

Morphology of Roots, Stems, Leaves and its modifications

1. Morphology of Roots and its modifications

Introduction

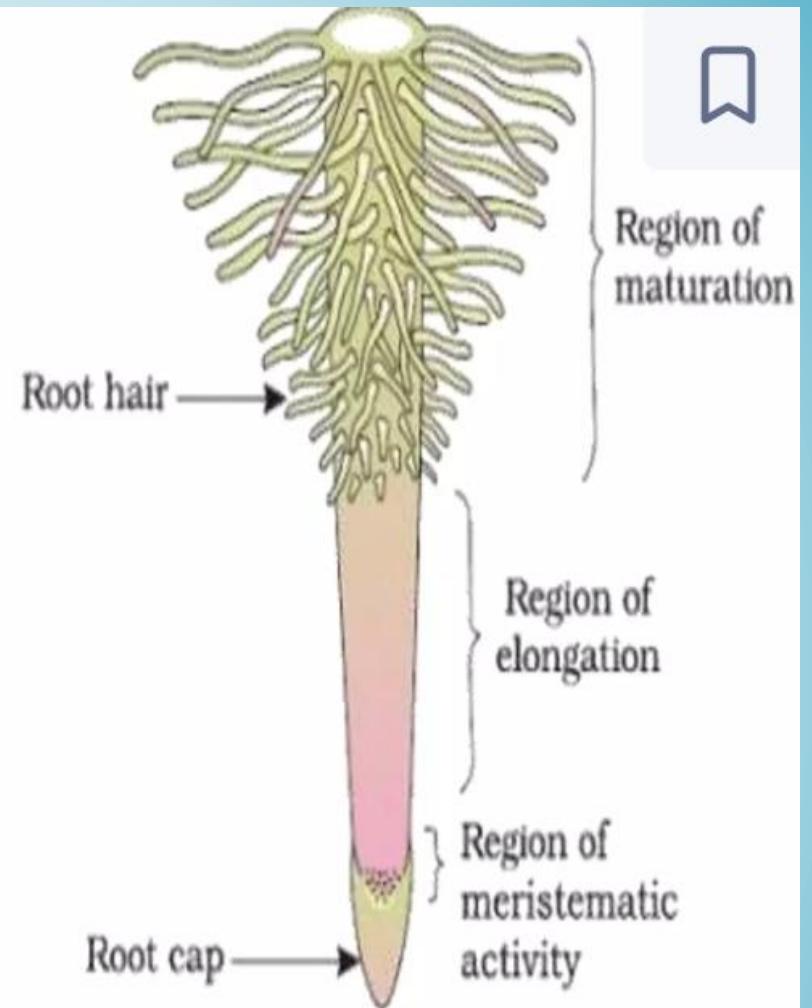
- ◆ Morphology deals with the study of forms and features of different plant organs such as roots, stems, leaves, flowers, seeds and fruits.
- ◆ It includes shape, size, colour, odour, taste etc. of various plant organs their modification.

Introduction

- ◆ The root is descending organ of the plant and is originally the direct prolongation of radicle of the embryo.
- ◆ It grows downwards, fixes the seedling and later the plant as a whole to the ground, and absorb raw food materials from the soil particles.

The following regions may be distinguished in a root from the APEX upwards.

- 1) Root cap
- 2) Region of cell division
- 3) Region of elongation
- 4) Region of maturation



Different kinds of root

Normal root

- ◆ All the roots which arise at the base of the stem from the radicle are called normal roots.

Adventitious root

- ◆ Roots which do not arise from their normal point of origin i.e. from the base of the stem but they are produced from part of stem, branch or leaf.





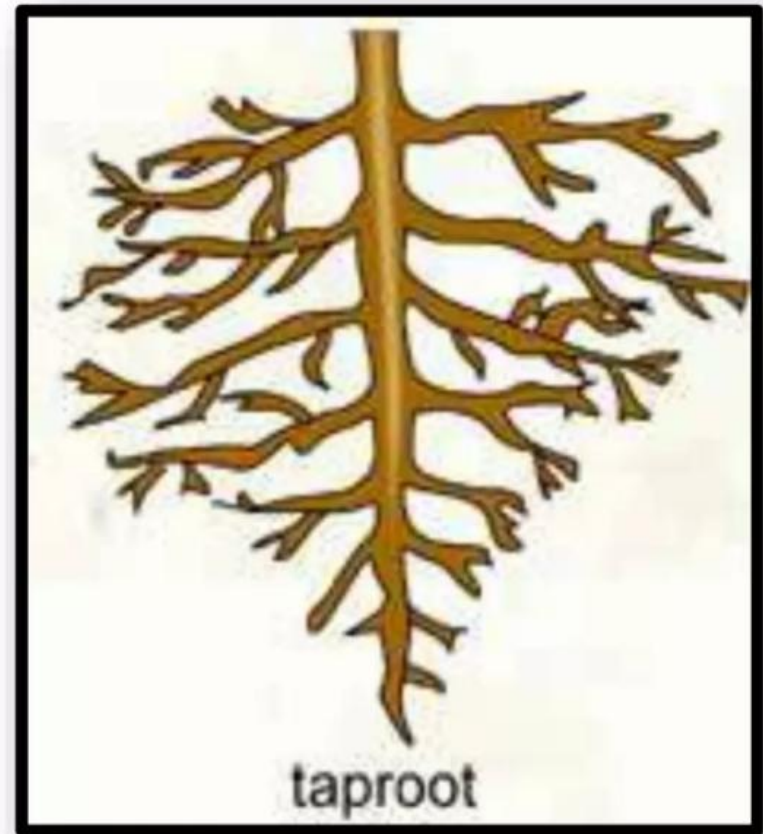


Kinds of root system



Tap root

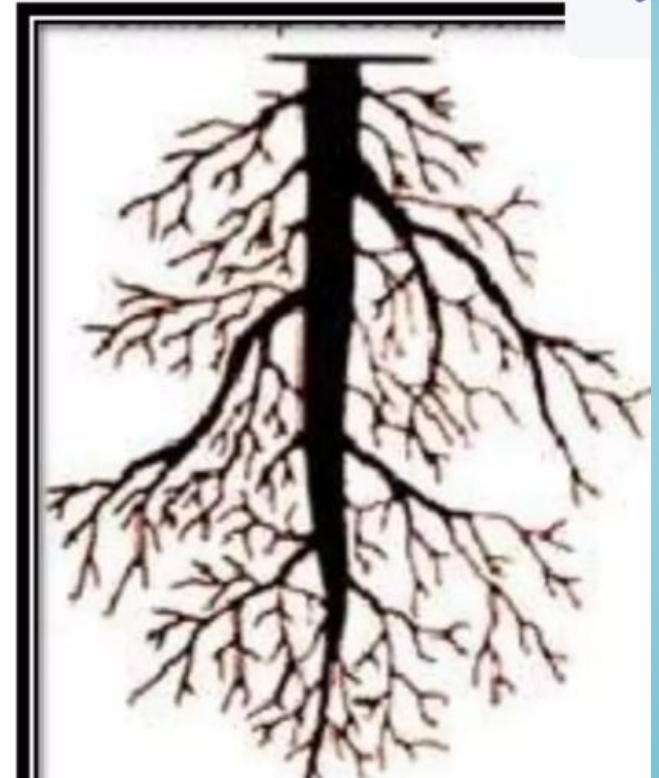
- ◆ When the main root is the direct prolongation of the radicle is called primary root.
- ◆ If the primary root continue to grow stronger than its secondary branches is called tap root
- ◆ Eg. Datura root



Kinds of root system

Fibrous branching tap root

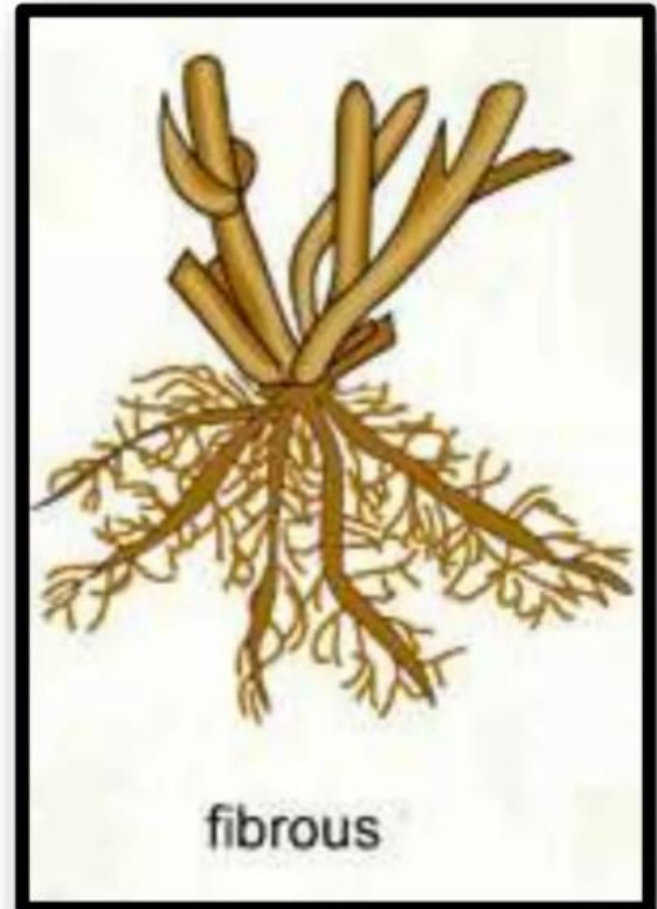
- ◆ When the primary root is short and lateral roots are thin, long, and fibrous is called fibrous branching tap root.
- ◆ Eg. Sunflower root



Kinds of root system

Fibrous root

- ◆ When there is no tap root but a large number of fibrous root arise from the base of the stem is called fibrous root.
- ◆ Eg. Grass



Functions of root

Mechanical

- ◆ Fixation of plant into the soil.

Physiological

- ◆ Absorption of water, minerals and raw material from the soil.

Special functions

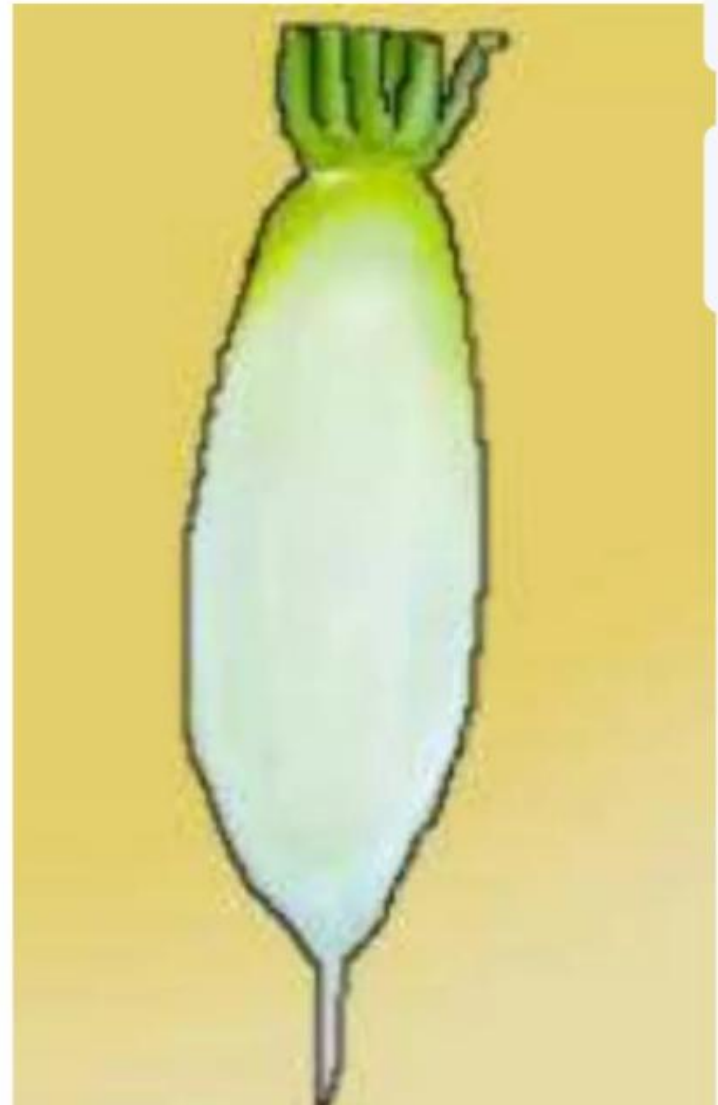
- ◆ Storage of food, water and other materials. Eg. carrot, beet
- ◆ Some root provide support. Eg. Banyan
- ◆ Respiratory function
- ◆ The root of gulvel do photosynthesis

Tap root modifications

- Tap root system is modified into different forms to carry out special function. It is differentiated into following types:
 - 1) **Fusiform:**
 - 2) **Napiform**
 - 3) **Conical**
 - 4) **Tuberous or tubercular**
 - 5) **Pneumatophores**

FUSIFORM:

It is a modified tap root. The primary root is swollen in the middle while both the ends gradually taper forming a spindle shaped structure.
e.g. Radish



Modification of tap root for storage



Napiform

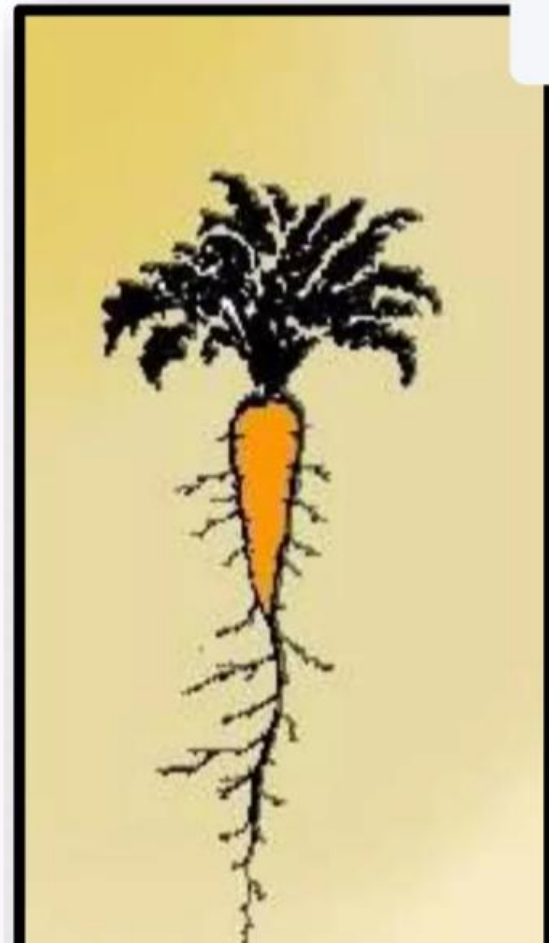
- ◆ When it is considerably broad at the upper part then become rounded and abruptly tapering towards the lower end.
- ◆ Eg. Beet



Modification of tap root for storage

Conical

- ◆ When the root is broad at the base and gradually tapers towards the apex like cone is called conical root
- ◆ Eg. Carrot

