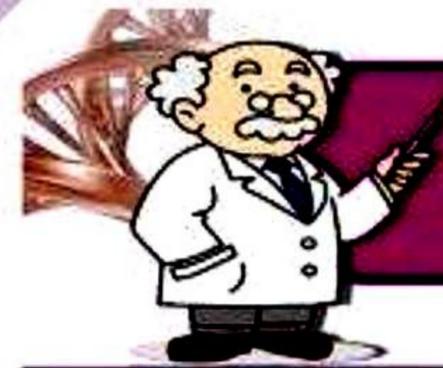




SECTION – A CORE EXPERIMENT



EXPERIMENT



1

Aim

To study and describe flowering plants of families Solanaceae, Fabaceae and Liliaceae, adventitious root, herbaceous woody stem, Simple and compound leaves.

PRINCIPLE

The identification of plants is based primarily on morphological features, particularly the floral characters. The branch of science that deals with identification, nomenclature and classification of organisms is called taxonomy. The angiosperm or flowering plants show a large diversity in external structure called as morphology. Bentham and Hooker's system of classification is a universal classification system used to classify the plants. Plant body mainly consists of a main axis, which may be branched or unbranched bearing lateral appendages. The main axis is divided into two major parts, i.e., underground part that develops from radicle and is brown in colour called roots and aerial part that develops from plumule called shoot. It is comprised of stem, leaves and fruits.

Flower is basically the extended shoot having a condensed axis called thalamus and a number of appendages called floral leaves. A typical flower has four types of floral leaves called sepals, petals, stamens and carpels in distinct whorls known as calyx, corolla, androecium and gynoecium, respectively. The flower arises on the mother axis and possesses a stalk called pedicel. The pedicel is borne in the axil of a small leaf-like structure called bract.

TERMS RELATED TO FLOWER

1. **Actinomorphic:** Flowers can be divided into two halves through any vertical plane.
2. **Zygomorphic:** Flowers can be divided into two equal halves only along one vertical plane.
3. **Asymmetrical:** Flowers which cannot be divided into equal halves by any plane.
4. **Bracteate:** A flower having bract at base.
5. **Ebracteate:** A flower without a bract.
6. **Pedicellate:** A flower having a stalk or pedicel.
7. **Sessile:** A flower without a stalk or pedicel.
8. **Complete:** A flower having all the four whorls present.
9. **Incomplete:** A flower where one or more than one of the whorls are absent.
10. **Bisexual:** A flower having both male (stamen) and female (carpel) sex organs.
11. **Unisexual:** A flower having either male or female reproductive organs.
12. **Hypogynous (Superior ovary):** Gynoecium occupies the highest position while the other parts are situated below it.
13. **Perigynous (Half inferior):** If gynoecium is situated in the center and other parts of the flower are located on the rim of the thalamus almost at the same level.

14. Epigynous (Inferior ovary): The ovary situated in a flask shaped thalamus and other parts of flower arise above the ovary.

FLORAL LEAVES

A flower consists of four whorls namely, calyx, corolla, androecium and gynoecium.

CALYX

It is the outermost whorl of flower. It is green in colour. These can be of following types protects the flower when it is not in fully-developed state.

Forms of Calyx

1. **Polysepalous:** Calyx consists of free sepals free at their ends, e.g. Brassica.
2. **Gamosepalous:** Calyx consists of united sepals, e.g. Peppaver.

Duration of Sepals

1. **Caducous:** Sepals fall off as soon as the floral bud opens, e.g. poppy.
2. **Deciduous:** Sepals fall off after pollination, e.g. Brassica.
3. **Persistent:** Sepals remain attached with fruit, e.g. Solanum.

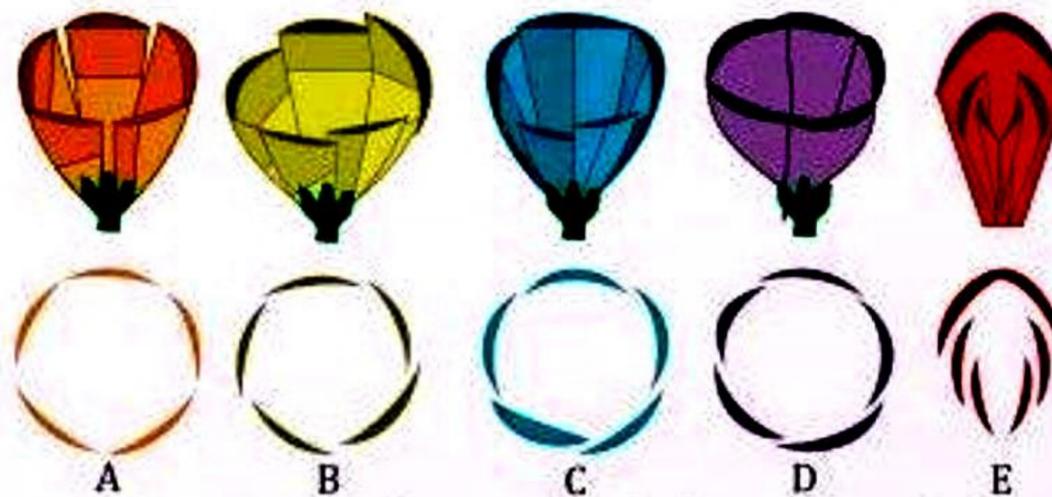
COROLLA

The corolla is the second whorl of the flower and is composed of petals. Petals are the most colourful parts of a flower. Corolla may be gamopetalous (petals united) or polypetalous (petals free). The arrangements of sepals or petals in the floral bud, with respect to the members of the same whorls are called aestivation.

AESTIVATION

The mode of arrangement of sepals or petals in the floral bud is called aestivation. It is of the following types:

1. **Valvate:** Sepals and petals are close to each other by their edges, but do not overlap, e.g. Calotropis.
2. **Twisted:** Regular overlapping of one margin of each petal or sepal by the next petal / sepal occurs, e.g. Hibiscus or China rose.
3. **Imbricate:** Five sepals / petals are arranged in such a way that one sepal / petal is completely external and another sepal / petal is completely internal, while three petals are partially external and partially internal, e.g. Cassia.
4. **Vexillary:** When the largest of the five sepals/petals overlaps the two lateral sepals/petals, which in turn, overlap the two small anterior sepals/petals (keel), the aestivation is called as vexillary, e.g. pea. It is also known as descending imbricate.
5. **Quincuncial:** Out of five sepals/petals two are completely internal, two external and one has one margin external and the other margin internal.



Different types of aestivation of calyx and corolla

A. Valvate, B. Twisted, C. Imbricate, D. quincuncial, E. Vexillary

ANDROECIUM

Androecium is the third whorl of the flower which contains the male reproductive organ, stamens. A stamen consists of an anther and a filament.

The stamens are variously fused among themselves. They can be of the following type:

1. **Monadelphous:** Stamens may be united into one bunch or one bundle. e.g. China rose.
2. **Diadelphous:** Stamens may be united into two bundles. e.g. pea.
3. **Polyadelphous:** Stamens may be united into more than two bundles. e.g. Citrus.

Based on the attachment of filament to anther, it can be of the following type:

1. **Basifixed:** Filament of stamen is attached to base of the anther.
2. **Adnate:** Filament attached along the whole length of anther.
3. **Dorsifixed:** Filaments attached to the back of anther.
4. **Versatile:** Anther lobes attached with filament in the middle portion with both ends free.



GYNOECIUM

Gynoecium is the female reproductive part of the flower and is made up of one or megasporangium. It is the innermost whorl, consisting of stigma, style and ovary.

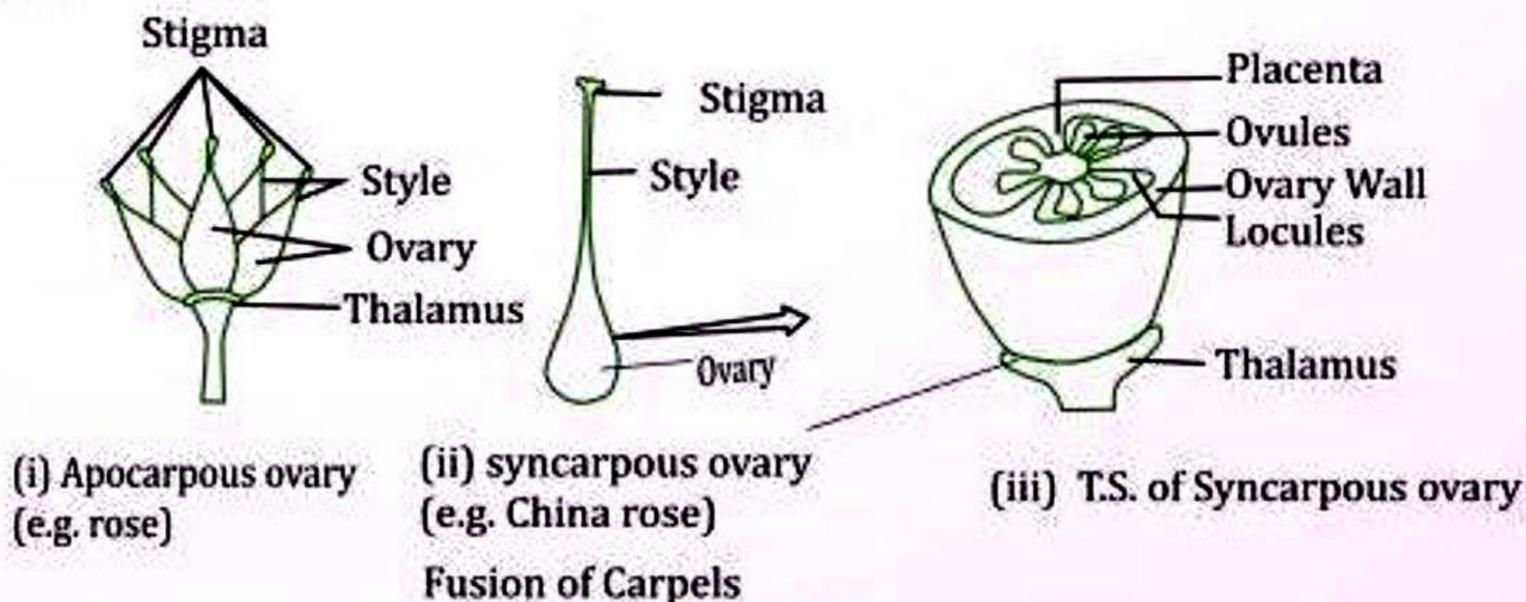
1. Forms of Gynoecium

- (i) **Monocarpellary:** When pistil contains one carpel, e.g. sweet pea.
- (ii) **Bicarpellary:** When pistil contains two carpels, e.g. Petunia.
- (iii) **Pentacarpellary or Polycarpellary:** When pistil contains five or many carpels, e.g. China rose.

