B.SC. SEMESTER-II

BOTANY PAPER-II

(MORPHOLOGY OF ANGIOSPERM AND FLORICULTURE

UNIT-1: (Vegetative Morphology)

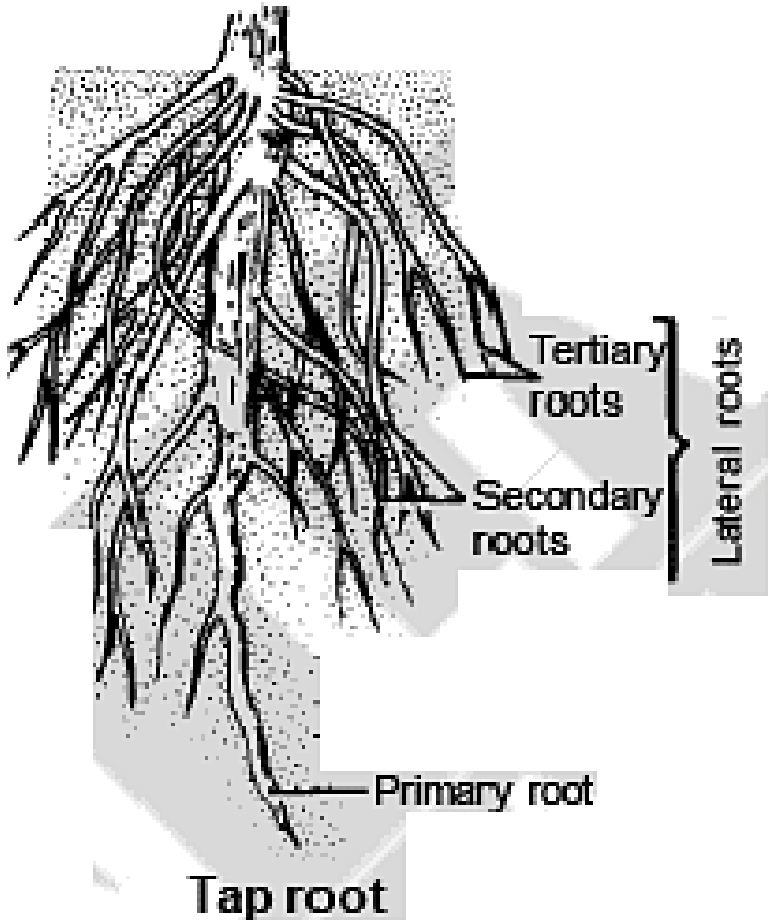
1. Root: Tap root and adventitious root, modification of root for storage and respiration

2. Stem: Shape, surface, and nature. Branching (Monopodial and Sympodial), Modification of stem (Runner, Rhizome,Tuber, bulb)

3. Leaf: Typical leaf, Types (Simple and Compound), Types of phyllotaxy, Venation, Modification of leaf (Tendril, Phyllode)

1. Root:

- Tap root and adventitious root, modification of root for storage and respiration
- The root is an underground part of the plant that absorbs water and minerals from the soil and anchors the plant firmly.
- In some plants, the roots change their shape and get modified to absorb and transport water and minerals from the soil to different parts of the plant.
- They are also modified for support, food storage, and respiration.
- The root modifications perform two major functions- Physiological and Mechanical.



Modifications of Tap Roots

For Food Storage

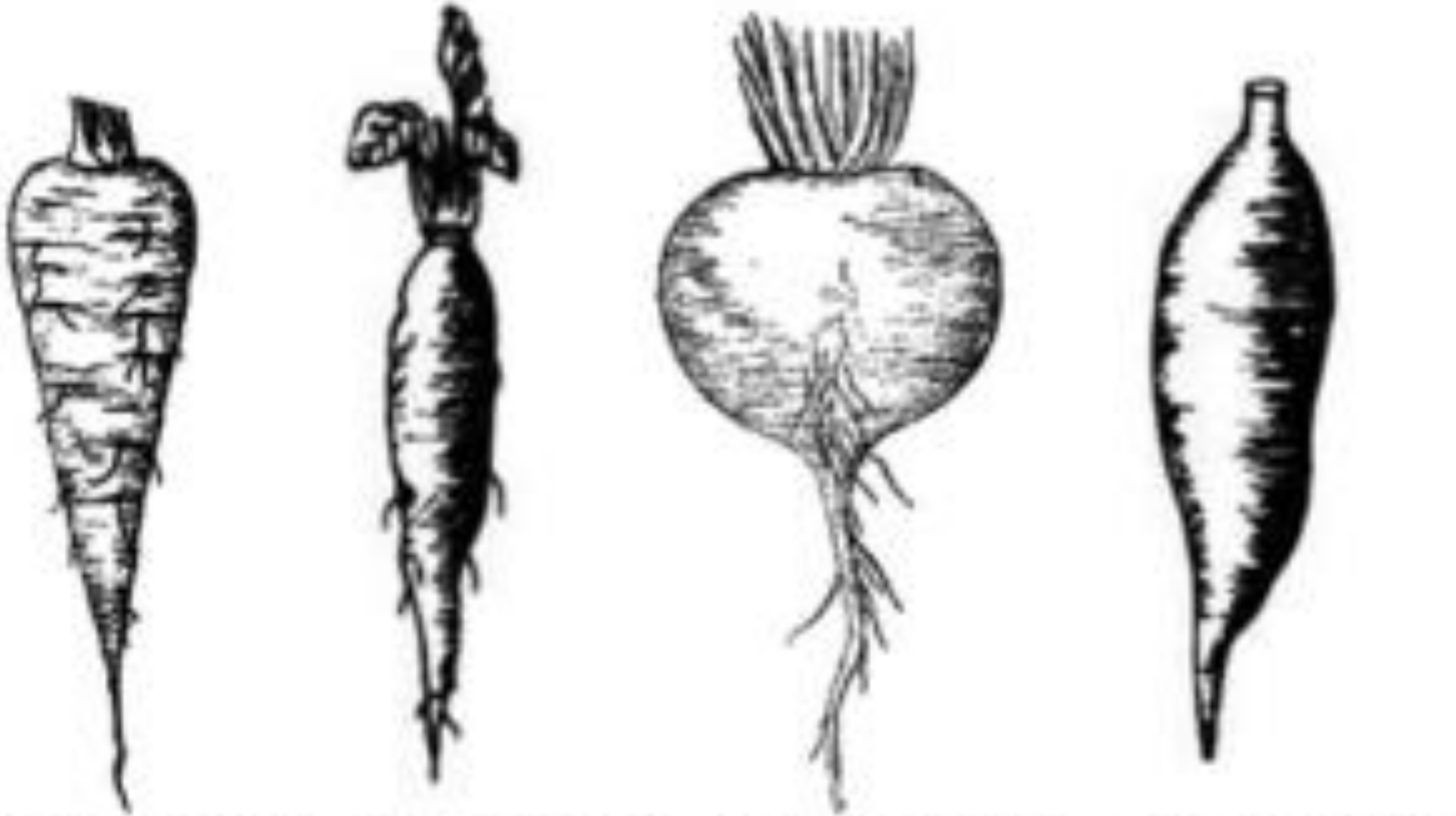
- In some plants, the roots become fleshy due to the absorption of food material.
- The aerial parts of these plants are worn out due to unfavourable conditions.
- When the conditions are favourable again new buds emerge either from the fleshy root or from a small bit of stem above.
- For eg., the taproots of carrot and turnip get swollen to store food.
- Depending upon their shapes, they are classified as;

a) Conical roots are broad at the base and conical at the apex, eg., carrot

b) Fusiform roots are swollen in the middle and tapering towards both the ends, eg., radish

c) Napiform roots are spherical at the base and taper towards the apex, eg., turnip

d) Tuberous roots have no specific shape. They appear thick and fleshy, eg., sweet potato


Conical root
Fusiform root
Napiform root
Tuberous root

For better Respiration

Pneumatophore

In some halophytes such as *Rhizophora* that grow in swampy areas, the roots emerge out of the ground and grow upwards to get oxygen for respiration. The root tips of these plants have minute pores called lenticels through which they respire.

Nodulated Roots

Roots of the leguminous plants are modified into root nodules which contain nitrogen-fixing bacteria such as *Rhizobium* They help in fixing the atmospheric nitrogen into nitrates and make it available to the plant.

Modification of Adventitious Roots

For Food Storage

Adventitious roots are modified into:

- **Simple Tuberous Roots** are swollen and do not assume any shape. For eg., sweet potato
- **Nodulose Roots** are single beads. They become swollen at the apex and have a definite shape, eg., ginger
- **Fasciculated Tuberous Roots** is the cluster of adventitious roots for food storage. They have a definite shape, eg., Dahlia
- **Moniliform Roots** are swollen and constricted, eg., grasses
- **Annulated Roots** has an appearance of discs placed one over the other, eg., Acacia nilotica.

For Support

•**Prop Roots**: These roots develop from the branches of the tree, hang downwards, and penetrate into the ground thereby supporting the tree. Eg., roots of the banyan tree.

•**Stilt Roots:** These roots grow obliquely from the basal node of the stem. Eg., roots of the sugarcane.

•**Climbing Roots:** These roots arise from the nodes and attach themselves to some support to climb over it. Thus, they provide support to the plant. Eg., Money plant

•**Clinging Roots:** These roots enter the crevices of some support and fix the plant. Eg., epiphytes orchids

•**Buttress Roots:** These are vertically elongated basal part of the stem which spread in different directions in the soil. These are horizontally compressed and appear like planks. Eg., *Bombax*.

