

**Laboratory Manual of Biology**  
**for B.Sc. Medical Science Students**



# **Laboratory Manual of Biology**

## **for B.Sc. Medical Science Students**

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*Dedicated  
to  
Our Parents*



## CODE OF CONDUCT FOR STUDENTS

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- Students must follow all verbal and written instructions carefully. If you are unsure of the procedure, ask your teacher for help before proceeding.
- The use of personal audio or video equipment is prohibited in the laboratory.
- Students must not eat, drink, apply cosmetics or chew gum in the laboratory
- Students must report any incident (including all spills, breakages or other releases of hazardous material) to the instructor immediately; no matter how insignificant it may appear. They should report all injuries such as cuts, burns or other signs of physical harm.
- Do not run in the laboratory and always tie your hair while working in the lab.
- Do not engage in practical jokes or boisterous conduct in the laboratory
- Always wear a lab coat while working in the laboratory.
- Always Keep your working area neat and clean, free of any unnecessary objects such as your bags or others.
- Wash your hands thoroughly after participating in any laboratory activities.
- Keep your hands always away from your face, eyes, mouth and body while using chemicals.
- Properly dispose of broken glassware and other sharp objects (e.g., syringes, needles, blades, etc) immediately in the designed containers.
- Never pour chemical waste into sink drains or wastebaskets. And do not block the them with debris

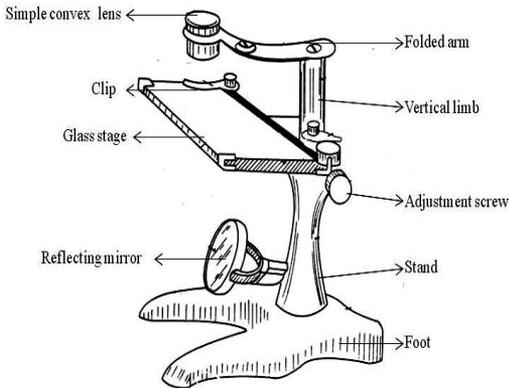
- Thoroughly clean your laboratory work space at the end of laboratory session.

## MICROSCOPY

### 1. Detail of Dissecting Microscope

A dissecting microscope consists of the following parts:

1. **Base:** It is usually bifurcated or U-shaped stand that rests on surface over which other parts of the microscope are supported.
2. **Stand:** It is a short vaulted cylindrical rod fixed at one end to the base. It is used for grasping the microscope.
3. **Vertical limb:** It is also a short, cylindrical rod that fits into the hollow tube of stand and can be shifted up and down with the help of adjustment screw.
4. **Folded arm:** It is a horizontal flat arm adhered to the end of the vertical limb. At the other end of the folded arm, a lens is fitted. The arm can be shifted up and down with the help vertical limb for focusing an object. This arm can also be moved sideways. It supports all components above the base.
5. **Stage:** It is usually a rectangular glass plate adhered to the upper end of the stand. It is used to keep the slide or the object to be seen. Two clips are also fitted on the stage. Clips help to hold the slide in position. It is near to objective lens.
6. **Mirror:** A concave reflecting mirror is usually attached to the lower end of the stand. It is used of reflecting light rays on the stage.



**Dissecting Microscope**

## 2. Detail of Compound Microscope

### A. Mechanical Parts

1. **Base:** It is usually a horse-shoe shaped or u-shaped structure and provides a stable support for the microscope.
2. **Pillar:** It is small vertical projection from the base.
3. **Arm:** It is usually curved and used for handling the microscope; it supports the body tube and coarse adjustment.
4. **Inclination Joint:** At this joint, the arm is attached to the pillar. The microscope can be tilted at this joint.
5. **Stage:** It is usually a rectangular plate attached to the lower end of the arm. It is used for placing an object to be magnified. It has a hole in the Centre for the light rays to pass.
6. **Clips:** There are two clips attached to the stage which are used for holding the slide on its correct position.
7. **Diaphragm (Condenser):** It is attached to the base of the stage and regulates the amount of light enters, into the microscope. Normally, it is of two types: **disc-diaphragm**, and **iris-diaphragm**.
8. **Body tube:** It is a tubular hollow part attached to the upper part of the arm. It can be moved up and down with the help of screws. It carries two lens objectives at the upper side and eyepiece at the lower side.
9. **Nose piece:** It is circular metallic structure attached below the body tube. Different objective lenses of different powers can be fitted into it.
10. **Coarse adjustment screw.** It is larger sized screw used for precise focusing of the object. By moving this body tube can be moved up and down.
11. **Fine adjustment screw:** It is a smaller-sized screw used for perfect focusing of the image.

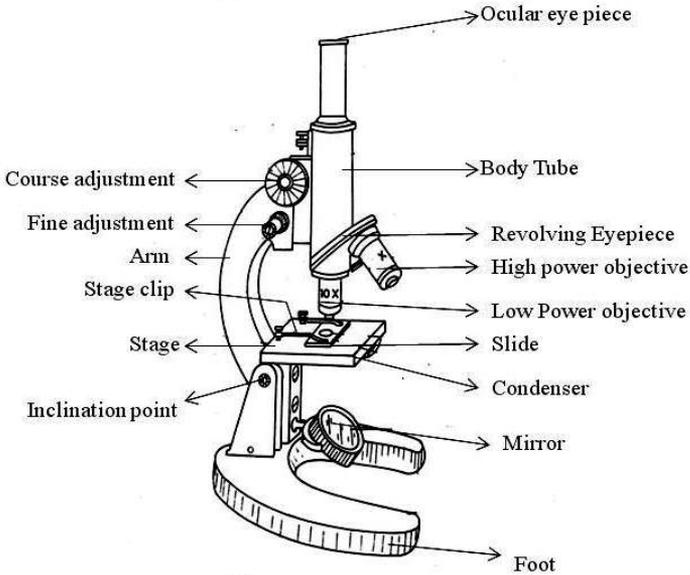
### B. Optical parts

A compound microscope is used for magnifying very small objects to study histological details. It has the following optical parts:

1. **Mirror:** It is attached to the lower end of the arm. It is used for reflecting light rays into the microscope. Its plane surface is used

to direct the light over the object seen under the low power and concave surface is used to focus the light seen under the high power.

- 2. Objective lens:** They are attached to the nose piece. Usually, two objective lenses are seen with magnifications 10X, (low power); and 45X (high power). A provision for third objective lens is also seen in the nose piece (when present it is of 100X).
- 3. Eyepiece lens or ocular:** It is a lens fitted at the top of body tube through which the magnified image of the object is seen. It is of magnification 10X or 5X.



**Compound Microscope**

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## ABOUT THE BOOK

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This lab manual covers a synopsis of plant anatomy, physiology, taxonomy as well as animal kingdom and its classification, suitable for B.Sc. students studying botany and zoology. The manual comprises of plant propagation methods, plant anatomy study and plant physiology study by various processes. It comprises of characteristic features of specimen of non-chordates and Chordates. The book also consists of experiments related to Economic botany and zoology for students to learn about the subject. It also emphasizes the microscopic study of live and preserved specimens. The experimental parts related to preparing temporary mounts are presented in a simple way with discussion on all subjects. The experiments are written and designed keeping in view the ease of availability of resources and reproducibility by students. The manual discusses all subjects of botany and zoology and will be very helpful for under graduate students in learning and understanding subjects. This laboratory manual is designed for B.Sc. Biology students. It includes various aspects of botany and zoology to give a comprehensive detail to students. This manual will help them to get the detail of methods used for plant propagation, floral description and economical uses of various plants. Animal system classification with various temporary mounts study give a brief account regarding animal system to students.

## ABOUT THE AUTHORS

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# **SECTION-A: BOTANY**

**UNIT-1**

**Plant Propagation**

**UNIT-2**

**Plant Anatomy**

**UNIT-3**

**Plant Physiology**

**UNIT-4**

**Plant Taxonomy**

**UNIT-5**

**Economical Botany**

**UNIT-6**

**Temporary Peel Mounts**



# Unit-1

## PLANT PROPAGATION

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### PLANT PROPAGATION BY SEXUAL METHODS

#### AIM 1: TO STUDY STRUCTURE OF MONOCOT AND DICOT SEED.

##### Material required

Seed of monocot and dicot, hand lens.

##### Theory

**Seed:** A seed is the fertilized ovule and made up of a seed coat, embryo and endosperm. The embryo has epicotyle, hypocotyle and one (as in wheat, maize) or two cotyledons (as in gram and pea). The seeds which store their food in endosperm are called endospermic seed or albuminous seed e.g., maize and rice. The seeds which store their food in cotyledons (endosperm absent) are called non-endospermic or ex-albuminous e.g., bean, gram etc. Seeds remain in dormancy until better environmental conditions arise.

##### Seed Structure: External and Internal Structure

###### External feat

- (a) **Seed coat:** Seed coat is the outermost covering of a seed and it has two layers, the outer one is **testa** and the inner one is **tegmen**.
- (b) **Hilum:** The hilum is a scar on the seed coat through which the developing seed was attached to funiculus.

###### Internal features

- (a) Embryo have embryonic axis (Epicotyl and Hypocotyl) and Cotyledons

- (b) **Embryo:** The embryo forms the new plant once the favorable conditions are present.
- (c) **Cotyledon:** The cotyledon is the seed leaves, attached to the embryonic axis. There may be one (Monocotyledons), or two (Dicotyledons). The cotyledons are also the source of nutrients in the non-endospermic dicotyledons, in this case they replace the endosperm, and are thick and leathery. In endospermic seeds, the cotyledons are thin and papery.
- (d) **Epicotyl:** The embryonic axis above the point of attachment of the cotyledon(s) is known as Epicotyle.
- (e) **Hypocotyl:** The embryonic axis below the point of attachment of the cotyledon(s), connecting the epicotyle and the radicle, being the stem-root transition zone.
- (f) **Plumule:** The tip of the epicotyl, and has a feathery appearance due to the presence of young leaf primordia at the apex, and will become the shoot upon germination is known as Plumule.
- (g) **Radicle:** The basal tip of the hypocotyl which give rise to the primary root is known as radicle.

### **Observations**

#### **(A) Structure of Monocotyledon seed: e.g., *Zea mays* (Maize seed)**

Maize is monocotyledonous and endospermic.

- (i) **Seed coat:** Seed coat is fused with the ovary wall. So, seed of *Zea mays* is known as grain. It is not differentiated into testa and tegmen.
- (ii) **Endosperm:** It comprises the major part of grain and is filled with reserve food.

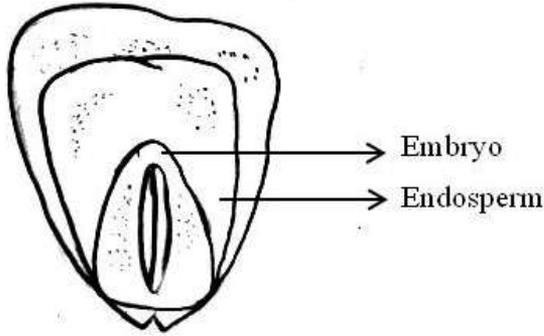
It is composed of two regions:

(a) Outer single layered aleurone layer mainly made up of aleurone proteins.

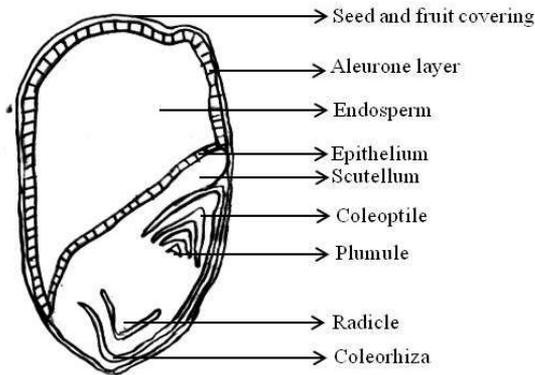
(b) Inner starchy endosperm. It is separated from embryo by a layer called epithelium.

- (iii) **Embryo:** The embryo is small and lateral in position. It consists of one large and shield shaped cotyledon known as scutellum and a short axis with a plumule and a radicle. Scutellum is separated from the endosperm by the epithelial layer which helps in digestion and absorption of food material stored in endosperm. The plumule

and radical are enclosed in sheaths which are called coleoptile and coleorhiza respectively.



The entire seed of *Zea maize*

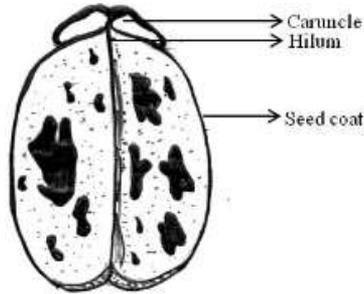


L.S of Monocotyledon seed: e.g., *Zea maize*

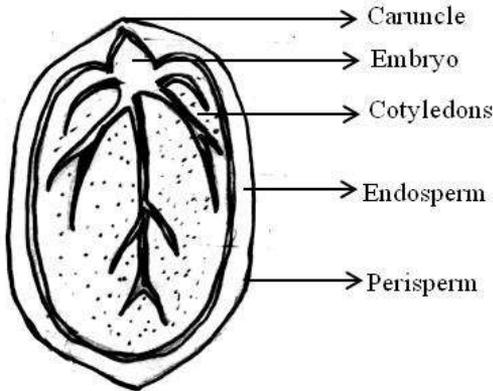
## (B) Structure of Dicotyledonous seed

### 1. Dicotyledonous albuminous seed: e.g., *Ricinus communis* (Castor seed)

Castor seed is dicot, endospermic seed. A castor seed is roughly oblong (egg type shape) in outline with distinct convex (dorsal) and flat (ventral) surfaces. A castor seed has following parts.



The entire seed



L.S of albuminous seed: e.g castor seed

- (i) **Seed coat:** It is made up of testa and tegmen. Testa is the outer layer of seed coat that is thick, hard and brittle. The external surface of the seed is smooth, shining and mottled (spots or patches with different shades or colors) brown in colour. **Raphae** is represented by a shallow ridge present on the flat surface of testa. The distinct bifurcation of raphae represents chalaza. **Tegmen** is the inner layer of seed coat that appears dull and papery. Persistent nucellus is present as perisperm.
- (ii) **Caruncle:** It is a white spongy bilobed outgrowth present near the narrow end of the seed. A small pore known as **micropyle** is completely covers by the caruncle. **Hilum** (dark scar) present near

the micropyle is partially covered by Caruncle. Caruncle absorbs water which percolates through the micropyle into the seed.

- (iii) **Endosperm:** It is a white oily food storage tissue that is present inner to the tegmen. From this layer castor oil of commerce is extracted.
- (iv) **Embryo:** Embryo lies in the centre of endosperm. It consists of a radicle, a plumule and two lateral cotyledons, all of which are present on a short embryo axis. The cotyledons are thin, semi-transparent and oval in outline. Radicle lies outside the cotyledons towards the micropylar end. It is a knob-like outgrowth. Plumule lies in between the two cotyledons and is quite indistinct. Epicotyl is also indistinct. In between the place of origin of the two cotyledons and the radicle is present a short hypocotyl. Thus, Castor-oil seed is **dicotyledonous** (having two cotyledons), **endospermic** (with a special food storing tissue called endosperm) and **perispermic** (having perisperm or persistent nucellus).

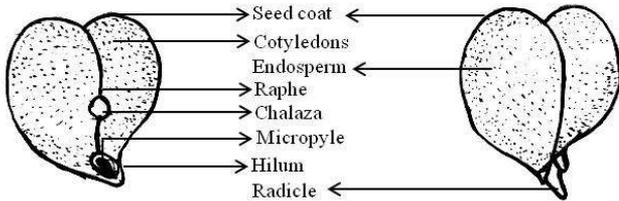
## 2. Dicotyledonous exalbuminous seeds: e.g., Gram seed (*Cicer arietinum*)

Gram seed is a dicot, non-endospermic seed. The seeds are produced within the pods or leguminous fruits.

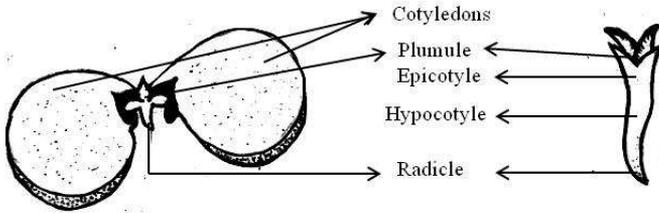
It has following parts:

- (i) **Seed Coat:** It consists of two layers-outer **testa** and inner **tegmen**. Testa is thick and brownish. The tegmen is thin, membranous, and whitish and remains fused with testa. The **pointed beak** like end of the seed has a minute pore called **micropyle**. If a soaked seed is gently pressed, a drop of water oozes out of the micropyle. A **small oval scar seen** near the micropyle is called **hilum** through which the seed was attached to fruit. A shallow ridge present on the testa of the seed is known as Raphae. The distinct bifurcation of raphae represents chalaza.
- (ii) **Embryo:** It presents inner to seed coat. It consists of **two circular yellowish cotyledons** that are attached to the **embryo axis**. The part of embryo axis above the point of attachment to the cotyledons is called epicotyle. The tip of epicotyle is called **plumule**. Similarly, the region of the embryo axis below the point of attachment of cotyledons is called the **hypocotyle**. The tip of hypocotyle is called

**radicle.** During germination, the radicle comes out first through the micropyle and grows to form a tap root. The plumule gives rise to shoot system.



**The entire seed**



**Embryo with unfolded cotyledons and axis of embryo**

**Structure of ex-albuminous seeds: e.g., Gram Seed  
(*Cicer arietinum*)**

## AIM 2: TO STUDY METHODS OF SEED GERMINATION

### Material required

Seed of monocot and dicot, water, soil

### Theory

The dormant embryo in the seed when provided with favorable conditions such as proper temperature and moisture, the embryo starts germinating and develop into small seedling. The process by which dormant embryo come out of the seed coat and established itself as a seedling is called germination. The embryo utilized the food material stored in the cotyledons or in the endosperm when it is present. Most seeds germinate by either of two methods:

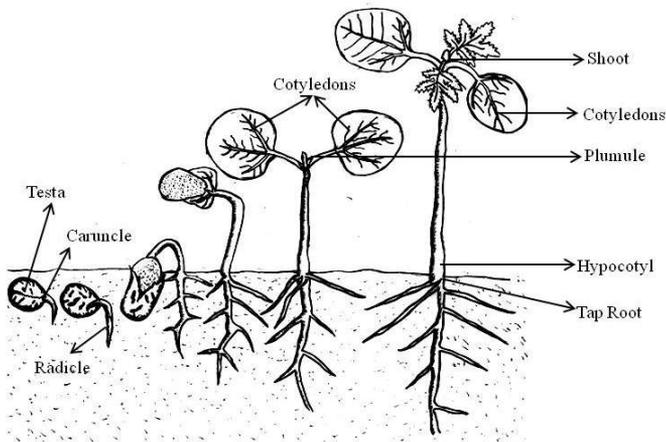
1. Epigeal germination-Cotyledons come out above the earth during germination.
2. Hypogeal germination- Cotyledons remain inside the earth during germination.

### Procedure

Take a pot filled with soil and sow the seed of given material in it. Observe the process of germination.