2. Fusion of Carpels

Depending upon fusion, the carpels are of two types:

- (i) **Apocarpous:** A pistil has two or more carpels that are free from each other, e.g. lotus and rose.
- (ii) **Syncarpous:** A pistil with two or more carpels which are fused with each other, e.g. China rose and tomato.



1. Locules in Ovary

The cavity enclosed by ovary wall is called locule. The number of locules in the ovary corresponds to the number of carpels in the gynoecium. Depending on the number of chambered locules in the ovary, ovaries are of following types:

- (i) **Unilocular:** Ovary with one locule or chamber, e.g. pea.
- (ii) **Bilocular:** Ovary with two locules or chambers, e.g. tomato,
- (iii) **Trilocular:** Ovary with three locules or chambers, e.g. Ricinus.
- (iv) **Multilocular:** Ovary with many locules, e.g. orange and lemon.

2. Placentation in Ovary

The arrangement of ovules within the ovary is known as placentation. The placenta is a tissue, by which ovules are attached to the inner wall of the ovary. The placentation can be of following different types.

- (i) **Marginal:** The placenta forms a ridge along the ventral suture of the ovary and the ovules are borne on this ridge forming two rows. This is called marginal placentation, e.g. pea.
- (ii) **Axile:** When the placenta is axial and the ovules are attached to it in the fashion of a multilocular ovary, the placentation is called axile, e.g. China rose, tomato and lemon.
- (iii) **Parietal:** Ovule develops on the inner wall of ovary or on peripheral part of the ovary and is single-chambered. It becomes two-chambered due to the formation of a false septum during maturation in mustard and argemone.
- (iv) **Free central:** Ovules are borne on central axis and septa are absent and the ovary contains only one chamber (unilocular), e.g. Dianthus and Primrose.
- (v) **Basal:** Placenta develops at the base of the ovary and a single ovule is attached to it as in sunflower, marigold, etc. Here, the placenta develops directly on the thalamus.
- (vi) **Superficial:** Multicarpellary, syncarpous and multilocular ovary with placenta scattered all around the partition wall, e.g. water lily.

FLORAL DIAGRAM

It is the graphical or diagrammatic representation of theoretically transverse section and ground plan of a floral bud in relation to the mother axis. A floral diagram provides the information about the number of parts of a flower, their arrangement and the relation they have with one another. It tells about the following characters of the flower:

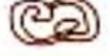
1. The presence or absence of bract and bracteoles
2. Position of odd sepals
3. Number and arrangement of floral leaves in relation to one another.
4. Aestivation of sepals and petals.
5. Symmetry of flower.
6. Types of placentation, etc.

In the floral diagram, the position of the mother axis with respect to the flower is represented by a dot on the top of the floral diagram. Calyx, corolla, androecium and gynoecium are drawn in successive whorls, calyx being the outermost and gynoecium being in the centre.

FLORAL FORMULA

The symbolic representation of floral characters of a flower is called floral formula. The various symbols used in a floral formula are shown in the table below, e.g. floral formula of Brassica (mustard) is Ebr

$$\oplus \varnothing K_{2+2} C_{x4} A_{2+4} \underline{G}_{(2)}$$

Symbol	Description	Symbol	Description
⊕	Actinomorphic	♂	Unisexual staminate flower
P	Perianth	K	Calyx
A	Androecium	G	Gynoecium
%	Zygomorphic	♀	Unisexual pistillate flower
Br	Bracteate	C	Corolla
A _(n)	No. of fused stamens	G _n	Superior ovary with free carpels
♂	Bisexual flower	Epi	Epicalyx
Ebr	Ebracteate	C _(n)	No. of fused petals
 C A	Epipetalous stamen	G _n	Inferior ovary with fused carpels
●	Mother axis		Bract
	Epicalyx		Calyx or sepals
	Corolla or petals		Stamens (ditheous)
	Stamens (monothecous)		Nector secreting disc around carpel
	Monocarpellary gynoecium		Bicarpellary syncarpous gynoecium
	Polycarpellary syncarpous gynoecium		Monoadelphous androecium
	Syngenesious androecium		

MATERIAL REQUIRED

Locally available plant specimens of families-Solanaceae, Fabaceae and Liliaceae. Each plant should have at least a small branch with few internodes, leaves, flowers and fruits, glass slides, water, beaker, petridish, razor, blade, needle, brush, hand lens and a dissecting microscope.

PROCEDURE

1. Take a flowering plant, which is locally available of families-Solanaceae, Fabaceae and Liliaceae.
2. Keep the plant in a beaker containing water.
3. Study the habit of plant, its root system, stem and leaf morphology, inflorescence and flowers.
4. Describe the floral features and vegetative parts of the plant.
5. Observe the flower bud under dissection microscope or a hand lens and note down the aestivation patterns of calyx and corolla, number of sepals and petals and number of stamens.
6. Cut T.S. of the flower, place it on a slide and observe under the dissecting microscope to study position of stamens, number of carpels and position of ovary (epigynous, perigynous or hypogynous)
7. Mount a stamen on a slide and study the attachment of filament to anther (basifixed, dorsifixed, versatile and adnate), dehiscence pattern of anther (porous and longitudinal) and number of anther lobes.
8. Mount the pistil and study the ovary, style and stigma.
9. With the help of a sharp blade, cut a T.S. of the ovary and observe the type of placentation and number of locules.
10. Draw the well labelled diagram of plant and its parts and write down the floral formula and comments in

A- FAMILY-SOLANACEAE

It is a very large family, commonly called as the potato family. It is widely distributed in tropics, sub-tropics and even temperate zone. *Solanum nigrum* (makoi), *Petunia alba*, *Solanum tuberosum* (potato), *Solanum melongena* (brinjal), etc. are some plants belonging to this family.

Classification (*Petunia Alba*)

Division	-	Phanerogams
Sub-division	-	Angiospermae
Class	-	Dicotyledonae
Order	-	Polemoniales
Family	-	Solanaceae
Genus	-	<i>Petunia</i>
Species	-	<i>Alba</i>

Habit Annual herb.

Root Usually branched tap root system.

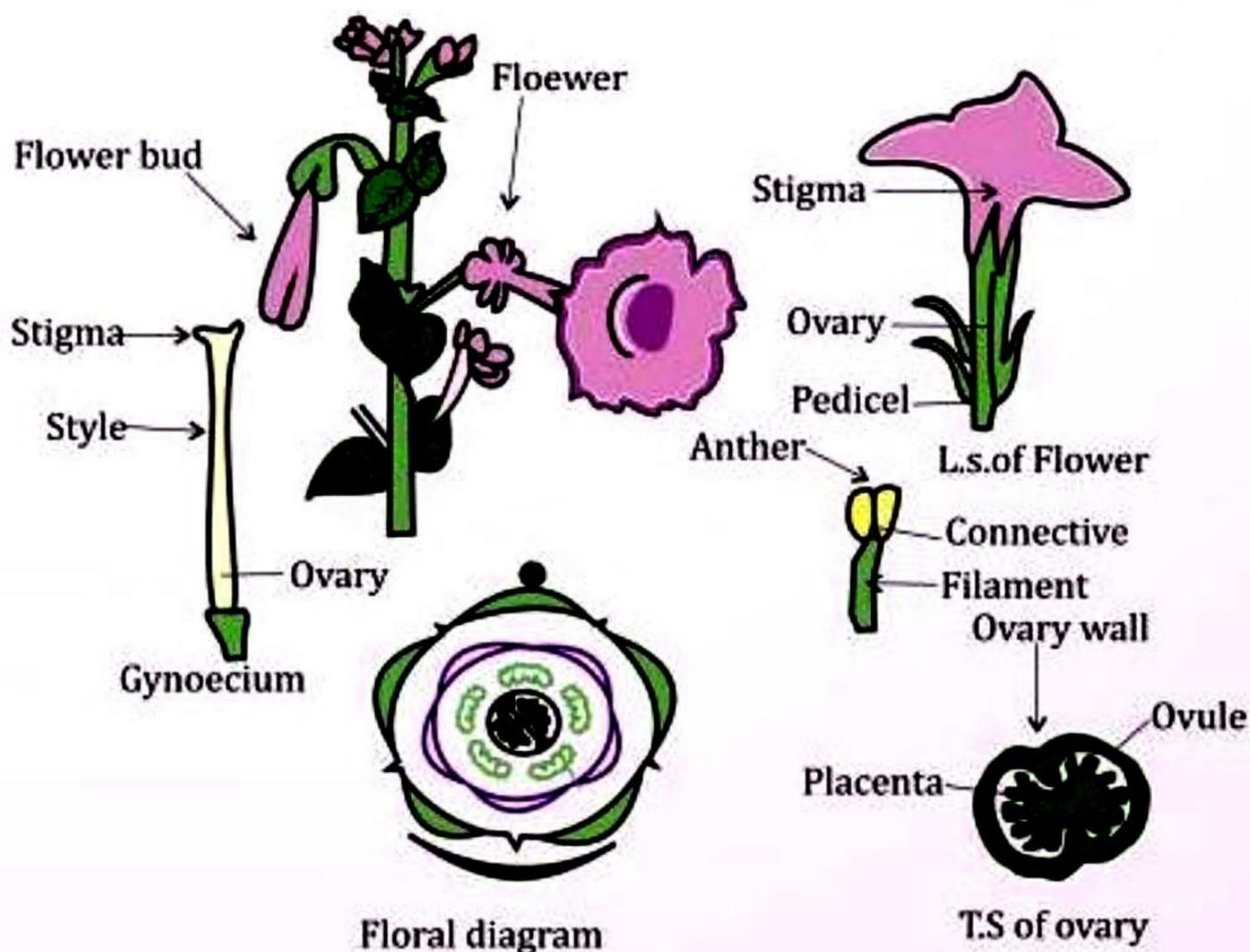
Stem Herbaceous, erect, cylindrical branched, green and smooth.

Leaves Alternate in basal part, opposite, simple, petiolate or sessile, ovate, acute and reticulate venation.

Inflorescence Axillary cyme.

Flower Ebracteate, pedicellate, actinomorphic, complete, bisexual, pentamerous and hypogynous.

Calyx Five sepals, united or gamosepalous, valvate aestivation, persistent and green coloured.



Corolla	Five petals, united or gamopetalous, valvate aestivation, tubular and white colour.
Androecium	5 polyandrous, epipetalous, alternating with the petals, filaments are of different lengths, anthers basifixed, inserted (within corolla tube) inferior.
Gynoecium	Bicarpellary, syncarpous, ovary superior, placed obliquely in the flower, bilocular with swollen placenta bearing many shining ovules, placentation axile, style simple, long and stigma bilobed.
Fruits	Capsule.
Floral formula	$Ebr \varphi K_{(5)} \overset{\curvearrowright}{C_{(5)} A_{(5)}} \underline{G}_{(2)}$

Characteristics of the family

1. Pentamerous, actinomorphic, flower bisexual, funnel-shaped corolla.
2. Stamens are epipetalous, calyx and corolla fused.
3. Ovary is bilocular, placenta swollen and ovary obliquely placed.