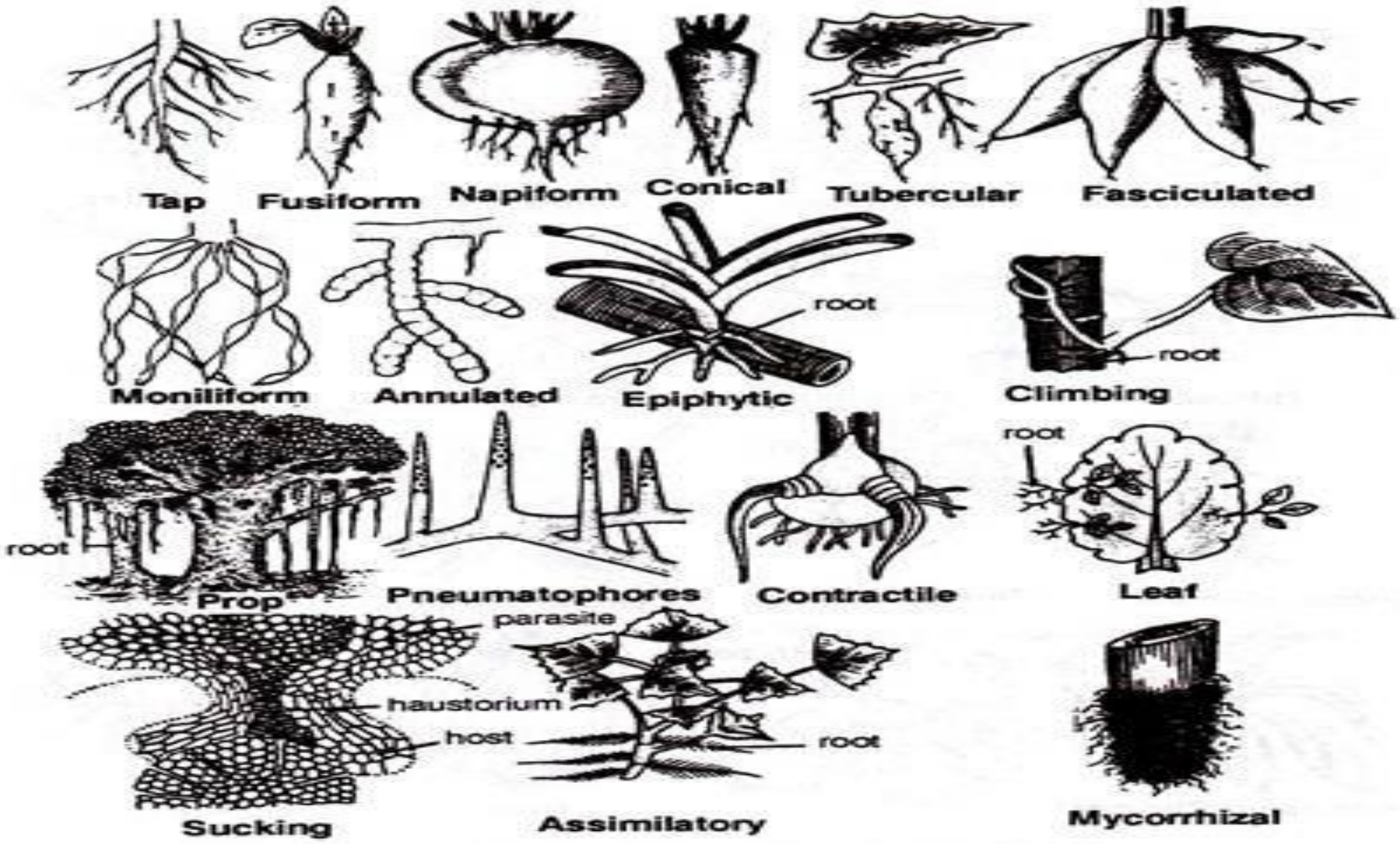


Fig. 64. Kinds of root.

For Special Functions

Epiphytic Roots:

- These roots are aerial, hanging and spongy.
- They have a porous wall and absorb moisture from the atmosphere.
- These aerial roots possess a special sponge-like tissue known as velamen.
- Velamen absorbs and stores moisture from the air since these plants do not have direct contact with the soil.

Sucking Roots:

- These are microscopic, developed by the roots to absorb nutrients from the host.
- These are also known as parasitic roots or haustoria because these are found in non-green parasitic plants.
- These roots arise from the nodes and penetrate into the host tissue.
- They then enter into the conducting tissue from where they obtain the required food material.

Floating Roots:

- These arise from the nodes of the aquatic plants and help in floating and respiration. Eg., Jussiaea.
- These roots are very spongy in nature and look like a mass of white cotton.
- The plant floats due to its buoyancy.
- They dry when taken out of the water.

Assimilatory Roots:

•These are also known as photosynthetic roots.
•These, when exposed to the sun, develop chlorophyll and manufacture food. Eg., In Tinospora, the roots hang as green threads from the nodes during the rainy season.
•They assimilate carbon dioxide in the presence of sunlight.

Mycorrhizal Roots:

The symbiotic association of a fungus with higher plants is called mycorrhizal root.
The fungus absorbs nutrients from the soil for the plant, and the plant, in turn, provides organic food to it. Eg., *Pinus*

Reproductive Roots:

In some plants such as sweet potato, the adventitious roots give rise to buds which develop into leafy shoots. Root cuttings are the main mode of reproduction.
Thus we see how roots modify themselves according to the functions they perform.

STEM MORPHOLOGY

Definition:

Stem is the ascending axis of a plant which develops from the plumule and epicotyl of the embryo.

Characteristics of Stem

- The stem is the ascending portion of the axis of the plant.
- It develops directly from the plumule and bears a terminal bud for the growth in length.
- It is generally errect and grows away from the soil, i.e towards light hence it is negatively geotropic and positively phototropic in nature. It has leaves, branches, flowers and fruits.
- It bears distinct nodes and internodes.
- The branches and leaves develop exogenously on stem. When youn stem is green in colour. Leaves and branches normally develop from the nodes.
- Stem bear multicellular hairs on its external surface.
- The stem when ends in a floral bud the growth stops The stem bears different kinds of buds like terminal (apical) bud, axillary buds, adventitious bu floral buds etc

1. Diversity in Habit of the Plant:

The plants can be classified into different categories according to their height or according to th life cycle.

1. According to the height:

They may be:

(1) Herbs (small plants with soft stem) E.g., Cassia occidentales (tarota)

(ii) Shrubs (medium sized plant with hard and woody stem) E. g., Calotropis procera (rui)

(iii) Trees (Tall Plants with hard and woody stem and branches) E.g., Mangifera indica (mango)

2. According to the life cycle:

They may be:

(i) Annuals (Plants which complete their whole life in one year or less) E.g., Parthenium histerofo (congress grass)

(ii) Biennials (Plants completing life cycle in only two years) E.g., Raphanus sativa (radish)

(iii) Perinial (Plants serviving for many years). They are polycarpic (i.e. they produce flower and again and again) E.g., Azadirachta indica (neem)

Shape of stem:

External shape:

The external shape of stem is cylindrical, angular flattened or reduced

Angular: Stem showing many lateral angles in a transverse section, e.g. *Asparagous*, *Coriandrum*

Cylindrical: Stem showing circular outline in transverse section, e g. *Citrus*

Decumbent: Stem bending in one direction, eg, *Tridax*

Surface of stem:

Stem surface is hairy, glabrous, waxy or spiny

Glabrous: A smooth surface without hairs, e.g. *Citrus*

Glaucous: A stem surface shining and smooth

Hairy: A surface covered with hairs, e.g. *Calotropis*

Waxy: A stem having wax coating, eg. *Calotropis*

Geniculate: A zigzag stem, or bending abruptly at node, e.g., *Vitis Vinifera.*

Texture of stem:

Herbaceous: The stem is soft, non-woody, dying to the ground at the end of the growing season

Woody: The stem is hard in texture and possessing secondary xylem, e.g. *Mangifera indica*

Nature of stem:

Nature of stem, ie, erect, prostrate, twining or climbing.

Erect: It is rigid, strong and growing upright, e.g. Cassia

Prostrate: It grows flat or parallel on the ground, e.g. Portulaca

Twining: Stem ascending by coiling on the support without any special device, e.g. Cuscuta

Climbing: It grows towards upper side by means of tendrils, petioles, adventitious roots, or som means.

II. Diversity in Branching of the Stem:

- The mode of arrangement of the branches on the stem is known as branching.
- The branches develop exogenously from the lateral vegetative buds.
- Branching may be of monopodial or sympodial type (ie, racemose and cymose type)
- In monopodial type shoot grow through the action of a single apical meristem - a single re dividing, elongating and differentiating cell at the tip of the shoot.
- In sympodial shoot axillary branches take over the role of the main axis and prov continuous growth, while the main axis slows or stop growing.1

1. Racemose type:

In this type of branching the growth of the main stem is indefinite, i,e, it continues to grow indefinitely by its terminal bud and gives off branches in acropetal succession. Here the lower branches are older and longer than the upper branches.
Eg: - *Polyalthia, Casurina, Eucalyptus* etc.

2. Cymose type:

In this type of branching the main axis or the stem does not grow indefinitely due to the limited growth of the terminal or apical bud. Here the growth is definite and the main stem produces one or more lateral branches which grow more vigorously than the terminal one. The process may be repeated again and again.