### Observations

1. **Epigeal germination in Dicot seed:** In epigeal germination, the cotyledons come out above the soil due to rapid elongation of the HYPOCOTYLE (portion of embryonic axis lies below the cotyledons). Germination of this kind is known as epigeal or epigeous (epi-upon, geal-earth). In most of such cases, cotyledons are flat, green and form the first green leaves which make food for the growing seedling. e.g bean, whereas when the cotyledons are very thick, they don't turn leafy and gradually shrivel up and fall off. e.g castor

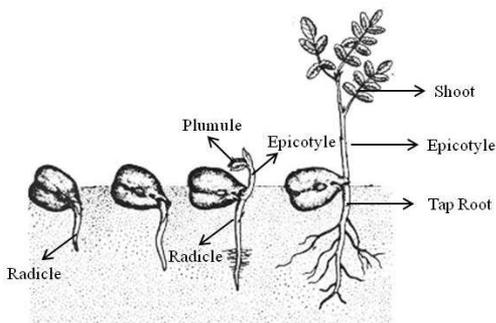


Epigeal germination in dicot castor seed

### 2. Hypogeal germination:

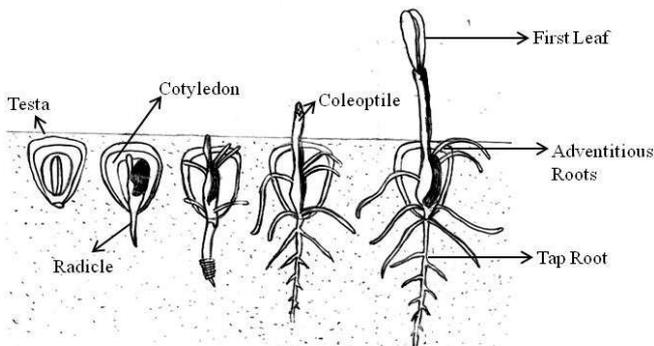
- (a) **Hypogeal germination in dicot seed:** In this type of germination, the cotyledons remain inside the ground and the epicotyl (portion

of embryonic axis lies above the cotyledons) elongates, pushed the plumule upwards above the earth. Germination of this kind is known as hypogeal or hypogeous (hypo-below, geal-earth). e.g. gram. The cotyledons don't turn green but gradually dry off.



### Hypogeal germination in dicot gram seed

- (b) Hypogeal germination in Monocotyledonous seed:** Monocotyledons seeds generally showed hypogeal germination (except in case of onion). They are mostly albuminous seeds and utilized the stored food present in the cotyledons during germination. On absorption of water and the seed get swells up, the radicle pierces through the protective sheath coleorhizae (collar-like structure) and grows downwards to form the primary root. The primary root soon perishes and a cluster of fibrous roots appears from the base. The plumule pierces through the protective sheath coleoptile and grows straight to form the shoot system. The plumule form the first leaf and further grow as stem.



### Hypogeal germination in monocot maize seed

## Precautions

1. Water the seeds regularly with minimum water.
2. Do not sow the seed too deep in the soil.
3. Observe the seed regularly to find each stage of germination.

## AIM 3: TO STUDY VARIOUS METHODS OF SEED SOWING IN PLANT.

### Material required

Clean earthenware seed pan, soil mixture (Garden soil, leaf mould, farm yard manure (cow-dung manure) and sand), crock pieces, fibrous material (husk or coconut cover), garden implements like khurpi watering cane, seeds to be sown.

### Theory

Seeds pan which have height of 4-6 and a diameter of 14 inches at the top are generally used to grow seedling. Seeds pan with 1-3 drainage holes are filled with fertile soil mixture. Soil provides proper nutrients for high growth to seedling and for fighting against the soil borne diseases as seedling was observed to be very prone to soil borne diseases. Seeds are sown by different methods depending upon the size of seeds.

### Methods

1. **Formation of drainage system:** Drainage systems is prepared by covering the drainage hole with crock pieces in overlapping manure and then add fibrous material and spread a handful of sand over it. Drainage system prevents the soil from getting washed down through drainage hole and help in maintain air and moisture condition at the base of the pot which is required for plant growth.
2. **Preparation of soil mixture:** Soil mixture is prepared by mixing equal amount of garden soil and leaf mould with handful of sand. The mixture is properly mixed and moist and placed in the pot.
3. **Seed sowing:** Depending upon the size of seeds, seeds are sown by three methods:
  - (a) **Broad-casting:** When the size of the seeds is very small i.e. mustards, khus-khus etc., seeds are mixed with 5-6 times the volume of sand and broad-casting or sprinkled over the surface of the soil.
  - (b) **Drilling:** If the seeds are slightly big in size or medium sized seeds e.g. fennel, carrot etc. are sown by this method. Furrows

are made with the help of fingers at a distance of 2-3 cms and 1-1/2 cm deep. The seeds are sprinkled and sow uniformly inside the furrow and covered with soil.

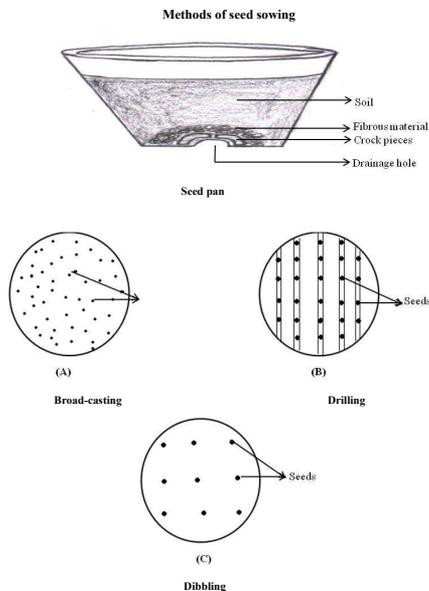
(c) **Dibbling:** When the size of the seeds is very large e.g. gram, rajma etc. They are sown individually in hole which are made at equidistance. The size of the hole should be the double the size of the seeds. The seeds are sown singly in hole, covered with the prepared soil.

4. **Watering and mulching:** Light watering is done with water cane. A layer of mulch is spread over the seed pan and pan is placed at the shaded place.

Remove the mulch layer on the fourth day after germination of seeds and expose the seed pan to sunlight.

**Precautions**

1. The soil should be properly moist (neither too wet nor too dry)
2. Only certified should be used
3. Over-crowding of seeds should be avoided
4. Do not forget to remove the mulch layer after germination of seeds.



**Plant Propagation by Asexual Methods**

◆  
**PLANT PROPAGATION BY NATURAL ASEXUAL METHODS.**

**AIM 4: TO STUDY PLANT PROPAGATION BY NATURAL METHODS-  
BULB, TUBER, RHIZOME AND CORM.**

**Material required**

Knife, plant material to be propagated, loamy soil (garden soil, leaf mould, cow dung manure, sand, brick powder) water can, khurpi, and clean earthenware.

**Theory**

Regeneration of new plants from the vegetative parts of the parent plant is called natural method of asexual propagation or vegetative propagation or reproduction. It is done with the help of vegetative parts such as roots, stem or leaves. It is of different types based on the vegetative organ involved such as stem, leaf, roots etc.

**Vegetative Propagation by Stem**

Stem has nodes and internodes. In the axils of the leaf's, axillary buds arise. On detachment from the parent plant or even when they are attached to parental plant, these buds can develop into new plants. There are different types of stems for vegetative propagation. They are:

**Underground Stem**

Rhizomes, Tuber, Bulb, Corm

**Subaerial Stems modification**

Runners, Suckers, Stolen, off-sets

**Procedure**

Propagate the plant by using different vegetative structure (tuber, corm, rhizome). Fill the clean earthenware with drainage system (upto 1/6 portion of earthenware) and with the prepared loamy soil (in the remaining part). One inch should be left without filling in the earthenware from the above for watering. Place the plant portion such as an eye in case of potato in the centre of pot and covered it with soil. Initially light irrigation is given with water cane.

**Observations**

**1. Asexual means of propagation through underground Stem**

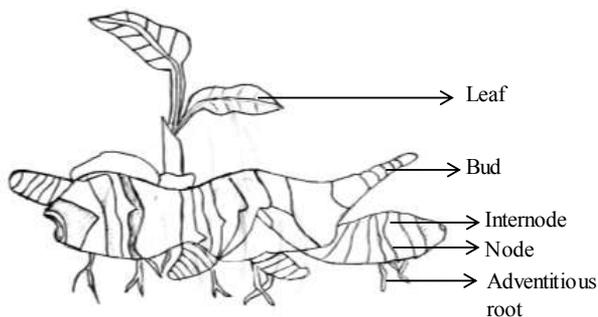
Underground stem has the ability to form the complete plant through its axillary bud. The axillary bud remains dormant and on

return of favorable condition it can change to complete plant. The underground stems may be variously modified into the following kinds:

**(a) Rhizomes**

- A rhizome is a thick, underground, horizontally growing prostrate stem which usually stores food material.
- It has nodes and internodes, scale leaves, axillary buds, adventitious roots and a terminal bud. It has scaly leaves at the node which enclosing the axillary buds at their axis.
- Some of the axillary buds develop into branches which grow upwards into the air and then produce normal green foliage leaves.
- Usually, the growing points of the rhizome continue to remain underground causing an elongation of the rhizome.
- Roots develop from the lower surface of the rhizome. e.g., Ginger, Turmeric.

**Propagation is by division:** Division of lateral branch, each having at least two lateral buds (axillary buds), are planted and new shoot develop from the nodal bud.



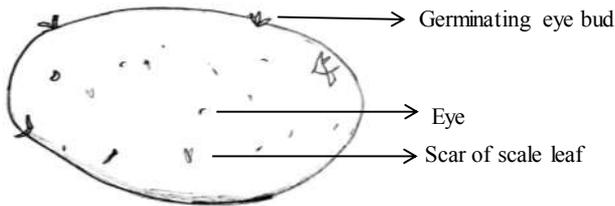
**Rhizome of Ginger**

**(b) Tuber**

- Tuber is a swollen end of an underground branch which arises from the axil of a lower leaf. These underground branches grow horizontally outwards in the soil.
- Each tuber is irregular in shape due to the deposition of food materials (starch).

- On the surface of each tuber many leaf scars are seen. These leaf scars are the impressions of fallen scale leaves.
- Each such leaf scar encloses an axillary bud. A leaf scar with an axillary bud is called an eye. e.g. potato

**Propagation by division:** Division of potato by knife, each piece contains an eye of potato. Each piece is capable of producing new plants by vegetative propagation.



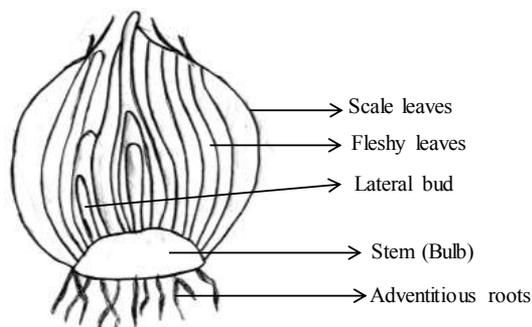
**Tuber of Potato**

### (c) Bulb

- Bulb is an underground modified shoot consisting of reduced stem (represented by a short disc), having number of scale leaves above and cluster of adventitious roots at the base.
- It can be terminal and adventitious in position.
- Growing point develop in the axis of scale leaves (axillary buds) to produced miniature bulbs or bublets While terminal buds give rise to arial shoot.
- Bulbs are of two types
  - (i) Tunicated:** In tunicated bulb, the concentric leaf bases form a complete covering or tunic. The inner leaves are fleshy while the outer ones are dry. e.g bulbs of garlic and onion etc.
  - (ii) Non tunicated:** Here, these bulbs don't not possess the enveloping covering. Scale leaves don't not form tunic, or complete covering. They are individually present. e.g.. Easter lily, Oriental lily.

**Propagation by separation of small bulbs and cutting:** The small bulb which arises in the axis of scaly leaves are separated from the mother bulb and planted separately; from this a completely new plant is formed.

Some Bulb which do not produced smaller bulbs are propagated by cutting out the growing tip and planting separately.

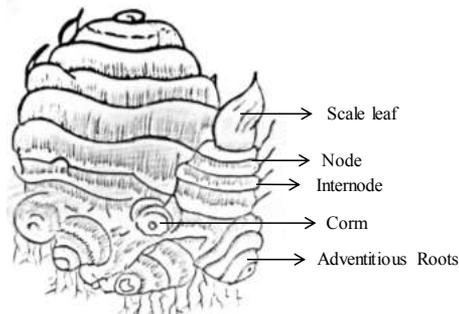


**Bulb of onion**

#### (d) Corm

- A corm is a greatly swollen underground basal portion of an erect stem enclosed by scale like leaves which bears axillary buds in their arises. The swelling is due to the storage of reserve food material.
- It has node, internodes terminal, axillary buds and roots.
- At the apex of corm, terminal bud is present and from which terminal shoot will arises.
- Axillary buds are produced at each node, if main shoot doesn't grow then, axillary develop into flowering shoot.
- The older corm begins to shriveled and disintegrated as its contents is depleted due to growth and developmental of aerial stalk and flower production.
- At the end of the growing season, the aerial part dies and with the return of favorable conditions usually one axillary bud (rarely more than one) near the apex develops into a new shoot utilizing the food reserve material in the old corm. The new plant produces a new corm at its base which on separation change to complete plant.

**Propagation by separation of new corm:** Several small corms develop from the base of large corm can grow independently after separation and form new plants.



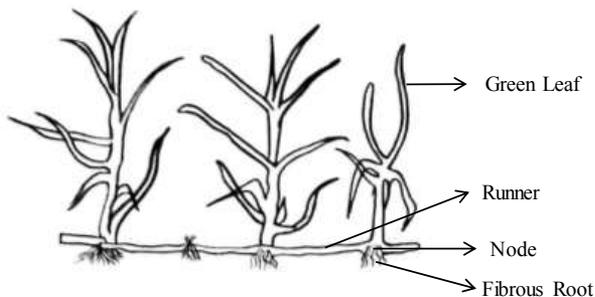
**Corm of Colocasia**

## 2. Propagation by Subaerial Stems modification:

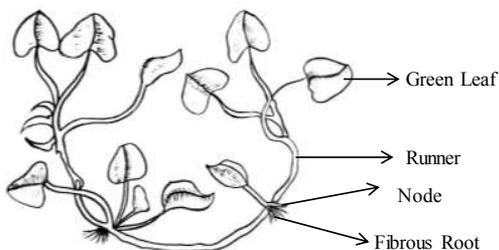
The branches of stem which is very close to the surface of the ground, on separation from the parent plant develop new plants. These branches are classified as follows:

### (a) Runners

- The runner arises from the base of the stem as a lateral branch and runs along the surface of the soil.
- It develops distinct nodes and long internodes.
- At any node, the runner produces roots below and leaves above from axillary buds.
- In this way many runners are often produced by the mother plant and they spread out on the ground on all sides. Runners break at places and each piece develops into an independent plant. e.g. strawberry, grass, oxalis etc.



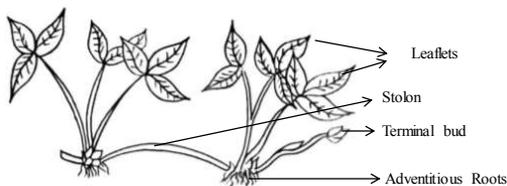
**Runner of Grass**



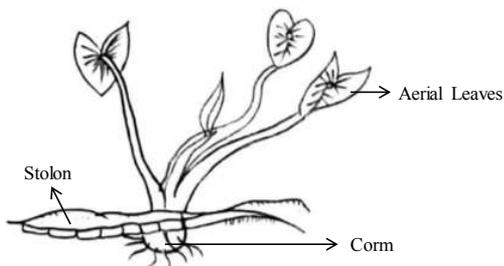
**Runner of *Centella asiatica***

**(b) Stolon**

- The stolon arises from the base of the stem as a lateral branch but did not runs along the surface of the soil.
- It develops distinct nodes and long internodes.
- It first grows obliquely above the ground and then bends down towards the ground to attached to the soil through the development of root at the node.
- The terminal bud changed to shoot and, in this way, a new plant will develop. e.g. strawberry and Colocasia.



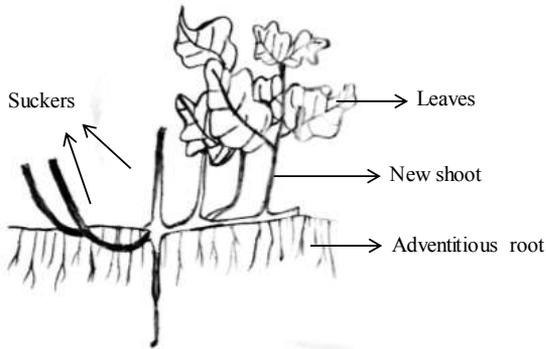
**Stolon of *strawberry***



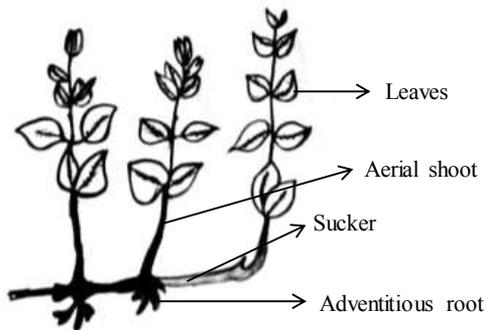
**Stolon of *Colocasia***

**(c) Suckers**

- Suckers are underground runners, modification of stem, root and both.
- A lateral branch arises in the axis of the leaf just below the surface of the ground, travel horizontally underground for some distance and then grow in upwards.
- Suckers are shorter than stolon.
- The stem sucker arises from the base of stem below the soil level.
- Root sucker usually growth from adventitious buds.
- All suckers grow at the expense of parent plant till they themselves develop roots and lead an independent existence. e.g. Sucker of *Chrysanthemum* and *Mentha*



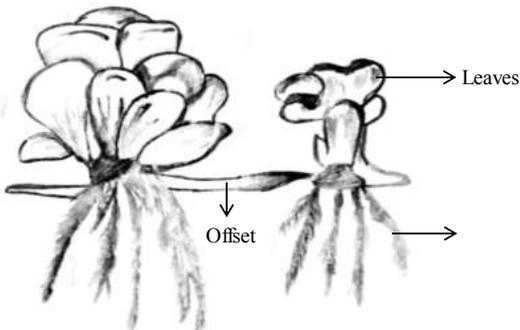
**Sucker of *Chrysanthemum***



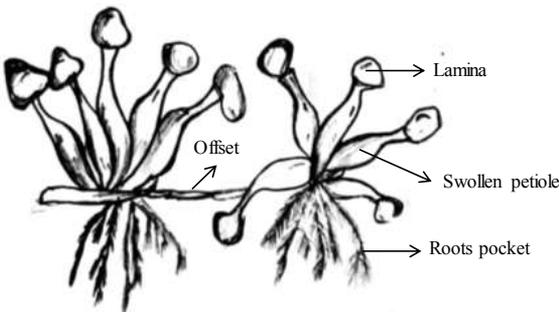
**Sucker of *Mentha***

**(d) Offset:**

- An offset is a short thick runner like branch which produces a new plant at its tip.
- They are modification of runner, in which a thick, prostrate growing lateral branch arises from the axis of lower branch get root at the node and bear a tuft of leaf.
- It is mostly found in aquatic plants with rosette leaved forms.
- The offsets grow in all directions from the main stem of the parent plant.
- The new plant is just one internode far from the parental plant
- On separation from parental plant, it forms an independent plant. e.g., *Pistia* (water lettuce), *Eichornia* (water hyacinth).



**Offset of *Pistia***



**Offset of *Eichornia***

## Precautions

1. The soil should be moist and loamy.
2. Remove the dead and disease branch before the propagation.
3. Separate the plant parts without damaging the roots.

## AIM 5: VEGETATIVE PROPAGATION OF PLANT BY UNDERGROUND LAYERING.

### Material required

A clean sharp knife, a pot containing light loam, a piece of brick or stone, root promoting growth substance, healthy plant to be propagated.