B- FAMILY-FABACEAE

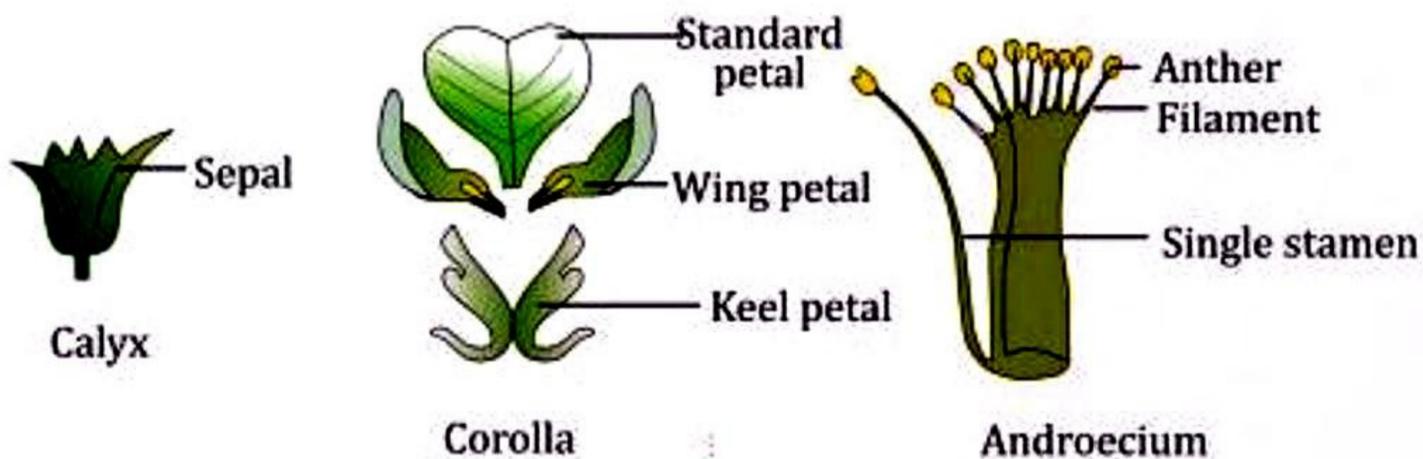
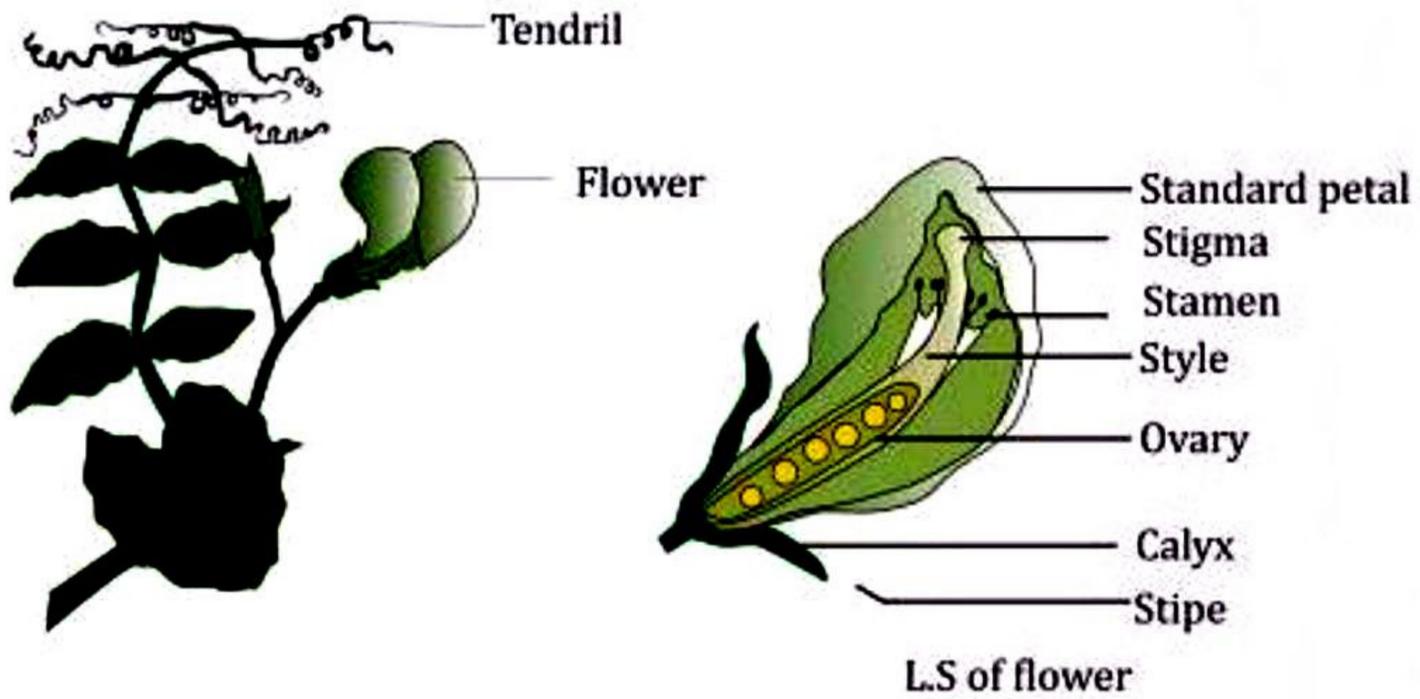
The family was earlier called as Papilionaceae which is a subfamily of family-Leguminosae. The family includes 600 genera and 13000 species. It is distributed all over the world, except the Arctic region.

Classification (*Pisum sativum*)

Sub-Division	-	Angiospermae
Division	-	Phanerogams
Class	-	Dicotyledonae
Order	-	Rosales
Family	-	Fabaceae
Genus	-	<i>Pisum</i>
Species	-	<i>sativum</i>

Habit	Herbaceous and annual climber.
Root	Tap root system with lateral roots having many nodules which contain nitrogen fixation Rhizobium bacteria.
Stem	Weak, cylindrical, branched, herbaceous green, aerial and climbing with the help of leaf tendrils.
Leaf	Stipulate petiolate, imparipinnately compound, common rachis ends in a branched tendril, terminal leaflet is always a tendril and alternate leaflets with reticulate venation.
Inflorescence	Racemose
Flower	Bracteate, Bracteolate, pedicellate complete, zygomorphic, Bisexual, pentamerous, hypo or perigynous and papilionaceous.
Calyx	Five sepals, gamosepalous or united sepals, ascending imbricate aestivation, valvate aestivation, odd sepal anterior and green coloured.
Corolla	Five petals, polypetalous (petals separated), papilionaceous (i.e. the five petals are unequal and have a bilateral symmetry where posterior or outermost largest petals is called standard, lateral pair of petals are clawed and are called the wings and two united anterior petals are called keel, which encloses the stamen and the carpel in 1 + 2 + 2 arrangement), descending imbricate or vexillary aestivation.

Androecium	Ten stamens ranged in a single whorl diadelphous (9+1 arrangement, where 9 unite at base and form a tube around the Ovary and the 10th posterior stamen is free), anther basifixed, dithecous and introrse.
Gynoecium	Monocarpellary, ovary superior unilocular and many ovules with marginal placentation.
Fruit	Legume (pod).
Seed	One to many, non-endospermic.
Floral formula	$Br \Phi \varnothing K_{(5)} C_{1+2+(2)} A_{(9)+1} \underline{G}_1$



Characteristics of the family

1. Nodulated taproot.
2. Zygomorphic flowers having papilionaceous corolla.
3. Stamens diadelphous.

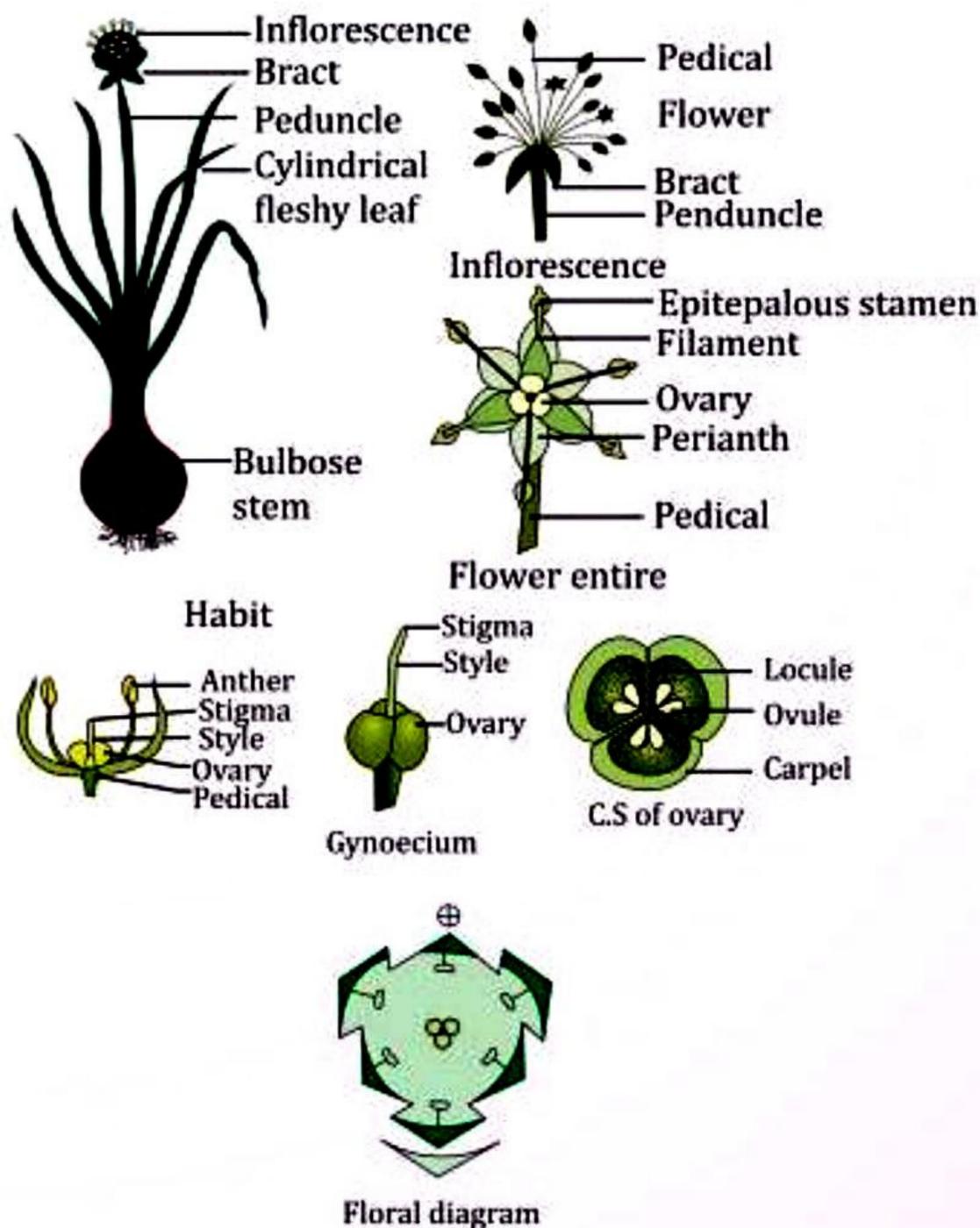
4. Monocarpellary ovary with marginal placentation.
5. Legume fruit.
6. Persistent calyx.