Cymose branching is sub-divided into **(i) Uniparous cyme**
(ii) Biparous cyme

Uniparous cyme is further divided into:- **(a) Helicoid cyme**
(b) Scorpiod cyme

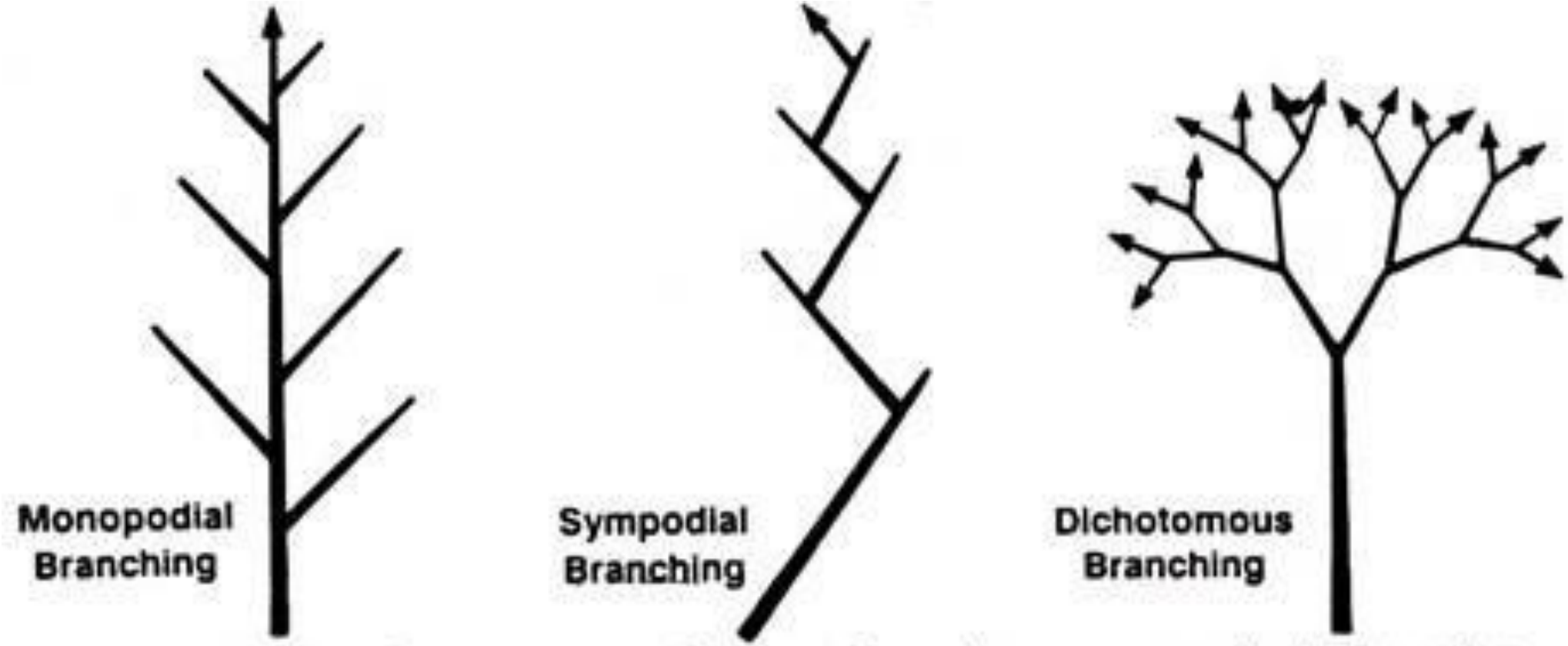

Monopodial Branching
growth of main axis causes increase in height
Sympodial Branching
growth of lateral branches causes increase in height
Dichotomous Branching
growth of all branches causes increase in height

Fig. 157.

Modification of stem:-

Modification are changes in form and function to fulfilled their needs such as storage of food, reproductive growth and survival through unfavourable seasons, vegetative propagation, photosynthesis, mechanical support.

Modification occurs in aerial, sub aerial and underground stem.

Some modification are Runner, Tuber, Bulb, Cladode.

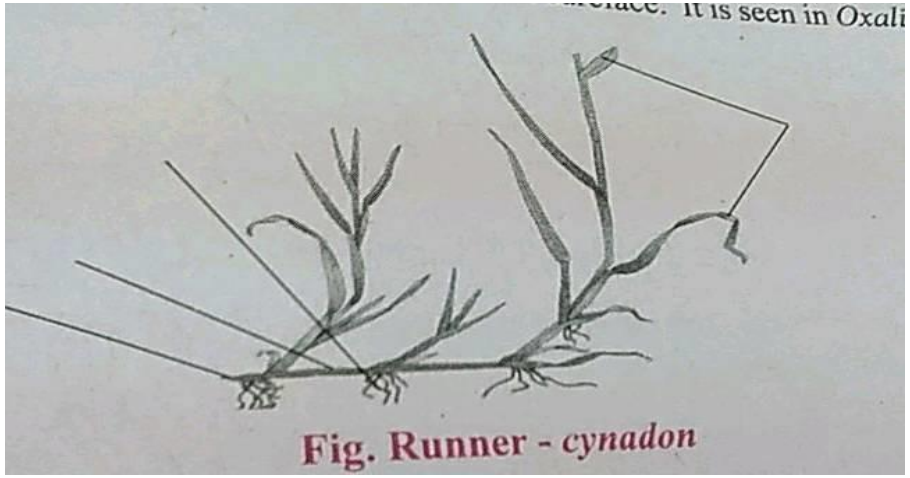


Fig. Runner - *cynadon*

Runner :-

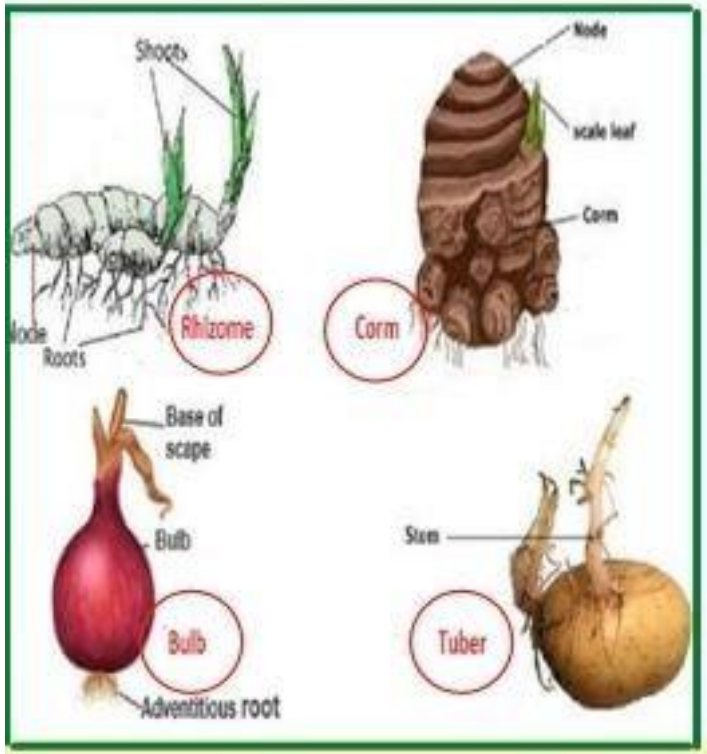
It is a sub aerial modification of stem.

They are special green, narrow above ground prostrate branches develop at the base of erect shoot called crowns.

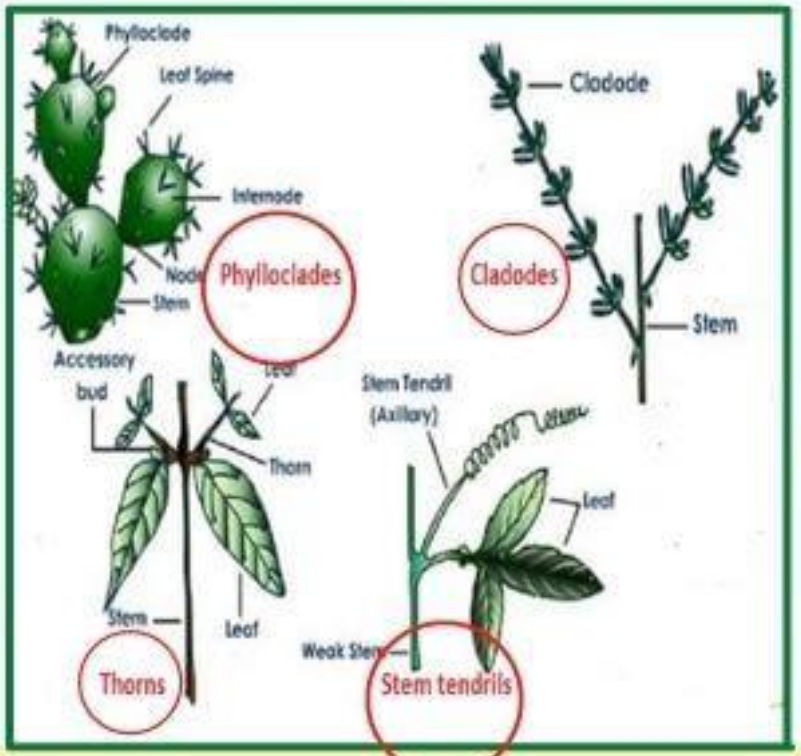
Each runner has generally one or more nodes.

The nodes bears scale leaves and axillary bubs
examples:-Cynodon dactylon

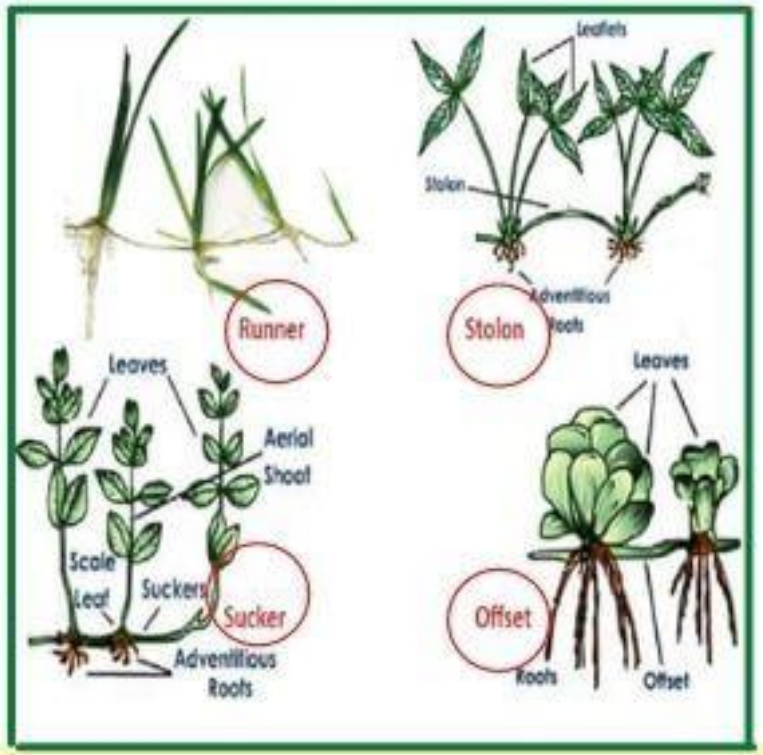
Underground Stem



Aerial Stem



Sub-Aerial Stem



Tuber:-

The underground stem become enlarged at the growing tips by the accumulation of storage of food, commonly starch, tuber are produced.