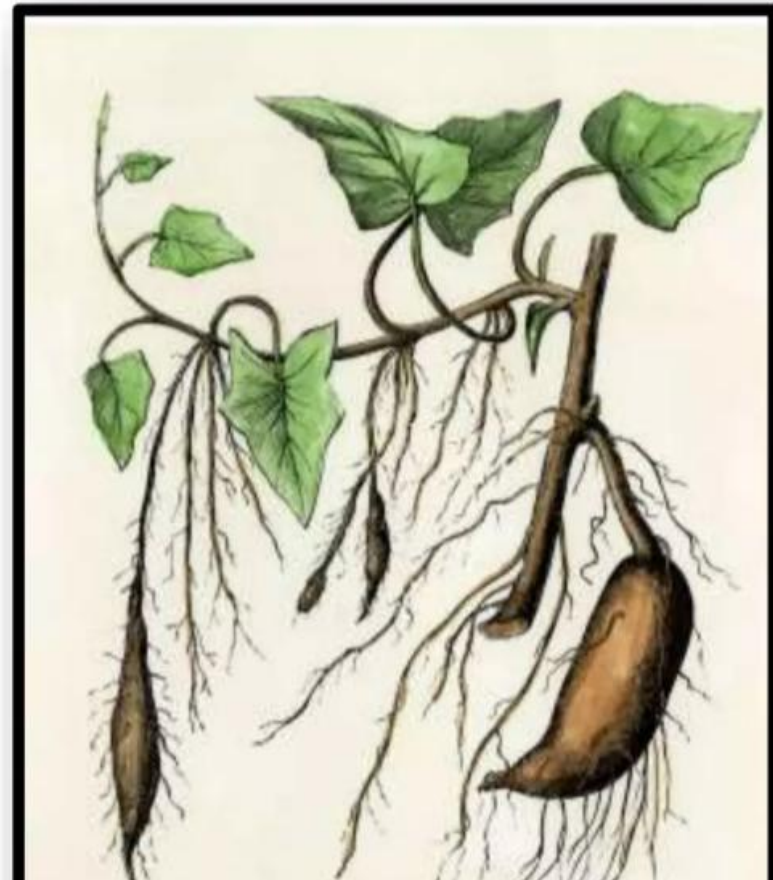


Modification of adventitious root for storage



Tuberous root

- ◆ Adventitious roots are generally fine and fibrous as in grass but often they become thick, swollen and fleshy by storage of food material.
- ◆ They are without any definite shape and produced singly.
- ◆ Eg. Sweet potato



Tuberous or tubercular

- In this case, the root is thick and fleshy but does not form any definite shape, e.g., *Mirabilis*



Pneumatophores

These roots grow vertically up and come out of the water or marshy soil like conical spikes. They occur in large numbers around the tree trunk. Such roots are provided with numerous pores (breathing pores) through which air is taken for respiration, e.g., Rhizophora.



Branched root modified for respiration

Pneumatophores root

- ◆ Plants growing in marshy places and salt lakes, develop special kind of roots for breathing, called 'pneumatophores' or respiratory roots.
- ◆ These roots rise vertically upwards & come out of the water like conical spikes around the trees.
- ◆ These roots are provided with numerous pores toward the upper end, called 'lenticels'.
- ◆ Lenticels through which air is taken in for respiration. Eg. Rhizophora



B. Adventitious root modification

- Roots produced from any portion of the plant other than the radicle is called adventitious roots. It may be changed to different forms for special functions such as storage, mechanical support and vital functions.

(a) For storage of food:

(b) For mechanical support:

(c) For vital functions:

For storage of food

Tuberous root

roots grow from the nodes of the running stem. These roots swell and get modified to irregular forms, known as tuberous. These are produced singly, e.g., Sweet potato (*Ipomoea batatas*).



Fasciculate root

In Dahlia,
Asparagus the
tuberous roots
are developed
from base of
the stem! in
clusters.



Nodulated root

Plants belonging to leguminosa family develops nodules. These are produced by nitrogen fixing bacteria and they get carbohydrates from plants

This swelling developed by roots is known as nodulated root

E.g. plants of leguminosae family

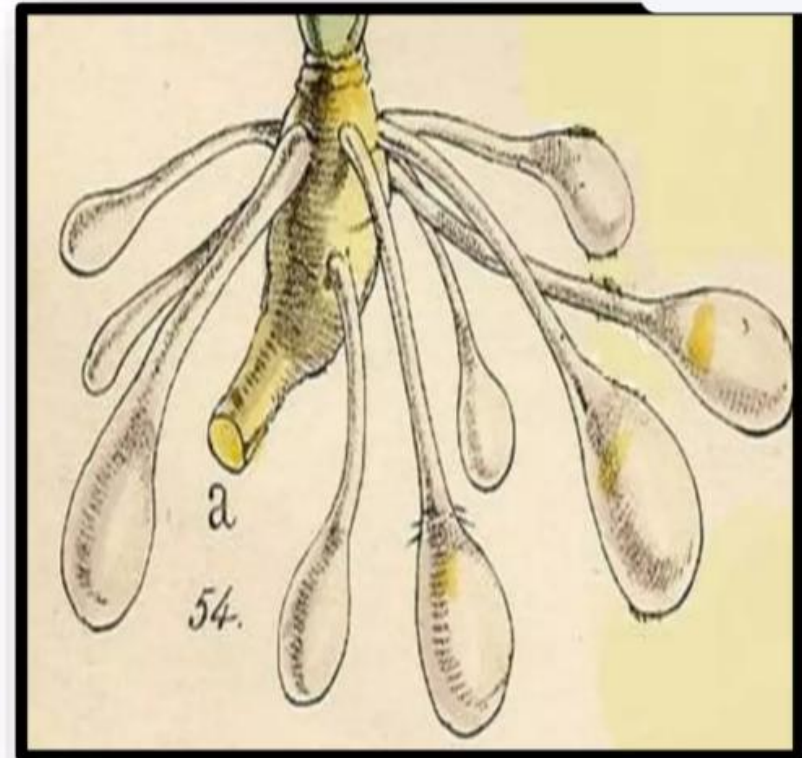


Modification of adventitious root for storage



Nodulous root

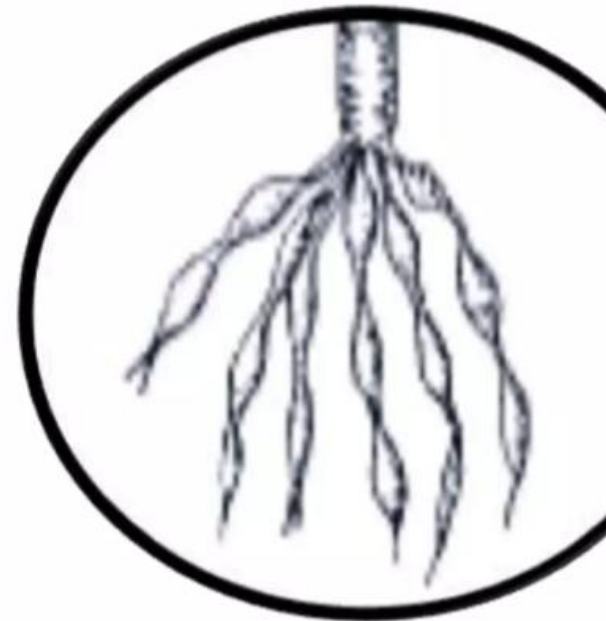
- ◆ When the slender root becomes suddenly swollen at the apex, it is said to be nodulose root.
- ◆ Eg. Turmeric, Arrow root



Modification of adventitious root for storage

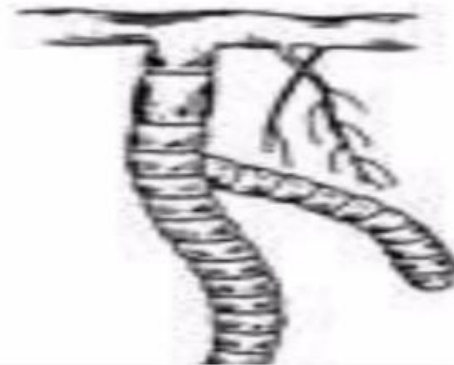
Moniliform or Beaded root

- ◆ When there are some swellings in the root at frequent intervals, it is called as ‘moniliform’ or ‘beaded’ roots.
- ◆ Eg. Indian spinach, Bitter gourd



Annulated roots

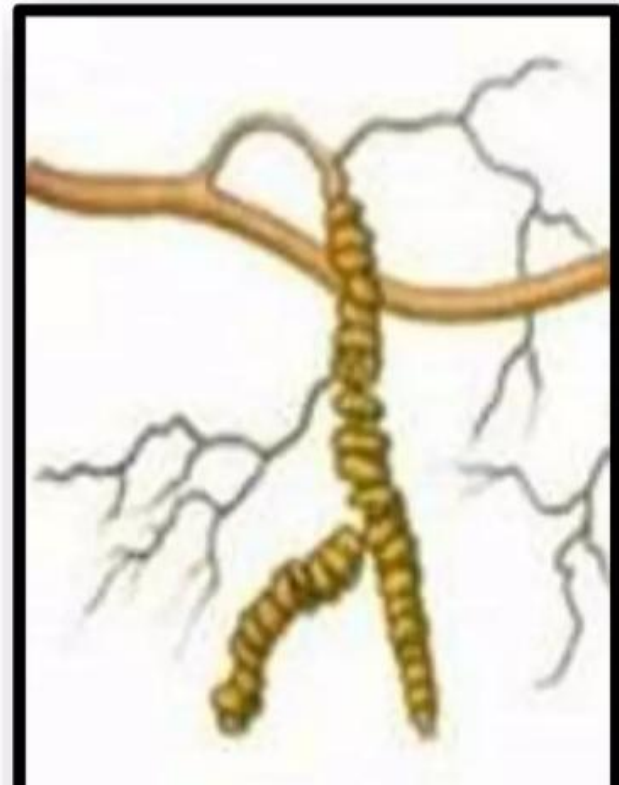
In this type, the root has a series of ring-like swellings appearing as if formed by number of discs placed one above another, e.g., *Cephalis*



Modification of adventitious root for storage

Annulated roots

- ◆ When the roots have a series of ring-like swelling on its body, it is called as 'annulated'.
- ◆ Eg. Ipecac

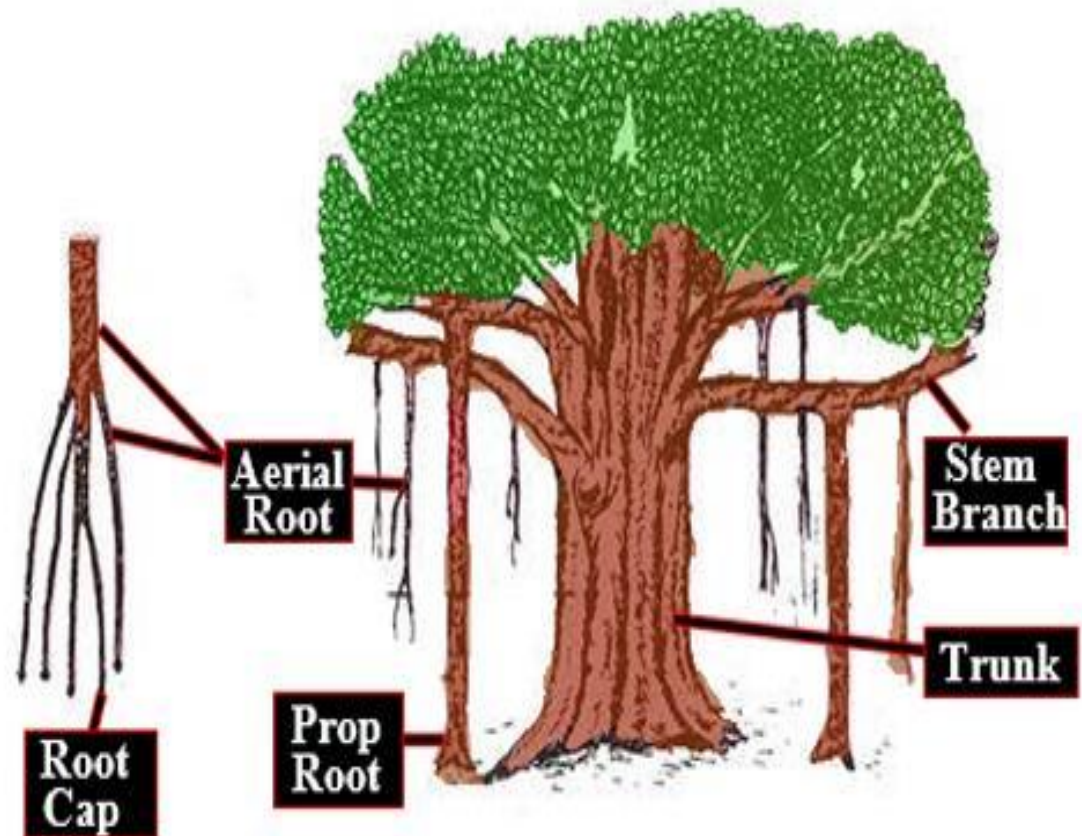


For Mechanical Functions

Prop Roots

- These roots are developed from the horizontal branches of some trees in vertically downward direction. On reaching the soil each root grows into thick and woody pillar-like structure which gives support to the branch from where it developed.
- These are found in Indian rubber and banyan.

Adventitious Root

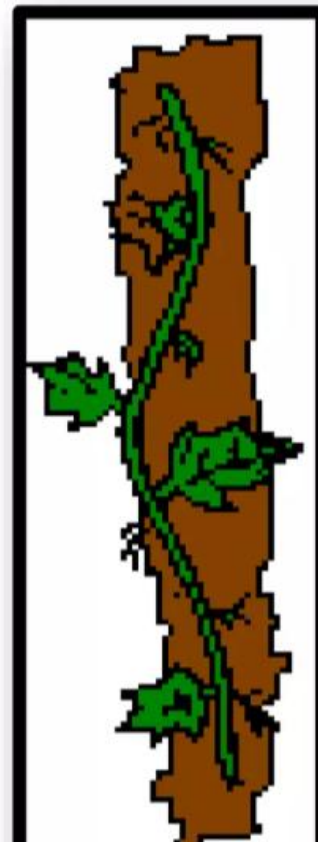




Modification of adventitious root for mechanical support

Climbing root

- ◆ The plant produce climbing root form their nodes and often internodes, by means of which they attach themselves to their support and climb it.
- ◆ Eg. Piper betel

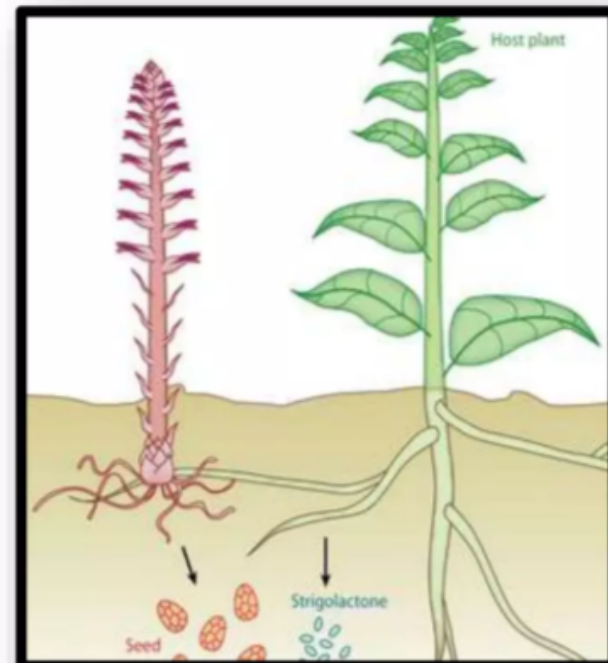


Modification of adventitious root for vital functions



Sucking roots or haustoria

- ◆ There are some plants which grow on the branches of the other plant and obtain their food by sending special roots called the sucking roots or haustoria into the substance of the host plants and absorb the nourishment from them. Such plants are called parasitic plants.
- ◆ Eg. *Cuscuta*