C- FAMILY-LILIACEAE

This family-Liliaceae includes about 250 genera and 3700 species of plants showing worldwide distribution. About 200 species are available in India. Plants belonging to this family are usually perennial herbs and are rarely shrubs or climbers like Ruscus, Smilax, etc.

Classification (*Allium cepa*)

Division	-	Angiospermae
Class	-	Monocotyledonae
Order	-	Liliflorae
Family	-	Liliaceae
Genus	-	<i>Allium</i>
Species	-	<i>cepa</i>



Habit	Perennial herb.
Root	Adventitious fibrous or fleshy
Leaf	Radical, cylindrical
Inflorescence	Umbellate, cymose, rarely solitary.

Flower	Bracteate, pedicellate, incomplete and hypogynous.
Perianth	6 petals (3+3 arranged whorls), often united into tube or slightly gamophilous at the base, petaloid, white in colour, each petal is marked with a brown midrib, imbricate aestivation.
Androecium	Six stamens, polyandrous, arranged in two whorls of 3 each, antiphyllous, epiphyllous, anther dithecous and basifixed
Gynoecium	Tricarpellary, syncarpous, trilocular with two or more ovules per locule, axile placentation, ovary superior and style short with three lobed stigmas
Fruit	A loculated capsule and rarely a three-celled berry
Seed	Endospermic, embryo curved or straight.
Floral formula	$Br \oplus \overset{\curvearrowright}{\text{P}}_{(3+3)} \overset{\curvearrowright}{\text{A}}_{(3+3)} \underline{\text{G}}_{(3)}$

PRECAUTIONS

1. Plant should be taken carefully so that root, stem, leaves and fruits should not be damaged.
2. The flower should be dissected carefully and each part should be placed separately for proper study of each part
3. The study of flower should be done immediately after dissection because it may get dried.

D- MORPHOLOGY OF TAP ROOT AND ADVENTIOUS ROOTS

PRINCIPLE

A typical angiospermic plant is differentiated into well defined vegetative organs-the root, stem and leaves. It also produces reproductive parts viz., flowers, fruits and seeds at certain stages in the life cycle. These plants are autotrophic and synthesize their own food.

Root is the non-green, cylindrical, descending axis of the plant that normally grows downwards into the soil. It is branched, the branching being endogenous i.e., developing from the deeper pericycle. It is not distinguished into nodes and internodes and does not bear leaves and flowers.

Root performs two major functions-absorption of water and minerals from the soil and fixation of the plant in the soil.

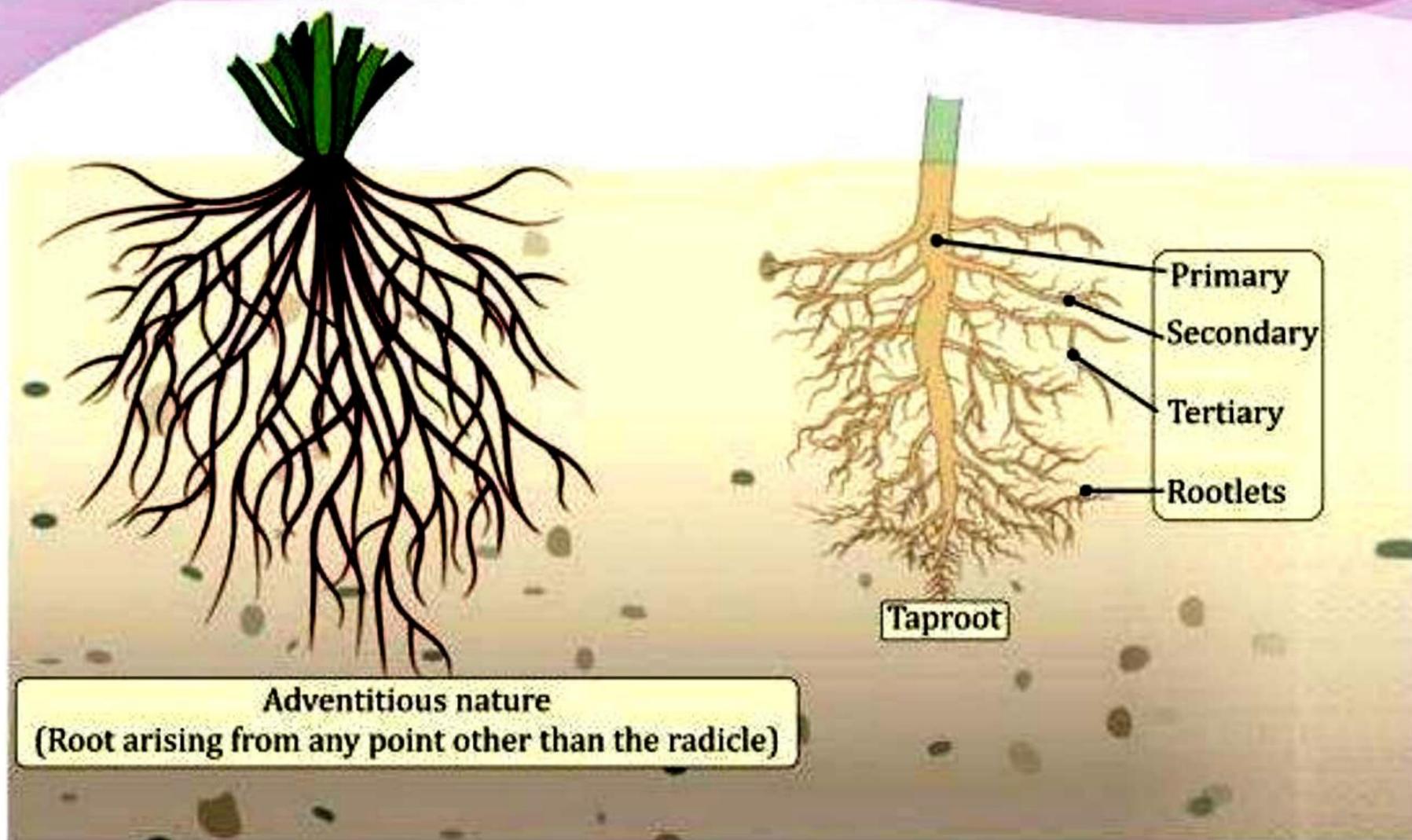
REQUIREMENTS

Fresh specimen of the roots of Petunia or Brassica, or Solanum (Mako) or any dicot herbaceous plant, roots of wheat, rice, grass or any monocot herbaceous plant.

PROCEDURE

1. Dug out a small herbaceous plant from the soil.
2. Wash the root system of the plant, gently under running tap water.
3. Observe the specimen carefully and note down its characteristics or salient features.
4. Draw the specimen on the practical notebook. Mention clearly only the parts actually visible in the specimen.
5. Write down the morphological features of the specimen.
6. Kinds of Root Systems

The roots along with their branches constitute the root systems. There are two main kinds of root systems, the tap root system and the adventitious root system.



OBSERVATIONS AND COMMENTS

Identification

1. ROOT OF BRASSICA

Tap root system of Brassica

Comments

- (i) It develops from the radicle. The radicle grows to form the primary or the tap root.
- (ii) It continues growing actively producing lateral branches, the secondary roots.
- (iii) The latter further branch producing tertiary roots. The tertiary roots may further branch and rebranch producing finer roots, the root-lets.
- (iv) The tap root with its branches of various orders constitutes the tap root system.

The primary root is conspicuous, being larger and stouter than all other roots of the system. It is thick at the base and tapers gradually towards the apex. Tap roots are characteristic of most of the dicot plants.

2. ADVENTITIOUS ROOT SYSTEM OF GRASS

Comments

- (i) Adventitious roots develop from any part of the plant other than the radicle.
- (ii) In many plants, especially the monocotyledons, the primary taproot ceases to grow and does not become the main or the primary root of the plant.
- (iii) It is replaced by the development of a large number of equally prominent roots from the base of the stem. Such roots are called adventitious roots.
- (iv) Along with their branches, they form a thick cluster and constitute adventitious root system. Adventitious roots may also develop from the nodes or internodes of the stems and their branches or even from the leaves as in Bryophyllum (vern. patharchat).
- (v) A cluster of slender, adventitious roots along with the branches is called the fibrous root system.

E- MORPHOLOGY OF HERBACEOUS AND WOODY STEMS

PRINCIPLE

Stem is usually an above-ground, aerial, erect, ascending axis of the plant body which develops from the plumule and epicotyl of the embryo of a germinating seed.

It is distinguished into nodes and internodes. It bears the similar axes, the branches, and the dissimilar appendages, the leaves. The main stem and its branches grow by terminal (apical) buds. The nodes bear the leaves, each having an axillary bud. The branches develop from buds and are exogenous in origin. The stem along with its leafy branches constitutes the shoot system of the plant.