### Theory

layering is the process of vegetative propagation in which new plants are produced usually from the stem when it is still attached to the parental plant. In layering branch from one-year old plant is selected and an injury is given between two nodes. The injured portion is then covered with soil [loamy soil (clay, sand, and a significant organic matter) and peat moss] which induced the root formation. Mosses maintained the moisture, prevent fungal infections and induce root growth. After 6-8 weeks, the roots will arise from the injured portion. The layered portion of the branched starts growing and new branches will form from it due to the sprouting of buds. The layered portion is then cut away from the parent plant. On planting in soil, it established as a new plant.

**Physiology of layering:** Layering involves wound-mediated induction of adventitious root formation. When a cut is given in the stem (by removing the bark or by cutting the stem), the flow of cell sap, growth hormones and food gets interrupted at the injured portion. The collected sap at the injury point, initiate the formation of parenchymatous tissue known as callus. Auxin an important natural hormone generally induces root formation and moves through the phloem from the shoot tip to the roots. Auxin accumulates above the wound and induces the formation of roots. Light restriction to the injured portion by covering it with moss or soil often helpful in promoting the root formation. External application of auxin in small amount increase the rate of formation of layered plants.

**Time taken for root formation:** 6-8 weeks or depends upon the plant species

**Time for layering:** During raining seasons or just before the commencement of growing season.

### **Type of injury**

- (a) **Tongue cut:** Mostly given to plants with flexible stem and generally to monocot stem. A cut is given on the underside of branch between the nodes by passing the knife obliquely towards the tip.
- (b) **Ring bark cut:** Mostly given in plants with stiff stem and generally to dicot stem. In this case, two circular cuts are given below the node and they are joined by making a longitudinal cut. Then bark is peel off exposing the cambium and the wood (xylem).

**Type of layering:** 1) Underground layering 2) Air layering

- 1. **Underground layering:** Mostly given to plants with flexible stem. e.g. jasmine, mango. Mostly **tongue cut** is given to plants.
- 2. **Air layering/ Chinese layering:** Mostly done in case of plants which have stiff stem. e.g. citrus, guava, mulberry and ornamental plants like hibiscus. Mostly **ring bark cut** is given to plants.

### **Procedure and observations for underground layering**

- 1. One-year healthy branch is selected while still attached to the parent plant. A tongue cut of **1.5 cm or 1/2 inches long** is given below the nodes by passing the knife obliquely towards the tip on the underside of the branch.
- 2. The **diameter of cut should be 1/3 of the diameter** of stem and it should be **20-30 cm** below the tip of branch.
- 3. **Leaves** are removed from the stem **3-4 inches** above and below the injury point.
- 4. A **midrib is placed in the cut portion** in order to prevent the attachment of tongue to stem.
- 5. A pot containing light loam soil is brought near the branch. A hole is made in the centre of the pot, injured portion is placed in the hole and covered with soil.
- 6. A piece of **brick or stone** is placed over the soil to keep the branch in position. Light irrigation is given.
- 7. After a few weeks, when the layered portion shows signs of growth, it is separated from the parent plants by cutting below the portion

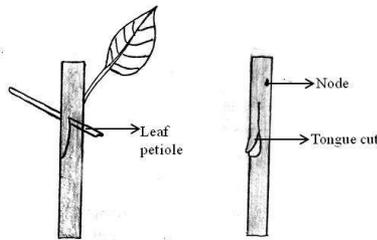
from where root arises. Thus, a new plant is produced through underground layering.

### Precautions

1. The soil should be just moist neither too dry nor too wet.
2. The cut made on the injury portion should not go beyond the diameter of the stem
3. Selected branched should be healthy and free of diseases
4. Leaves should be removed from the portion where the cut is to be made.
5. Choose plants with stems have enough flexibility to bend to the ground without damage
6. Keep the stem intact while giving the tongue or ring bark cut.

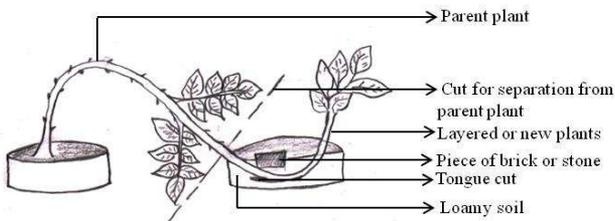
### Vegetative propagation of plant by layering

#### Type of injury



Tongue cut

#### Tongue cut



#### Underground layering in Jasmine

**AIM 6: VEGETATIVE PROPAGATION OF PLANT BY AIR LAYERING.****Material required**

A clean sharp knife, moss, polythene sheet, tape, root promoting growth substance, healthy plant to be propagated.

**Theory**

layering is the process of vegetative propagation in which new plants are produced usually from the stem when it is still attached to the parental plant. In layering branch from one-year old plant is selected and an injury is given between two nodes. The injured portion is then covered with soil [loamy soil (clay, sand, and a significant organic matter) and peat moss] which induced the root formation. Mosses maintained the moisture, prevent fungal infections and induce root growth. After 6-8 weeks, the roots will arise from the injured portion. The layered portion of the branched starts growing and new branches will form from it due to the sprouting of buds. The layered portion is then cut away from the parent plant. On planting in soil, it established as a new plant.

**Physiology of layering:** Layering involves wound-mediated induction of adventitious root formation. When a cut is given in the stem (by removing the bark or by cutting the stem), the flow of cell sap, growth hormones and food gets interrupted at the injured portion. The collected sap at the injury point, initiate the formation of parenchymatous tissue knows as callus. Auxin an important natural hormone generally induces root formation and moves through the phloem from the shoot tip to the roots. Auxin accumulates above the wound and induces the formation of roots. Light restriction to the injured portion by covering it with moss or soil often helpful in promoting the root formation. External application of auxin in small amount increases the rate of formation of layered plants.

**Time taken for root formation:** 6-8 weeks or depends upon the plant species

**Time for layering:** During raining seasons or just before the commencement of growing season.

**Type of injury**

- (a) **Tongue cut:** Mostly given to plants with flexible stem and generally to monocot stem. A cut is given on the underside of branch between the nodes by passing the knife obliquely towards the tip.

◆

(b) **Ring bark cut:** Mostly given in plants with stiff stem and generally to dicot stem. In this case, two circular cuts are given below the node and they are joined by making a longitudinal cut. Then bark is peel off exposing the cambium and the wood (xylem).

**Type of layering:** 1) Underground layering 2) Air layering

1. **Underground layering:** Mostly given to plants with flexible stem. e.g- jasmine, mango. Mostly **tongue cut** is given to plants.
2. **Air layering/ Chinese layering:** Mostly done in case of plants which have stiff stem. e.g. citrus, guava, mulberry and ornamental plants like hibiscus. Mostly **ring bark cut** is given to plants.

### Procedure and observations for Air layering

1. One-year healthy branch is selected and **about 1-1/2 inches long** 'ring bark cut' is given **below 20-30cm** away from the tip of branch.
2. **The 1<sup>st</sup> circular cut is given 1/2cm below the node and 2<sup>nd</sup> circular cut is given at 2.5 cm or 1-1/2 inches to the first cut** only in bark region, keeping the wood intact. Then **two circular cuts are joined by one longitudinal cut** in order to peel off the bark.
3. The exposed portion of cambium is covered with moist moss which is placed in a **polyethylene sheet**. Before putting the polythene moss, the polythene sheet (allow passage of gases and maintained moisture) is treated with some root promoting hormones such as auxin.
4. Sheet is tied tightly with the string from both the sides.
5. After 6-8 weeks when roots are visible from the polythene sheet, the sheet and moss is removed and the layered branched is cut away from the parent plant. The layered branch can now be planted separately either in the pot or in the ground.

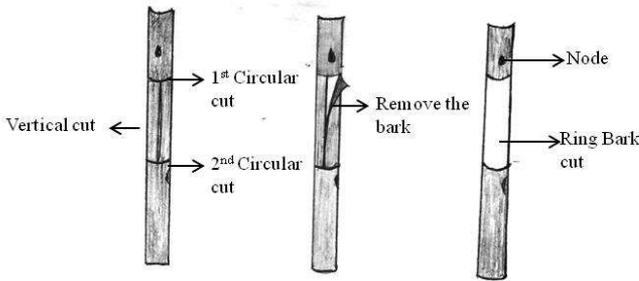
### Precautions

1. The cut made on the injury portion should not be too long or too short.
2. Selected branched should be healthy and free of diseases.

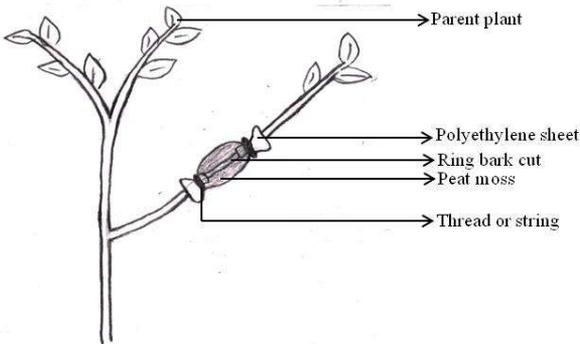
3. Leaves should be removed from the portion where the cut is to be made.
4. Stem section should be well covered with the moss or soil.
5. Keep the stem intact while giving the tongue or ring bark cut.

### Vegetative propagation of plant by layering

#### Type of injury



**Ring bark cut**



**Air layering in mulberry**

### AIM 7: VEGETATIVE PROPAGATION OF PLANTS BY STEM CUTTING

#### Material required

Suitable material (rose), secateur, root promoting growth hormone, fungicidal wax, digging spade, measuring tape and water cane.

## Theory

Stem cutting is a process in which a piece of branch/stem along with 4-5 vegetative dormant buds is capable for forming a plant due to development of root at the wound portion. When an injured portion of stem is placed in some rooting medium. e.g. light/ lome soil/ sand etc and supplied with rooting hormone or other materials (fungicide and energy source), there will be the formation of roots from the wounded part after 6-8 weeks. The bud on the cut portion of the stem will sprout and forming a new plant which has same morphology as that of their parent plant.

**Physiology (Principle) of cutting:** It involve a wound induced *De Novo* synthesis of adventitious roots. When a cut is given at the lower end, the flow of cell sap gets disrupted. This will lead to the accumulation of food material and growth hormones at the cut portion. Due to the effect of the hormone, there occurs the formation of new parenchymatous tissue called callus and from callus, the adventitious roots will differentiate after some time. Presence of bud and few leaves on the stem portion helps in induction of adventitious root from the wounded portion.

## Types of cutting

- 1. Herbaceous Cuttings:** They are cutting taken from the new growth of non-woody plants They can be taken at any time during their growing season. Water the parent plant about 1 hour before taking cuttings.
- 2. Softwood, semi-hardwood and hardwood cuttings are taken from woody plants.**
  - (a) Softwood or Greenwood Cuttings** are taken from new growth, usually in mid to late spring or early summer before the wood has matured. This is one of the easiest methods and can be used for many kinds of plants including a wide variety of trees and shrubs.
  - (b) Semi-hardwood Cuttings** are taken from new growth usually in late summer after stems have grown somewhat, but are not yet fully mature.
  - (c) Hardwood Cuttings** are taken usually in late fall through mid winter when the wood is dormant. These cuttings should be

misted daily to keep the buds and newly forming foliage from drying out and to keep the soil or growing medium moist but not soggy. Watering is especially important during dry periods

**Time taken during cutting:** 6-8 weeks

**Time for cutting:** Either the raining season or just before the commencement of growing season (rose- October).

## **Procedure**

### **Type of cutting**

- (a) Select a one-year-old healthy branch of required plant and with the help of secateurs prepare cutting of equal length.
- (b) The length of stem cutting should be 6-9 inches and should have atleast 2-4 vegetative buds.
- (c) **Make a slanting cut down the bud on the upper side of the cutting and more slanting cut on the lower side just below the nodal region.** The logic behind making the cut slope down and away from the eye is that the excess natural sap that will rise from the inside of the stem to seal the cut naturally can pour down the opposing side of the stem and not interfere with the developing bud (eye). Slanting cut at the lower end permit more surface area to expose to rooting medium since there are more meristematic tissue in the vicinity of nodes. A cut below the node is more likely to succeed in rooting.
- (d) Treat the cutting with the rooting hormone on the lower side and with the fungicide wax on the upper side.
- (e) Plant the cuttings as soon as they are cut from the parent plants. They should not be allowed to dry or shriveled or wrapped in the moist cloth.

### **Preparation of Bed**

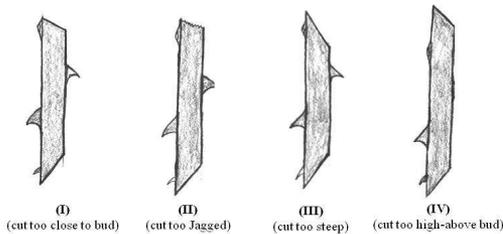
1. Place the stem cutting in a well-prepared flatbed having sandy soil.
2. They should be planted in rows which are 30cm apart and distance between two cuttings should be 10-15cm.
3. Keep 1/3 of the stem cutting portion inside the soil and 2/3 above the soil
4. Firmly fixed the cutting into the soil at an angle of 45 and after fixing irrigate them with water cane.

- Adventitious roots will arise from the cut/wounded region after 6-8-week. Cutting is lifted carefully and transferred to planting site in a more fertile soil after a complete growing season.

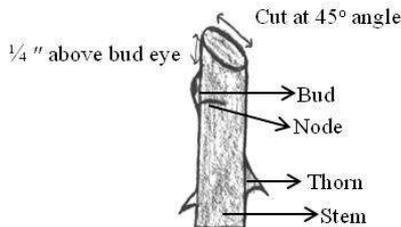
### Precautions

- The rooting soil should be kept moist but not soggy (wet and soft).
- If the leaves are present on the cutting, their number to be reduced to 1/3<sup>rd</sup>.
- Before planting the cutting, the basal portion of the cutting should be dipped in a rooting hormone.
- The cut should be not so high from the bud and not so deep inside the bud and it should be clean, not jagged. Cut too close to bud hinder with germination of bud and too far will cause die-off of stem near to including bud region.
- The cut ends of the cutting should be treated with a fungicide paste, to prevent fungal infection.
- The selected branch should be healthy and disease free.

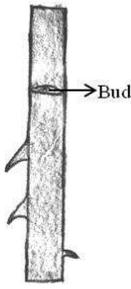
### Vegetative propagation by stem cutting



### Types of wrong cut

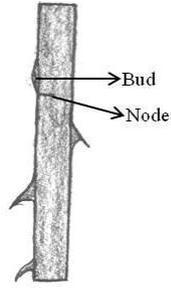


### Correct slant cut



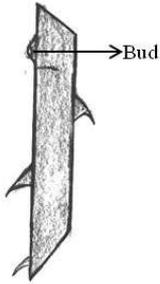
(A)

Locate the dormant bud



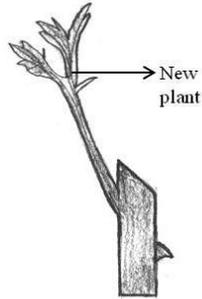
(B)

Keep the dormant bud on one side



(C)

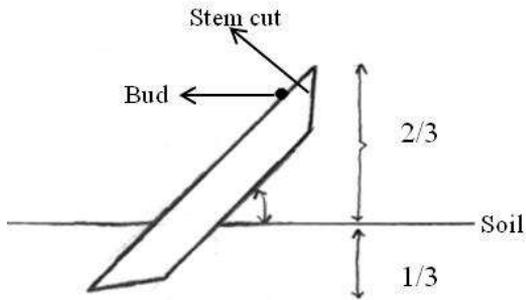
Make a slant cut



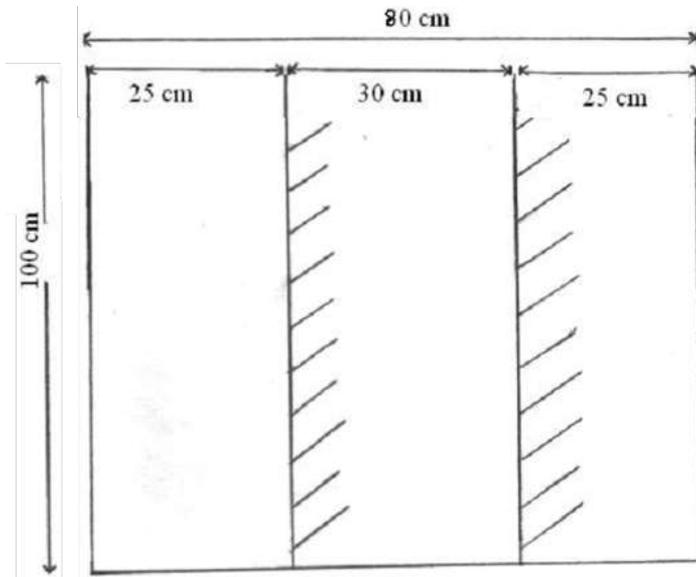
(D)

Emergence of new stem from bud

### Steps in stem cutting



### Planting of stem cutting



Bed for planting rose stem

## AIM 8: VEGETATIVE PROPAGATION OF PLANT BY APPROACH GRAFTING.

### Material required

A clean sharp knife, one-year old rooted stock of plants, a defoliated scion, a polyethene tape, fungicidal wax.

### Theory

Grafting is a technique of connecting two pieces of living plant tissue together so that they will unite and subsequently grow as one plant. The part of the graft combination which becomes the upper portion or top of the new plant is termed the **scion**, and the part which becomes the lower portion or root is termed the **rootstock**. **Scion** is a short piece of detached shoot containing several dormant buds. **Rootstock** develops into the root system of the grafted plant. Grafting is done to obtain a tree which has characteristics of two plants and for repairing of damage portion.

**Physiology of grafting:** In grafting, the vascular cambium of the scion must be aligned with the vascular cambium of roots. In woody

plants, the cambium is a very thin ribbon of actively dividing cells located just below the bark. The cambium produces conductive tissue for actively growing plant. The vascular cambium of both (stock and scion) initiates formation of parenchymatous mass of cell known as callus tissue at the graft portion. The callus cells intermixed and interlocked and formed cambium at the graft portion which gives rises to secondary xylem and phloem and bring continuity between the vascular tissue of both plants. The necessary moisture and minerals are supplied by the stock and the growth hormones, food is supplied by the scion.

**Type of grafting:** 1) Approach grafting 2) veneer grafting

**1. Approach grafting or In-arching:** In this grafting both scion and stock are on their own root stock till the union is completed. e.g- Mango and Guava

**2. Veneer grafting:** In this grafting, scion is inserted into the lateral side of the stock which is generally large in diameter than the scion. e.g. Mango and Nerium

**Time taken for grafting:** 6-8 weeks or depends upon the plant species.

**Time for grafting:** In case of evergreen plant during the growing season. In case of deciduous plant, just before the commencement of growing season.