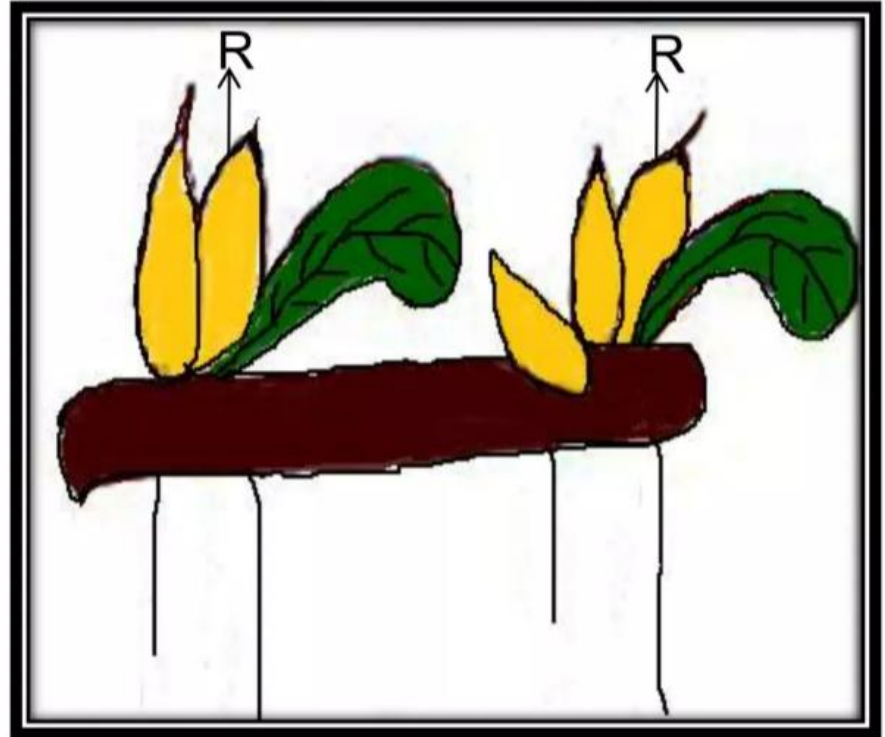


root for vital functions



Respiratory roots

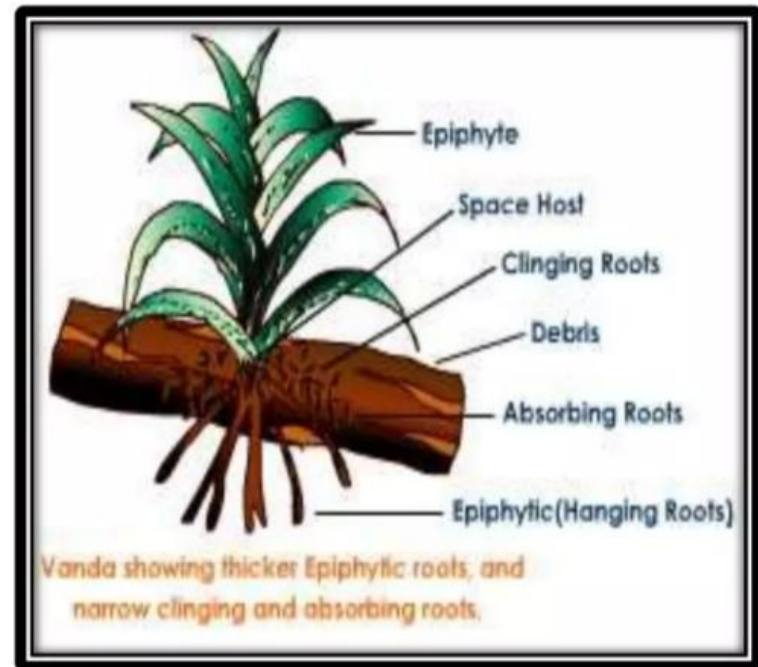
- ◆ In aquatic plants, the floating branches develop adventitious roots, which are soft, light, spongy and colourless.
- ◆ They develop above the level of water and serve to store air and facilitate respiration.
- ◆ Eg. *Jussiaea repens*



root for vital functions

Epiphytic roots

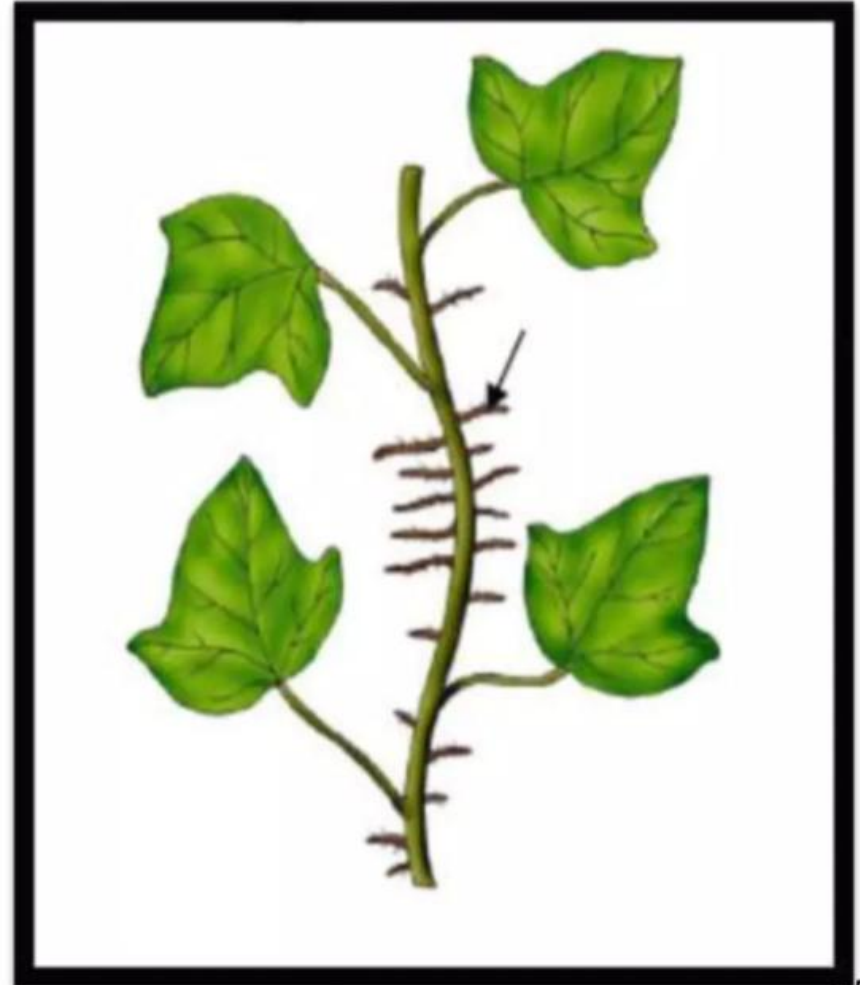
- ◆ The orchids which grow on branches of trees, Such plants are known as epiphytes.
- ◆ They never suck the supporting plants.
- ◆ They develop special roots which hung freely in the air.
- ◆ Each hanging roots are surrounded by spongy tissue called 'velamen'. With these, the hanging root absorbs moisture from the air.
- ◆ Eg. vanda



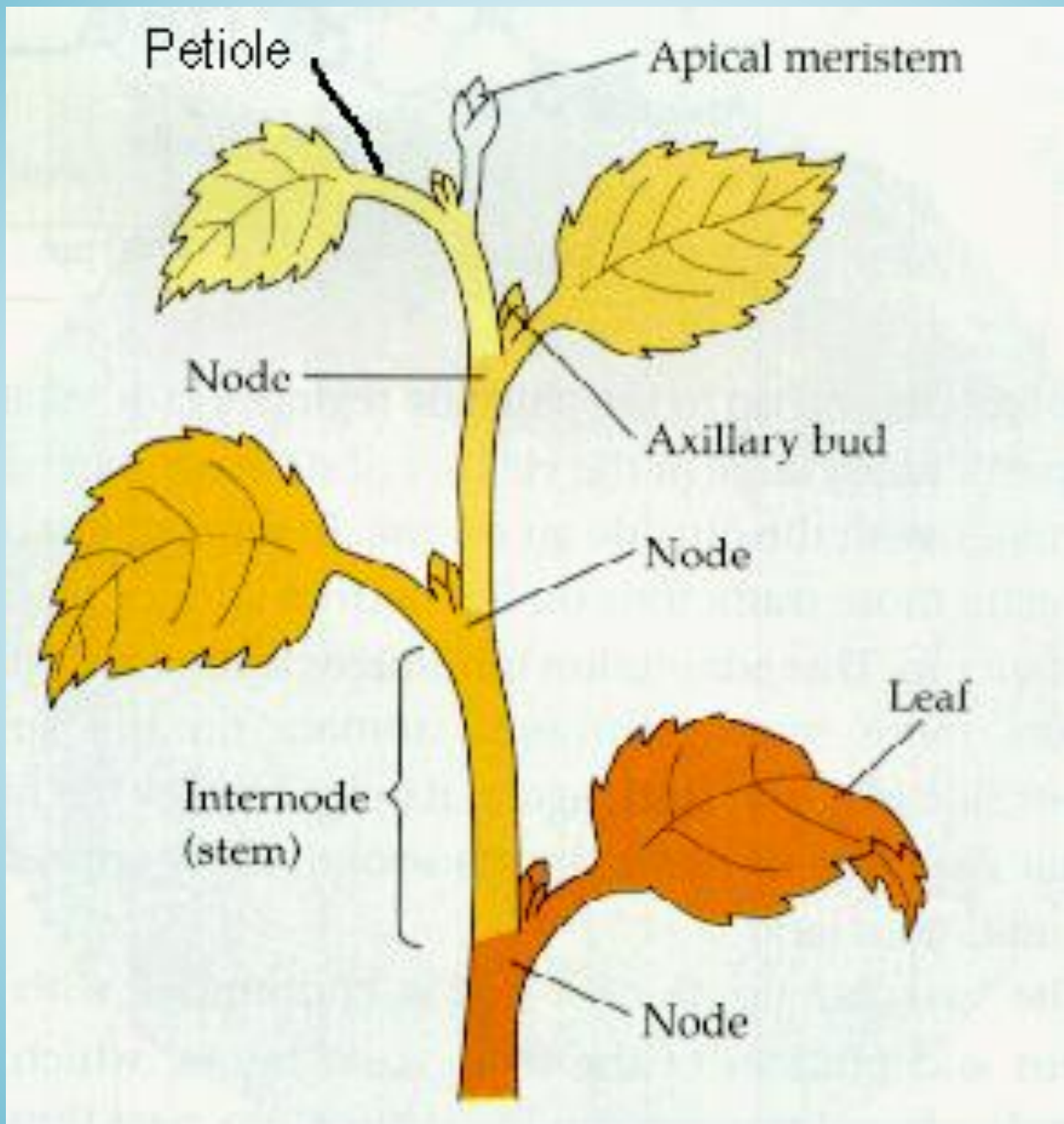
root for vital functions

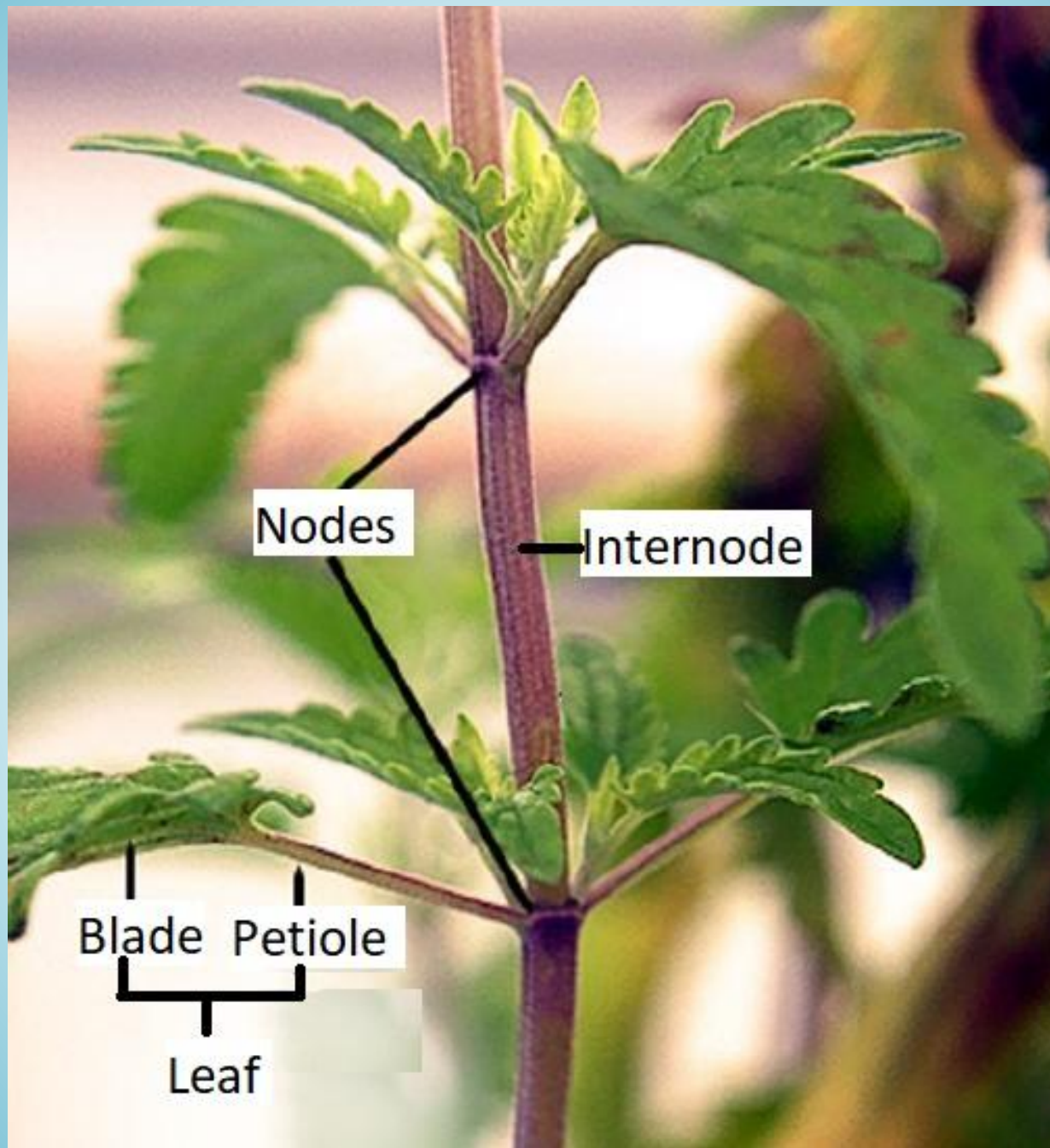
Assimilatory roots

- ◆ Branches of tinospora climbing on neighbouring trees produce long, slender, hanging roots which develop chlorophyll and turn green in colour. These green roots are assimilatory roots.
- ◆ Eg. Chest nut