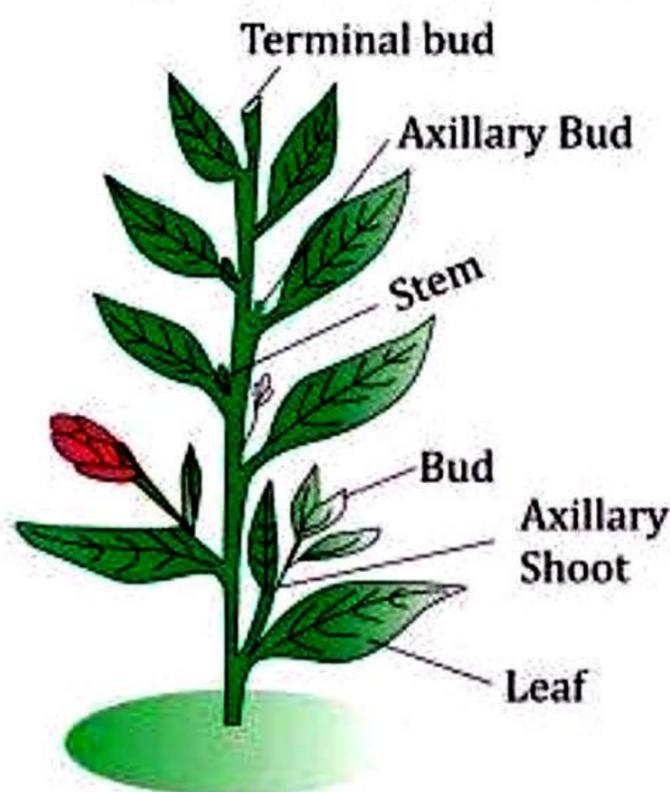
REQUIREMENTS

Fresh specimens or charts of Brassica, or Petunia/Rose/Cotton/Banyan/Peepal/Mango

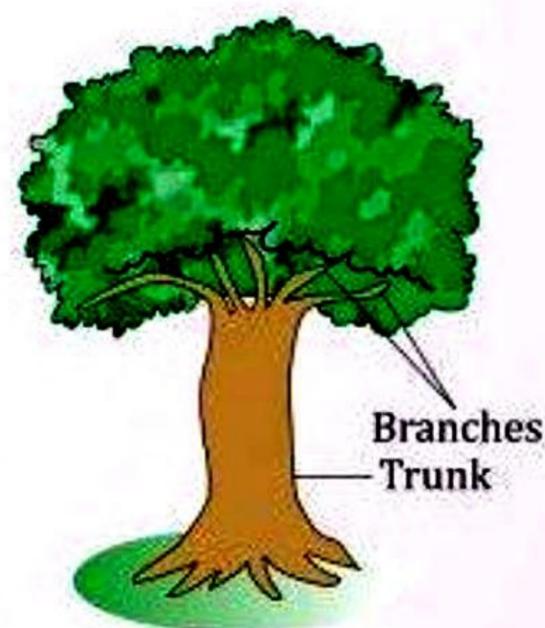
PROCEDURE

1. Observe the specimen carefully and note down its characteristics or salient features.
2. Draw the specimen on the practical notebook. Mention clearly only the parts actually visible in the specimen.
3. Write down the morphological features of the specimen.

Depending upon the size, nature of the stems and duration or lifespan, the plants are classified into three main categories : the herbs, shrubs, and trees.



Shrub of Rose plant



Tree of Banyan

OBSERVATIONS AND COMMENTS

Identification :

1. SHOOT OF SOLANUM (Vern. Mako)

Comments

- (i) It is the above ground part of the plant called shoot system.
- (ii) It is made-up of stem, its branches, leaves, flowers and fruits.
- (iii) It possesses swollen areas or nodes, part of stem between two adjacent nodes is called internode.
- (iv) This is a small plant with soft and pliable stems which do not attain longer heights.
- (v) It is annual plant.

2. SHRUB OF ROSE

Comments

- (i) They are medium-sized plants.
- (ii) They have stems which are herbaceous above and woody below.
- (iii) Many stem branches of almost equal size arise from near the base of plant.
- (iv) There is no main trunk and the plants give a bushy appearance.
- (v) They are mostly perennial.

3. TREE OF BANYAN

Comments

- (i) They are larger than shrubs and live for many years i.e, perennial.
- (ii) A tree possesses a main stout stem called the trunk.
- (iii) The trunk and its branches are woody.
- (iv) In most of the trees, the trunk remains unbranched for some distance above the ground level and then bears the branches.

F- MORPHOLOGY OF LEAF, IT'S ARRANGEMENT, SHAPES, VENATION, SIMPLE AND COMPOUND LEAVES

PRINCIPLE

The leaves are green, flattened, thin, lateral, exogenous appendages borne at the nodes of the stems. They are mostly stalked, of limited growth and bear axillary buds. They are the chief photosynthetic organs of the plant. Collectively they constitute the foliage of the plant. They are always borne in an acropetal manner on the stem or its branches.

REQUIREMENTS

Preferably fresh or preserved specimen of the leaves of peepal, shoeflower, jamun, calotropis, nerium, zizyphus, castor, canna, fan palm, bamboo, cassia, rose, acacia, moringa, coriander, bael, marsilea.

PROCEDURE

1. Observe the specimen carefully and note down its characteristics or salient features.
2. Draw the specimen on the practical notebook. Mention clearly only the parts actually visible in the specimen.
3. Write down the morphological features of the specimen.

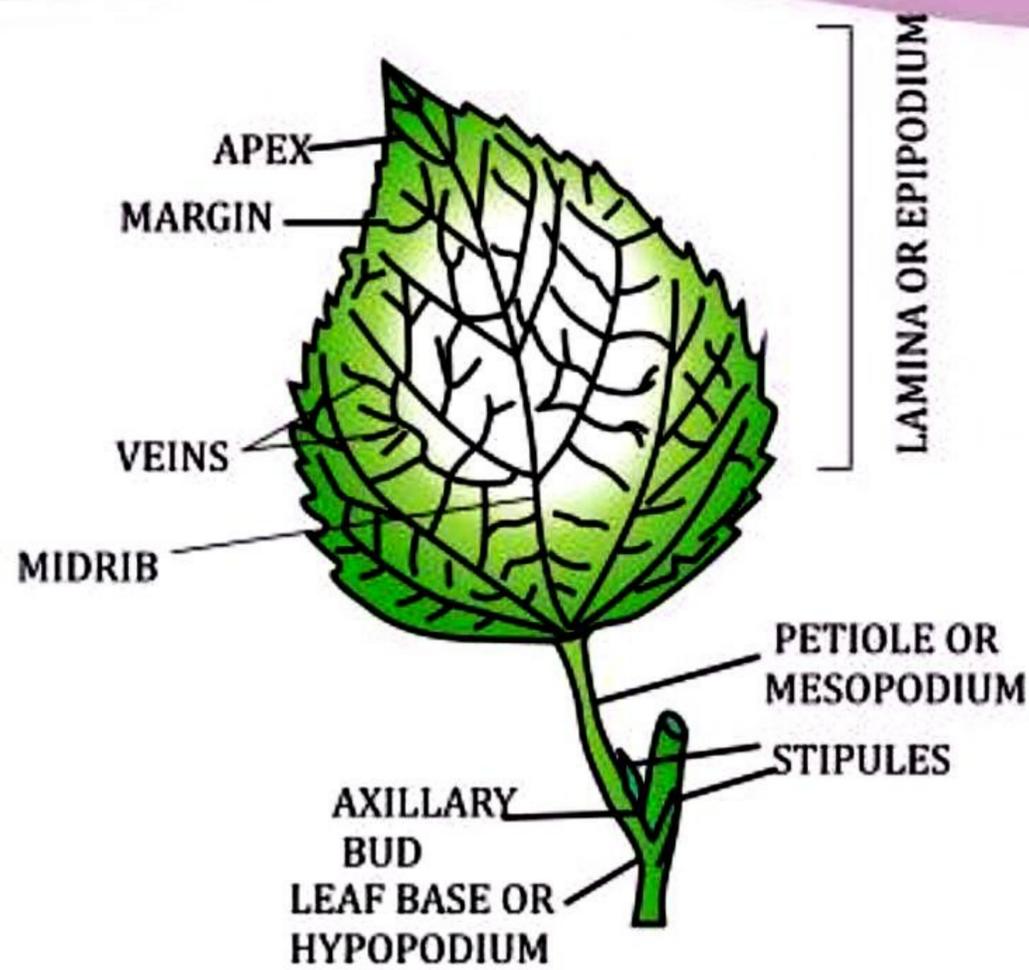
PARTS OF A LEAF

A typical foliage leaf is differentiated into three parts namely (i) leaf base (ii) petiole and (iii) lamina (leaf blade).

- (a) **Leaf base (vagina or hypopodium)** : It is the basal part of leaf by which it is attached to the node of the stem or its branches. In many plants, it is not demarcated from the petiole. In some plants e.g., legumes, it becomes distinctly swollen and forms a broadened cushion-like structure, the pulvinus. In most of the monocotyledons e.g., grasses, the broadened leaf base of sessile leaves clasps and forms a sheath-like structure around the stem at the node. Such a leaf base is called sheathing leaf base.

In several dicotyledonous plants, the leaf base bears a pair of small, scale-like, lateral appendages or outgrowths called the stipules.

- (b) **Petiole** : It is the stalk of the leaf. It is normally cylindrical and is attached to the base of the lamina. It is a stout structure which raises the lamina above the stem to expose it to the sunlight for photosynthesis. In some plants, the leaves do not have a petiole and such leaves are called as sessile.



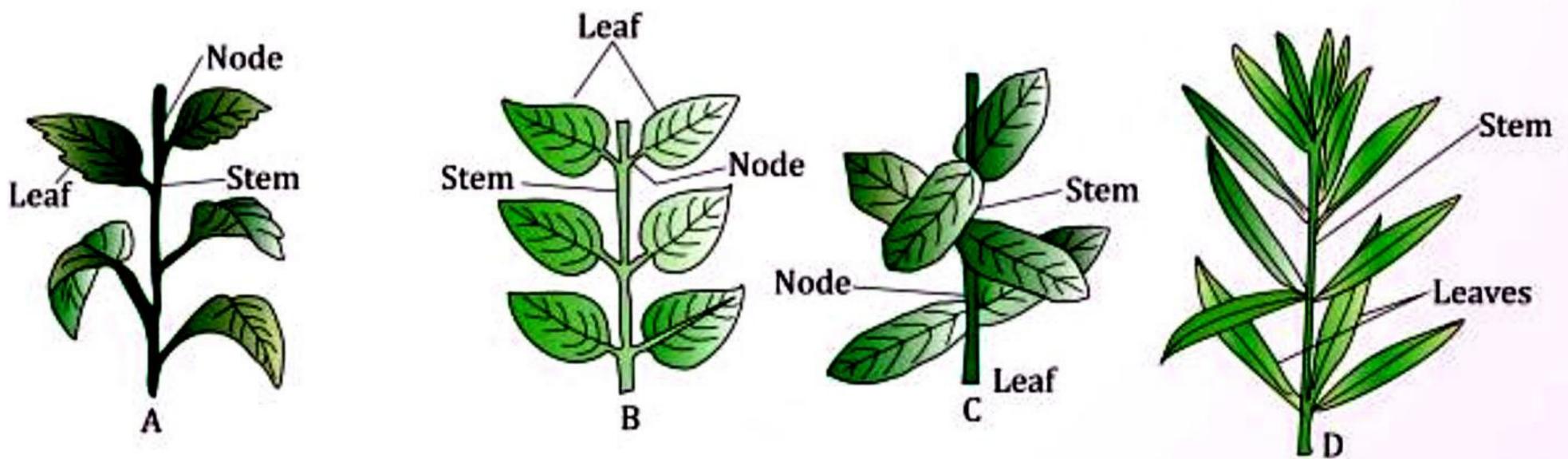
(c) **Lamina (leaf blade)** : It is the thin, flat, expanded and most conspicuous part of the leaf. It is green in colour and thus the main seat of photosynthesis. It also helps in the exchange gases.