### **Procedure and observations**

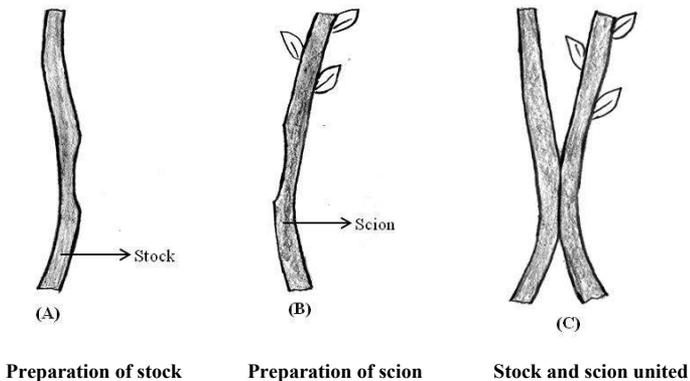
1. Select a one-year healthy branch from the scion tree which has same vigor and growth as that of rootstock.
2. Make a cut with the sharp knife on the scion, **6-8 inches above from the soil in** order to expose the cambium. A similar cut is also made on the stock at same height so that the identical cambium pater will expose.
3. The length of cut **should not be more than 1-1/2 inches** and thickness **not more than 1/3 to the thickness of scion/stock.**
4. The cut **must be smooth and flat** so that when scion and stock are pressed together there is a close contact of cambial cell.
5. The two braches brought close to each other and cut surfaces are tied tightly together with the sting **without leaving any space between the scion and stock.**

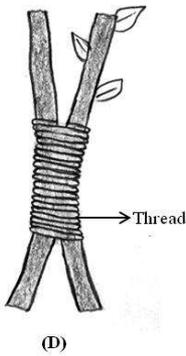
- After a few weeks, when the graft union is completed, a straight cut is given below the graft union on scion separating it from the parent plant, while a slant cut is given above the graft union on the rootstock which separates the grafting new plant. Covered the cut portions with **fungicidal wax**. Thus, a new plant is formed which have characteristic of both scion and stock.

### Precautions

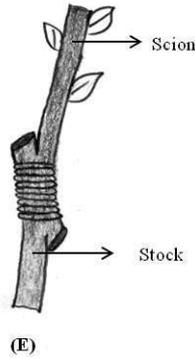
- The rootstock and scion should be regularly irrigated before and after grafting.
- The cuts made on rootstock and scions are of same size and should be neat.
- The cut made rootstock and scion should not go beyond 1/3 of diameter.
- Selected rootstock should be healthy, free of diseases, compatible with many varieties and well adapted to climatic condition with well developed root system.
- Leaves should be removed from above and below the portion where the cut is to be made.
- All exposed portion after grafting should be covered with fungicidal material to prevent fungal infection.

### Vegetative propagation by Approach grafting





Stock and scion tied



Stock top remove and scion separated from parent plant

### Steps in Approach grafting

## AIM 9: VEGETATIVE PROPAGATION OF PLANT BY VENEER GRAFTING.

### Material required

A clean sharp knife, one-year old rooted stock of plants, a defoliated scion, a polyethene tape, fungicidal wax.

### Theory

Grafting is a technique of connecting two pieces of living plant tissue together so that they will unite and subsequently grow as one plant. The part of the graft combination which becomes the upper portion or top of the new plant is termed the **scion**, and the part which becomes the lower portion or root is termed the **rootstock**. **Scion** is a short piece of detached shoot containing several dormant buds. **Rootstock** develops into the root system of the grafted plant. Grafting is done to obtain a tree which has characteristics of two plants and for repairing of damage portion.

**Physiology of grafting:** In grafting, the vascular cambium of the scion must be aligned with the vascular cambium of roots. In woody plants, the cambium is a very thin ribbon of actively dividing cells located just below the bark. The cambium produces conductive tissue for actively growing plant. The vascular cambium of both (stock and

scion) initiates formation of parenchymatous mass of cell known as callus tissue at the graft portion. The callus cells intermixed and interlocked and formed cambium at the graft portion which gives rise to secondary xylem and phloem and bring continuity between the vascular tissue of both plants. The necessary moisture and minerals are supplied by the stock and the growth hormones, food is supplied by the scion.

**Type of grafting:** 1) Approach grafting 2) veneer grafting

1. **Approach grafting or In-arching:** In this grafting both scion and stock are on their own root stock till the union is completed. e.g- Mango and Guava
2. **Veneer grafting:** In this grafting, scion is inserted into the lateral side of the stock which is generally large in diameter than the scion. e.g., Mango and Nerium

**Time taken for grafting:** 6-8 weeks or depends upon the plant species.

**Time for grafting:** In case of evergreen plant during the growing season. In case of deciduous plant, just before the commencement of growing season.

### Procedure and observations

#### 1. Preparation of scion:

- (a) Scion of 20-25cm is selected from the terminal shoot of the past season growth which is one-year old and still in dormant stage.
- (b) The selected scions are defoliated (removal of leaves) on the mother plant about 8 to 10 days prior to grafting, keeping a part of petiole intact on the selected terminal shoot. This activates the terminal bud and increase the percentage of success in grafting. This twig is known as de-foliated pre-cutted scion.

- (c) Make **1-inch-long** sloping cut at the base of the scion on one side and **1/2-inch-long** cut on opposite to it.

2. **Preparation of stock:** A slanting downward and inward cut, **of about 1 inch long** is made on the one-year-old selected rootstock, 25-40 cm above the crown portion of stock which exposes a flap of bark with some woods till attached.

3. The scion is inserted into the stock so that the cambium layers match on the longer side.

4. The graft union is tied lightly with transparent polyethylene strip without including any air space.
5. After successful grafting which **takes 6-8 weeks**, the scion shoot starts growing and shows vigorous growth, the rootstock just above the graft union is cut and covered with fungicidal wax
6. Untie the graft union portion forming a new plant which have characteristic of both scion and stock.

### **Precautions**

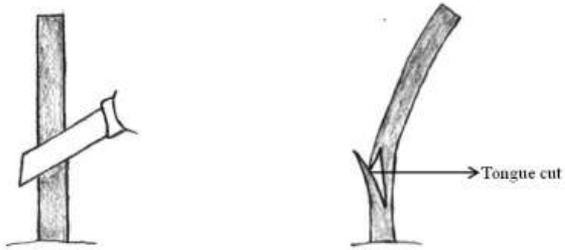
1. The stock and scion should be regularly irrigated before and after grafting.
2. The reverse tongue cut given on the root stock should not be much deeper.
3. Selected stock should be healthy, free of diseases, compatible with many varieties and well adapted to climatic condition with well-developed root system.
4. Leaves should be removed from above and below the portion where the cut is to be made.
5. All exposed portion after grafting should be covered with fungicidal material to prevent fungal infection.

### **Vegetative propagation by Veneer grafting**

#### **Steps in Veneer grafting**



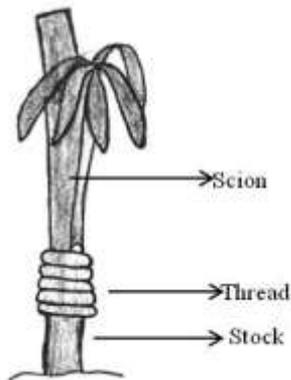
**(A) Preparation of scion**



**(B) Preparation of stock**



**(C) Stock and scion united**



**(D) Stock and scion tied**

**AIM 10: VEGETATIVE PROPAGATION OF PLANTS BY BUD GRAFTING****Material Required**

A clean budding sharp knife, secateurs, one-year old rooted stock plant of some variety, scion branch from the desired variety, a polyethene/cellophane tape, plant fiber, fungicidal wax.

**Theory**

Bud grafting is a technique in which a vegetative dormant bud is taken in place of scion branch. The scion bud is inserted into the opened bark of the stock and the two are tied together so that an organic connection may take place between them. When the scion bud starts sprouting and produced new branches, the stock branch is cut from above the point of union and covered with fungicide. Grafting is done to obtain a plant which has characteristics of two the plants and for repairing of damage portion.

**Physiology of grafting:** In bud grafting, the vascular cambium of the bud (scion) must be aligned with the vascular cambium of roots stock. The cambium is a very thin ribbon of actively dividing cells located just below the bark. The cambium produces conductive tissue for actively growing plant. The vascular cambium of both (stock and bud) initiates formation of parenchymatous mass of cell known as callus tissue at the graft portion. The callus cells intermixed and interlocked and formed cambium at the graft portion which gives rise to secondary xylem and phloem. Formation of secondary vascular tissue brings continuity between the vascular tissue of both bud and root stock. The necessary moisture and minerals are supplied by the stock and the growth hormones is supplied by the scion.

**Time taken for grafting:** 6-8 weeks or depends upon the plant species

**Time for grafting:** At the commencement of growing season.

**Procedure**

- 1. Preparation of scion bud:** The collected bud sticks should be hard in nature and adapted to environmental condition.
  - (a) Leaf blades are clipped from the budstick, leaving the petiole intact. The petiole act as a convenient “holder” to holding the bud while it is to be cut from the stem.

- (b) The bud and a small piece of the wood underneath it is cut from the budstick using an upward slicing motion. The cut should begin about 1/2 inch below the bud, and should go deep enough into the wood so that when the cut is finished, it is about 1/2 above the bud.
  - (c) The scion bud consisting of bud with a piece of bark and very little piece of wood.
- 2. Preparation of stock:** A one-year old rooted plant of some local varieties is selected as root stock. It should be disease free, adapted to the local climatic condition and compatible with many varieties.
- (a) All the branches are removed and only one branch of thickness (1-2.5cm) is retained.
  - (b) Leaves and thorns are removed from the place where cut is made.
  - (c) A T-shaped cut is given between the two nodes by first giving a vertical cut downward in the bark region without damaging the wood, followed by a horizontal cut.
  - (d) The bark is lifted carefully where the cut is made, the length and width of T should be slightly more than the scion bud.
- 3. Inserting the Scion:** Holding the scion bud carefully by the stem portion, slide it carefully down into the “T” pocket until the top of the bud stem is flush against the top of the “T” cut. Avoid touching the cut surface of the bud with your fingers.
- 4. Securing the Graft:** After inserting the bud, the two are tied with a polyethylene tape, keeping the bud expose or do not tape over the bud.
- 5. Aftercare of bud grafting:** After 6-8 weeks, when the scion bud shows growing sign (arises of stem/ leaves or drying of leaf stalk) and loosened or removed the tape. The rootstock is cut few centimeters above the union, covered with fungicide wax (4-part copper carbonate+ 4-part red lead+ 5-parts of linseed oil) after the scion branch reaches a height of 1.5 inches. After the upper portion of the rootstock is removed, the scion bud grows vigorously.

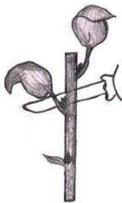
### Precautions

1. Buds must be cut from the budstick just prior to grafting, otherwise they will dry out or preserve it from wilting by keeping it in water.

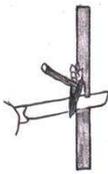
2. The complete operation should be performed in very short time, in order to prevent drying off of bud.
3. The selected bud scion should be neither too young or under develop nor too old or over develop.
4. Selected stock should be healthy, free of diseases, compatible with many varieties and well adapted to climatic condition with well developed root system.
5. The union of bud scion and root stock should be in proper orientation of cambium or conductive tissue (xylem and phloem)
6. The stock and scion should be regularly irrigated before and after grafting.
7. All exposed portion after grafting should be covered with fungicidal material to prevent fungal infection.

### **Vegetative propagation by Bud grafting**

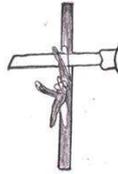
#### **Steps in Bud Grafting**



**Bud stick**



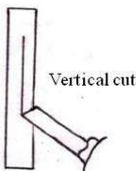
**Removal of bud scion**



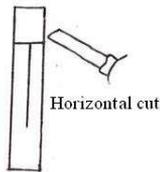
**Scion**

**Bud scion**

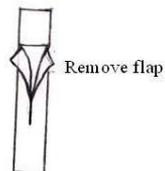
#### **Preparation of scion bud**



**Vertical cut**

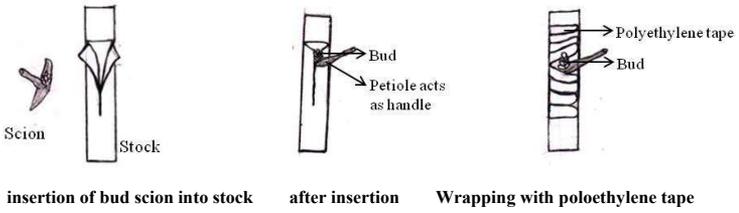


**Horizontal cut**



**Opening of flap of bark**

#### **Preparation of rootstock**



### Grafting of plants

## Unit-2

# PLANT ANATOMY

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**AIM: 11 TO STUDY THE ANATOMY OF DICOT AND MONOCOT STEM THROUGH PERMANENT SLIDES.**

### Theory

Stems, roots and leaves of plants are made up of different types of tissues. These tissues occur in different combination and form the plant tissue system. Study of internal structure of plants is known as anatomy and through permanent slides it become easy to analyze these structures. Stem is the aerial part of plant, it has node, internode, branches and leaves. Leaves are responsible for photosynthesis.

### I. Anatomy of Dicotyledonous stem (e.g., young stem of sunflower)

- 1. Epidermis:** This is the outermost layer composed of parenchymatous cells, without intercellular spaces. The outer walls are covered with a waxy layer called cuticle. Cuticle prevents loss of water from the plant. Stomata for gaseous exchange are scattered in the epidermis. A large number of multicellular hairs are also present.
- 2. Ground tissue:** It is the tissue below the epidermis. It is composed of thin-walled parenchyma cells. It is divided into three parts: hypodermis, general cortex and endodermis.
  - (a) The hypodermis** is composed of 3-4 layers of the thick collenchyma cells. These cells give support and flexibility to the stem.
  - (b) The general cortex** is the large region between the hypodermis and endodermis. It is composed of a few layers of parenchyma cells having conspicuous intercellular spaces. The cells

of the cortex may contain some chloroplasts and perform photosynthesis. They may also serve as storage sites of food.

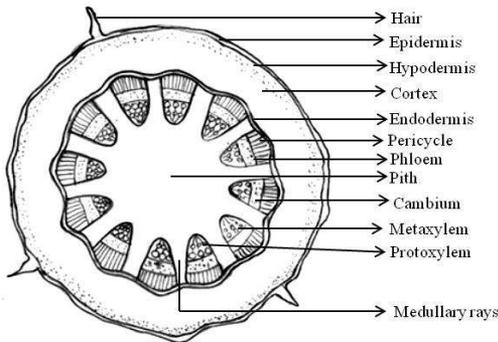
- (c) **The endodermis** is the innermost layer of cortex. It may or may not be distinct. The cells are somewhat **barrel-shaped, parenchymatous and compactly arranged with no intercellular spaces**. They contain numerous starch grains and the layer is therefore referred to as a **starch sheath**. It controls the movement of water and minerals into the vascular tissues.
- 3. Pericycle:** It lies **below the endodermis**. It is heterogenous having both sclerenchyma (dead and rigid) and parenchymatous cells. Sclerenchyma patch is present opposite to vascular bundles and parenchymatous patch is present in between the two vascular bundles and performs the storage function.
- 4. Vascular bundles:** The vascular bundles of herbaceous dicot stem e.g., sunflower, are **arranged in a circle**, which lies between the cortex and the pith. Each vascular bundle is composed of **Xylem, Phloem, Cambium** and are present in the form of a ring. The bundles are **conjoint** (xylem and phloem on same radii), **collateral** (phloem towards outside, xylem towards inside), **endarch** (arrangement of xylem-proxylem inside, metaxylem outside) and **open** (presence of cambium) having well developed pith on the inner side.
- (a) **Xylem:** It is the innermost layer of vascular bundles and lies towards the centre of the stem. Xylem is composed of **vessels, tracheids, xylem fibres and xylem parenchyma**. The **protoxylem** consists of **small** annular, spiral and scalariform **vessels** lies towards the centre, whereas metaxylem has big **reticulate and pitted vessels** lies towards the circumference. This type of arrangement is known as **endarch xylem**. The xylem parenchyma cells are thin walled and situated around the protoxylem towards the inner side of the bundle.
- (b) **Phloem:** It lies below the pericycle and is composed of **sieve tubes, companion cells and phloem parenchyma and phloem dicot**. The phloem cells store starch, protein and fats.
- (c) **Cambium:** It is a strip of **thin-walled cells lying in between the phloem and xylem**. The cambial cells consist of a single layer of closely fitted cell which appears rectangular in shape in cross section. Cambium **forms the secondary xylem and phloem**.

5. **Pith**- It is the central part of the stem, composed of **parenchymatous cells** with **conspicuous intercellular spaces**. Its main function is storage of food and transverse conduction of food materials. The pith extends in between the adjacent vascular bundles to form elongated structures called the **pith rays or medullary rays**. The cells in the rays are **thin-walled, parenchymatous and radially elongated**. The pith rays store food materials and also help in internal translocation of water and other substances.

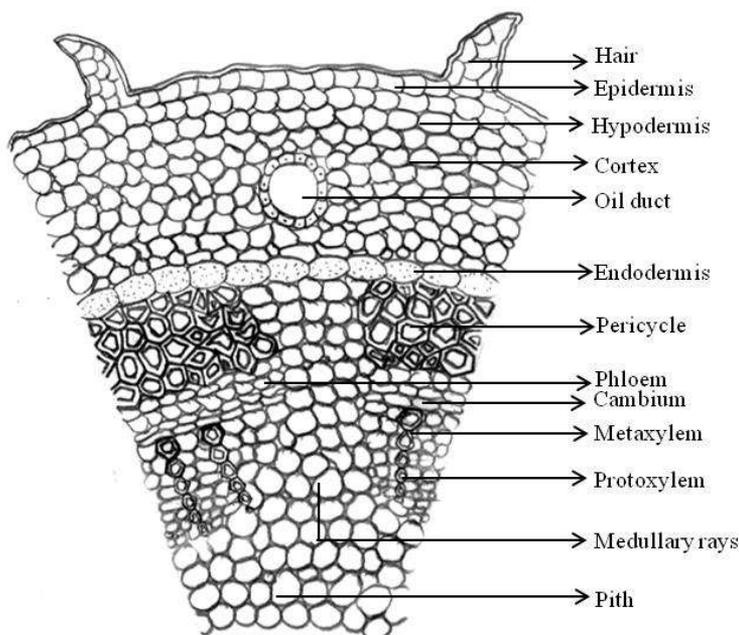
**Following are some of the diagnostic features of a young dicot stem**

1. Stem have epidermis, cortex (**hypodermis, general cortex, endodermis**), **pericycle**, vascular **bundle**, **pith** and **medullary rays**.
2. Presence of **cuticle and trichomes**.
3. Presence of stomata.
4. Presence of a **hypodermis made up of collenchyma**.
5. Presence of a wavy endodermis containing numerous starch grains.
6. Presence of a bundle cap above each vascular bundle, formed by sclerenchyma.
7. Presence of **eight vascular bundles, arranged in the form of a broken ring**.
8. Presence of **conjoint, collateral and open vascular bundles** with an **endarch xylem**.
9. Presence of **pith and medullary rays**.

**Anatomy of Dicot Stem**



**Outline of Dicot Stem**



T.S of Dicot Stem

## II. Anatomy of Monocotyledonous stem

1. **Epidermis:** Epidermis is the outermost covering of the stem represented by a single layer of **compactly arranged, barrel-shaped parenchyma cells**. **Intercellular spaces are absent. Trichomes are absent.** A cuticle is present. The epidermis contains numerous minute openings called **stomata**.
2. **Ground Tissue:** Ground tissue is a major component of the stem. It is not differentiated into endodermis and general cortex. The ground tissue is represented by several layers of **loosely arranged parenchyma cells enclosing prominent intercellular spaces**. **Sometime, it is differentiated into hypodermis only.** The ground tissue is meant for storage of food.
  - (a) **Hypodermis:** Hypodermis is a region that lies immediately below the epidermis. It is represented by a **few layers of compactly arranged sclerenchyma cells**.