2. Morphology of Stems and its modifications





Nodes

Internode

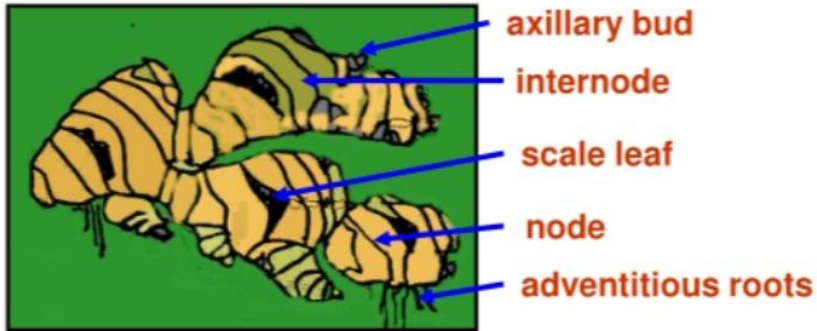
Blade Petiole

Leaf

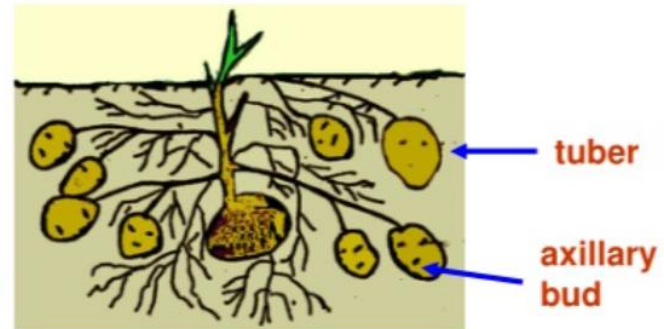


STEM MODIFICATIONS

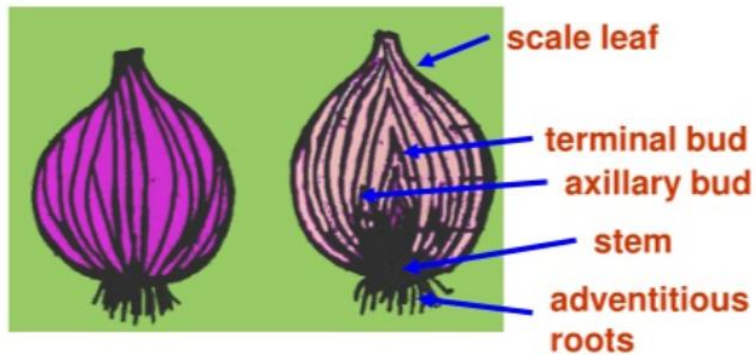
RHIZOME



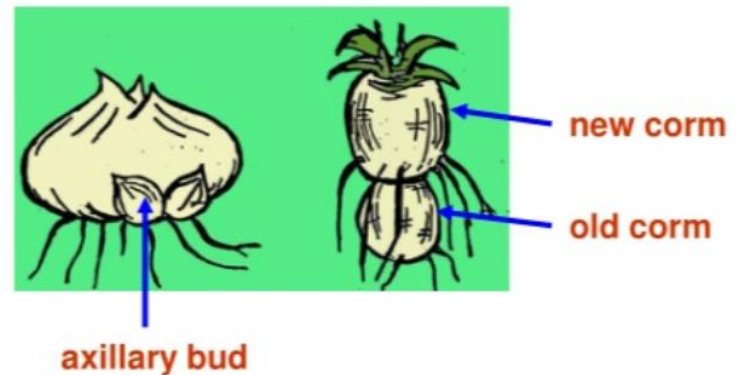
TUBER

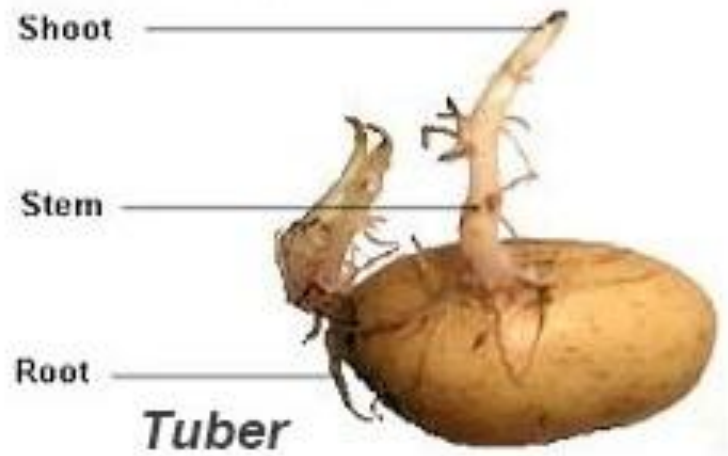
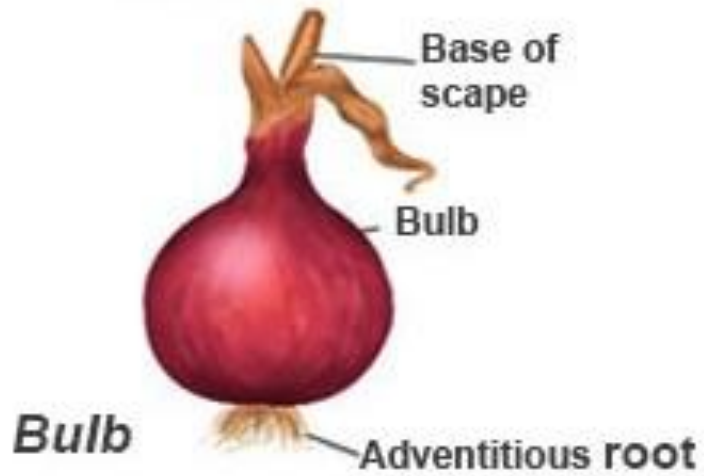
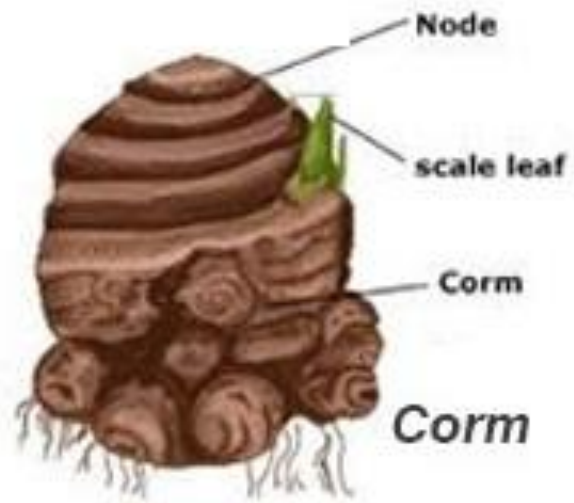
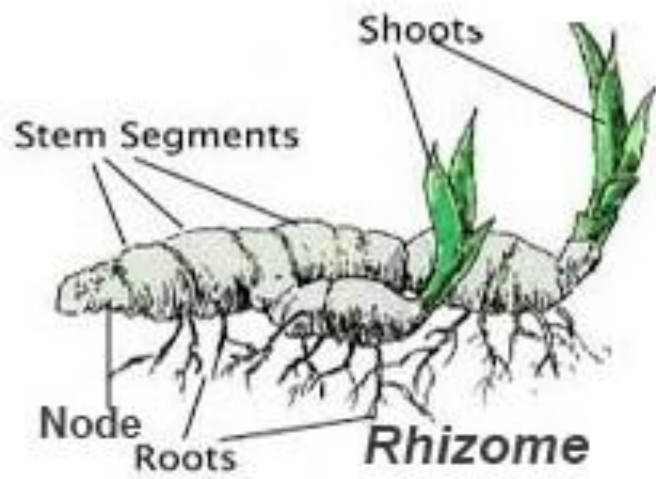