The lamina is traversed and strengthened by a large number of veins and veinlets.

LEAF ARRANGEMENT

(Phyllotaxy or Phyllotaxis)

Phyllotaxy is the mode of arrangement or distribution of leaves on the stem and its branches in such a way that they receive maximum sunlight to perform photosynthesis. Phyllotaxy is of three main types :



(a) **Alternate or Spiral** : In alternate phyllotaxy, a single leaf is borne at a node e.g., *Hibiscus rosasinensis* (shoe flower, *Rosa*, *Ficus religiosa* (vern. peepal), etc. They are usually arranged spirally around the stem.

(b) **Opposite** : In opposite phyllotaxy, two leaves are borne opposite to each other at a node.

It is of two types,

(i) It is termed as opposite superposed when the pairs of leaves at the successive nodes are borne in the same plane, e.g., *Quisqualis* (rangoon creeper), *Eugenia jambolana* (black berry, vern. Jamun).

(ii) The phyllotaxy is said to be opposite decussate when the pairs of leaves at successive nodes are

placed at right angle to each other. Here the leaves are found to be arranged in four vertical rows, e.g. in *Calotropis* (madar vern. Ak, *Ocimum* (sacred basil, vern. Tulsi), *Zinnia*, etc.

- (c) **Whorled or Verticillate** : In whorled or verticillate phyllotaxy, more than two leaves are borne at a node. They are arranged in a circle or a whorl. Such an arrangement is called whorled or verticillate e.g., *Nerium* (oleandar, vern. Kaner), *Alstonia* (devil tree), *Galium*, etc.

SHAPE OR OUTLINE OF LAMINA

1. **Acicular** : Needle-shaped; long narrow and cylindrical, e.g., *Pinus*.
2. **Cylindrical** : Like a cylinder but thick, may be pointed anteriorly, e.g., *Onion*.
3. **Linear** : Long narrow and flat like a ribbon with more or less parallel margins, e.g., *Grasses*.
4. **Lanceolate** : Like a lance; tapering towards base and apex but more gradually towards the apical end, e.g., *Eucalyptus*, *Oleander*,
5. **Oblanceolate** : Lanceolate but tapering more towards the base.
6. **Oval or Elliptical** : Like lanceolate but shorter and broader (egg shaped), e.g., *Carissa* (vern. Karanda), *Guava*, *Jamun*.
7. **Ovate** : Rounded at base and tapering towards the apex, e.g., *Ocimum*, *Shoe Flower*, *Banyan*.
8. **Spatulate**: (Spathulate) Like a spatula or thumb, rounded at apex and narrow towards the base, e.g., *Calendula*.
9. **Cuneate** : Wedge-shaped, e.g., *Pistia* (vern. Chhoti Kumbi).
10. **Deltoid** : Triangular, e.g., *Populus deitoides*.
11. **Hastate** : Arrowhead shaped with two basal lobes pointing outwardly, e.g., *Convolvulus arvensis*.
12. **Sagittate** : Arrowhead shaped but with the lobes pointed downwardly, e.g., *Sagittaria*.
13. **Lyrate**: Pinnatifid or pinnatipartite with terminal lobes large and rounded, and lateral lobes progressively smaller towards the base e.g., *Radish*, *Mustard*.
14. **Runcinate** : Pinnatifid or pinnatipartite lamina with terminal large pointed lobe and the smaller lobes pointed towards the base, e.g., *Launaea*, lower leaves of *Sonchus*.
15. **Oblique** : The two halves of the leafblade unequal, e.g., *Dalbergia*, leaflets of *Neem* (*Azadirachta*).
16. **Falcate** : Leaf blade flat and narrow, sickle-shaped, e.g., *Eucalyptus*, phyllodes of *Acacia*. Sometimes two terms are used to describe the shape of lamina, e.g., ovate-lanceolate (leaflets of *Rose*).

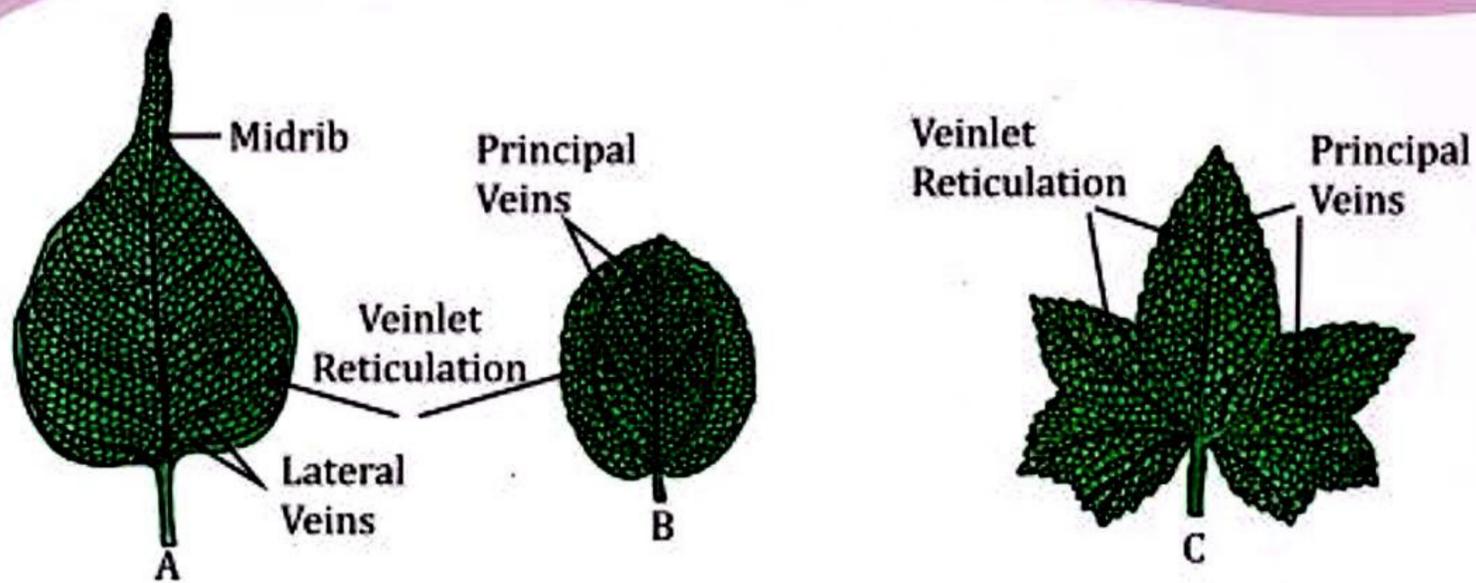
VENATION

The mode of distribution or arrangement of veins in the lamina (leaf-blade) is called venation. The veins help in the conduction and impart rigidity and firmness to the lamina to maintain its shape. The angiosperm leaves show two principal types of venation : reticulate and parallel.

1. RETICULATE VENATION

It is characteristic of dicot leaves (exception *Calophyllum*). In this type, the lamina bears the main vein (midrib) or veins arising from the tip of the petiole. They give rise to lateral branches, the veins which traverse the entire lamina. These veins branch and rebranch into finer veinlets that form a reticulum or network all over the leaf. Depending upon the number of main veins, reticulate venation is of following two types :

- (a) **Unicostate reticulate venation** : The lamina has a single prominent vein or midrib running from the base to the apex, e.g., *Ficus religiosa* (vern. Peepal, *Mangifera indica* (mango), etc. This type of venation is also called pinnate reticulate venation.
- (b) **Multicostate reticulate venation** : The lamina has more than one equally prominent veins running through its entire length. This type of venation also called as palmate reticulate venation. It is of two types multicostate reticulate convergent and multicostate reticulate divergent.



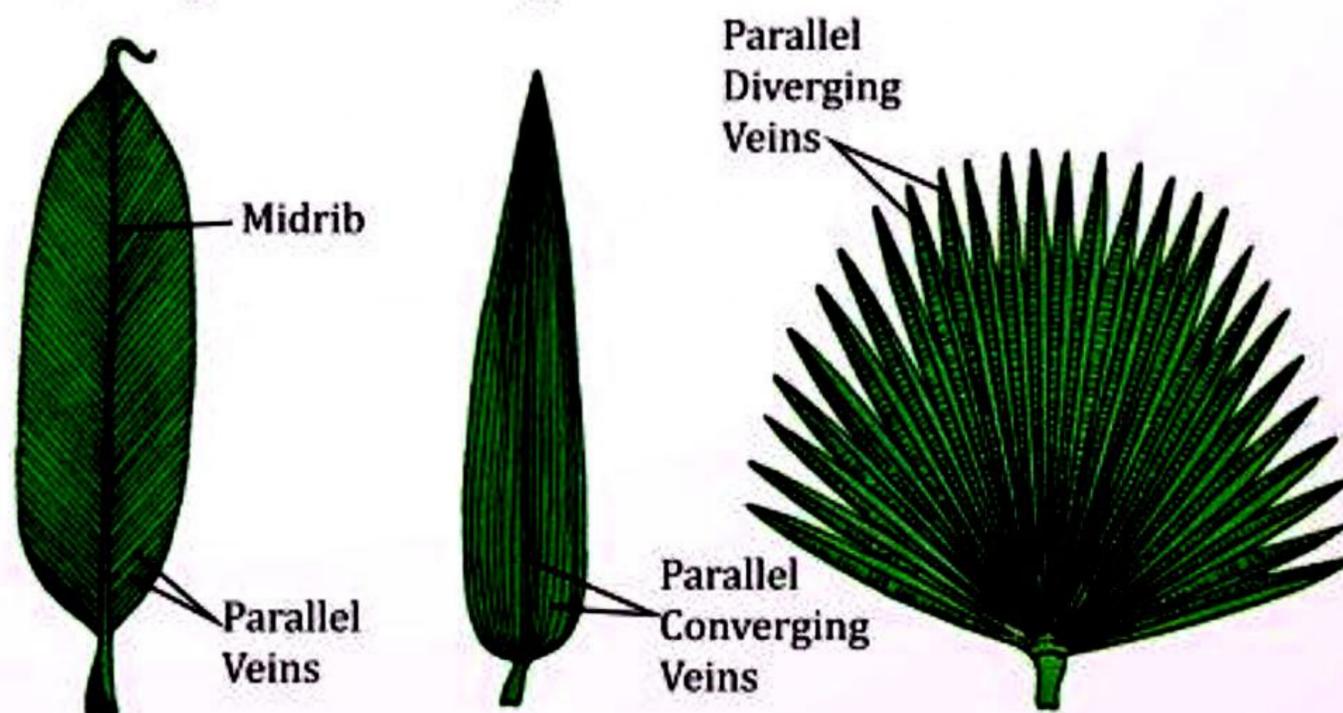
- (i) In multicostate reticulate convergent venation (*Zizyphus*, vern. Beri, *Smilax*, vern. Tejpat), the main veins converge towards the apex of the leaf blade or lamina.
- (ii) In multicostate reticulate divergent venation (*Ricinus communis*, castor, vern. Arind) *Carica papaya*, papaw, vern. Papeeta; *Luffa*, *Vitis*), the main veins diverge as they proceed upwards from the tip of the petiole towards the margin.