The eyes of potato are nodes at each of which 1-3 bubs are produced in the axis of small scaly like leaves.
Examples:- potato

Bulb:-

It is underground pyriform-spherical structure that possesses a reduce convex or slightly conical disc- shaped stem and several fleshy enclosing a terminal bub.

The bub possesses a numbers of adventitious roots arising from the lower side of the stem.

Bulbs are of two types:-

Tunicated bulb

- The bulb is covered by a sheath of dry membranous scales alled tunic.
- The fleshy scale arranged in a more a or less concentric fashion
- Tunicated bulbs arte further two kinds:-
- Simple tunicated bulb and compound tunicated bulb

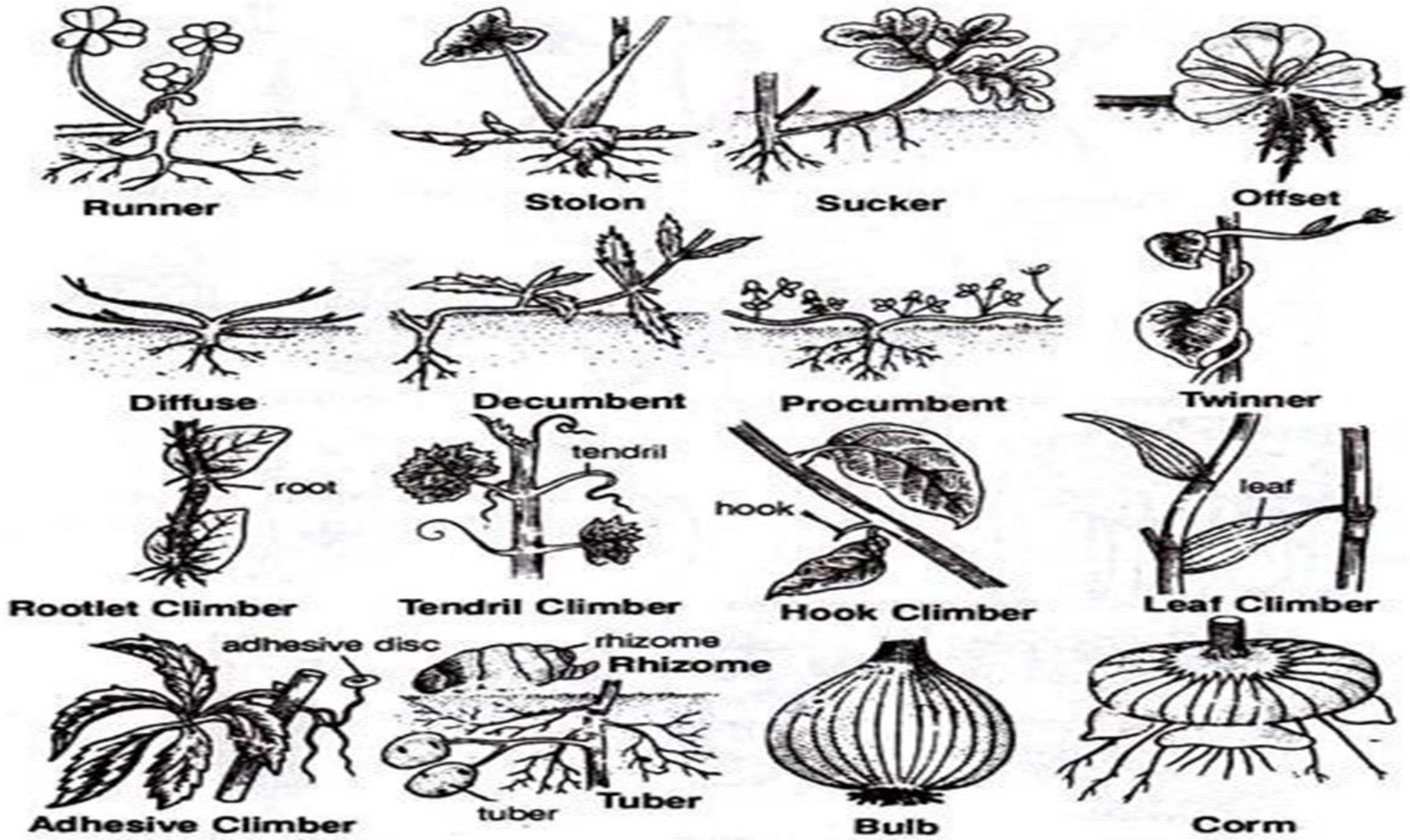


Fig. 65. Kinds of stem and their modifications.

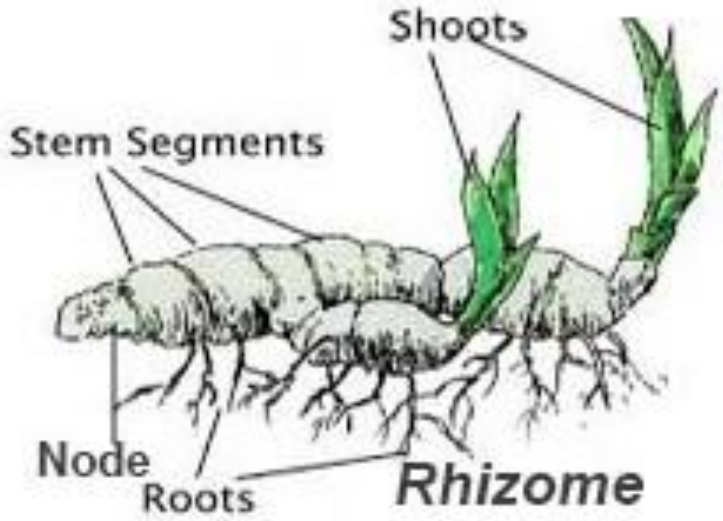
Examples of simple tunicated bulb is Onion and examples of compound tunicated bulb is Garlic.

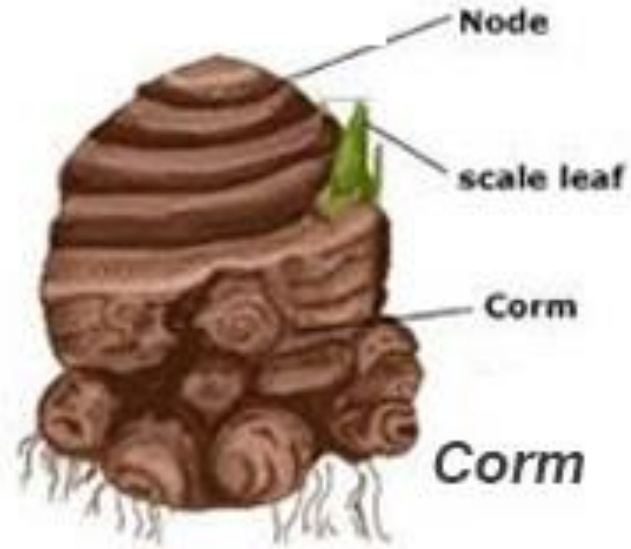
Rhizome:-

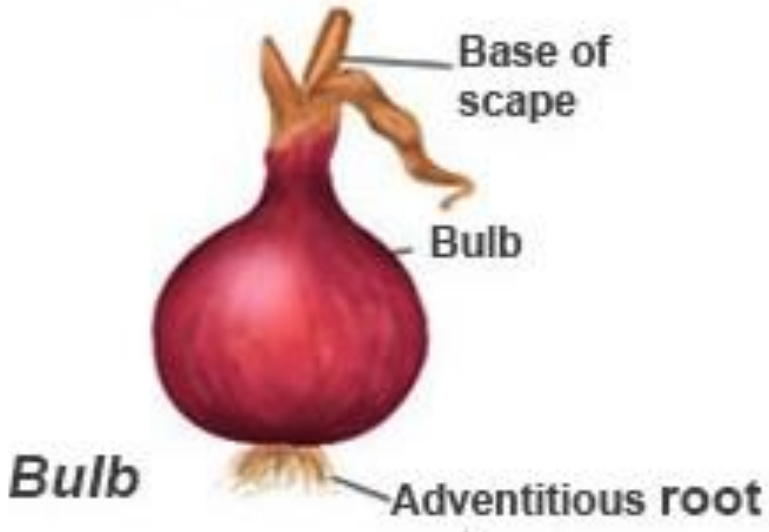
- It is a perennial fleshy underground stem which continues its growth indefinitely in the soil produced new leaves or aerial shoot.
- The stem differentiated into nodes and internodes,
- Adventitious roots occurs on the lower side.
- Modification for food storage.
- Examples:-Ginger

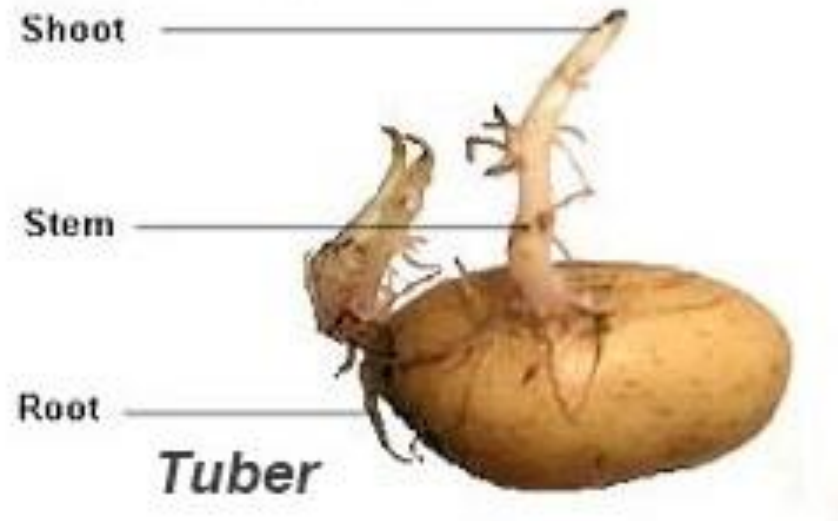
Corm:-

- It is a short upright stem, covered with scaly leaves.
- It is hard as compared to bulbs.Examples: Colocasia, Yam, Saffron


Shoots
Stem Segments
Node
Roots
Rhizome


Node
scale leaf
Corm
Corm


Base of scape
Bulb
Bulb
Adventitious root


Shoot
Stem
Root
Tuber

Leaf morphology

Leaf morphology is the branch of science in which study of external feature, forms, and relative positions of leaf of plant.