BULB



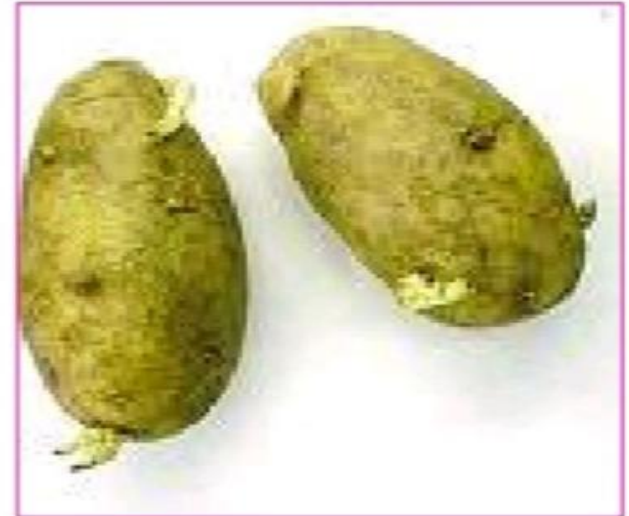
CORM







Ginger - rhizome



Potato- tuber



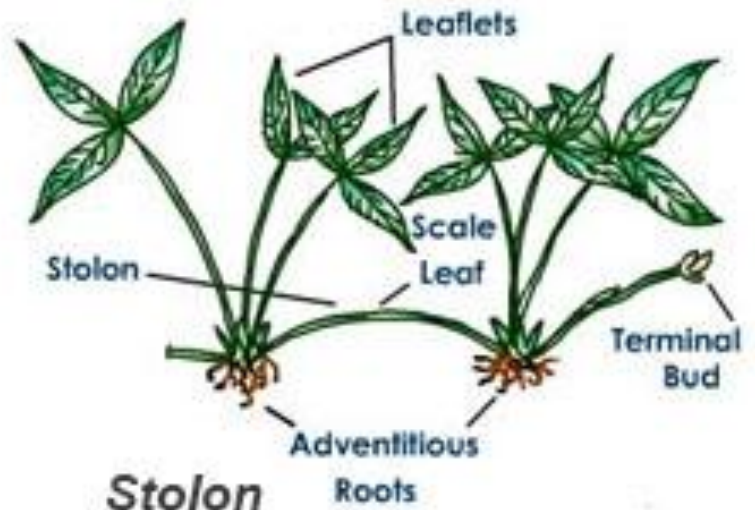
Gladiolus - corm



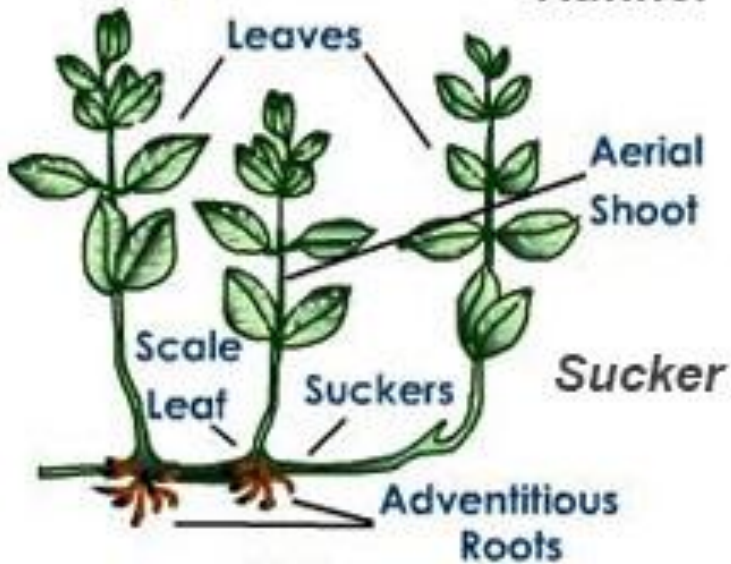
Onion - bulb



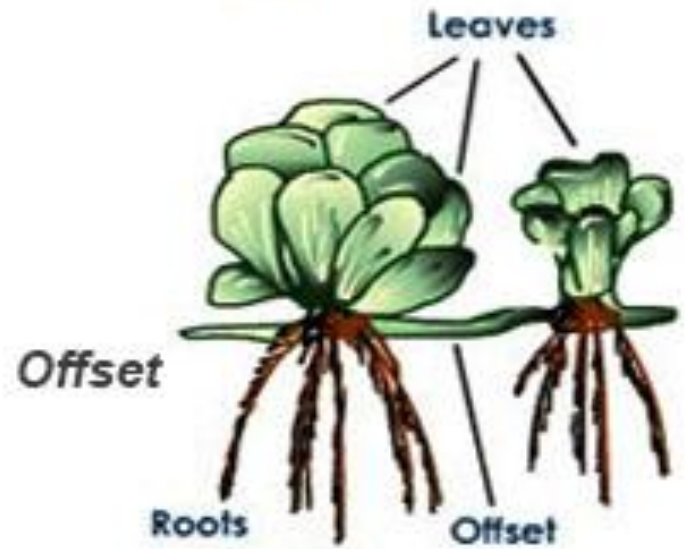
Runner



Stolon



Sucker



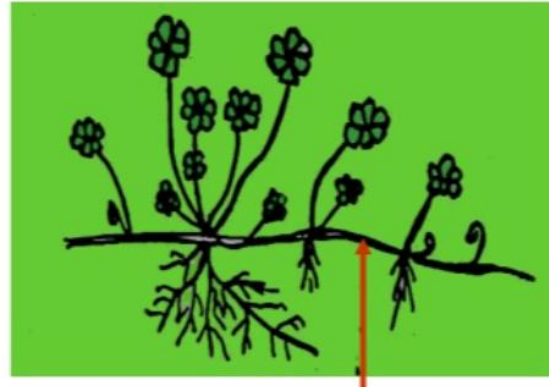
Offset

STOLON



stolon

RUNNER



runner

SUCKER



sucker

new rhizome

old rhizome

SUCKER



sucker



Stolons



Banana - suckers



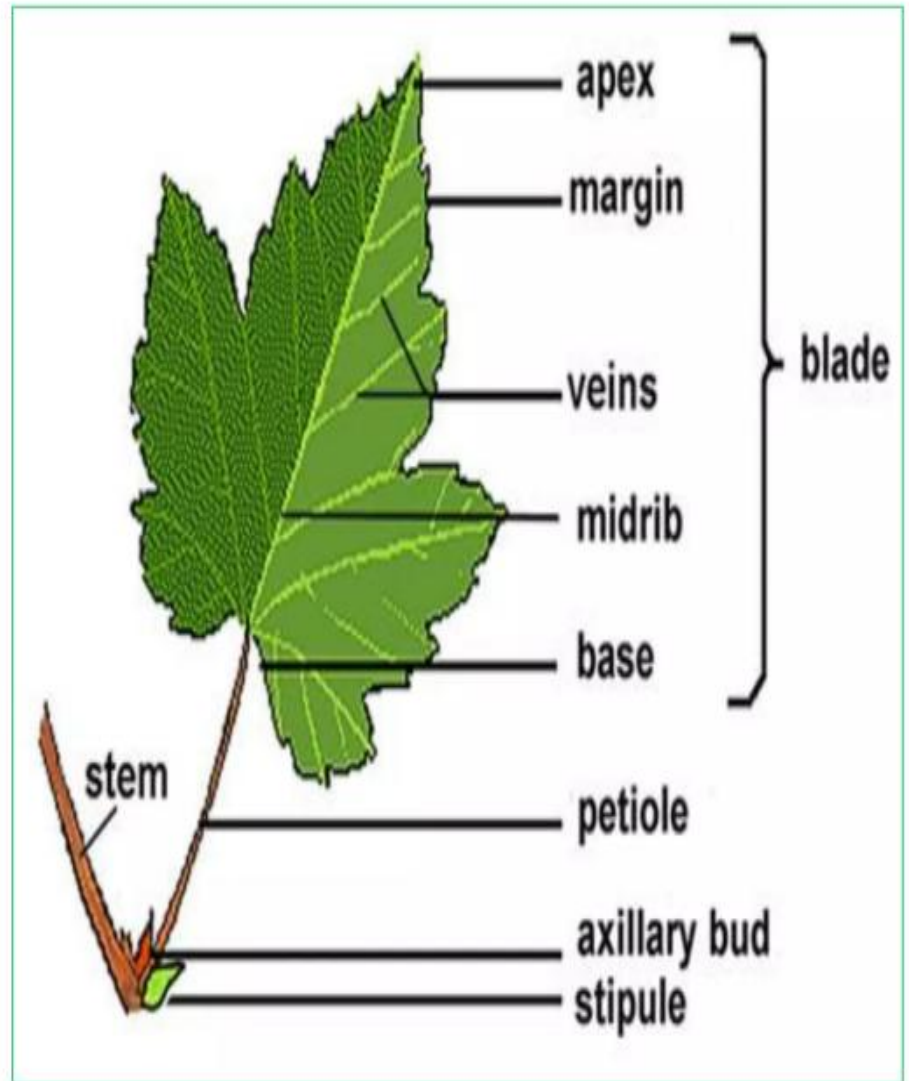
Runners

3. Morphology of Leaves and its modifications

SIMPLE LEAF

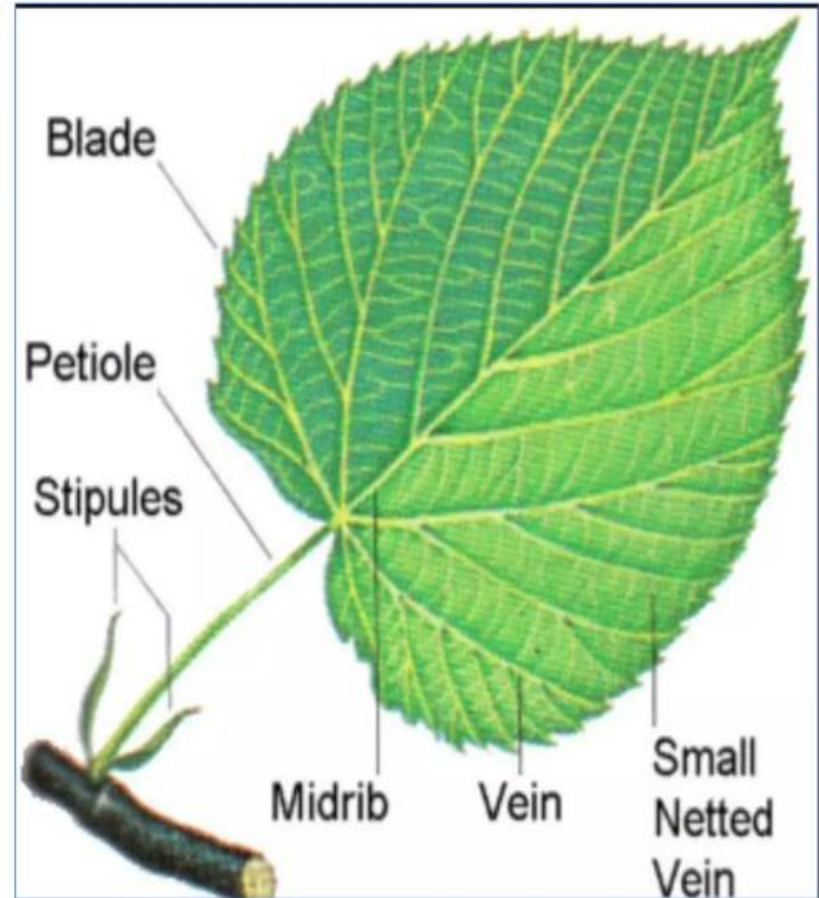
The Leaf (Latin: Folium) a thin leaf or plate.

- a lateral outgrowth or an appendage on the stem.
- possesses neither nodes nor internodes and buds or lateral branches arise in its axil.



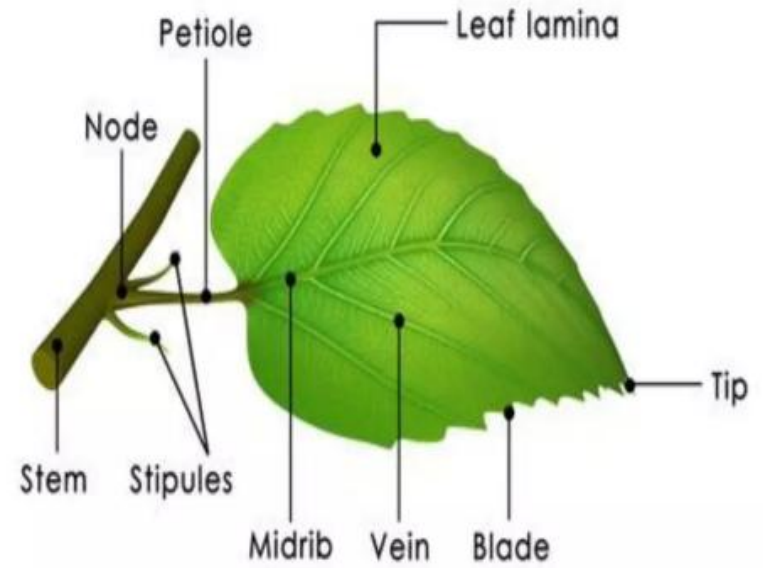
CHARACTERS OF LEAF

- - **flattened form**
- - **thin texture**
- - **presence of chlorophyll**
- - **presence of veins**



LEAF MORPHOLOGY

- Leaf lamina
- Stipule
- Petiole
- Node
- Internode
- Axillary bud
- Stem Axil

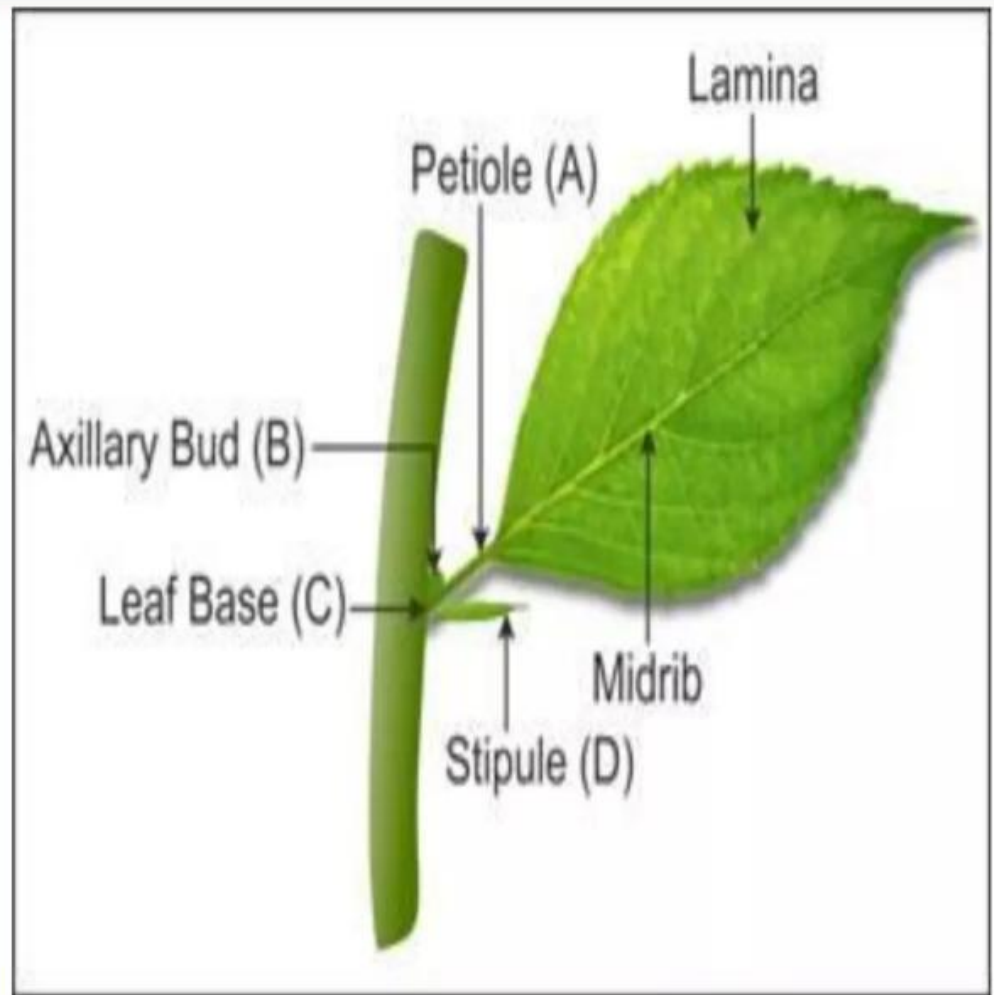


Leaves have two main parts: The leaf blade and the Stalk or the petiole.

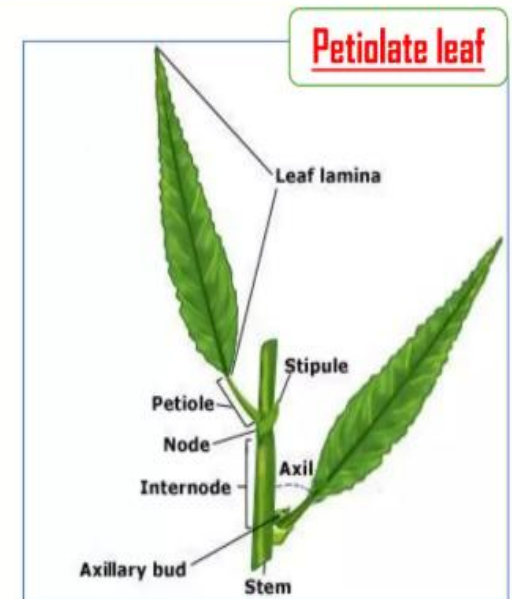
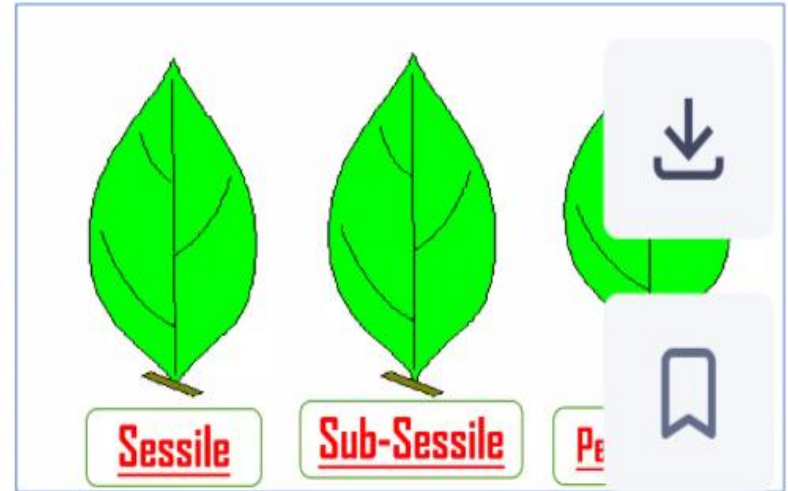
The leaf blade: It is also called the lamina. It's generally broad and flat.

The petiole: It is the stalk-like structure which connects the leaf blade to the stem. The petiole has tiny tubes, that connect the veins on the leaf blade to the stem.

Petiolate: The leaf blade is situated on the petiole, e.g., Hibiscus, Ficus



- **Sessile:** Without a petiole or stalk, e.g., Ixora.
- **Sub-Sessile:** Having a short stalk, e.g., Polygonum.
- **Stipules:** either of a pair of small, usually leaflike appendages borne at the base of the petiole in many plants.
- **Stipulate:** The leaf with stipules, e.g., rose, Ixora,
- **Exstipulate:**
- The leaves having no stipules, e.g., Ipomoea.



LEAF BASE OF SESSILE LEAVES

- **Connate**: Two sessile opposite leaves meeting each other across the stem and fusing together, e.g., *Lonicera flava*.
- **Auriculate**: Leaf with expanded bases surrounding stem, e.g., *Calotropis*.
- **Perfoliate**: A leaf with basal lobes so united as to appear as if stem ran through it, e.g., *Aloe perfoliata*.

SESSILE LEAVES (without petiole)



Connate



Perfoliate



Auriculate



Types of Leaves

Simple

Single undivided leaf



Compound

Leaf divided into multiple leaflets attached at the stem

Pinnately Compound

Feather-like arrangement of leaflets from midvein



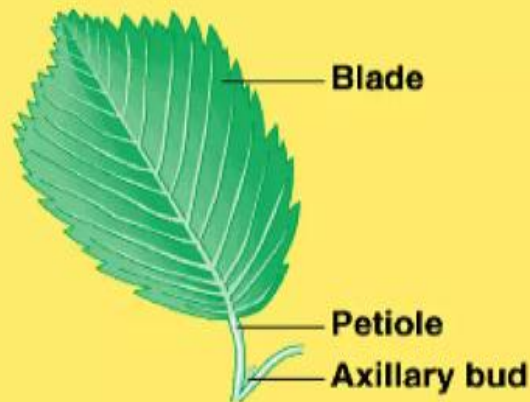
Palmately Compound

Leaflets radiating from a single point

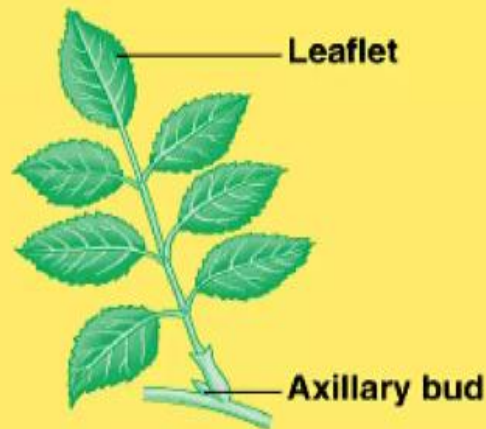


KINDS OF LEAVES

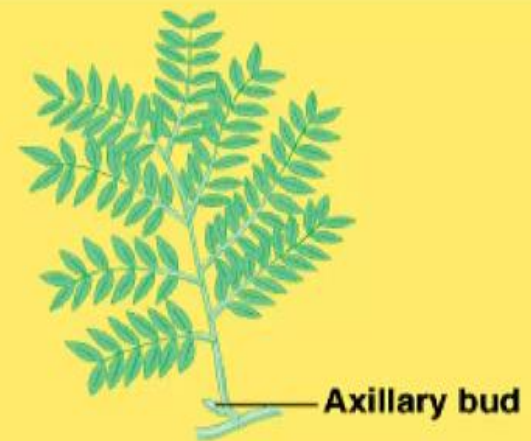
- Two major kinds of leaves are seen. They are **simple leaves and compound leaves**. A **simple leaf has a single blade on its stalk and the stalk is attached to the plant body**. A **compound leaf is a leaf stalk that has more than one leaf blade on it, and the multiple leaf blades are called leaflets**