3. **Vascular Bundles:** They are found irregularly scattered in the **ground tissue**. Towards the periphery, the bundles are **smaller in size while towards the centre, they are larger in size**. The **smaller bundles are younger, while the larger ones are older**. Hence, the arrangement is described as **centrifugal**. Each vascular bundle has a covering called **bundle sheath** formed by a single layer of **sclerenchyma cells**. The vascular bundle encloses both **xylem and phloem**. Xylem is found towards the **inner surface and phloem towards the outer surface**. **Cambium is absent**. Hence the vascular bundles are described as **conjoint, collateral and closed**.

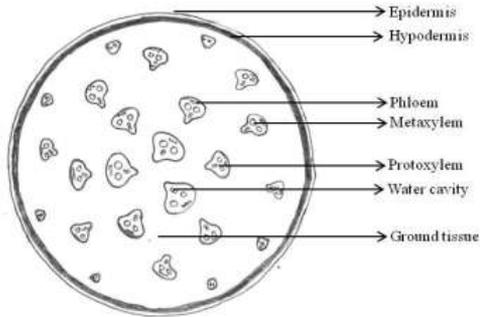
(a) **Xylem:** In the xylem, there are **two metaxylem and two protoxylem** vessels arranged in **‘the shape of ‘Y’**. The lower protoxylem vessel is **non functional and remains as a water filled cavity called lysogenous cavity or protoxylem cavity**. Xylem is described as **endarch**.

(b) **Phloem:** In the phloem, only **sieve tubes, companion cells and phloem fibers** are present. **Phloem parenchyma is absent**.

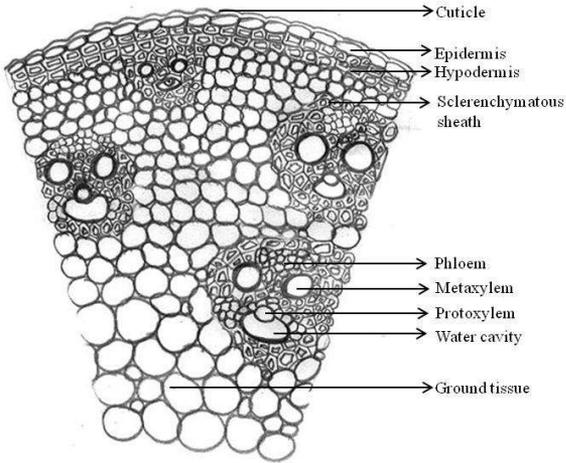
### **Diagnostic Features of a Monocot Stem**

1. Stem have epidermis, ground tissue (Undifferentiated), vascular bundle.
2. **Absence of trichomes.**
3. Presence of stomata.
4. Presence of **undifferentiated ground tissue**.
5. Presence of numerous **vascular bundles irregularly scattered with centrifugal arrangement**.
6. Vascular bundles are **conjoint, collateral & closed with endarch xylem**.
7. Presence of only **two protoxylem & two metaxylem** vessels in each bundle.
8. **Presence of a lysogenous cavity.**
9. **Absence of phloem parenchyma.**
10. Presence of **sclerenchyma bundle sheath**.

## Anatomy of Monocot Stem



**Outline of Monocot Stem**



**T.S of Monocot Stem**

**AIM 12: TO STUDY THE ANATOMY OF DICOT AND MONOCOT ROOT THROUGH PERMANENT SLIDES.**

### Theory

Stems, roots and leaves of plants are made up of different types of tissues. These tissues occur in different combination and form the plant tissue system. Study of internal structure of plants is known as plant

anatomy and through permanent slides, it become easy to analyze these structures. Root is the lower part of the plant present in the soil and responsible for anchorage and absorption of water and mineral from the soil.

## I. Anatomy of dicot root

- 1. Epidermis/Epiblema:** Epiblema is the outermost covering of the root formed by single layer of compactly arranged, barrel-shaped, parenchyma cells. The cells are characteristically thin-walled since they are involved in absorption of water. **Cuticle layer and stomata are absent.** Some of the epiblema cells are produced into long **unicellular projections** called **root hairs**.
  - 2. Ground tissue:** It is differentiated into general cortex and endodermis.
    - (a) Cortex:** Cortex is a major component of the ground tissue of root. **It is represented by several layers of loosely arranged parenchyma cells. Intercellular spaces are prominent.** The cortex is mainly meant for storage of water.
    - (b) Endodermis:** **It is the innermost layer of cortex formed by compactly arranged barrel-shaped cells.** Some of the cells in the endodermis are thin-walled and are known as **passage cells**. The passage cells allow water to pass into the xylem vessels. The remaining cells in the endodermis are characterized by the presence of thickening on their radial walls. These thickenings are known as **casparian thickenings**. They are formed by the deposition of a **waxy substance called suberin**. The casparian thickenings play an important role in creating and maintaining a **physical force called root pressure**.
- Stele:** **Stele consists of pericycle, conjunctive tissue and vascular bundles.**
- 3. Pericycle:** Pericycle is a region that lies immediately below the endodermis. It is represented by a **single layer of parenchyma cells**.
  - 4. Conjunctive Tissue:** Conjunctive tissue is represented by a group of radially arranged **parenchyma cells found in between the vascular bundles (between xylem and phloem)**. The cells are specialized for storage of water.
  - 5. Vascular bundles:** Vascular bundles are radial (i.e. xylem and phloem are at different radii), exarch condition (protoxylem is towards periphery and metaxylem towards Centre). They are 2-8

in number in dicot root. **Cambium is developed at the time of secondary growth from the conjunctive tissue and pericycle.**

(a) **Xylem** is exarch (i.e., protoxylem towards the periphery and metaxylem towards the centre) and consists of **tracheids, vessels, xylem parenchyma and xylem fibers.**

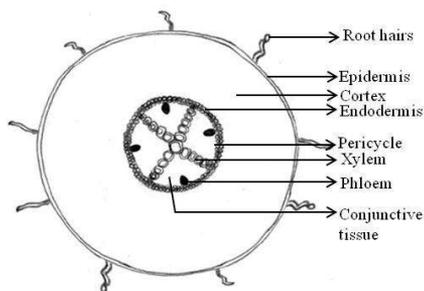
(b) **Phloem:** The **phloem** forms oval masses beneath the pericycle, alternating with xylem bundles. Phloem consists of **sieve tubes, companion cells and phloem parenchyma.** Usually, phloem fibers are absent or reduced.

6. **Pith:** A small pith is present in the centre in young root but generally pith is absent in the older root.

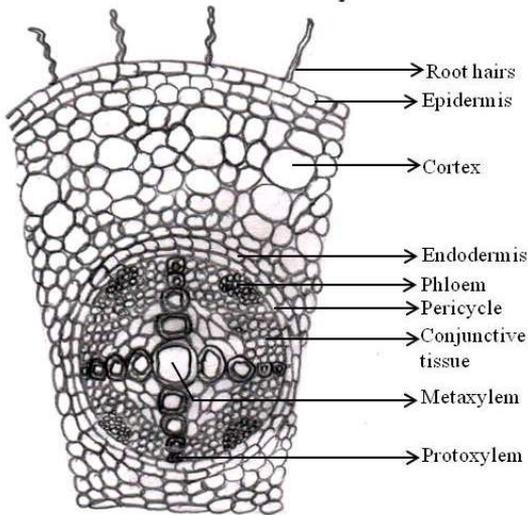
### Diagnostic Features of a Dicot Root

1. Presence of **thin wall celled epiblema/Epidermis.**
2. **Absence of cuticle, and stomata.**
3. Presence of **unicellular root hairs.**
4. **Absence of hypodermis.**
5. Presence of **passage cells and casparian thickenings in the endodermis.**
6. Presence of **uniseriate pericycle (one cell wide) made up of parenchyma.**
7. Presence of **conjunctive tissue.**
8. **Absence of pith.**
9. Presence of **radial, exarch and open vascular bundles.**

### Anatomy of Dicot Root



Outline of dicot root



**T.S of Dicot Root**

## II. Anatomy of Monocot Root

1. **Epiblema/ Epidermis:** Epiblema is the outermost covering of the root formed by a single layer of compactly arranged, **barrel-shaped parenchyma cells**. The cells are characteristically thin-walled since they are involved in absorption of water. Cuticle layer and stomata are absent. Some of the epiblema cells are produced into long **unicellular projections called root hairs**.
2. **Ground tissue:** It is differentiated into general cortex and endodermis.
  - (a) **Cortex:** Cortex is a major component of the ground tissue of root. It is **represented by several layers of loosely arranged parenchyma cells**. Intercellular spaces are prominent. The cortex is mainly meant for storage of water.
  - (b) **Endodermis:** It is the **innermost layer of cortex formed by compactly arranged barrel-shaped cells**. Some of the thin-walled cell in the endodermis are known as **passage cells**, which allow movement of water into the xylem vessels. The remaining cells in the endodermis are characterized by the

presence of thickening on their radial walls. These thickenings are known as **casparian thickenings**. They are formed by the **deposition of a waxy substance called suberin**. The casparian thickenings play an important role in creating and maintaining a **physical force called root pressure**.

**Stele:** Stele is the central cylinder of the root consisting of **pericycle, conjunctive tissue, pith and vascular bundles**.

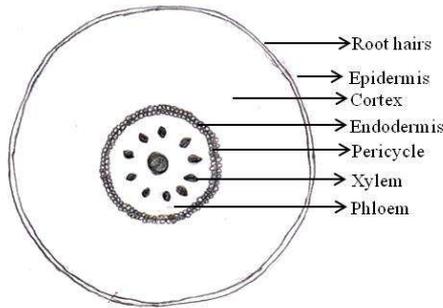
3. **Pericycle:** Pericycle is the outermost covering of the stele represented by a single layer of parenchyma cells.
4. **Conjunctive tissue:** It is represented by loosely arranged parenchyma cells found in between the vascular bundles. The cells are specialized for storage of water.
5. **Vascular bundle:** It is **radial** (Xylem and phloem are found at different radii alternating with each other) in arranged, **polyarch** (presence of many alternating xylem and phloem bundles), and close (absence of vascular tissue) and exarch condition (the protoxylem lies towards periphery and metaxylem toward center). Secondary growth is absent in monocot roots due to lack of vascular and cork cambium.
  - (a) **Xylem:** Xylem is made up of protoxylem and metaxylem vessels. The protoxylem has smaller vessels with spiral or annular thickening, whereas the walls of metaxylem contains pitted thickening.
  - (b) **Phloem:** It consists of **sieve tubes, companion cells and phloem parenchyma**. Usually, phloem sclerenchyma or fibers are absent. The phloem is also exarch (protophloem towards the periphery and metaphloem towards the center).
6. **Pith:** It is **large, well developed portion of monocot root**. It occupies the **central portion and made from thin walled parenchymatou tissue** with intercellular spaces. It contains abundant amount of starch grains.

### Diagnostic Features of a Monocot Root

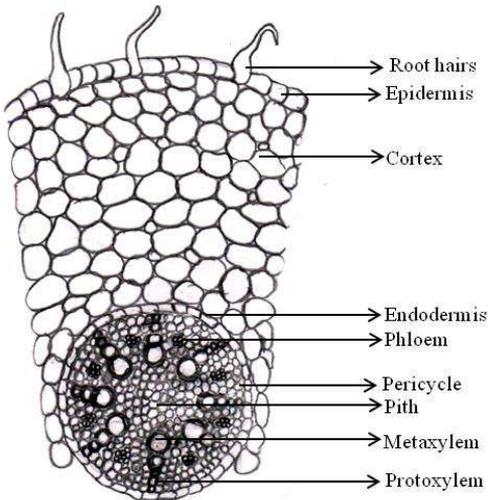
1. Presence of **thin wall celled epiblema**.
2. **Absence of cuticle and stomata**.
3. **Presence of unicellular root hairs**.

4. Presence of **passage cells and casparian thickenings in the endodermis.**
5. Presence of **parenchyma cells in the pericycle.**
6. Presence of **conjunctive tissue.**
7. **Presence of distinct pith.**
8. Presence of **radial, polyarchy, exarch, and close vascular bundles.**

### **Anatomy of Monocot Root**



**Outline of Monocot Root**



**T.S of Monocot Root**

### AIM 13: TO STUDY THE ANATOMY OF DICOT AND MONOCOT ROOT THROUGH PERMANENT SLIDES.

#### Theory

Stems, roots and leaves of plants are made up of different types of tissues. These tissues occur in different combination and form the plant tissue system. Study of internal structure of plants is known as plant anatomy and through permanent slides, it become easy to analyze these structures. Leaf is flattened, green structure found on stem/ branches, responsible for photosynthesis.

#### I. Anatomy of dicot leaf (dorsiventral leaf)

A dicot leaf is also known as dorsiventral as its upper and lower surface is different in structure. The transverse section of a dicot leaf has three main parts – epidermis, mesophyll and the vascular system.

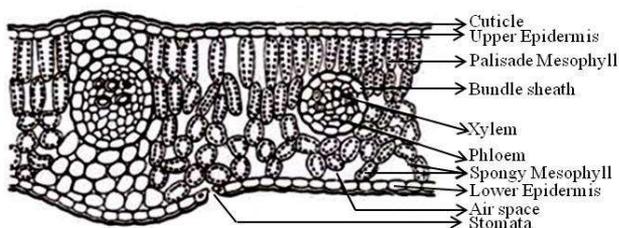
- 1. Epidermis:** It is outermost covering of the leaf that forms the boundary between the atmosphere and underlying mesophyll. It is present on both ventral or adaxial (upper epidermis) and dorsal or abaxial (lower epidermis) surface. Both the upper and lower epidermis are covered by a cuticular layer. Usually, upper epidermis is thickly cuticularized. Both the layers are composed of **compactly arranged, barrel-shaped cells. Intercellular spaces are absent.** Multicellular hairs called trichomes are present on both the layers. **Hypostomatic condition-** Stomata occur only in the lower epidermis, was observed.
- 2. Mesophyll -** It is the ground tissue between the upper and lower epidermis. In dorsiventral leaf, it is differentiated into **palisade parenchyma and spongy parenchyma.**
  - (a) Palisade parenchyma:** It lies towards the upper epidermis and consists of one, two or three layers of elongated cells which were densely packed without intercellular spaces and chloroplasts. Its tight packing prevents the loss of water from stomata.
  - (b) Spongy parenchyma:** It lies towards the lower epidermis and made from loosely arranged, irregular, thin-walled cells parenchymatous tissue with large intercellular spaces and

air cavities. Hence, it helps in gaseous exchange during transpiration and photosynthesis.

3. **Vascular bundles** - Numerous vascular bundles are scattered in spongy parenchyma. Each bundle is conjoint, collateral and closed.
4. **Vascular bundle:** Vascular bundle is surrounded by large colourless **parenchyma cells, this layer is known as Bundle sheath** or border parenchyma. The bundle sheath may also extend towards the upper and lower epidermis or towards both. These cells constitute **bundle sheath extension**. **Xylem lies toward the upper epidermis** and **phloem toward lower epidermis**. Single mid-vein vascular bundle is larger and several smaller veinlet vascular bundles are smaller.
  - (a) **Xylem:** It consists of vessels, tracheids, wood fibers and wood parenchyma (lies toward the upper epidermis). Xylem tracheids and vessels help in conduction of water and minerals and provides mechanical supports while parenchyma helps in lateral transport.
  - (b) **Phloem:** Phloem consists of **sieve tubes, companion cells and some cells of phloem parenchyma** (lies towards lower epidermis). The phloem companion cells and sieve tubes help in conduction of food materials and phloem parenchyma helps in lateral conduction and storage of food materials.

### **Diagnostic Features of a dicot (dorsiventral) leaf**

1. **Presence of two epidermal layers.**
2. **Presence of cuticle and trichomes in both the epidermal layers.**
3. **Veins irregularly scattered in the mesophyll.**
4. **Hypostomatic** - stomata are present only on lower epidermis
5. **Differentiated Mesophyll** - into upper palisade parenchyma and lower spongy parenchyma.
6. **Presence of a bundle sheath** made up of **parenchyma**.
7. **Presence of Collenchymatous bundle sheath extensions** - between bundle sheath of midrib vein and the upper/ lower epidermal layers.
8. **Conjoint, collateral vascular bundles.**



T.S of Dicot Leaf

## II. Anatomy of a monocot leaf (Isobilateral leaf)

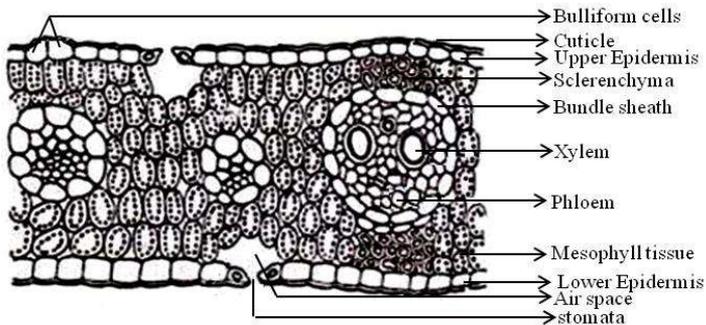
A monocot leaf is also known as **Isobilateral leaf** as its upper and lower surface is similar in structure. The transverse section of a monocot leaf has three main parts – epidermis, mesophyll and the vascular system.

- 1. Epidermis:** Epidermis is single layered, present on both the surfaces. It is composed of compactly arranged oval or barrel shaped thin walled parenchymatous cells which were cuticularized at the upper surface. Amphistomatic condition- stomata on both the surfaces, was observe. In the Upper epidermis, a few cells lens shaped cells which are larger in size, less cuticularized and occurs in group called motor cells or **bulliform cells**. These cells become empty and regulate the curling and uncurling (rolling up) of the leaves during dry conditions.
- 2. Mesophyll:** It is the ground tissue that is present between the two epidermal layers. **It is not differentiated into palisade and spongy parenchyma** and contains chloroplasts. It is composed of cells that are almost spherical, oval or angular with irregular intercellular spaces. Mesophyll tissues are not found in the mid-vein region.
- 3. Vascular bundles:** Vascular bundles are of two types- small bundles are abundant and larger bundles are found in between them. The bundles are **conjoint, collateral, closed** and each covered by parenchymatous **bundle sheath** cells containing starch grains. The larger bundles have distinct phloem towards the lower epidermis and xylem toward upper surface. The small bundles are surrounded by individual sheath and contain not distinct and less developed phloem and xylem. In mid vein region, sclerenchymatous cells extend from the vascular bundle to the lower and upper epidermis. This extension of sclerenchyma is called **bundle sheath extension**.

- (a) **Xylem:** Xylem consists of two pitted oval metaxylem; in between them tracheids are also found. Xylem parenchyma are less numerous. Protoxylem is represented by a lysogenous cavity. Xylem tracheids and vessels help in conduction of water and minerals and provides mechanical supports while parenchyma helps in lateral transport.
- (b) **Phloem:** Phloem has sieve tubes, companion cells and phloem parenchyma. The phloem companion cells and sieve tubes help in conduction of food materials and phloem parenchyma helps in lateral conduction and storage of food materials.

**Diagnostic Features of monocot (isobilateral) leaf**

1. Presence of two epidermal layers.
2. Presence of cuticle and trichomes in both the epidermal layers.
3. Presence of a **bundle sheath made up of parenchyma**.
4. **Amphistomatic** - stomata on both layers
5. **Motor Cells - present in upper epidermis**
6. **Undifferentiated mesophyll** - tissue not differentiated into palisade and spongy parenchyma
7. **vascular bundles**-Conjoint, collateral, closed
8. **Two protoxylem and two xylem** - present in each vascular bundle
9. Presence of **sclerenchymatous bundle sheath extensions** - between bundle sheath of vascular bundles and the upper/ lower epidermal layers.