Typical leaf:-

- A leaf is part of plant that is usually green and attached to it by a stem or stalk.
- A leaf is a dorsiventrally flattened organ of a vascular plant and is the principal lateral appendage of the stem, usually borne above ground and specilized for the photosynthesis.
- The leaves and stem together from the shoot.

Parts of leaf:-

Apex, Margin, Midrib, Base, Petiole, Leaf lamina, Vein.

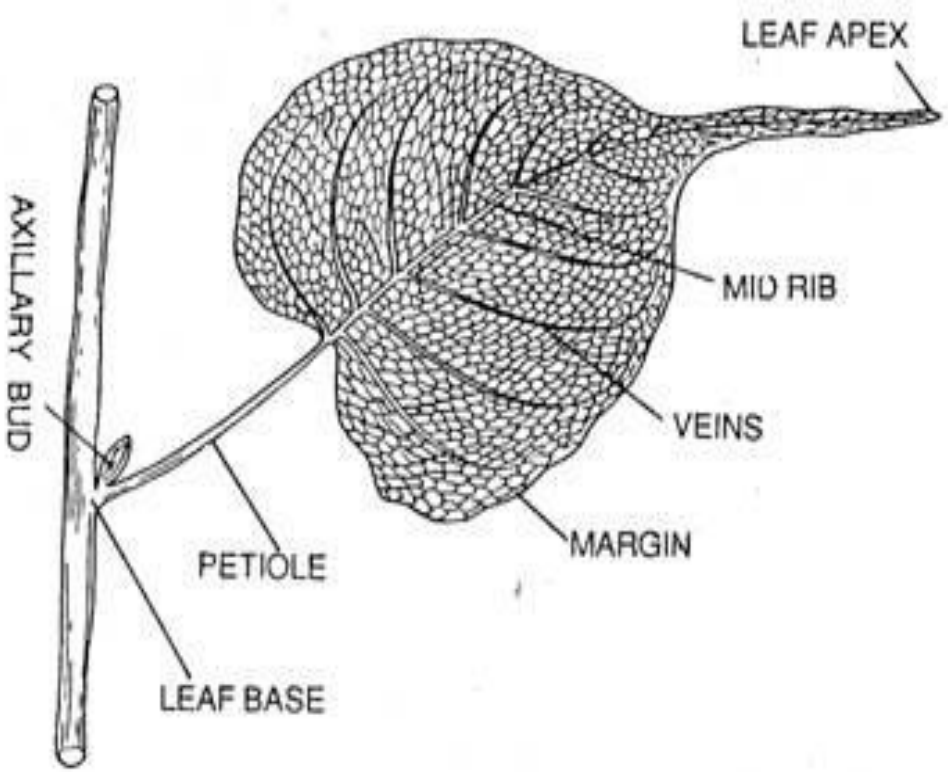


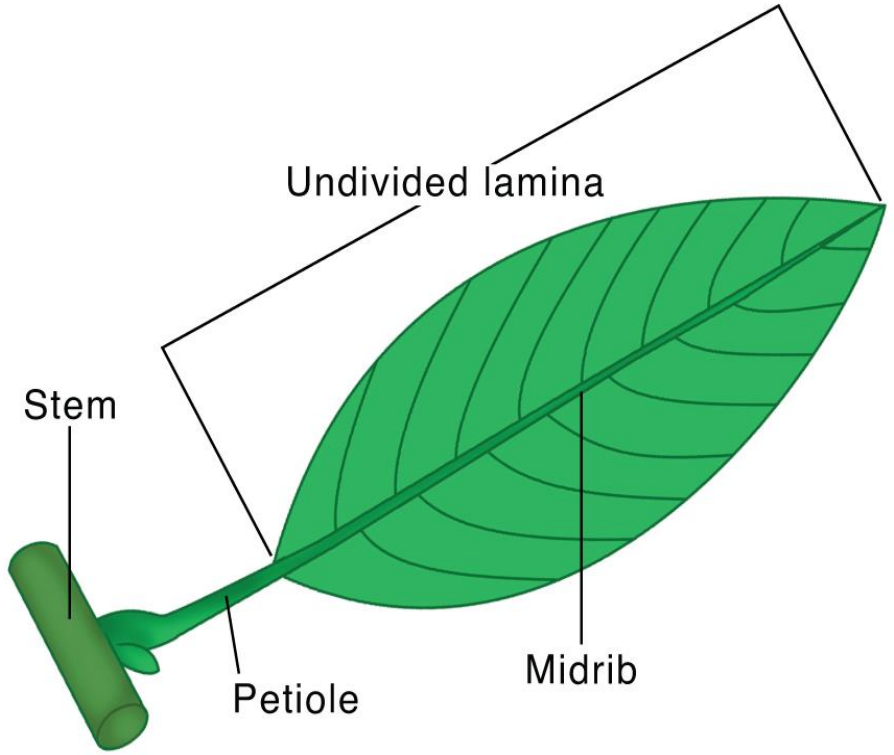
Fig. 34.34. Leaf of *Ficus religiosa* (**pipal**) showing various parts of the leaf.

Types of leaf:-

There are two main types of leaf:- 1) Simple leaf
2) Compound leaf

Simple leaf:-

A leaf which may be entire and consists of single lamina called as simple leaf. leaf is not broken up into separate lobes or leaflets these leaves possess axillary buds in their axils. example Mango, guava



Compound leaf:-

The leaves divided into two or more leaflets, incision touch the midrib.

Further compound leaf classified into three types

1) pinnately compound leaves

2) palmately compound leaves

B) Compound Leaf:

- A leaf in which the leaf blade is incised up to the midrib or petiole called as compound leaf.
- Compound leaf divided in to lobes or segments, called leaflets, example-Goldmohur. This leaf also possesses buds in its axil. Leaflets do not have axillary buds.
- Compound leaves are of two types- pinnately compound and palmately compound leaf.

(a) Pinnately compound leaves:

- A compound leaf in which the leaflets are arranged along the sides of common axis (rachis). In other words a leaf in which the leaf blade is incised up to the midrib, Example: Tamarind.
- On the basis of degree of rachis which produces leaflets, it is of following four types-

i. Unipinnate,
ii. Bipinnate,
iii. Tripinnate
iv. Decompound.

(1) Unipinnate:

A pinnately compound leaf which bears the leaflets directly on the rachis.
It is of two kinds, paripinnate and imparipinnate.

(i) Paripinnate:

It is a unipinnate leaf with even number of leaflets, example: Cassia.

(ii) Imparipinnate:

It is a unipinnate leaf with odd number of leaflets, example: Rose

(2) Bipinnate:

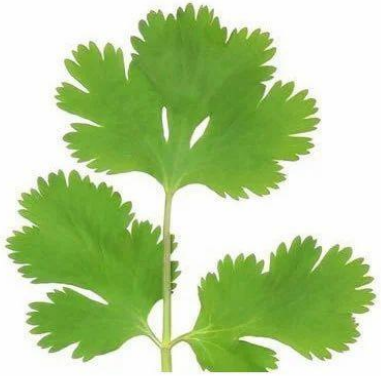
It is a twice pinnate compound leaf, i.e. midrib produces secondary rachis on which the leaflets are borne. Example: *Acacia*, Touch-me-not plant.

(3) Tripinnate:

It is thrice pinnate compound leaf, i.e. secondary rachis produces tertiary axes on which leaflets are borne, example: Moringa.

4) Decompound:

It is a compound leaf which is more than thrice pinnate, example: Coriander, Carrot.



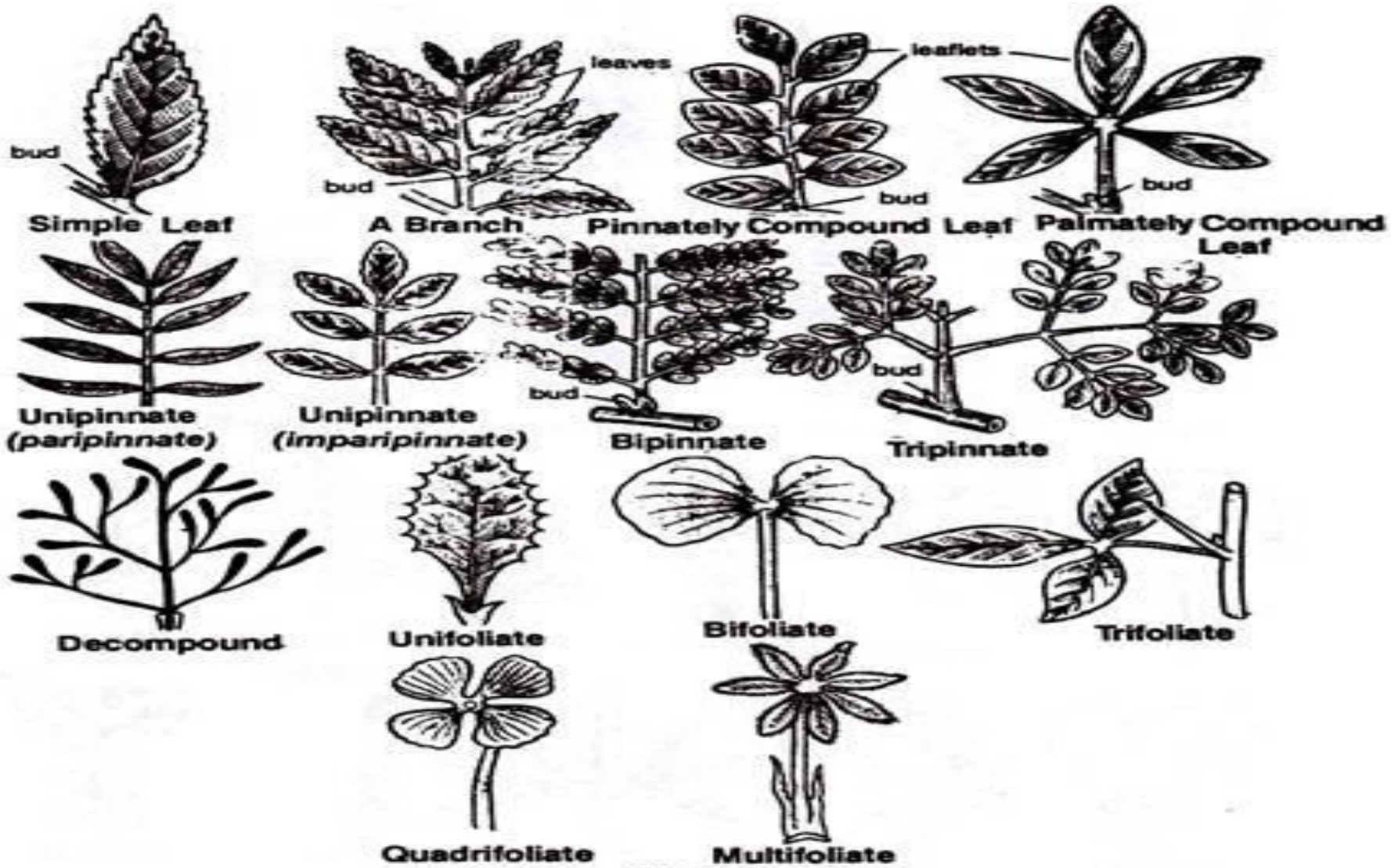


Fig. 69. Kinds of leaves.

