAF TENDRILS

-In certain plants having **weak stem**, entire **leaf** or a part of it gets modified into an **elongated**, thin, cylindrical, **coiled**, **wiry**, sensitive structure known as tendril.

These tendrils help the plant to climb up on some **support**.

In *wild pea (Lathyrus)*, **entire** leaf is tendrillar,in *sweet pea (Pisum sativum)* terminal **leaflets** are tendrillar, in *Gloriosa* only the **leaf apex** modifies into tendril, and in *Smilax*, **stipules** become tendrillar.

Morphology of Leaf

MODIFICATIONS OF LEAVES

LEAF HOOKS

- In *Bignonia unguis-cati* (Cat's nail), the **terminal three leaflets** get modified into three stiff **curved** & pointed **hooks** which look like **cat's nail**.
- They cling to bark of tree (**support**) and help the plant for **climbing**.

Bignonia is an elegant hook-climber

Morphology of Leaf

MODIFICATIONS OF LEAVES

PHYLLODE

In some plants, petiole becomes **flat**, **green** and **leaf like** and performs **photo synthesis.** This is known as **phyllode**.
For example, in *Acacia auriculiformis*, the normal **leaf** is bipinnately compound and **falls** off soon.

The petiole gets modified into phyllode. This is xerophytic adaptation to reduce transpiration