**T.S of Monocot Leaf**

## Unit-3

# PLANT PHYSIOLOGY

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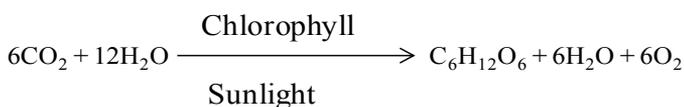
### **AIM 14: TO DEMONSTRATE EXPERIMENTALLY THAT LIGHT IS ESSENTIAL FOR PHOTOSYNTHESIS.**

#### **Apparatus and Materials Required**

A de-starched plant or leaf, light screen, alcohol, a strip of black paper, iodine solution and water bath.

#### **Theory**

Photosynthesis is a biochemical process by which green plants synthesize simple sugar in the presence of sunlight using carbon dioxide from the atmosphere and water from the soil. This simple sugar (glucose) is later converted to starch.



The rate of photosynthesis depends on the many factors such as light, chlorophyll content, amount of carbon dioxide and water amount. The most important factor for photosynthesis is light. The rate of photosynthesis depends on the quantity and quality of light. The chlorophyll molecule in green leaves absorb light, get excited and emit electrons. The emitted electrons are used in the production of adenosine triphosphate (ATP). ATP is then utilized by plant to form the glucose molecule and then glucose is converted to starch. Hence, plants change the light energy into chemical energy in the form of glucose molecule.

The rate of photosynthesis is the maximum in the presence of red and blue lights, while in green light the rate is minimum because green light is reflected by the chlorophyll molecules.

### Procedure

1. Take the potted plant and keep it in a dark place for 2-3 days so that the leaves get de-starched.
2. Cover a part of one of its leaves with light screen. Make sure that light screen cover both the sides of the leaf.
3. Now place this plant in sunlight for 3-4 hours.
4. after 3-4 hours remove the light screen.
5. Discoloured the leaf with alcohol, place this leaf in the beaker containing water and boil it for about 10 minutes. Take out the leaf and now boil it in alcohol, using the water bath, for 10 minutes. This removes the chlorophyll. Take out the leaf and wash it under running water. Boiling the leaf in ethanol makes it brittle, the water softens it.
6. Test the decoloured leaf with iodine solution. Place this leaf in the Petri dish and put a few drops of iodine solution on it. Now observe the change in colour.

### Observations

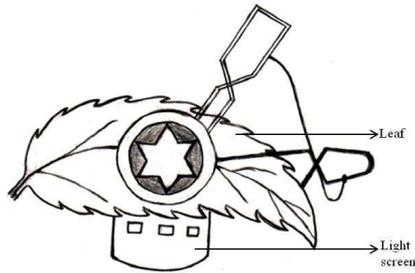
The leaf turns blue-black except in the covered region. As this covered region did not receive light, photosynthesis did not occur. Hence no starch was formed there. So, it does not turn blue-black on treatment with iodine. The uncovered region received light and starch was formed in it due to photosynthesis. The starch turned the iodine solution blue-black colour in the uncovered region.

**Result:** Light is essential for photosynthesis.

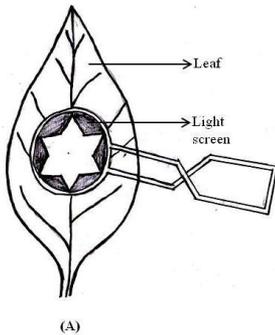
### Precautions

1. Before starting the experiment, the leaf must be de-starched.
2. The leaf must be covered with black paper properly to prevent the entry of light.
3. Boiling the leaf in alcohol should be done in the water bath.

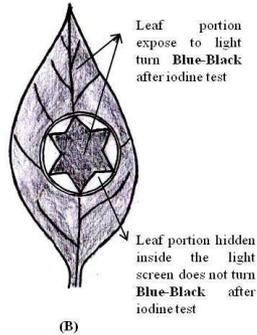
## Role of Light in Photosynthesis



Experiment setup



(A) Leaf expose to light



(B) Expose leaf tested with iodine solution

**Light is essential for Photosynthesis is experimentally proved using light screen**

**AIM 15: TO DEMONSTRATE EXPERIMENTALLY THAT CHLOROPHYLL IS ESSENTIAL FOR PHOTOSYNTHESIS.**

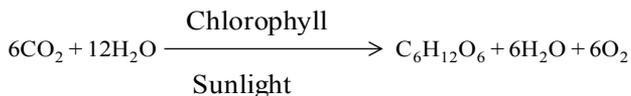
### Apparatus and Materials Required

A variegated leaf (e.g., *Coleus*), test tube, alcohol, iodine solution and water bath.

### Theory

Photosynthesis is a biochemical process by which green plants synthesize simple sugar in the presence of sunlight using carbon dioxide

from the atmosphere and water from the soil. This simple sugar (glucose) is later converted to starch.



The rate of photosynthesis depends on many factors such as light, chlorophyll content, amount of carbon dioxide and water amount. The chlorophyll molecule in green leaves absorb light, get excited and emit electrons. The emitted electrons are used in the production of adenosine triphosphate (ATP). ATP is then utilized by plant to form the glucose molecule and then glucose is converted to starch. Hence, plants converted the light energy into chemical energy in the form of glucose molecule. The amount of chlorophyll molecule affects the rate of photosynthesis. Photosynthesis is not possible in the absence of chlorophyll molecule as it can absorb sun light and can convert it into chemical energy in the form of ATP.

### Procedure

1. Take a variegated leaf of coleus or any other suitable plant. The green part of the leaf has chlorophyll but the white part of the leaf does not have chlorophyll.
2. Outline the leaf and its various coloured areas on the paper.
3. Place this leaf in the beaker containing water and boil it for about 1 minute. This kills the cells in the leaf, break down the membrane, iodine solution gets through cell membrane to reach starch inside the chloroplasts and react with them.
4. Take out the leaf and now boil it in 95% alcohol, using the water bath, for 1 minute. This removes the chlorophyll from the green part. The green parts of the leaf get decolourised. The green colour of the leaf and the brown iodine solution can look black together, so it is required to remove chlorophyll by dissolving it out with alcohol. Take out the leaf and wash it under running water.
5. Take out the leaf and wash it under running water. Boiling the leaf in ethanol makes it brittle, the water softens it.
6. Pour iodine solution over the colourless leaf and observe the change in colour of the leaf
7. Compare the green portion with the colour portion of the leaf.

## Observations

It was observed that green portion of the leaf turn blue black with iodine while the coloured portion remains yellowish in colour.

## Result

Chlorophyll is essential for photosynthesis.

## Discussion

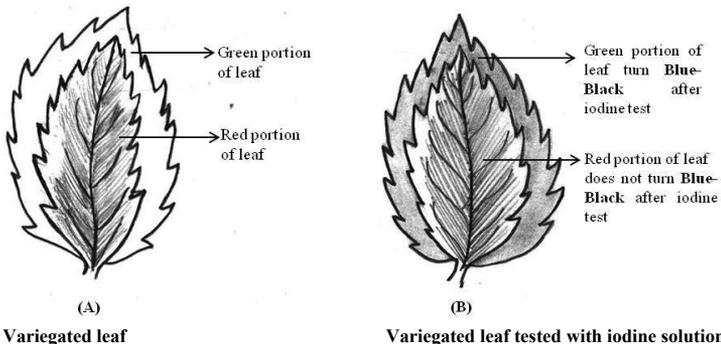
Outer part of leaf that was originally white (without chlorophyll) does not turn blue-black on adding iodine solution showing that no starch is present in this outer part of the leaf. From this observation it was concluded that without chlorophyll, there will be no synthesis of starch during photosynthesis or there is no photosynthesis.

The inner part of leaf which was originally green (contained chlorophyll) turns blue-black on adding iodine solution showing that starch is present in this inner part of the leaf. From this observation it was concluded that the starch is formed during photosynthesis in the presence of chlorophyll. In other words, chlorophyll is necessary for the process of photosynthesis.

## Precautions

1. The leaf should be variegated.
2. Boiling the leaf in alcohol should be done in the water bath.

## Role of Chlorophyll in Photosynthesis



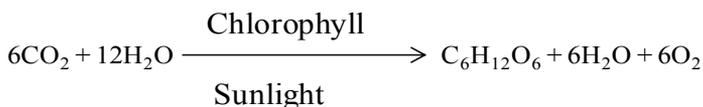
**Chlorophyll is required for Photosynthesis is experimentally proved variegated leaf**

**AIM 16: TO DEMONSTRATE EXPERIMENTALLY THAT CARBON DIOXIDE IS REQUIRED FOR PHOTOSYNTHESIS BY MOLL'S HALF LEAF EXPERIMENT.****Apparatus and Materials Required**

A potted healthy plant with long and narrow leaves or leaf dip in water, a wide mouthed glass bottle, split cork, Potassium Hydroxide solution (KOH), vaseline, Iodine solution.

**Theory**

Photosynthesis is a biochemical process by which green plants synthesize simple sugar in the presence of sunlight using carbon dioxide from the atmosphere and water from the soil. This simple sugar (glucose) is later converted to starch.



The rate of photosynthesis depends on many factors such as light, chlorophyll content, amount of carbon dioxide and water amount. The chlorophyll molecule in green leaves absorb light, and convert it into adenosine triphosphate (ATP). ATP is then utilized by plant to form the glucose molecule and then glucose is converted to starch. Hence, plants converted the light energy into chemical energy in the form of glucose molecule. During photosynthesis, carbon dioxide present in atmosphere is absorbed by plant and with the help of ATP generated by chlorophyll and water in the presence of chlorophyll and sunlight, carbon in the carbon dioxide is fixed into glucose molecule. Thus, carbon dioxide is an essential component of photosynthesis.

**Procedure**

1. Select a healthy potted plant with long and narrow leaves and keep it in darkness for two or three days so that leaves are free from starch.
2. Take a wide mouthed glass bottle, a cork and add 5-10ml of potassium hydroxide solution into the bottle.

3. Close the mouth of the bottle with split cork.
4. Insert half portion of the selected leaf into the bottle through the split cork.
5. The other half of the leaf is outside the cork.
6. The bottle is kept air tight by applying vaseline around the rim of the mouth of the bottle.
7. Keep this apparatus in sun light for 3-4 hours. After the completion of time, detach the leaf from the plant and take it out of the bottle.
8. Test the detached leaf for starch test with iodine solution.

### **Observation**

The portion of the leaf remained outside the bottle is showed blue-black colour with iodine solution while the portion remaining inside the bottle remain yellow in colour when treated with iodine solution.

### **Results**

Green leaves can perform photosynthesis only when  $\text{CO}_2$  is available. Hence carbon dioxide is essential for photosynthesis.

### **Discussion**

The portion of the leaf remaining outside the bottle receives all conditions for photosynthesis (viz.,  $\text{CO}_2$ , light and chlorophyll) and so starch formation takes place normally which is evident from the presence of blue colour on leave when treated with iodine.

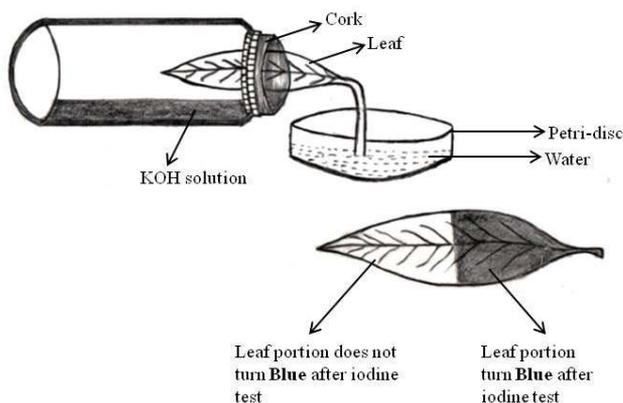
The other half of the leaf which remains inside the bottle and where no  $\text{CO}_2$  is available due to absorption by KOH solution remains yellow showing no starch formation. This proves that photosynthesis cannot take place in an atmosphere which is completely devoid of  $\text{CO}_2$ .

### **Precautions**

1. The bottle should be kept airtight by applying vaseline around the rim of the mouth of the bottle.
2. Make sure that potassium hydroxide does not come in contact with leaf inside the bottle.

- The leaf should not be detached from the plant till the experiment is completed.

### Role of Carbon Dioxide in Photosynthesis



### Moll's half leaf experiment to demonstrate the requirement of carbon dioxide for Photosynthesis

#### AIM 17: TO DEMONSTRATE EXPERIMENTALLY THAT OXYGEN IS EVOLVED IN GREEN PLANTS DURING PHOTOSYNTHESIS.

##### Material Required

A large Beaker, Some hydrilla Plant, one Funnel, one Test tube, water and a glowing splinter of wood and lamp

**Principle:** Photosynthesis is a physiological process performed by green plants to manufacture their carbohydrate food. It is a complex chemical process occurs in the chloroplasts of mesophyll tissue of green plants. **During photosynthesis process green plants utilizes energy from solar radiation,  $\text{CO}_2$  from atmosphere, water and minerals from obtained from soil to prepare their carbohydrate food and in turn evolve oxygen. Hydrilla plants are aquatic algal plants. These plants can carry out photosynthesis with the dissolved  $\text{CO}_2$  in water.**

Baking soda ( $\text{NaCO}_2$ ) dissolved in water and increases the concentration of dissolved  $\text{CO}_2$  in water. With increase in supply of  $\text{CO}_2$ , rate of photosynthesis increases and thus more air bubbles (Oxygen)

will evolve. Distilled water lacks dissolved  $\text{CO}_2$  and boiled and cooled water has less amount of dissolved  $\text{CO}_2$  in it. So, there will be no oxygen evolution in this water due to absence of photosynthesis.

A glowing matchstick is used to prove that the evolved gas is oxygen/ not another gas. When introduced into the test tube containing the collected oxygen gas, it will burst into a flame and confirmed that oxygen evolved in photosynthesis as oxygen help in burning.

### **Procedure**

1. Place the Hydrilla plant in the beaker and covered it with the funnel.
2. The cut end of the hydrilla plant remain towards the stem of the funnel.
3. Water should be poured in the beaker in such a way that the stem of the funnel kept beneath the water level.
4. A test tube completely filled with water should be inverted over the stem of the funnel.
5. The experimental set should be placed in Sunlight (or under electric light in the laboratory) for 3-4 Hours.
6. To test the nature of the gas collected, the test tube is removed quickly from the stem of the funnel and the mouth is closed with the thumb. Place a glowing matchstick into the test tube by removing the thumb from the mouth of the test tube.

### **Observation**

Air bubbles start moving from the cut end of the Hydrilla twigs and get collected at the upper end of the test tube. The collected gas at the top of the inverted test tube will displaced the water in the test tube. The glowing matchstick immediately burst into a flame indicating that the gas collected in the test tube is oxygen.

### **Result**

By this experiment, we proved that oxygen is produced during photosynthesis in the presence of sunlight.

### **Discussion**

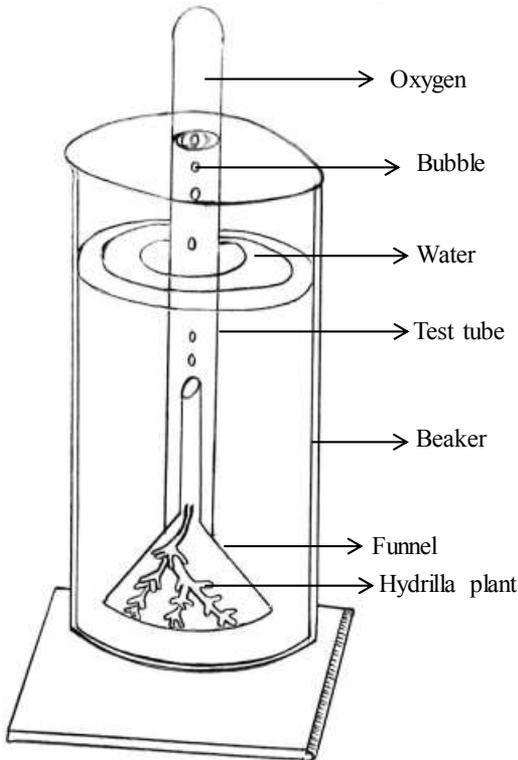
In light, photosynthesis is occurred which leads to evolution of oxygen gas. When a glowing matchstick is brought near to the tube,

oxygen is used during burning and it increase the rate of burning as seen in fast growing of matchstick. This proves that the gas, collected in test tube is oxygen which evolved during photosynthesis.

### Precautions

1. Setup should be kept in sunlight
2. The level of water in the beaker should be over the level of stem of the inverted funnel
3. While removing test tube, place your thumb near mouth of test tube to prevent escape of gas (oxygen) evolved and remove gently.

### Oxygen evolution during photosynthesis



**Demonstration for evolution of oxygen during photosynthesis in green plants**

◆  
**AIM 18: TO DEMONSTRATE UNEQUAL RATE OF TRANSPIRATION FROM THE TWO SURFACES OF A DICOT LEAF.**

**Material Required**

A potted dicot plant with dorsi-ventral leaves well marked, 5% CoCl<sub>2</sub> paper, microscopic slides, rubber bands or clips, forceps, stop watch, Vaseline and dessicator.

**Theory**

Transpiration is the process of evaporation of water in the form of water vapour into the atmosphere from the aerial parts of a plant. Transpiration occurs chiefly through the stomata of the leaves. The guard cells of stomata help to regulate the rate of transpiration by opening and closing the stomata. Transpiration helps in the absorption of water from the soil, in transportation of water from the roots to the leaves through the xylem vessels through transpiration pull. It cools down the plant surface during evaporation. Wind, temperature and light increase the rate of transpiration.

Plants are differed in the distribution, number, size and type of stomata. In dicots, greater number of stomata is present on the on the lower surface than on the upper surface of the leaf. Therefore, the loss of water from the lower surface is greater than from the upper surface. Rate of transpiration can be easily demonstrated by cobalt chloride paper test. Dry cobalt chloride paper that is blue in colour turns pink when it comes in contact with water. Using this property of cobalt chloride paper, it can be demonstrated that water loss during transpiration with the different rate from upper and lower surface of the dicot leaf. Transpiration rate can also be measured by using the time taken for the paper to change its colour from blue to pink.

**Procedure**

1. Take 5 % cobalt chloride solution from beaker and pour into the Petri dish. Take some filter paper strips and dip them in the cobalt chloride solution. Keep the strips in the solution for 3-5 minutes. They become pink in colour when wet. Remove the strips from the solution using forceps. Place the strips in the desiccators to allow them to dry. The filter paper becomes blue in colour on drying.

1. Select one healthy leaf and clean the leaf to remove the water droplets using a filter paper.
2. Take the dry paper of cobalt chloride from the desiccators.
3. Place the dried strips of cobalt chloride paper: one on the upper and the other on the lower surface of a leaf of the potted plant.
4. Take two glass slides and place one over the upper and the other over the lower side of the leaf.
5. Seal the edges of the glass slides with the help of vaseline and fixed the slides at their position by means of clips.
6. Keep the apparatus undisturbed for few minutes.
7. Note the time taken by the cobalt chloride paper to change its blue colour to pink.

### **Observation**

The time taken to change colour of the cobalt chloride paper from blue to pink on the lower leaf surface is less than the upper surface.

### **Result**

Conversion of cobalt chloride pink paper to blue, indicate that transpiration occurs in the leaf surfaces.