Palmately compound leaf:-

A compound leaf in which the leaflets are attached at the tip of the petiole. In other words a leaf in which the leaf blade is incised up to the petiole. Therefore, leaflets look like radiating from a common point as the fingers from palm. According to the number of leaflets present It is of following types:-

- Unifoliate
- Bifoliate
- Trifoliate
- Quadrifoliate
- multifoliate

(1) Unifoliate:

A single leaflet is attached to the petiole, example: Citrus.

(2) Bifoliate:

Two leaflets are attached to the petiole, example: Hardwickia.

(3) Trifoliate:

In this case there are three leaflets are attached to the petiole, example: Aegle, Oxalis.

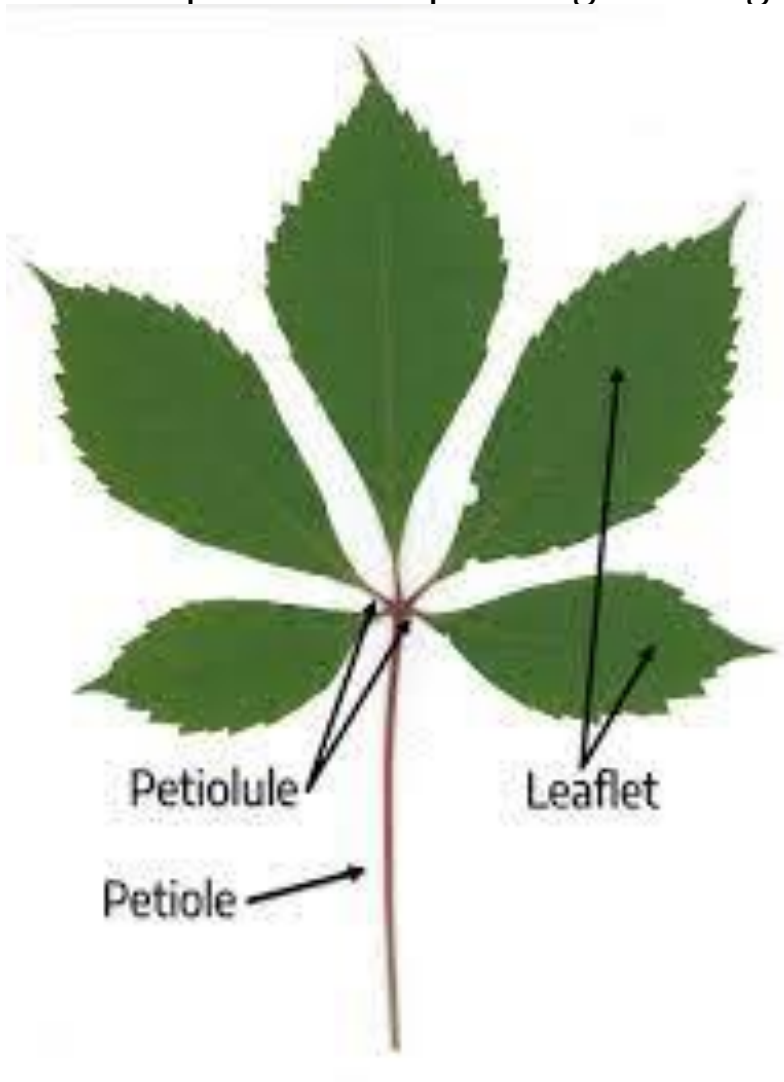
(4) Quadrifoliate:

Here four leaflets are attached to the petiole, example: Marsilea.

(5) Multifoliate or Digitate:

Five or more than five leaflets are attached to the petiole and spreading like fingers

Example: *Bombax*, *Gynandropsis*



Phyllotaxy:-

The arrangements of leaves on the stem is called as phyllotaxy.

It is following three different categories:-

Alternate

Opposite and

Whorled

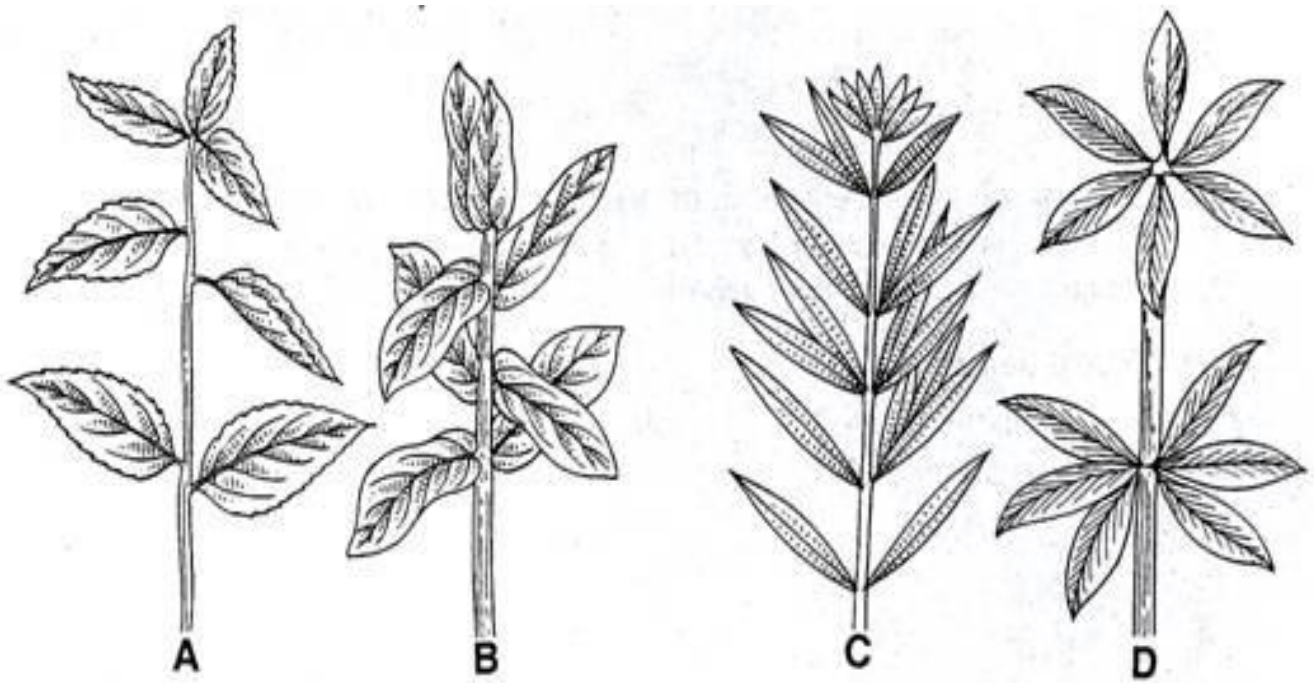


Fig. 34.35. Phyllotaxy of leaves. A, alternate; B, opposite decussate; C, whorled leaves of *Nerium*; D, whorled leaves of *Alstonia*.

A) Alternate or Spiral or Acyclic phyllotaxy

- In this type of arrangement, only single leaf develops at each node. T leaves in this case are seen to be spirally arranged round the stem.
- If an imaginary line is drawn along the bases of successive leav spiralwould be formed. These spirals are called as genetic spirals.
- All the leaves on the stem also appear to be arranged in fixed numb vertical rows, known as orthostichy.
- On the basis of number of leaves in one complete spiral and t orthostichy, alternate phyllotaxy broadly categorized in to followi types.

(a) Distichous or two ranked or 1/2 phyllotaxy: -
(b) Tristichous or three ranked or 1/3 phyllotaxy:
(c) Pentastichous or five ranked or 2/5 phyllotaxy: -
(d) Octastichous or eight ranked or 3/8 phyllotaxy: -

Alternate arrangement

(a) Distichous or two ranked or 1/2 phyllotaxy: -

- In distichous type of phyllotaxy leaves are arranged in two vertical rows or ranks. There are two leaves in each spiral, therefore known as 1/2 phyllotaxy In this arrangement the third leaf is stands over the first, fourth leaf is stands over the second and so on. Example: Ginger, Wheat, Rice.