Simple leaf

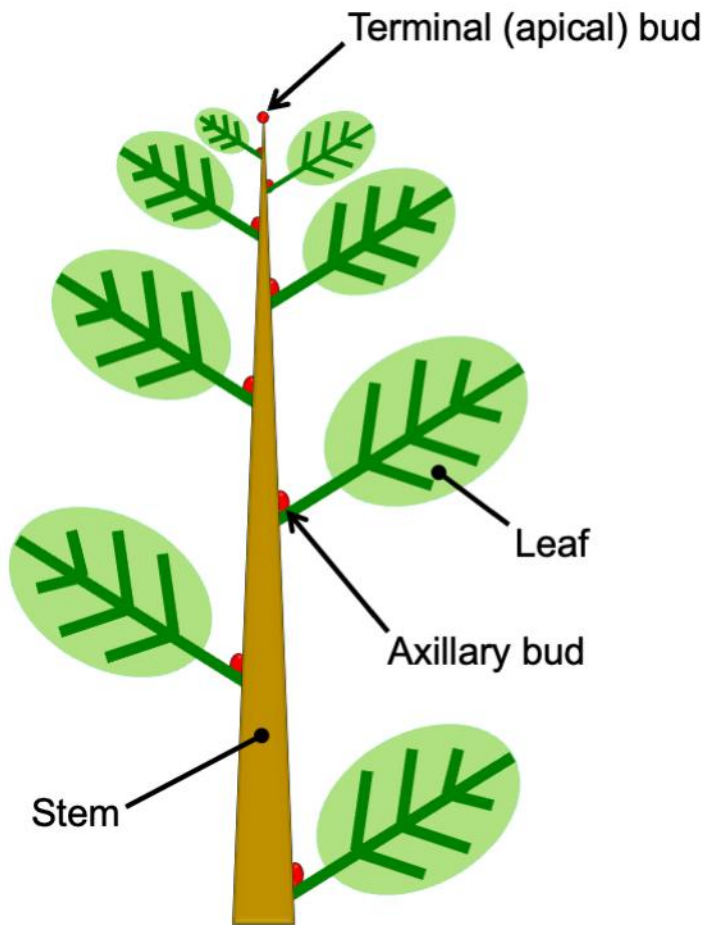


Compound leaf

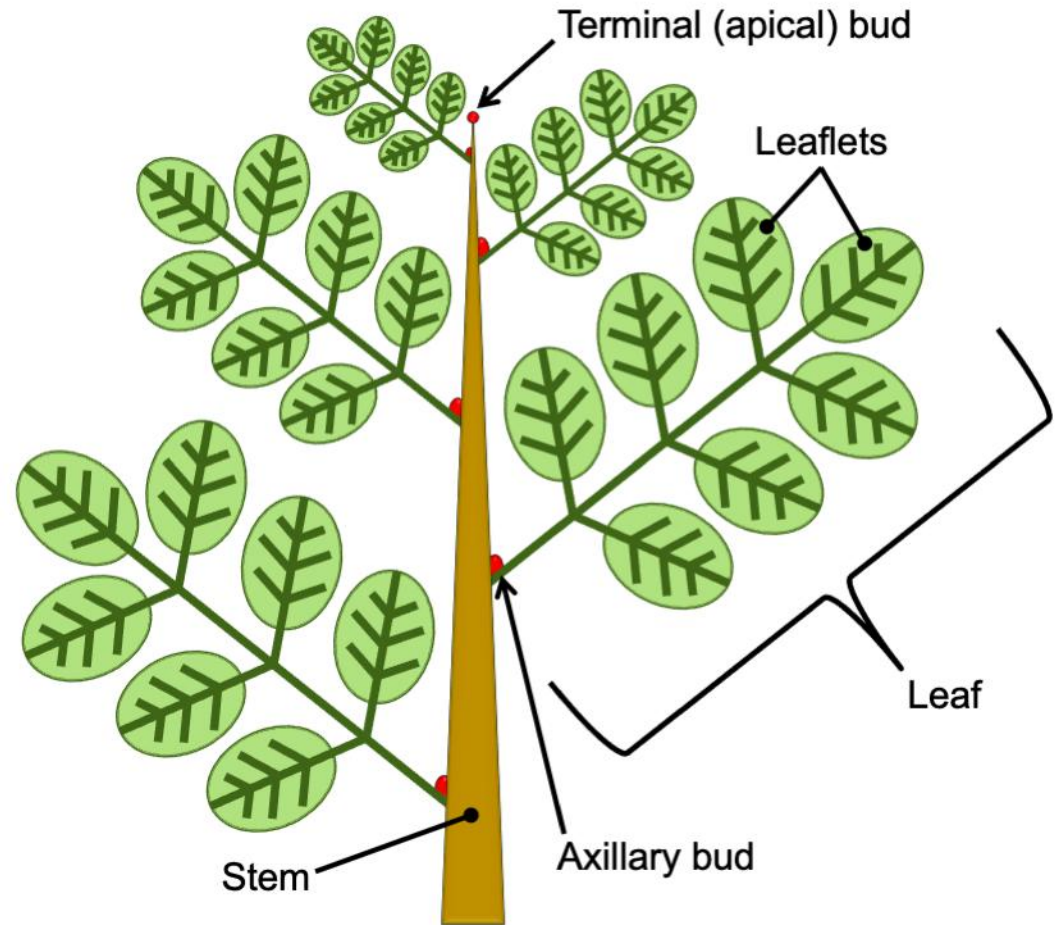


Doubly compound leaf

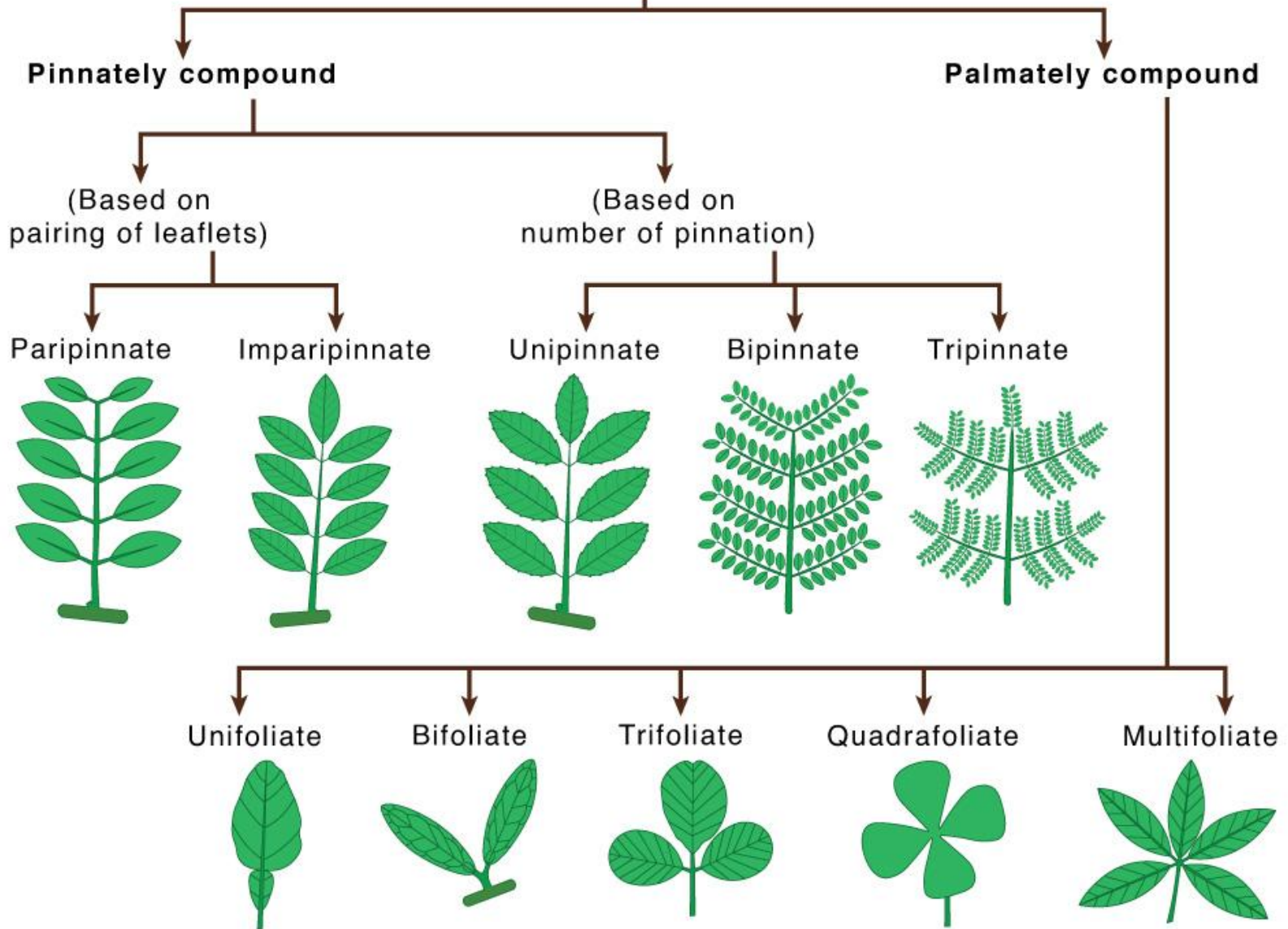
Simple leaves



Compound leaves

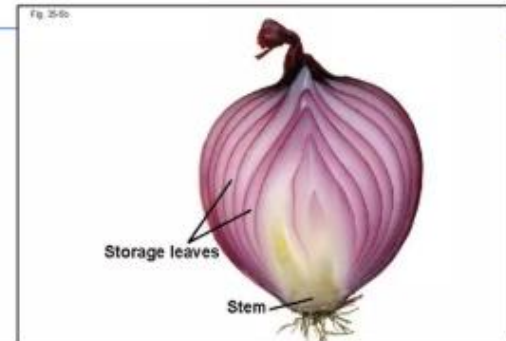
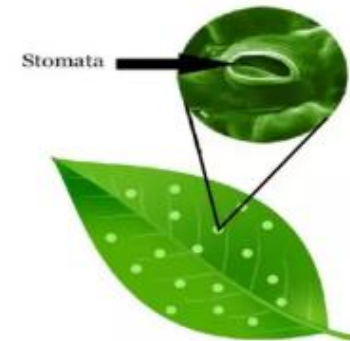


Compound Leaf

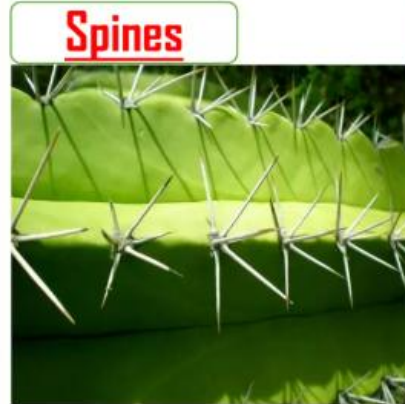


FUNCTIONS OF A LEAF

- **Manufacture of food** - Photosynthesis is the process by which green plants make their food from carbon dioxide and water in the presence of sunlight.
- **Transpiration** - interchange of gases between the atmosphere and the plant body and evaporation of water.
- **Guttation** - is the exudation of drops of xylem sap on the tips or edges of leaves of some vascular plants,
- **Storage**
- **Défense**



- **Tendrils**: The leaves of a pea plant are modified into tendrils that help the plant in climbing.
- **Spines**: The leaves in cactus are modified into sharp spines that act as an organ of defense
- **Phyllode**: The leaves of some Australian acacia are short-lived and soon replaced by flattened, green structures called as phyllodes that arise from the petiole of the leaves.
- **Pitcher**: The leaves of the pitcher plant are modified into pitcher-like structures, which contain digestive juices and help in trapping and digesting insects. In insectivorous plants, the leaves are especially adapted to catch and digest insects to fulfil their nitrogen requirement.



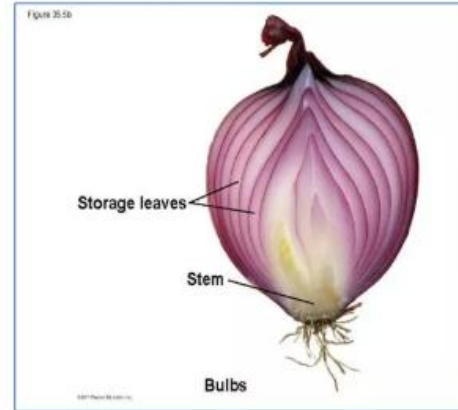
Spines

Tendrils

Pitcher

Phyllode

- **Storage Leaves:** Some plants of xerophytic habitats and members of the family Crassulaceae generally have highly thickened and succulent leaves with water storage tissue. These leaves have large parenchymatous cells with big central vacuole filled with hydrophilic colloid.
- **Scale-leaves:** Typically these are thin, dry, stalkless, membranous structures, usually brownish in colour or sometimes colourless. Their function is to protect the axillary bud that they bear in their axil. Sometimes scale-leaves are thick and fleshy, as in/onion; then their function is to store up water and food.