### **Discussion**

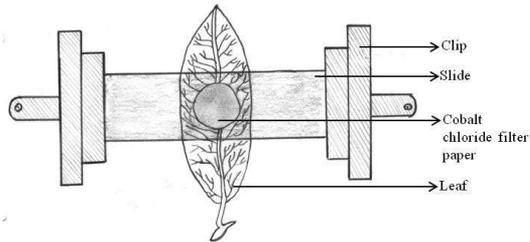
The upper surface of the leaf has a smaller number of stomata whereas the lower surface has a large number of stomata. The quick change in the colour of cobalt chloride paper on the lower surfaces indicated the higher rate of loss of water vapour (transpiration) from this surface than the upper one. Cobalt chloride changes colour from blue to pink when it gets moist. This shows that unequal transpiration occurs from the two sides in leave due to differential distribution of stomata.

### **Precautions**

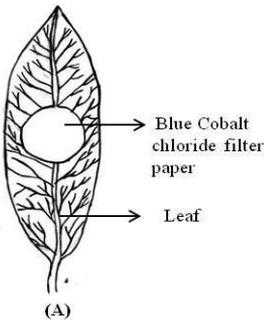
1. Cobalt chloride papers should be properly dried before keeping them in the desiccators.
2. The cobalt chloride paper should be fixed on both the surfaces of leaf properly.
3. The cobalt chloride papers should be of the same size.

4. Always use a well-watered potted plant for the experiment.
5. Always handle the dried cobalt paper with dry hands or forceps.
6. The leaf surface should not be wet while applying the cobalt chloride strips.
7. Change in colour should be noted carefully.

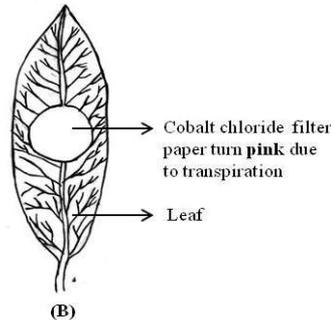
### Transpiration



Experiment setup



Leaf with blue cobalt chloride paper



Leaf with pink cobalt chloride paper

### Measuring of transpiration by cobalt chloride method

**AIM 19: TO DEMONSTRATE THE PROCESS OF OSMOSIS IN LIVING PLANT CELLS BY POTATO OSMOSCOPE.**

#### Material Required

Potato tuber, knife or scalpel, 20% sugar solution, red colour or safranin, distilled water, petri-dish, alpin, peeler.

## Theory

Water diffuses by osmosis from a region of its high-water potential to a region of low water potential through the water potential gradient. **Osmosis can therefore be defined as the diffusion of water from a region of high-water potential to a region of low water potential through a partially permeable membrane.** In plants osmosis is required in during various process such as water absorption, cell to cell movement of water, closing and opening of stomata and during cell extension.

Osmosis is a special type of diffusion of water through a partially permeable membrane. It is affected by concentrations of solutes in the water. Since water is a polar molecule, many substances can dissolve in it. These dissolved substances are termed solutes, and water is a solvent. Water molecules cluster around molecules of a solute, leading to availability of less 'free' molecules of water which can diffuse to other areas. This effectively lowers the concentration of free molecules of water. Water Potential is measured by the concentration of free water molecules and their tendency to diffuse to another area. **More is the free water molecule, higher is the Water Potential.**

The potato acts an osmoscope when its cells were separated by two solutions which differ in their water potential.

## Procedure

1. Peel off the skin of a potato of medium or large size. Cut its one end to make the base flat. Make a hollow cavity in the potato almost up to the bottom with the help of knife.
2. Fill the cavity of the tuber with 20% sugar solution
3. Insert an alpin on the wall of the potato cavity to mark the original level of sugar solution in it. This set up is called potato osmoscope or potato osmometer.
4. Clean a large petri-dish and fill it with water. Add 2 or 3 drops of red colour or safranin so that water of the dish becomes coloured.
5. Keep the potato osmoscope it in the dish, containing coloured water.
6. Leave the experimental set up undisturbed for about 30 minutes.
7. Observe for the change in the level of sugar solution in the potato osmoscope.

## Observation

After 30 minutes it is observed that the level of sugar solution rises inside the cavity of potato osmoscope and gets colored. The level of sugar solution becomes stable after certain period.

## Discussion

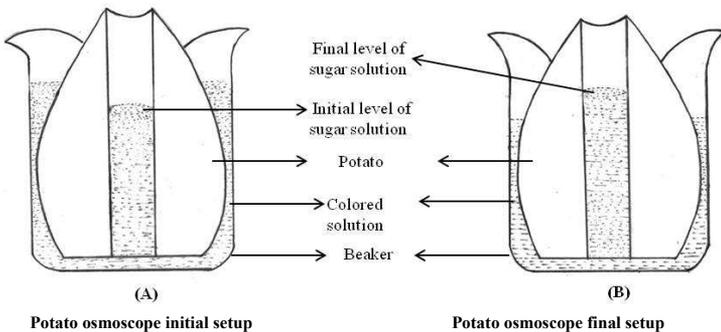
The potato cavity is surrounded by living cells. The plasma membrane of each cell acts as a semi permeable membrane. When potato osmoscope is placed in the dish filled with water, water diffuses into it through plasma membrane of potato tuber cells through a phenomenon of endosmosis i. e. movement of water from the region of its higher potential (from the petridish) to the region of lower water potential (in the cavity of potato osmoscope). This process of endosmosis continues until the water potential become same on both the side.

Hence, the rise in the sugar solution is due to the osmosis in the potato osmoscope.

## Precautions

1. Wall of the potato at the base should be thin.
2. Potato should be kept vertically.
3. Use the fresh and recently peeled potato.

## Osmosis



## Demonstration of process of osmosis in living plant cells by potato osmoscope

**AIM 20: TO DEMONSTRATE THE PROCESS OF AEROBIC RESPIRATION IN GERMINATING SEED BY USING GANONG'S RESPIROMETER.****Apparatus and Materials Required**

Ganong's respirometer, blotting paper, cotton web, KOH solution, beaker and germinating seeds.

**Theory**

Respiration is a catabolic process which involves the breakdown of food or complex organic molecules into simpler products, with the release of energy. This process can take place either in the presence of oxygen (aerobic respiration) or in its absence (anaerobic respiration).

The overall reaction mechanism of aerobic respiration involves the oxidation of carbohydrate and the subsequent production of  $\text{CO}_2$ ,  $\text{H}_2\text{O}$  and energy.



Germinating seeds have a high rate of respiration that can be calculated by using Ganong's respirometer. In plants, carbohydrates, particularly sucrose and starch, are the most important substrates. However, some seeds also contain stored fats and proteins. During aerobic respiration, oxygen is used and it is replaced by equal volume of carbon dioxide. The released carbon dioxide is absorbed by potassium hydroxide which creates a vacuum in the bulb, leading to movement of air from the U-tube to the bulb in order to keep the pressure constant, displacing the liquid in manometer and levelling. The rate of change of water level gives a direct and reasonably accurate reading about the rate of respiration in given material.

**Ganong's respirometer Apparatus**

- (i) Ganong's Respirometer has a large bulb. It is provided with a stopper having a lateral hole, which can be used to equalize the atmospheric pressure inside the apparatus.
- (ii) A graduated side tube or manometer fitted with the bulb, and
- (iii) A levelling tube connected with the manometer tube by rubber tubing. The whole apparatus is clamped on a stand.

**Procedure**

1. Fix the Ganong's respirometer to stand and place a piece of moist cotton in the bulb.

2. Fill the bulb with sufficient amount of germinating seeds with the seed coats removed.
3. Air-tight the openings of the bulb with the stopper so as to cut out the supply of air from outside.
4. Leave the set up aside for about an hour.
5. Pour a strong solution of KOH into the leveling tube.
6. Observe the change in level of water in the graduated and leveling tubes.
7. The rate of respiration can be calculated as increase in water level = Volume of O<sub>2</sub> consumed/time in hr x number of seeds. It can be expressed as rise in water level/hour/seed.

### **Observation**

After one hour, there is rise in the level of water in graduated tube.

### **Results**

Rise in the level of water in graduated tube is due to the absorption of CO<sub>2</sub>. This proves that CO<sub>2</sub> is evolved in respiration.

### **Discussion**

When respiration occurs in the germination seeds, they take the oxygen which is present inside the bulb and release equal amount of carbon dioxide, as KOH solution is poured in the labeling tube or present inside the bulb, it will absorb all the released CO<sub>2</sub>, leading to formation of vacuum inside the bulb. Air will move from the graduated tube to bulb in order to maintain the constant atmospheric pressure inside the bulb. This will cause upward movement of water in the graduated tube which is equal to the amount of oxygen used or amount of CO<sub>2</sub> release in respiration. In the experiment we used gram seed which have respiration quotient (volume of CO<sub>2</sub> evolved/volume of O<sub>2</sub> used) equal to one so here we can say that rate of oxygen used is equal to rate of CO<sub>2</sub> release and it showed the aerobic respiration.

### **Precautions**

1. Germinating green gram seeds give good results.
2. Take sufficient quantity of seeds to ensure evolution of CO<sub>2</sub>.



presence of oxygen (aerobic respiration) or in its absence (anaerobic respiration).

The overall reaction mechanism of anaerobic respiration involves the breakdown of carbohydrate in the absence of oxygen into Ethanol,  $\text{CO}_2$ , and energy.



In plants, carbohydrates, particularly sucrose and starch, are the most important substrates. However, some seeds also contain stored fats and proteins. During anaerobic respiration, oxygen is not used and only carbon dioxide is released. The released carbon dioxide can be absorbed by potassium hydroxide. This property of KOH can be used to demonstrate the rate of anaerobic respiration in germinating seed under anaerobic condition created by mercury.

### Procedure

1. Filled the petridish partly with mercury.
2. Place some germinating seed at the base of the test tube and then fill the test tube completely with mercury.
3. Invert it with the help of the thumb and put it over the petridish containing mercury.
4. Now keep the test tube upright by clamping with a stand in such a condition as if the mouth of the test tube remain in the mercury but not touched the bottom of the beaker.
5. Leave the experimental set for observation for few hours.
6. After few hours, introduced the KOH stick into the test tube with the help of a pair of forceps and take the observations.

### Observation

After few hours it was observed that the level of mercury at the top of the test tube has been displaced downwards by a gas released by germinating gram seeds. Introduction of KOH brought the mercury to the previous level at the top of the test-tube.

### Results

In the anaerobic environment, the seed performed anaerobic respiration and releases  $\text{CO}_2$ .

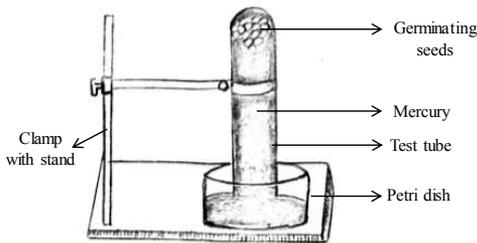
### Discussion

The seeds respired anaerobically since they could not absorb atmospheric oxygen due to presence of mercury. Thus, the respiration of germinating seeds takes place in complete absence of  $O_2$  supply and the gas produced is  $CO_2$  as evidenced by its absorption by KOH. This proves that anaerobic respiration has taken place in this environment.

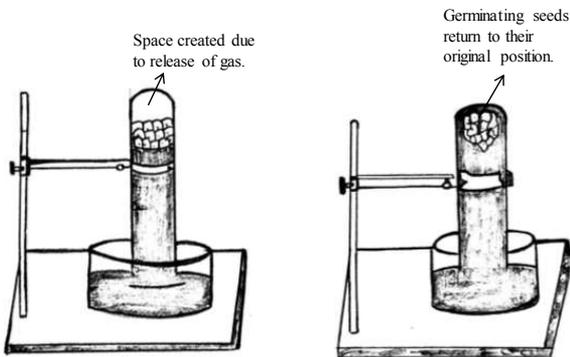
### Precautions

1. Germinating green gram seeds give good results.
2. Take sufficient quantity of seeds to ensure evolution of  $CO_2$ .
3. KOH solution should be prepared freshly and accurately.

### Anaerobic respiration



(A)- Experimental set-up



(B) and (C)-Experimental observations  
Demonstration of Anaerobic Respiration

## Unit-4

# PLANT TAXONOMY

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**AIM 22: TO STUDY FLORAL DESCRIPTION OF MALVACEAE FAMILY THROUGH *HIBISCUS ROSA-SINENSIS* FLOWER.**

### **Material required**

forceps, blade, cover slip, needle, blotting paper, given flower and dissecting microscope.

### **Theory**

Floral parts are found to be the conserved structure, are rarely affected by external factors. Floral description helps to decipher the characteristics of angiospermic family. In floral description different parts of a flower were studied with the set rules and a floral formula is formulated based on these characteristics.

### **Observations**

#### **Floral description**

**Flower:** Pedicellate, ebracteate, Bracteolate, epicalyx (5 to 8 Bracteoles creating a whorl outer to calyx forming epicalyx), Bisexual, Complete, Pentamerous, Actinomorphic, Hypogynous, large, Showy, Red in colour.

**Calyx:** Sepals 5, Green, gamosepalous, displaying valvate aestivation, hairy and inferior.

**Corolla:** Petals 5, coloured, polypetalous but little fused at the base because of adhesion with staminal tube, displaying twisted aestivation and inferior.

**Androecium:** Numerous stamens, monadelphous, filaments are fused to create a staminal tube around the style, staminal tube is

fused along with the petals at their bases- epipetalous, Anthers are monothealous, reniform (kidney shape), yellow, transversely attached to the filament, dehisce longitudinally and inferior.

**Gynoecium:** Ovary superior, 5 carpels (pentacarpellary), syncarpous, pentalocular with axile placentation, two ovules per loculus or chamber, Style long, slender, passes through staminal tube, Stigma 5, coloured and capitates.

**Floral Formula**

$$\text{Ebr Brl } \oplus \text{ } \text{♀ Epi-K}_{5-8} \text{ K}_{(5)} \overbrace{\text{C}_5 \text{A}_{(\infty)}} \text{ G}_{(5)}$$

**Diagnostic Characteristics of Malvaceae family**

- Presence of epicalyx
- Petals with twisted aestivation
- Stamens indefinite and monoadelphous.
- Anthers reniform and monothealous.
- Ovary pentacarpellary with axile placentation.

**Classification**

**Division:** Angiospermae

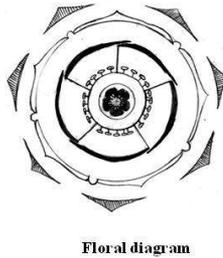
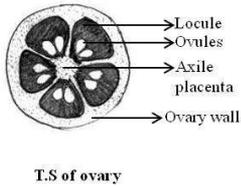
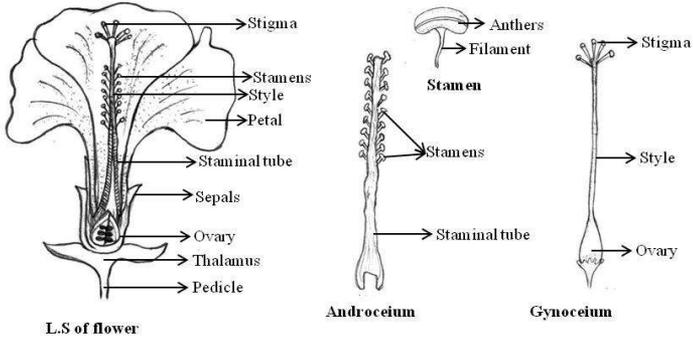
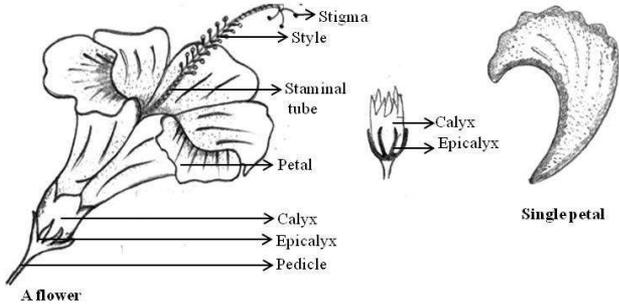
**Class:** Dicotyledonae

**Family:** Malvaceae

**Genus:** *Hibiscus*

**Species:** *rosa-sinensis*

**(China rose, Shoe flower)**



### Floral description

### AIM 23: TO STUDY FLORAL DESCRIPTION OF PAPILIONACEAE (FABACEAE) FAMILY THROUGH *DOLICHOS LABLAB* FLOWER.

#### Material required

forceps, blade, cover slip, needle, blotting paper, given flower and dissecting microscope.

#### Theory

Floral parts are found to be the conserved structure, are rarely affected by external factors. Floral description helps to decipher the characteristics of angiospermic family. In floral description different parts of a flower were studied with the set rules and a floral formula is formulated based on these characteristics.

#### Observations

##### Floral description

**Flower:** Pedicellate, Bracteate, Complete, Zygomorphic, Bisexual, Pentamerous, Hypogynous, Purplish or white in colour

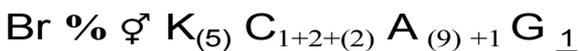
**Calyx:** Sepals 5, gamosepalous, equal or unequal, united in the form of tubular calyx, valvate aestivation, green in colour and inferior.

**Corolla:** Petals 5, Unequal, polypetalous, papilionaceous i.e. a posterior petal is large, known as standard (vexillum) petal, 2 lateral petals known as wings (Alae) petals and remaining two petals fused, form a boat shaped structure known as keel (keel) petals, The keel encloses stamens and pistils, Vexillary aestivation, purple in colour and inferior.

**Androecium:** Stamens 10, arranged in a ring, diadelphous 9 united to form one bundle and one is free, anthers ditheous, dehiscence by longitudinal slit and inferior.

**Gynoecium:** Monocarpellary, Ovary superior, elongated somewhat flattened, unilocular, marginal placentation, style curved and stigma hairy.

##### Floral formula



#### Diagnostic Characteristics of Fabaceae family

1. Flower zygomorphic

2. Corolla papilionaceous with vexillary aestivation
3. Androecium diadelphous
4. Gynoecium monocarpellary having marginal placentation.

**Classification**

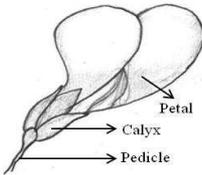
**Division: Angiospermae**

**Class: Dicotyledonae**

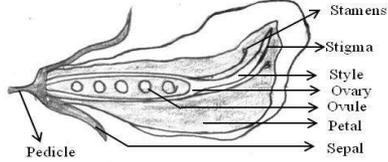
**Family: Fabaceae/ Papilionaceae**

**Genus: *Dolichos***

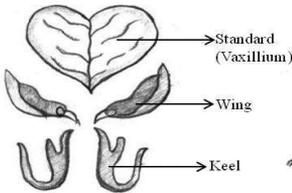
**Species: *lablab***



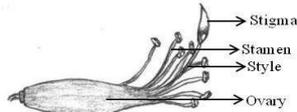
A flower



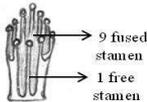
L.S of flower



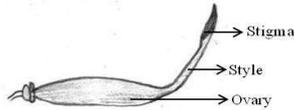
Corolla opened



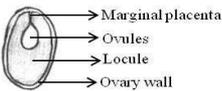
Androecium and Gynoecium



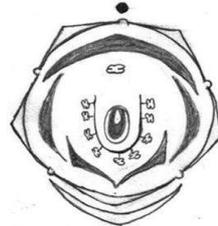
Androecium



Gynoecium



T.S of ovary



Floral diagram

**Floral description**

## AIM 24: TO STUDY FLORAL DESCRIPTION OF SOLANACEAE FAMILY THROUGH *SOLANUM MELONGENA* FLOWER.

### Material required

forceps, blade, cover slip, needle, blotting paper, given flower and dissecting microscope.