(b) Tristichous or three ranked or 1/3 phyllotaxy:-

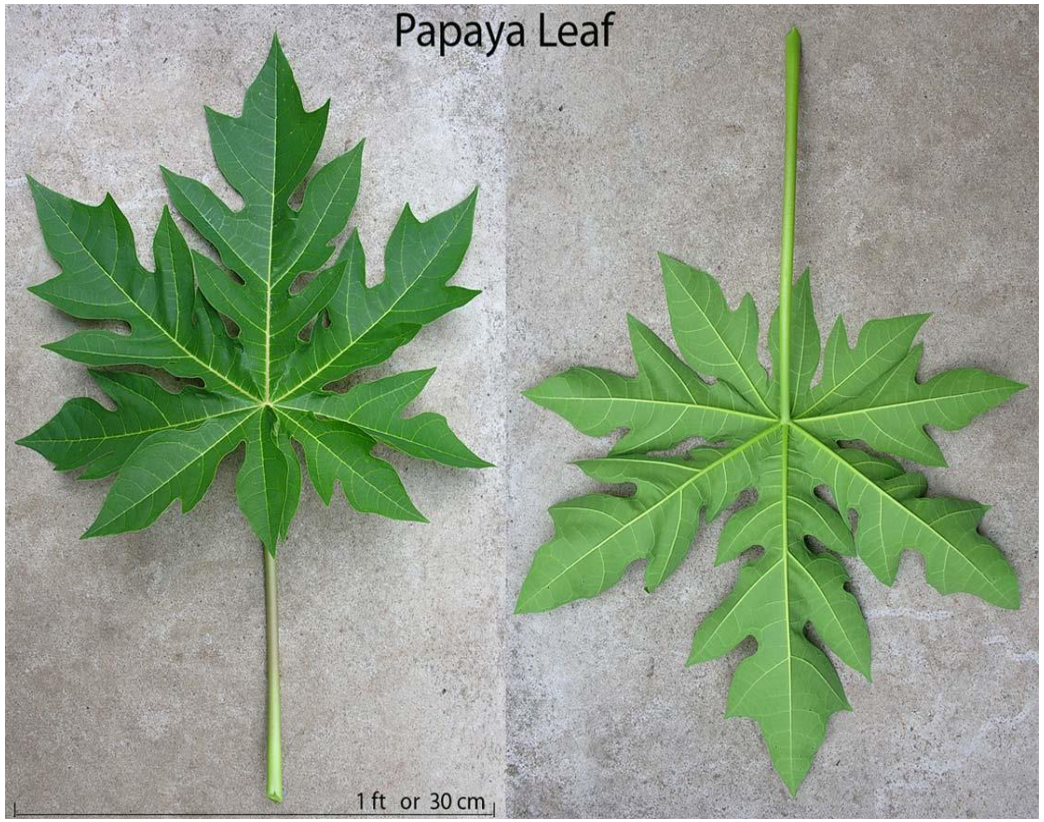
- In this type, leaves are arranged in three vertical rows or ranks. There are three leaves in each genetic spiral, therefore known as 1/3 phyllotaxy. Here fourth leaf is stands over first, seventh leaf is stands over the fourth and so on. Example: *Cyperous rotundus*.

(c) Pentastichous or five ranked or 2/5 phyllotaxy: -

In the pentastichous type leaves are arrange in five vertical rows or ranks. There are five leaves in two spirals, hence known as 2/5 phyllotaxy Here sixth leaf is stands over the first leaf; seventh leaf stands over second leaf and so on. Example: Hibiscus

(d) Octastichous or eight ranked or 3/8 phyllotaxy: -

In this type phyllotaxy, leaves are arranged in eight vertical rows or ranks. There are eight leaves in three genetic spirals, therefore known. as 3/8 phyllotaxy, Here ninth e ninth leaf is leaf is stands over the first, tenth over the second and so on.
Example: Papaya



(B) Opposite phyllotaxy

In the opposite type of leaf arrangement two leaves are occur at each node. They remain placed opposite to each other. On the basis of relative position of leaves borne by the adjacent nodes, opposite phyllotaxy categorized in to two types, i.e

(a) Superposed

(b) Decussate.

(a) Opposite Superposed: -

When the pairs of leaves at successive node are placed exactly one above the other, i.e. on the top of one another, it is called as superposed phyllotaxy. Here pairs of leaves are arranged in one plane only. Example: Guava

(b) Opposite Decussate: -

Here, the pairs of leaves that present right angle to the pair above and below. This type of phyllotaxy shows four rows of leaves along the stem. Example: *Ixora, Calotropis.*

(c) Whorled phyllotaxy-

- The whorl type phyllotaxy is when two or more leaves develop at each node. Examples of these plants are *hydrilla verticillata*, *Nerium*, etc.
- Note: The whorled phyllotaxy in plants can be easily identified by the plant's stem nodes, where each node has more than three or more leaves arising from them

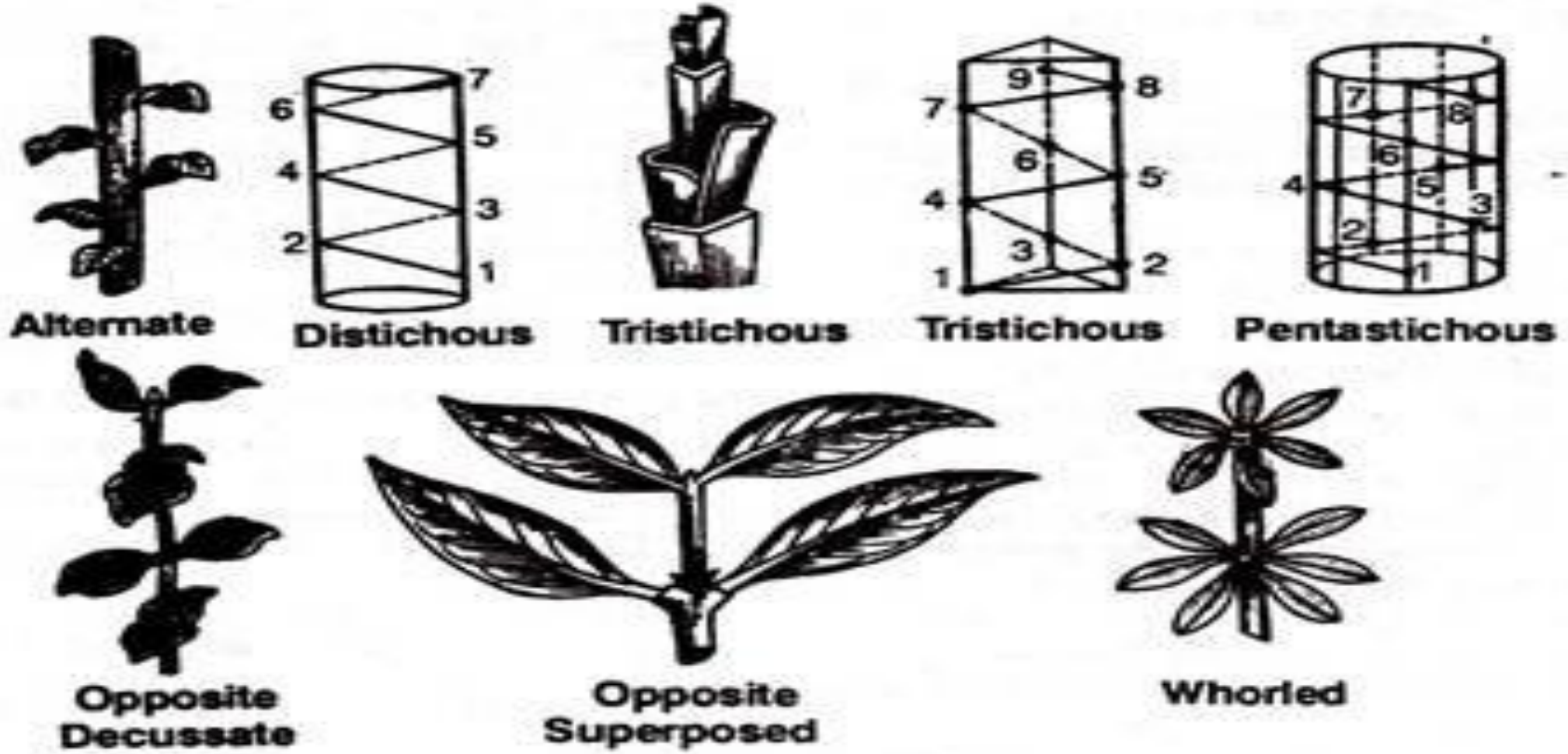


Fig. 68. Phyllotaxy.

Venation :-

The arrangements of vein in leaf lamina called as venation.

They are two types:-

i) Reticulate venation

ii)Parallel venation

The vein arranged in networking type, prominent midrib from which several secondary veins arise branch and anastomose like a network, It is two types

1. Reticulate unicostate venation

2. reticulate multicustate venation

(a) Reticulate unicostate venation:-

In the unicostate type of venation there is single prominent or strong vein. this single strong vein gives off lateral veins which proceed towards the margins or apex of the leaf. lateral veinlets are then interconnected to form a sort of network. e.g. mango, guava, banana.

(b) Reticulate multicostate venation:-

In this type of venation there are many strong veins which arise from the tip of petiole. all these strong veins of a leaf give off lateral veinlets to produce network like structure. there are two types of multicostate venation, convergent and divergent.

(1) Convergent:-

Here the number of strong veins is arises from the tip of the petiole and then convergent (curved) toward the leaf apex. e.g. *Zizypus sp.*

(2) Divergent:-

Here the number of strong veins arises from the tip of the petiole and then diverge from one another towards the leaf margin. e.g. *Castor, Cucumber*

Parallel Venation

- In parallel venation veins runs parallel to each other and do not form a network like structure.
- Monocots have parallel venation
- Banana, wheat, grasses, maize, and other plants have parallel venation
- Veins are placed parallel to one another
- Parallel venation is classified into two types : pinnate parallel venation/unicostate parallel venation and palmate parallel venation/multicostate parallel venation

(a) Unicostate parallel venation:-

In this type of venation single prominent midrib id present. this mid rib gives off many lateral veins which proceed toward the margin or apex of the leaf in parallel fashion e.g. Wheat, bamboo.

(b) multicostate parallel venation:-

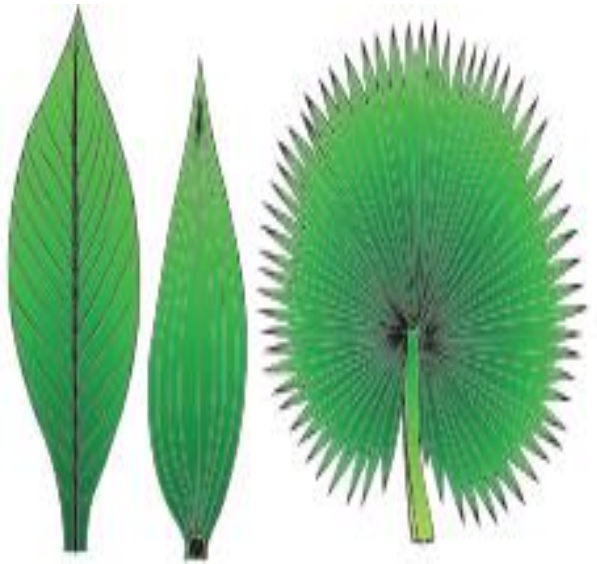
Here many prominent vein arise from the tip of the petiole which gives off veinlets in parallel pattern. it is of two type

(1) Convergent:-

many prominent veins are arising from the tip of petiole and converge towards the apex of leaf in parallel manner e.g. wheat bamboo.