2. PARALLEL VENATION

It is a characteristic of monocot leaves. In this type, the veins arising from the midrib or the main veins tend to run parallel to each other towards the margin or apex of the lamina. They do not form a network.

Depending upon the number of main-veins, the parallel venation is of following two types :

- (a) **Unicostate parallel venation** : The lamina has a single prominent vein or midrib running from the tip of the petiole to the apex of the leaf. It gives off lateral veins. The latter runs parallel towards the margin of the lamina and do not fuse to form network, e.g. *Canna*, *Musa paradisiaca*, etc.. This type of venation is also called pinnate parallel venation.
- (b) **Multicostate parallel venation** : The lamina has numerous equally prominent veins arising from the tip of the petiole and running parallel towards the leaf apex or lamina margin. They do not branch. This type of venation is also called palmate parallel venation. It is of two types multicostate parallel convergent and multicostate parallel divergent venation.
 - (i) In multicostate parallel convergent venation the parallel running equally prominent veins converge towards the leaf-apex (grass ; bamboo).
 - (ii) In multicostate parallel divergent venation, the parallel running equally prominent veins gradually diverge towards the margin of the lamina.

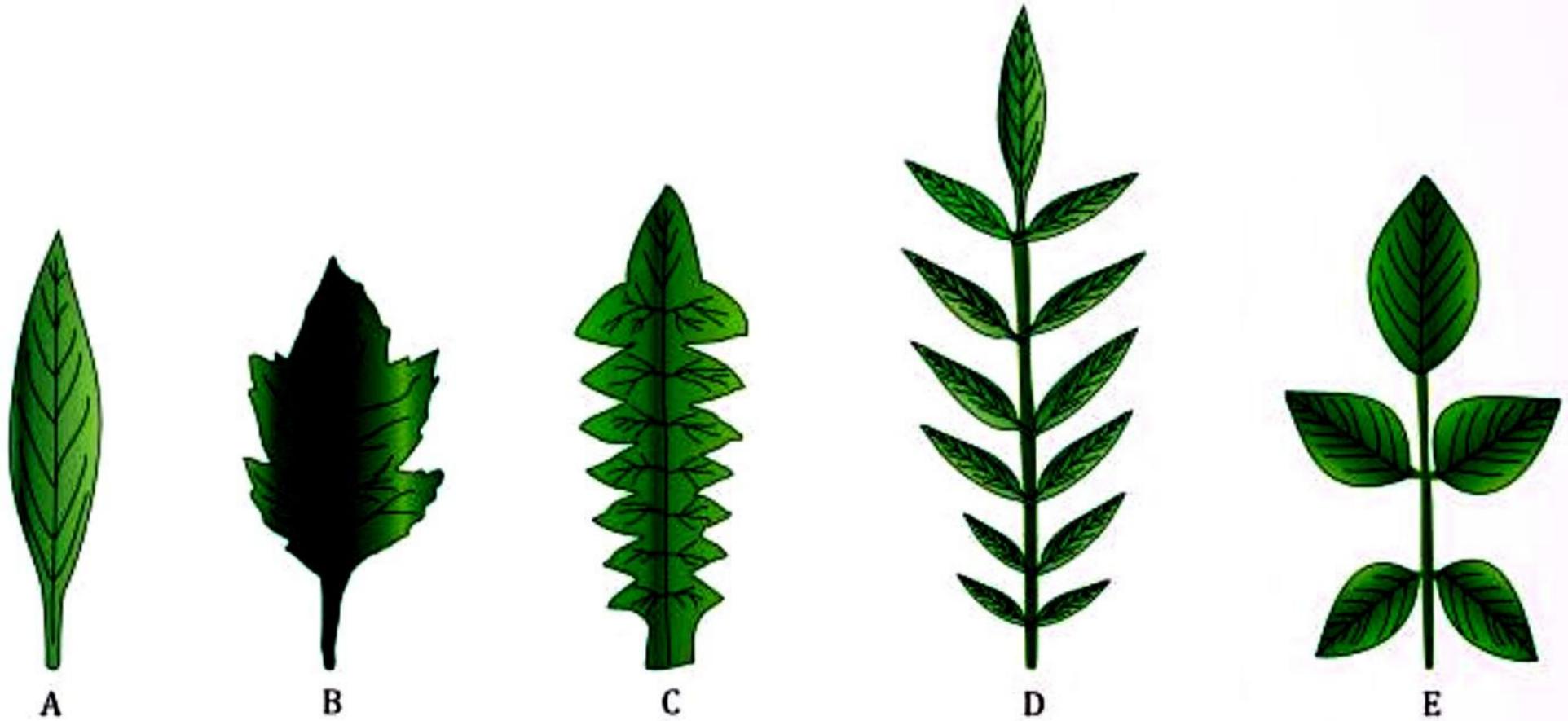


SIMPLE AND COMPOUND LEAVES

Depending upon the incisions of the lamina, the leaves are of two kinds - simple and compound.

1. SIMPLE LEAVES

A leaf having a single leaf blade is called simple leaf. The margins of the lamina of such leaves may be entire or deeply incised to various depths. The incisions never divide the lamina into distinct leaflets. e.g. *Ficus religiosa*, *Luffa*, *Ricinus communis*, *Cannabis*, *Tagetes*, *Mango* etc.



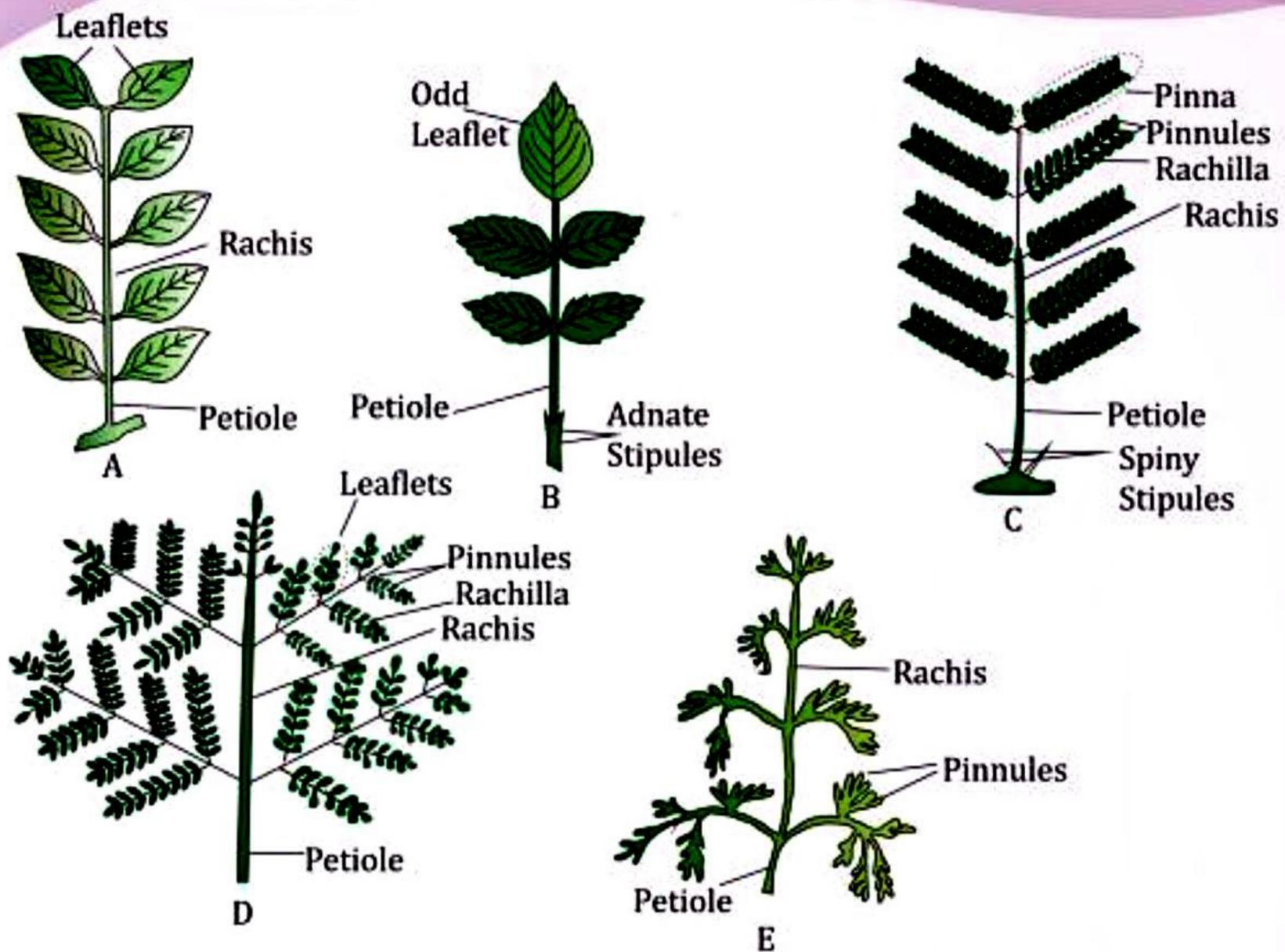
Incisions of leaf blade

The degree of incisions varies in different plants. In pinnately-veined (unicostate) leaves, the incisions proceed from the margin to the midrib while in palmately-veined (multicostate) leaves these proceed from the margin to the tip of the petiole. The incisions of the lamina may be fid (less than half way) Partite (more than halfway and sect (almost reach the midrib or tip of petiole).