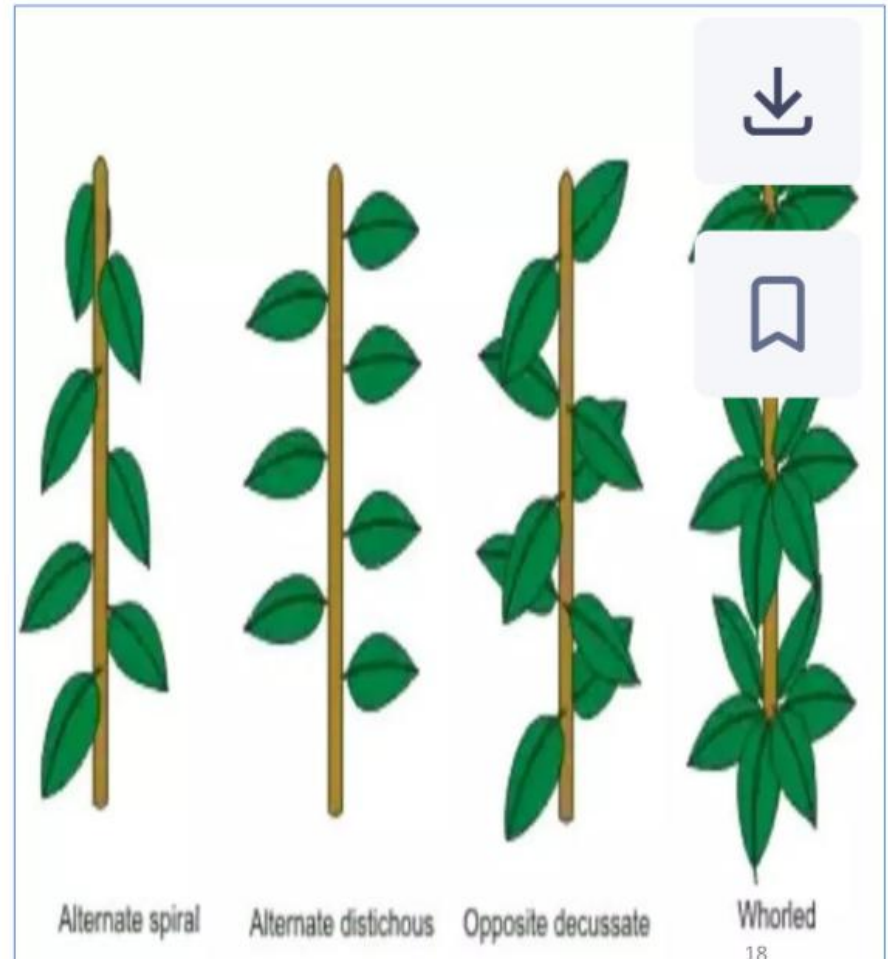
Storage leaves



Scale leaves

PHYLLOTAXIS

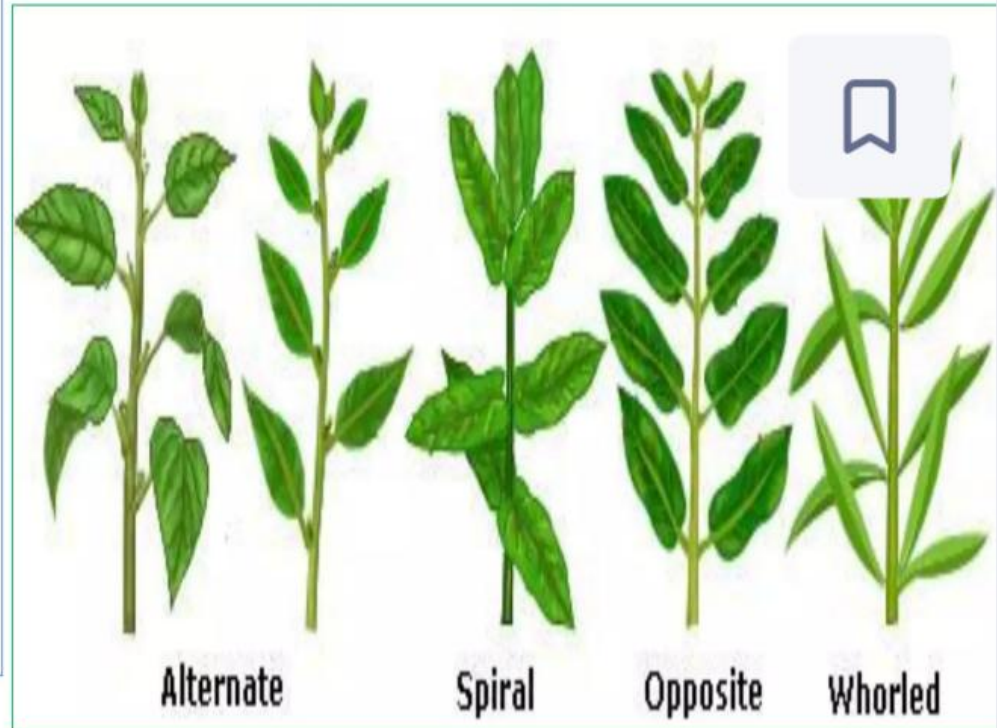
- ✓ It is the disposition of the leaves on the stem.
- ✓ The leaves being arranged on the stem in a definite manner characteristic for each species of plants.



PHYLLOTAXIS

- **Alternate**: A single leaf arises at each node in an alternate manner. Examples: China rose, Sun flower.
- **Spiral**: leaves are arranged in a spiral along the stem.
- **Opposite**: A pair of leaves arise at each node and lie opposite to each other. Examples: Calotropis, Guava.
- **Whorled**: More than two leaves arranged in a circle round an axis, e.g., Sparganium, Alstonia.

• Phyllotaxis, the regular arrangement of leaves or flowers around a plant stem



COMPOUND LEAF

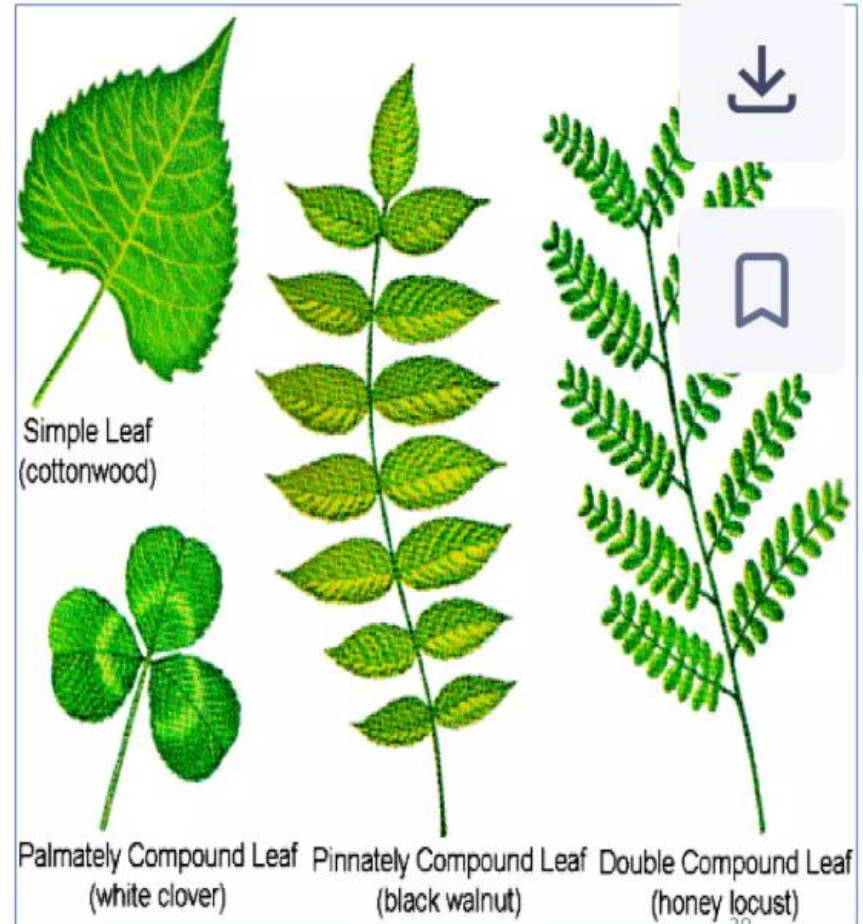
Forms of Compound leaves

✓ There are three types of compound leaves:

✓ **Palmately compound leaf**

✓ **Pinnately**, 2-pinnate, 3-pinnate, bipinnate, tripinnate, odd-pinnate, and even-pinnate

✓ **Double pinnately compound leaf**



A. PALMATELY COMPOUND LEAF

- (i) Unifoliate:** Having one leaflet only, e.g., Citrus.
- (ii) Bifoliate:** Palmate compound leaf with two leaflets, e.g., Prinsepia, Balanites.
- (iii) Trifoliate:** Such palmate compound leaf having three leaflets growing from same point, e.g., Oxalis, Vigna, Trifolium, Melilotus, etc.
- (iv) Quadrifoliate:** Compound palmate leaf with four leaflets arising at a common point, e.g., Marsilea (a pteridophyte).
- (v) Multifoliate:** Compound palmate leaf with five or more leaflets arising at a common point, e.g., Gynandropsis pentaphylla, Bombax ceiba.

11/19/2021

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Palmately Compound Leaves



Unifoliate



Bifoliate



Trifoliate



Quadrifoliate

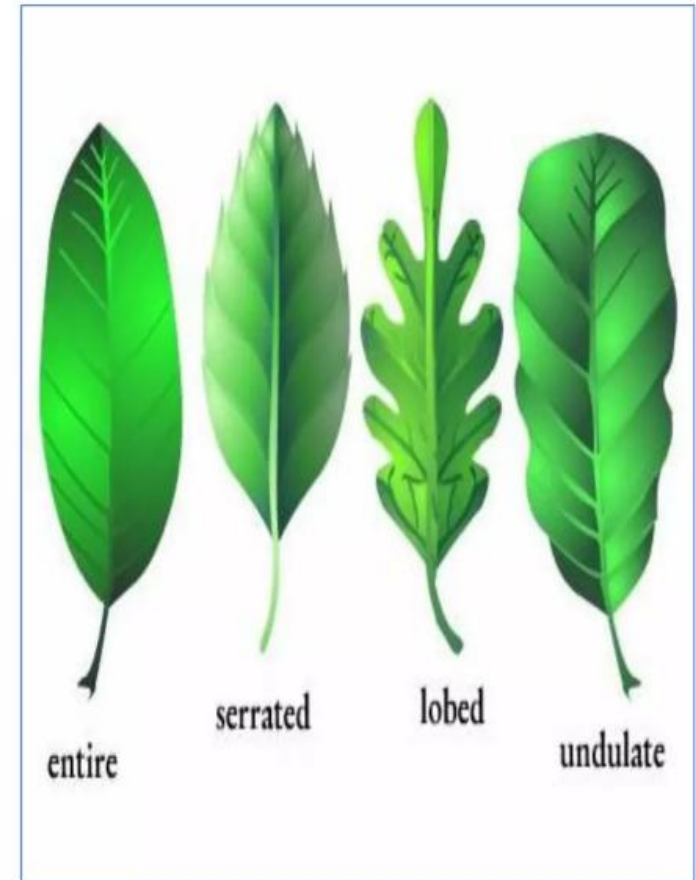


Multifoliate

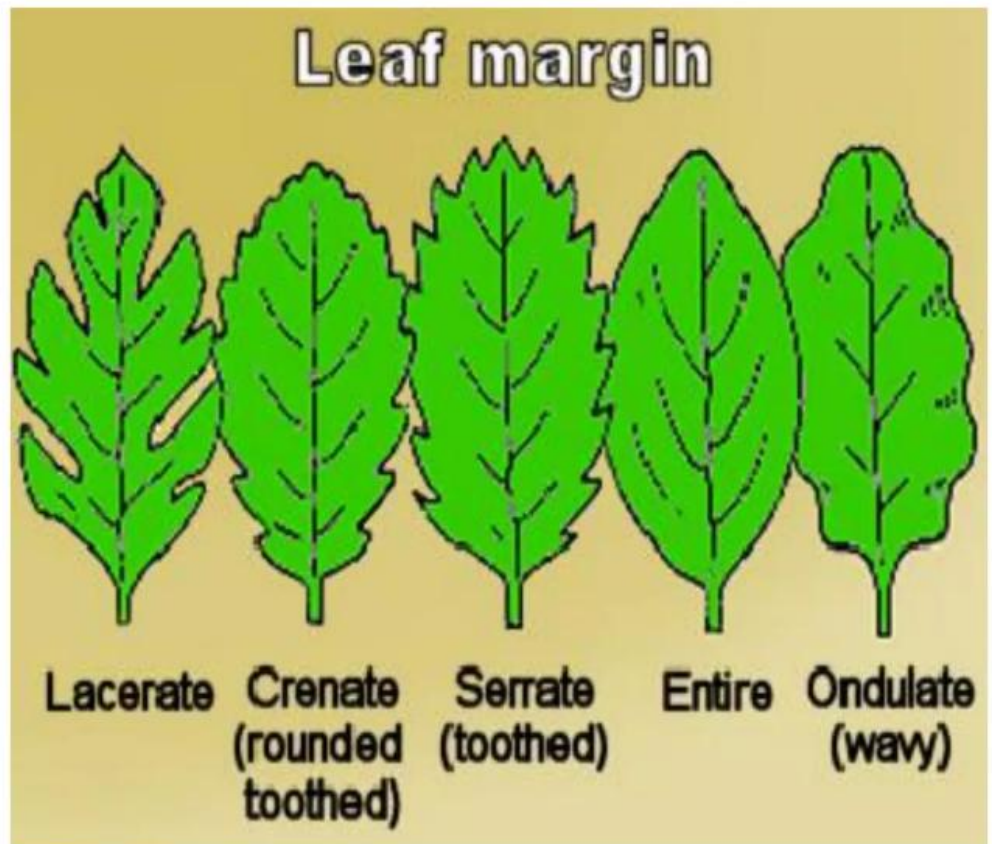


MARGIN OF LAMINA

- **Entire:** With continuous margin, e.g., Psidium, mango, madar
- **Serrate:** With serrate edges themselves toothed, e.g., China rose, nim
- **Lobed:** Leaf margin divided into many lobes, e.g., Ranunculus
- **Undulate:** The margin is wavy, e.g., Polyalthia
- **Dentate:** With large saw like teeth on the margin, e.g., Nympluiea, watermelon



- **Lacerate**: Having margin or apex deeply cut into irregular lobes, e.g., many members of Ranunculaceae.
- **Crenate**: With obtusely toothed margin, e.g., Bryophyllum, Centella
- **Convolute**: Rolled together
- **Laciniate**: Irregularly incise, fringed.



- **Laciniolate**: Minutely incised or fringed.
- **Ciliate**: Bearing fine hairs on the margin, e.g., *Cleome viscosa*.
- **Crispate**: Curled or extremely undulate margin.
- **Spinous**: Bearing many spines, e.g., *Argemone*.
- **Pectinate**: Comb like margin.

MARGIN



Ciliate
with fine hairs



Crenate
with rounded teeth



Der
with symm



Denticulate
with fine dentition



Doubly Serrate
serrate with sub-teeth



Entire
even, smooth throughout



Lobate
indented, but not to midline



Serrate
teeth forward-pointing



Serrulate
with fine serration



Sinuate
with wave-like indentations



Spiny
with sharp stiff points



Undulate
widely wavy



APEX OF THE LEAF TYPES



Acuminate
long-tapering



Acute
Sharp $> 90^\circ$



subobtuse
partially
obtuse

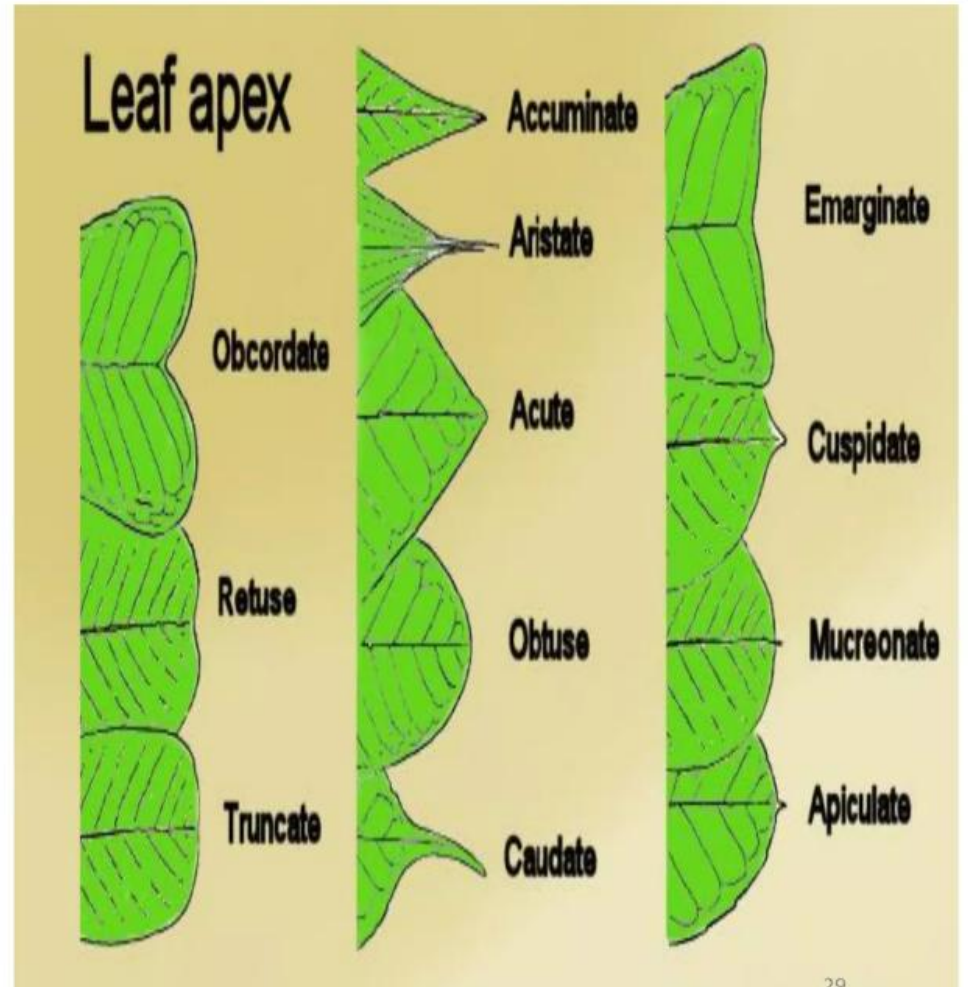


obtuse
Blunt

The outer end or apex of a leaf lamina that is opposite the petiole. Leaves apices vary greatly from plant to plant and are useful in classification and identification.