(2) Divergent :-

Many strong veins are arising from the tip of petiole and diverge towards the margins of leaf in parallel manner e.g. fan palm



(a) *Canna* (b) Bamboo (c) Borassus

Types of Parallel venation

(a) Pinnately parallel venation (b) Palmately parallel(Convergent) (c) Palmately parallel (Divergent)

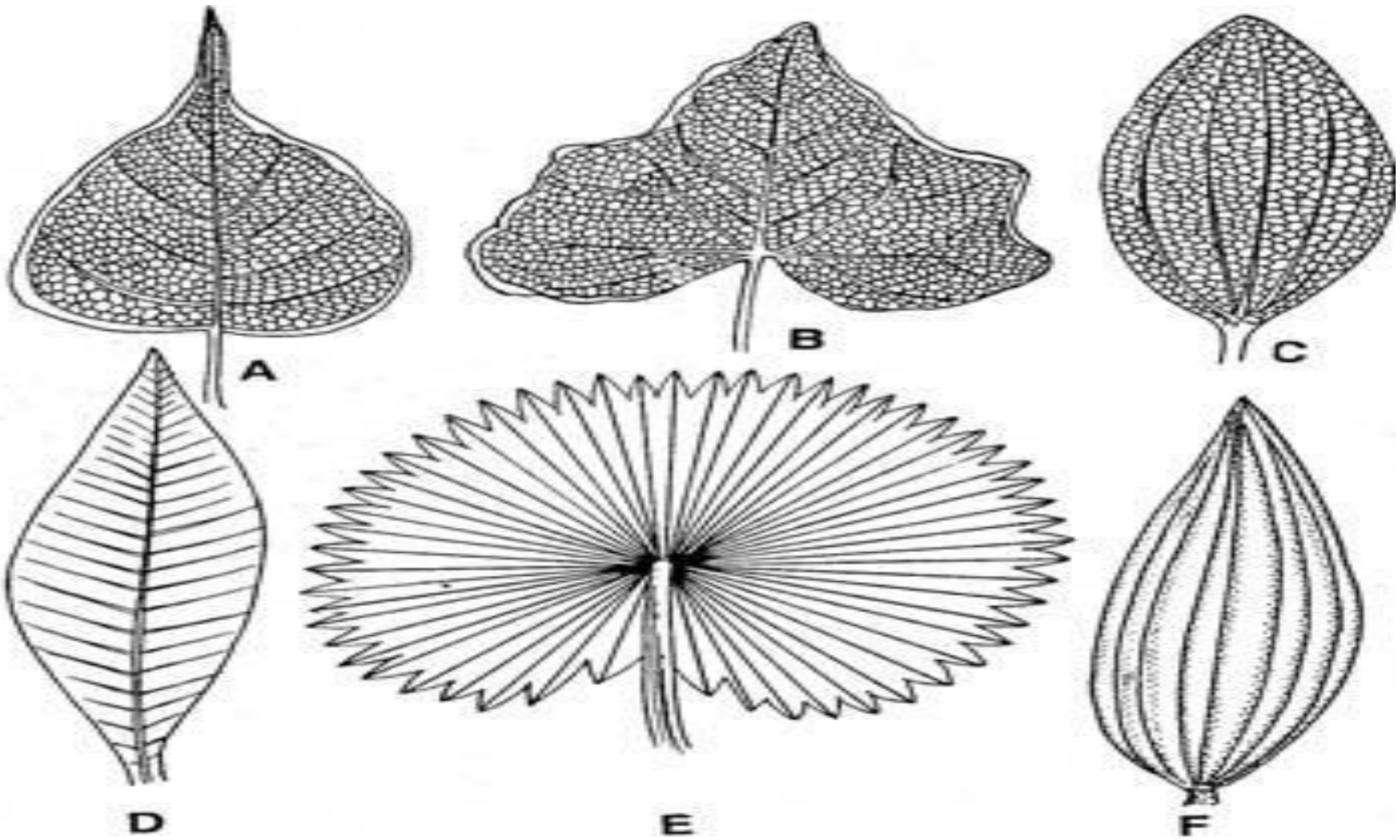


Fig. 34.44. Leaf venation. A, reticulate unicostate venation; B, reticulate multicostate—divergent venation; C, reticulate multicostate—convergent venation; D, parallel unicostate; E, parallel; F, multicostate—convergent.

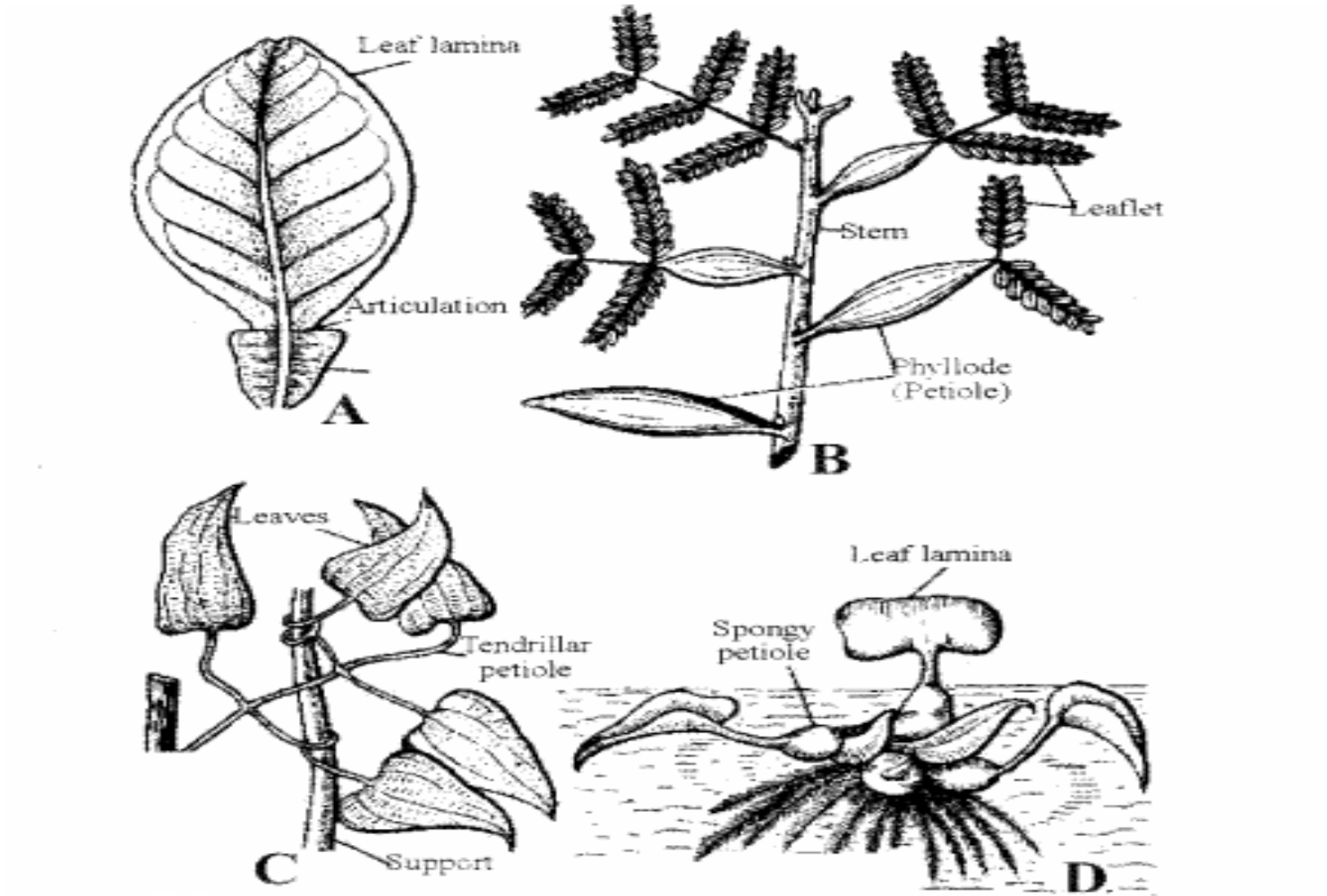
Modification of leaf (tendril, phyllode):-

(a) Tendril:-

- In some plant stem is very weak and hence they have some special organs for attachment to the support.
- Some leaves are partially or wholly modified into tendril.
- Some modification of leaf tendril are given below:-
  Examples:- Entrie leaf –*Lathyrus*,

(b) Phyllode:-

- Phyllod are flat, green coloured leaf like modification of petiole or rachis.
- The leaflets or lamina of the leaf are highly reduced.
- The phyllode perform photosynthesis and other leaf function
  Examples:- *Acacia auriculiformis*



Types of Petiole A. Winged petiole of *Citrus* B. Phyllode of Australian acacia, C. Tendrillar petiole, D. Floating or bulbous petiole.

(c) Leaf spines:

leaves of certain plants become modified into sharp, pointed structures, known as spines. A leaf can modified into spines is evident from the fact that, spines occupied the position of leaf and bears bud in its axil, as in case of opuntia. leaf spines develop at various positions. they may develop on margins (e.g. Argemone) or at margins and apex (e.g. *Solanum xanthocarpum*)

(d) Pitcher:

Leaves of some insectivorous plants modified into bag like structure, called pitcher. pitchers help such plants to attract, catch and digest the insects to derive the source of proteins. In Nepenthus plant the leaf midrib is prolonged and lamina is modified into pitcher like structure.

(e) Bladder:

It is very common in bladderwort plant (*Utricularia)*. the dissected segments of the leaf modified to form bladder like structures, with trap-door entrance. small aquatic insects are trapped inside such bladders.

THE END