2. COMPOUND LEAVES

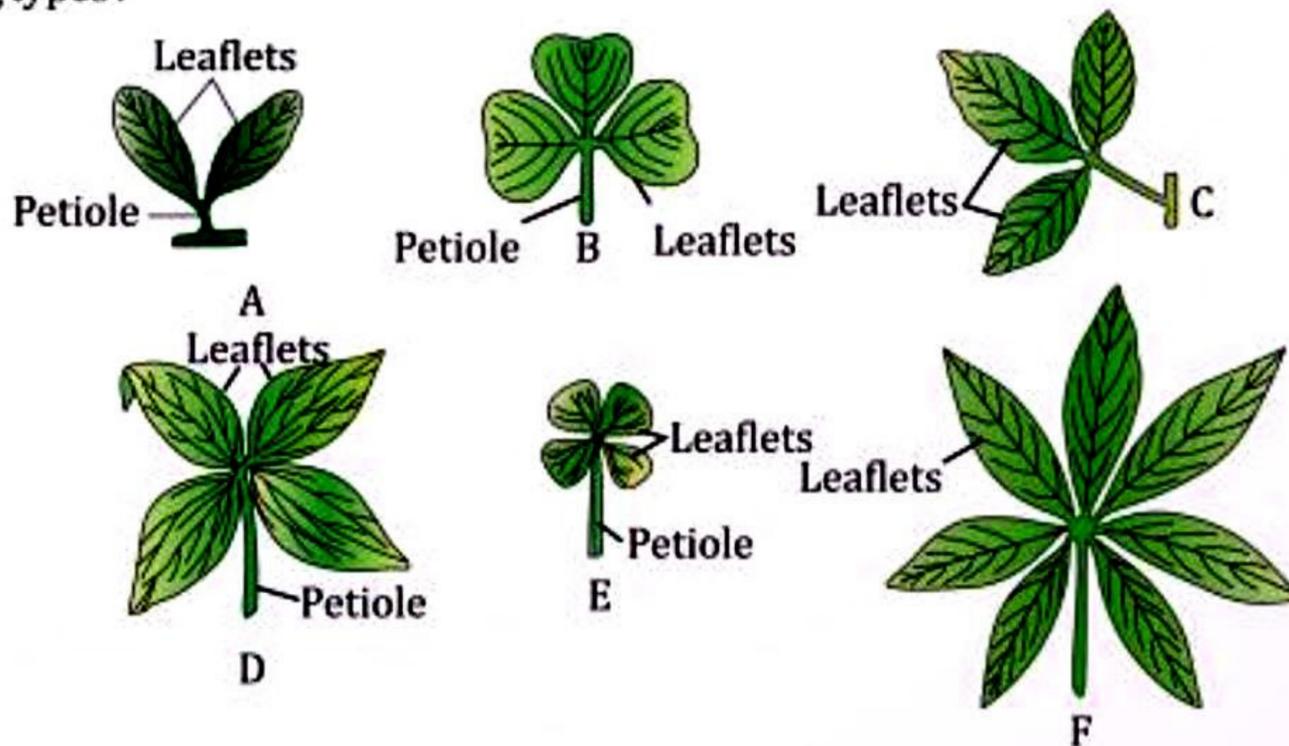
A leaf is said to be compound when its lamina is completely divided into distinct segments or leaflets. In such leaves the leaflets are distinct free from one another and articulated (joined) to the rachis (midrib) or the tip of the petiole. The leaflets, are known as pinnae. They are easily distinguishable by the absence of axillary buds. The compound leaves are of two types :

- (i) **Pinnate compound leaves** : In pinnate compound leaves, the leaflets are borne on an unbranched or branched axis, the rachis (a derivative of midrib). The branches of the rachis are called the rachillae, and the leaflets borne on them are called as pinnules.
- (ii) **Bipinnate** : The lamina is divided twice pinnately. Here, the rachis bears branches of the first order, the rachillae. The leaflets (pinnules) are borne on these primary branches (rachillae). *Acacia*, *Albizzia*, etc.
- (iii) **Tripinnate** : The lamina is thrice pinnate. Here the rachis is branched twice. The leaflets (pinnules) are borne on the branches of the second order. *Moringa* (vern. Soanjana), and *Melia azedarach* (vern. Dharek), etc.
- (iv) **Decompound** : The lamina is more than thrice pinnate. The rachis is branched more than twice. The pinnules are borne on the branches of the final or ultimate order. *Daucus carota* (carrot), *Foeniculum* (fennel), *Coriandrum* (coriander), etc.



3. PALMATE COMPOUND LEAVES

In a palmate compound leaf, the leaflets are borne terminally on the tip of petiole like the fingers of the palm. The palmate compound leaves are classified on the basis of the number of the leaflets. They are of following types :

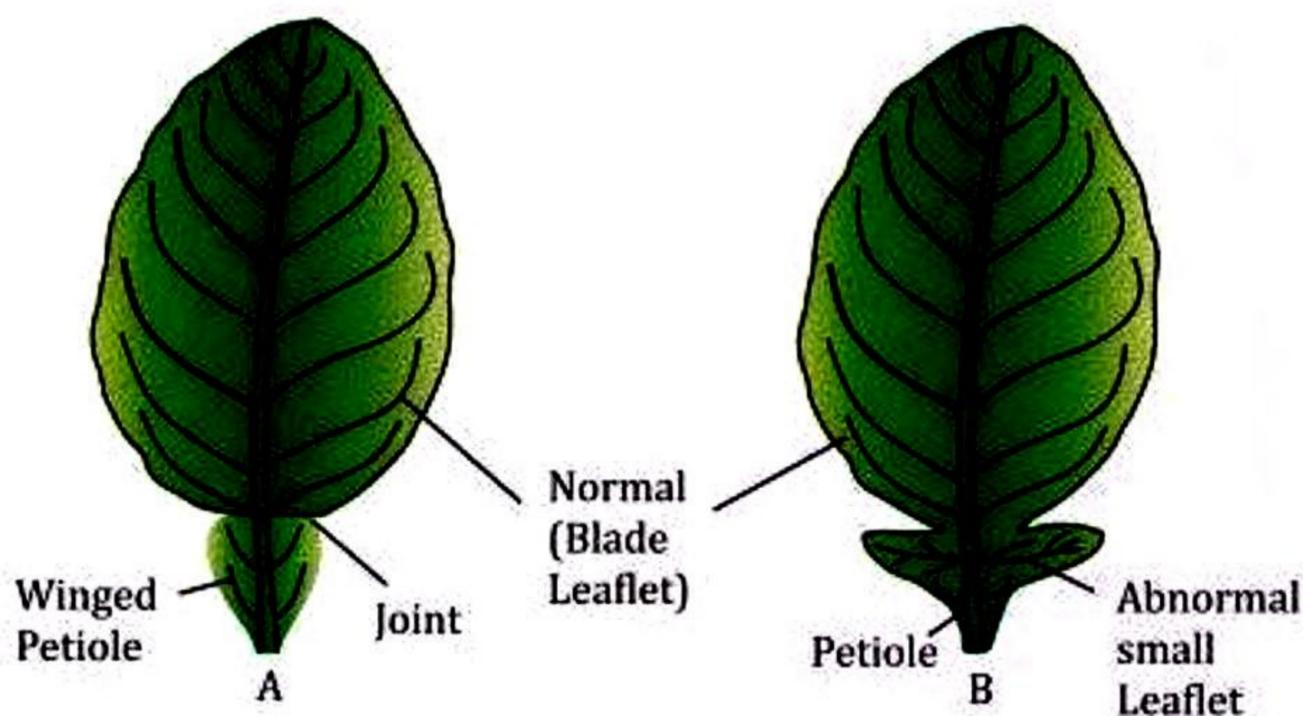


- (i) Multifoliate or digitate (five or more leaflets, present at the tip of petiole), e.g., Bombax (Red Silk Cotton, vern. Simbal), Cleome;
- (ii) Quadrifoliate or quadrate (four leaflets attached to tip of petiole), e.g., Paris quadrifolia; Marsilea also seems to have quadrifoliate leaves, although in reality its leaves are pinnately divided;
- (iii) Trifoliate or ternate (three leaflets, e.g., Aegle marmelos (Wood Apple, vern. Bael), Butea (Dhak), Oxalis;

(iv) Bifoliolate or binate (two leaflets, attached side by side at the tip of petiole), e.g., Balanites, Hardwickia;

(v) Unifoliolate (a single leaflets separated from the petiole by a constriction), e.g., Citrus.

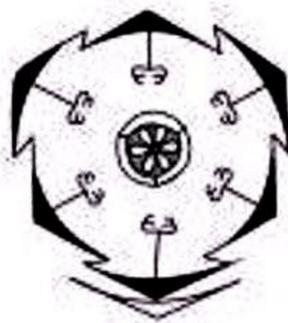
The leaf of a citrus appears to be a simple leaf with an undivided lamina and winged petiole. However, it has a joint or constriction between the lamina and the petiole of the leaf. The close relatives of Citrus possess trifoliolate leaves (Aegle marmelos,). Even in citrus many abnormal leaves bear two small leaflets just on the sides of the normal blade. This clearly shows that the leaf of Citrus is, in reality, a palmate compound leaf where the two lateral leaflets have been suppressed and only the central leaflet (the normal blade) is functional. Such a palmate compound leaf, with one functional leaflet, is called unifoliolate compound leaf.



VIVA VOCE

Q1. Draw the floral diagram and write the floral formula from the below given description of a flower. Bisexual, actinomorphic, hypogynous, sepals 5, gamosepalous, petals 5, free, imbricate aestivation, stamens 6, arranged in 2 whorls, superior ovary, trilocular and axile placentation.

Ans. The above given characters or features are of family-Liliaceae (Asphodelus tenuifolius). The floral diagram of Asphodelus can be given as follows:



Floral formula: $Br \oplus \text{A} \overline{\text{P}}_{(3+3)} \text{A}_{3+3} \underline{\text{G}}_{(3)}$

Q2. In which type of placentation would the ovary be always unilocular?

Ans. In free central placentation, ovary contains only one chamber (unilocular) and the placenta bears ovule that arises from the central axis, e.g. Dianthus.

Q3. If a flower is epigynous, what is the position of its floral parts?

Ans. In an epigynous flower, the innermost whorl, e.g. gynoecium is covered by the elongated margins of

thalamus. The other floral parts are borne at the top of the fused thalamus and ovary. The ovary is inferior, e.g. apple.

Q4. Which part of the fruit is equivalent to the ovule of the ovary?

Ans. Seeds are equivalent to the ovule of the ovary.

Q5. When is the ovary said to be superior?

Ans. When the gynoecium or ovary develops at the top and the stamens, petals and sepals are borne successively below it, the ovary is said to be superior and this condition is called hypogynous condition, e.g. Brassica.

Q6. What is the difference between apocarpous and syncarpous ovary?

Ans. Apocarpous ovary has more than one and free carpels, e.g. lotus and rose, while syncarpous ovary has more than one and fused carpels, e.g. China rose and tomato.

Q7. When is the phyllotaxy said to be whorled?

Ans. Phyllotaxy is the arrangement of leaves on stem. When the number of leaves arises from a node, it is called whorled.

Q8. What are the essential and non-essential whorls of a flower?

Ans. Androecium and gynoecium are the essential whorls of the flower, while calyx and corolla are non-essential whorls of the flower.