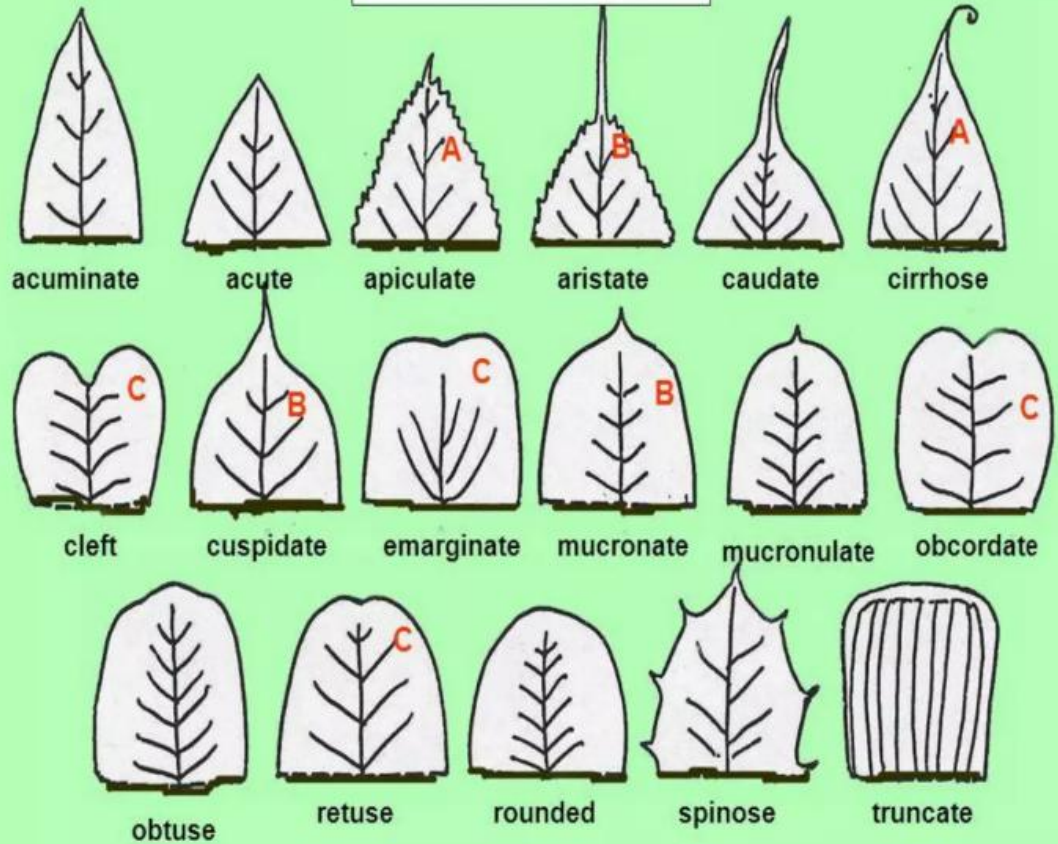
LEAF APEX

- **Acute:** Ending in a sharp point forming an acute angle, e.g., mango.
- **Acuminate:** Drawn out into long point; tapering; pointed, e.g., *Ficus religiosa*.
- **Obtuse:** With blunt or rounded end, e.g., Banyan.
- **Emarginate:** Having a notch at apex, e.g., Bauhinia.
- **Truncate:** Terminating abruptly, as if tapering end were cut off, e.g., *Caryota mens*.
- **Mucronate:** Abruptly terminated by a sharp spine, e.g., apex of leaflet of *Cassia obtusifolia*.



- **Cuspidate:** Terminating in a point.
- **Aristate:** Provided with awns or with a well developed bristle.
- **Retuse:** Obtuse with a broad shallow notch in middle, e.g., Oxalis.
- **Cirrhose:** Leaf with prolongation or mid-rib forming a tendril, e.g., Gloriosa.
- **Apiculate:** Forming abruptly to a small tip, e.g., Dalbergia.

LEAF APICES



A = CURLED, FLEXOUS B = STIFF, STRAIGHT C = NOTCHED 30

LEAF VENATION

System or disposition of veins in the leaves.

They are of several types:

Reticulate: Like net work, e.g., in most of dicots.

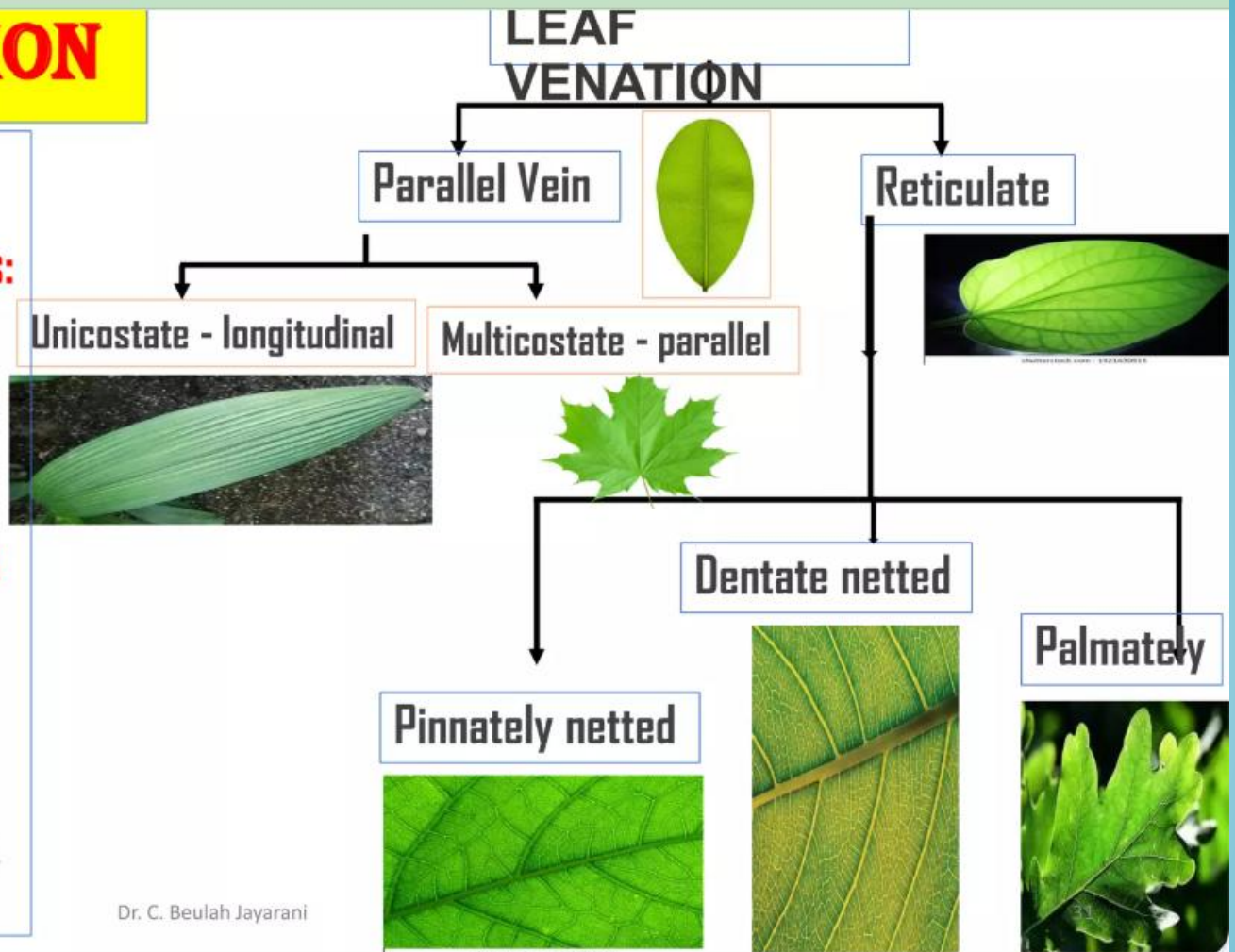
Parallel: Parallel veined, e.g., most of monocots.

(a) Unicostate reticulate:

Having only one principal vein, e.g., mango, banyan, etc.

(b) Multicostate

reticulate: Having many principal veins, e.g., castor, cucumber, etc.



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VENATION



Arcuate
secondary veins
bending toward apex



Cross-Venulate
small veins connecting
secondary veins



Dichotomous
veins branching
symmetrically in



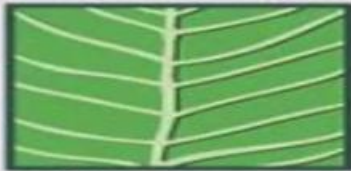
Longitudinal
veins aligned mostly
along long axis of leaf



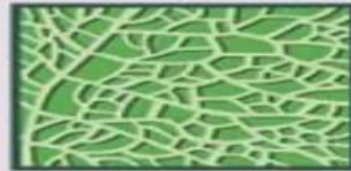
Palmate
several primary veins
diverging from a point



Parallel
veins arranged axially,
not intersecting



Pinnate
secondary veins
paired oppositely



Reticulate
smaller veins
forming a network

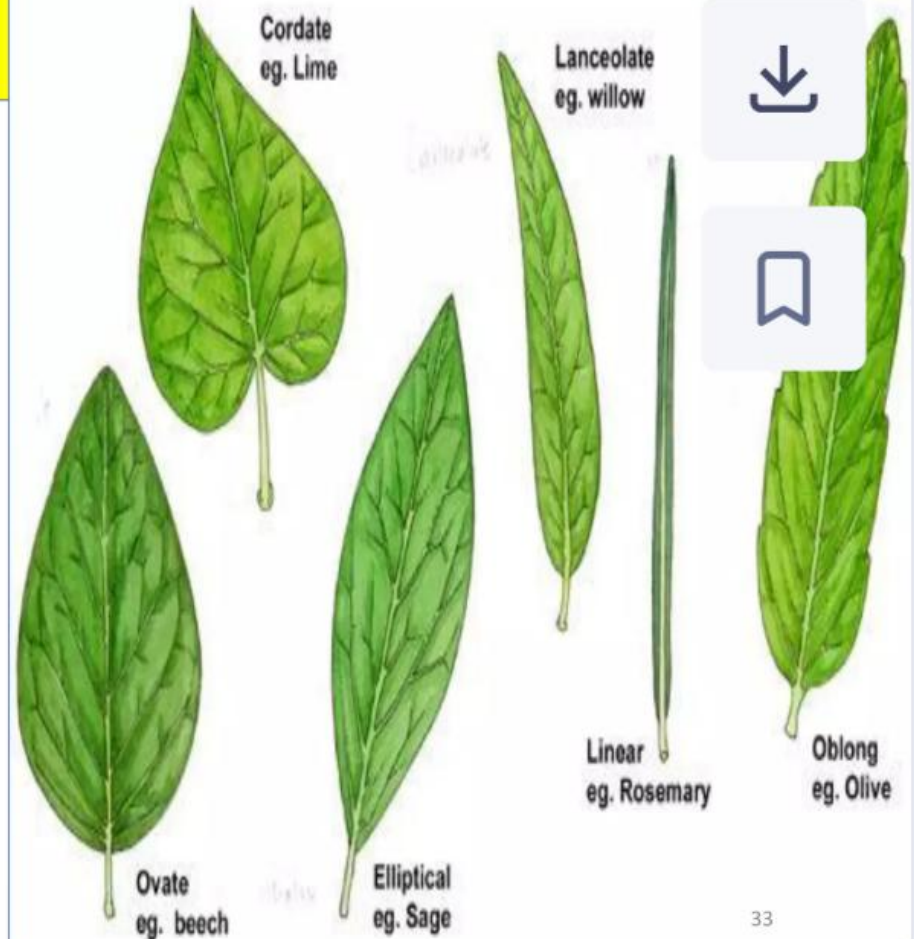


Rotate
in peltate leaves,
veins radiating

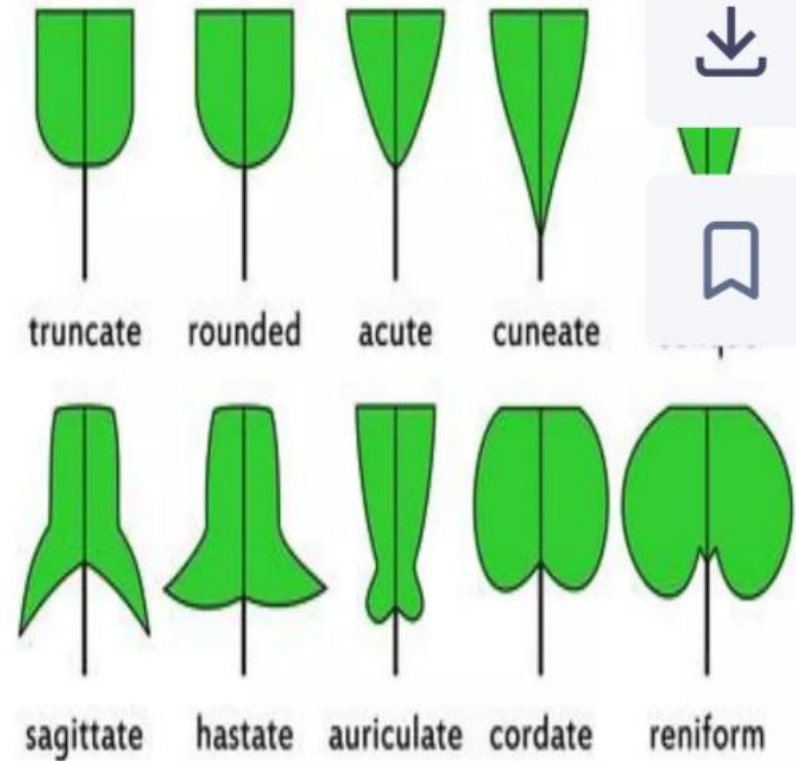


SHAPE OF LEAF LAMINA

- **Linear:** Long and narrow leaf, e.g., many grasses.
- **Lanceolate:** Lance-shaped leaf, e.g., bamboo, Nerium, etc.
- **Round or orbicular:** Leaf with a circular leaf blade, e.g., lotus, garden nasturtium, etc
- **Elliptical:** An ellipse-shaped leaf, e.g., guava, jack, etc.
- **Ovate:** Leaf with an egg-shaped leaf lamina, i.e., slightly broader at the base than at the apex, e.g., banyan, China rose, etc.



- **Spathulate:** Spatula-shaped leaf, i.e., broad and round at the top and narrower towards the base, e.g., *Calendula* and *Drosera*.
- **Oblique:** Leaf with two unequal halves, e.g., *Begonia*.
- **Oblong:** Leaf with wide and long leaf lamina. Here the two margins run more or less straight up, e.g., banana.
- **Reniform:** Kidney-shaped leaf, e.g., Indian pennywort.
- **Cordate:** Leaf with heart shaped leaf lamina, e.g., betel.



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