### Theory

Floral parts are found to be the conserved structure, are rarely affected by external factors. Floral description helps to decipher the characteristics of angiospermic family. In floral description different parts of a flower were studied with the set rules and a floral formula is formulated based on these characteristics.

### Observations

#### Floral description

**Flower:** Pedicellate, Ebracteate, Complete, Bisexual, Actinomorphic, Pentamerous and Hypogynous, purple in colour

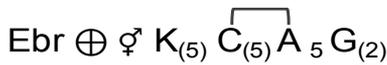
**Calyx:** Sepals 5, gamosepalous, green, persistent (in the fruit), valvate aestivation and inferior.

**Corolla:** Petals 5, gamopetalous, funnel shaped, valvate aestivation, purple in colour and inferior.

**Androecium:** 5 stamens, epipetalous (fused with petals and inserted into corolla tube), alternating with petals. Anthers are dithecous and open with apical pore, filamentous with unequal length.

**Gynoecium:** 2, bicarpellary, syncarpous, Superior ovary, bilocular but some time becomes tetra or multilocular due to formation of false septa, axile placentation and many ovules per locule. Ovary is placed obliquely in relation to mother axis of the flowers. Style is short and stigma capitate.

#### Floral formula



### Diagnostic Characteristics of Solanaceae family

1. Both Sepals and petals are fused
2. Calyx persistent in fruit

3. Corolla funnel shape
4. Ovary is bicarpellary and placed obliquely in relation to mother axis the flowers.

**Classification**

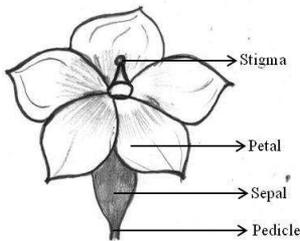
**Division:** Angiospermae

**Class:** Dicotyledonae

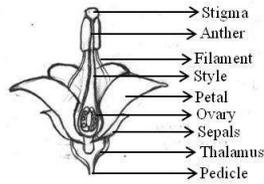
**Family:** Solanaceae

**Genus:** *Solanum*

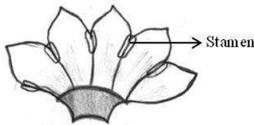
**Species:** *melongena*



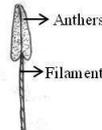
A flower



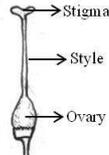
L.S of flower



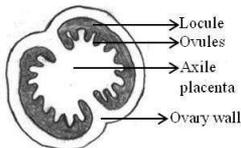
Epipetalous stamens



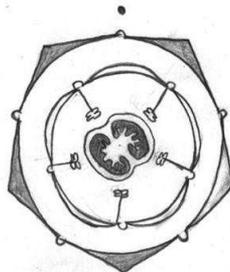
Androecium-  
single stamen



Gynoecium



T.S of ovary



Floral diagram

**Floral description**

## Unit-5

# ECONOMIC BOTANY

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**AIM 26: TO IDENTIFY AND CLASSIFY VEGETABLES PLANTS.**

### **Material Required**

Various vegetables needed for the study.

### **Theory**

**Vegetable are defined as a plant or part of a plant such as a cabbage, potato, turnip or bean, that are usually eaten with the main course of meal and are commonly salted or boiled or used for desert and salad.** Vegetables can be eaten either raw or cooked and play an important role in human nutrition, being mostly low in fat and carbohydrates, but high in vitamins, minerals and dietary fiber. Many nutritionists encourage people to consume plenty of fruit and vegetables, five or more portions a day often being recommended.

### **Procedure**

1. Identified the given plants with their common and botanical name
2. Write about their part use and uses.

### **Observations**

1. **Common name: Fenugreek (Methi)**

**Botanical name: *Trigonella foenum-graecum***

**Family: Fabaceae**

**Part used: Leaves and seeds**

## Uses

1. Fenugreek leaves can be used fresh or dried as a culinary herb.
2. It is included as an ingredient in spice blends. It is also used as a **flavoring agent in imitation maple syrup, foods, beverages, and tobacco.**
3. Seeds are often roasted to reduce **bitterness and enhance flavour**
4. Fenugreek is taken by mouth for **digestive problems such as loss of appetite**, upset stomach, constipation, inflammation of the stomach (gastritis).
5. Seeds are used as **insect repelled in storage food.**
6. It can be directly applied to skin to treat **local pain and swelling (inflammation), muscle pain, pain and swelling of lymph nodes**
7. The application of its seeds on head **promotes growth of hair and also prevents their falling off.**
8. It is used to regulate **cholesterol and glucose level.**

### 2. Common name: Spinach (Pālaka)

**Botanical name:** *Spinacia oleracea*

**Family:** Amaranthaceae

**Part used:** Leaves

## Uses

1. It contains both large amounts iron, calcium, and other essential vitamins and minerals.
2. Fresh, tender spinach leaves (baby spinach) can be **eaten raw either in salad and vegetable burgers or as juice.**
3. It is mixed with other seasonal greens vegetable to **prepare “saag”** which is eaten with roti and rice.
4. It improves **skin texture and eye sight** as it is rich in various vitamins such as B-complex.
5. Leaves are rich in fibre so used to treat **digestive problems such as loss of appetite**, upset stomach and constipation.

6. Regular consumption of spinach in the diet helps **prevent osteoporosis (weakness of bones), iron-deficiency anemia.**
7. Its leaves are believed to protect the human body from **cardiovascular diseases and cancers of colon and prostate.**

**3. Common name: Tomato**

**Botanical name:** *Lycopersicum esculentum*

**Family:** Solanaceae

**Part used:** Fruit

**Uses**

1. Tomato fruit can be eaten **raw or cooked and is used** in many dishes.
2. All kinds of tomatoes, including cherry, are one of the commonly featured **ingredients in salad** preparations worldwide.
3. Fresh tomato juice and soup are popular healthy **dishes served as an appetizer.**
4. The fruit may also be processed **into juice, soup, ketchup, puree, paste or powder.**
5. Tomatoes contain a chemical called **lycopene**, which is thought to play **a role in preventing cancer.**
6. Tomato juice **improve skin** by treating tanning, counters discoloration of skin, acne, shrinks open pores and regulates oil secretion.
7. The vitamins and iron present in tomato **juice prevent hair fall and add shine to dull, damaged and lifeless hair.**
8. Tomato juice has a **detoxification effect** on the body due to the presence of **chlorine and sulfur.** Thus, help in proper functioning of **liver and kidneys.**
9. Fiber in the tomato juice keeps the liver healthy, aids digestion, prevents constipation and thus, regulates and aids the bowel movement.
10. It prevents damage **to blood vessel walls and heart.**

**4. Common name: Potato**

**Botanical name:** *Solanum tuberosum*

**Family: Solanaceae**

**Part used: Underground modified stem-Tuber**

### Uses

1. Potato is considered as powerhouse of nutrients, vitamins and minerals. **Hence, it is included for a balanced diet.**
2. **It is used as ingredient in preparation of curries.**
3. Potatoes can also be **processed into starch, alcohol or flour.**
4. They may be **cut or sliced and made into potato chips or fries.**
5. It improves **glucose tolerance and insulin sensitivity.**
6. It lowers plasma **cholesterol and triglyceride concentrations.**
7. The starch present in it provides **protection against colon cancer.**
8. Raw tomato to use to **heal the burn area.**
9. They are also a component in the **nutrient media** used for **growth of microorganism** such as **fungi.**
10. It is rich in vitamin-C, helps body to **develop resistance against infectious agents** and scavenge harmful, pro-inflammatory free radicals.

### 5. Common name: Carrot

**Botanical name: *Daucus carota***

**Family: Apiaceae or umbellifere**

**Part used: Modified Root**

### Uses

1. Fresh carrots **can be used raw in vegetable as well as fruit salads.**
2. It is also used in the **preparation of cakes, pudding, pickles and soups** etc.
3. **Carrot juice** is a **refreshing drink**, enjoyed either alone or with fruit/vegetable juice.
4. In South Asia, delicious sweet dish, **“gaajar ka halwa,”** is prepared using grated carrot, almonds, cashews, pistachio, butter, sugar, and milk.

5. The leaves of the plant can **be used as feed for animals.**
6. It helps to treat **anemia, acne and improves eye sight.**
7. It reduced **risk of heart disease and high blood pressure** by lowering the cholesterol level of the body through pectin fibre.
8. It helps to **heal minor wounds, infection and injuries.**
9. It can help the **liver excrete fats and bile and improve skin health.**
10. Carotene concentration is used for **colouring butter and other food items.**

**6. Common name: Onion**

**Botanical name:** *Allium cepa*

**Family:** Liliaceae

**Part used:** Modified leaves known as Bulb

**Uses**

1. It is one of those vegetables which are **used as a vegetable, or as a spice to bring out the flavour of other dishes** without overpowering them.
  2. Onions are regarded as an **antiseptic and diuretic.**
  3. Its **juice or paste is used for wound healing, skin complaints (acne), insect bites, and toothache.**
  4. The **whole onion is an appetite stimulant and digestant.**
  5. It is used extensively in **salads, cheese pizza, burger, soup and curries.**
  6. It helps facilitate **insulin action and control sugar levels in diabetes.**
  7. In manufacturing, **the oil is used to flavor foods.**
  8. Onions contain **selenium that stimulates immune function.**
  9. Onion juice can work **great to relieve earache.**
  10. Onions can **prevent age-related osteoporosis**
- 7. Common name: Cauliflower**
- Botanical name:** *Brassica Oleracea*

**Family: Brassicaceae**

**Part used: condensed inflorescence known as curb**

### Uses

1. **Cauliflower is grown for consumption as a vegetable, either fresh or cooked.**
  2. **It is also widely used in pickles and soups.**
  3. The compound indole-3-carbinol, which appears to work as an anti-estrogen, appears to slow or **prevent the growth of tumors of the breast and prostate.**
  4. It may improve the **livers ability to detoxify carcinogenic substances.**
  5. It helps in **weight loss and maintains hormonal balance.**
  6. **It reduced risk of abdominal disorders.**
  7. It prevents **bone loss in male and female.**
  8. **Leaves and stem is used to feed the livestock.**
- 8. Common name: Bottle gourd (Lauki)**  
**Botanical name: *Lagenaria siceraria* (Molina) Standl**  
**Family: Cucurbitaceae**  
**Part used: Fruit**

### Uses

1. The **young fruits are edible and are usually cooked as a vegetable.**
2. It contains low calories also has **iron, Vitamin C and B complex.**
3. It has also **cooling, calming (or sedative), diuretic** properties.
4. Regular consumption of this vegetable provides relief to **people suffering with digestive problems and diabetics.**
5. It serves greatly to **hot curries as well as cooling yogurt dishes like Raita.**
6. As a vegetable, it is widely used in southern Chinese **cuisine as in a soup.**
7. Dried and empty bottle gourds are used as a **utensil in households across West Africa.**

8. They can also be fashioned into **birdhouses, lamps, and musical instruments.**
9. Due to white showy flowers and dense foliage, they are **used as a screen and ornamental plant.**
10. It can be **used like squash** but it has a firmer, crisper texture.

**9. Common name: Bitter gourd**

**Botanical name:** *Momordica charantia*

**Family:** Cucurbitaceae

**Part used:** Fruit

**Uses**

1. It contains higher concentrations of Vitamin A, Vitamin C, iron, **phosphorus** and carbohydrates.
2. It is used as **vegetable** and also utilized in the preparation of **soups, pickles and also in tea.**
3. **This vegetable is a panacea medicine for the diabetes. It helps in lowering the blood and urine sugar levels.**
4. It helps in **purifying blood tissues** as well as in **enhancing digestive system.**
5. Bitter gourd is **highly beneficial in the treatment of blood disorders** like blood boils, itching, ring-worm and other **fungal diseases.** Its regular use in endemic regions of **leprosy acts as a preventive medicine.**
6. Bitter gourd plant roots are used in folk medicine for **respiratory disorders** from ancient times.
7. The consumption of bitter gourds leaves is also an **effective medicine in early stages of cholera and other types of diarrhea** during summer.
8. The leaf juice is also beneficial in the **treatment of alcoholism.** Regular consumption of the bitter gourds strengthens the functioning of the liver.
9. **Dried and powdered whole bitter gourd** has been used in the **preparation of iced or milk tea** in some East Asian regions.

**10. Common name: Spong gourd (Toori)****Botanical name: *Luffa cylindrical* Rome.****Family: Cucurbitaceae****Part used: Fruit****Uses**

1. **Sponge Gourd are a commonly used as vegetables.**
2. Fruit dried fibrous interior acts as a natural loofah and is used to gently remove the surface layer of **dead skin, leaving the skin smooth and conditioned.**
3. It is used in **kitchen as a sponge** to remove stubborn food particles from dishes
4. It **helps to clean the air when kept in moist and warm environment** common to bathrooms by absorbing bacteria.
5. The paste of the leaves of the plant is applied over the **local area to treat swelling.**
6. The leaf of the Luffa is used **to treat intestinal worms.**
7. The juice of the leaf and the whole plant acts like a **blood purifier when consumed regularly.**
8. Sponge gourd possess many **healing and medicinal properties** and is quite useful in **asthma, skin diseases and splenic enlargement.**
9. Regular consumption is helpful **for rheumatism, backache, internal hemorrhage and chest pains**

**AIM 27: TO IDENTIFY AND CLASSIFY ORNAMENTAL AND FOLIAGE PLANTS.****Material Required**

Various ornamental and foliage plants needed for the study.

**Theory**

Ornamental plants are plants that are grown for decorative purposes in gardens. They are mostly known for their floral characteristics. But some ornamental plants also have showy foliage. The foliage may be deciduous, turning bright orange, red, and yellow before dropping off

in the fall, or evergreen, with distinct appearance. Ornamental and foliage plants are come in a range of shapes, sizes and colors suitable to a broad array of climates, landscapes, and gardening needs. These plants carry high commercial values due to their increasing demands. Some of ornamental and foliage plants also have medicinal value.

### Procedure

1. Identified the given plants with their common and botanical name
2. Write about their uses and method of propagation.

### Observation

**1. Common name: Asparagus**

**Botanical name: *Asparagus* sp.**

**Family: Asparagaceae**

**Part use in decoration: Leaves and stem**

#### Uses

1. The aerial part i.e. **leaves are used for ornamental purposes.**
  2. They are mostly **grown in hanging baskets, wall boxes, hanging baskets, window boxes, and planters of all kinds.**
  3. They are **used to make bouquet as filler**, it holds up better than delicate ferns.
  4. They are utilized to **decorate flower pot and table decoration.**
  5. They form a **dense, fine-textured foliage mass** that is useful as **screen against walls and fences.** They climb by means of small hooked prickles.
  6. They can be growing in **partially shaded ground beds, alone to produced mass effect** or can be intermixed with **larger, shade-tolerant flowers such as tuberous begonias.**
  7. They also carry medicinal value for **treatment of joint pain (rheumatism), hormone imbalances in women,** and stones in the kidney and bladder etc.
- 2. Common name: Rose**  
**Botanical name: *Rosa indica***  
**Family: Rosaceae**  
**Part use in decoration: Flower**

## Uses

1. They are known due to their beautiful and scented flower.
2. They can be grown in **pots and directly in soil in garden.**
3. They can be grown in **borders, containers, over arches and as groundcover.**
4. **Rose is always a major component of Bouquet.**
5. They are utilized to **decorate flower pot and in table decoration.**
6. It also carries **religious sentiment, used during festival and puja.**
7. Roses are widely used **across the world as symbols of love, sympathy or sorrow.**
8. They are main component of **decoration, cosmetic and perfume industry** and due to their commercial value, they have been modified into different colour through biotechnology.
9. Many rose gardens have been established which are used as **touristic place** e.g. rose garden in Chandigarh.
10. They are also **used in food items due to their strong and pleasant smell.**

### 3. Common name: China rose

**Botanical name:** *Hibiscus rosa-sinensis*

**Family:** Malvaceae

**Part use in decoration:** Flower

## Uses

1. Due to large and brightly colored flower, it is used as ornamental plant.
2. The plants are usually grown in **big pots and can also grow in the garden as a shrub.**
3. **They can grow in rows to form hedges and shrub border.**
4. China rose can **also be trained as a standard or small tree** form by removing upright stem and trimming the lower leaves.
5. It also carries **religious sentiment, used during festival.**

6. The hibiscus is commonly known in **Asia as the shoe flower** because it is used **to polish shoes**.
  7. It prevents heart diseases by regulating blood pressure through lower down of **blood cholesterol level**.
  8. The **juice of the leaves as well as the flower is considered good for inducing hair growth**.
- 4. Common name: Bougainvillia**  
**Botanical name: *Bougainvillea* sp.**  
**Family: Nyctaginaceae**  
**Part use in decoration: Bracts (flower)**

### Uses

1. They are known for **colour variation, found in Bract**.
  2. It can grow in both **small and large gardens directly in soil/ pot along the wall or in open**.
  3. **It makes one of the best hedges and border in gardens**.
  4. They **can be grown along the wall for beautification** due to their climbing habit.
  5. **Bougainvillea can be used bonsai and topiary purposes** through pruning.
  6. *Bougainvillea glabra* **is sometimes referred to as “paper flower”** because the bracts are thin and papery.
  7. Bougainvillea leaves are used to cure variety of disorders like for **diarrhea, diabetes and stomach acidity, cough and sore throat**.
- 5. Common name: Fern**  
**Botanical name: *Dryopteris* sp.**  
**Family: Polypodiaceae**  
**Part use in decoration: Leaves**

### Uses

1. Fern species are widely used as garden ornamental plants due to their leaves.
2. **They can grow in pots or directly in soil.**

3. Ferns are **shade and moisture loving plant, thus can be grow indoor such as table and office decoration purpose.**
4. They are also a **component for bouquet preparation.**
5. They can be used in **hanging basket.**
6. Boston ferns are **used as indoor plants; they contribute in eliminating toxins from the air such as formaldehyde.**
7. They are the essential component of **terrace garden due to their small size.**
8. Leaf paste or powder can be used to cure **a variety of ailments such as centipede bites, wounds, skin ailments, and coughs.**

**6. Common name: Painted Nettle**

**Botanical name: *Coleus blumei***

**Family: Lamiaceae**

**Part use: Flower**

**Description**

1. It is a bushy, woody-based evergreen perennial, growing to 60–75cm height.
2. It is widely grown due to its highly decorative variegated leaves.
3. Leaves have different colour and shape variation depending upon the varieties such as leaves are oval shaped with rounded tooth edges and brightly colored, with green edges and blood-red veins in the center as well as many splotches of dark red, maroon, and brown.
4. It is ideally planted in pots or as a border in garden or in hanging basket.

**7. Common name: Pot marigold**

**Botanical name: *Calendula officinalis***

**Family: Asteraceae**

**Part use: Flower**

**Description**

1. *Calendula officinalis* is a short-lived aromatic herbaceous perennial, growing to 80 cm (31 in) tall, with sparsely branched lax or erect stems.

2. Calendulas are considered by many gardening experts as among the easiest and most versatile flowers to grow in a garden, especially because they tolerate most soils
3. Pot marigolds typically bloom quickly under two months in bright yellows, golds, and oranges.
4. A **composite flower** is actually a cluster of small flowers, called florets, joined together in what is called a flower head. The florets often resemble petals. Some florets have both stamens and pistils; they are called disc florets. Some have only pistils; they are called ray florets. A composite flower can be made up of only disc florets or of a combination of disc and ray florets.
5. It is ideally planted directly in soil or in pots.

### **Propagation**

Marigold plant is propagated by the seeds. They are shown during the early spring.

### **AIM 28: TO IDENTIFY AND CLASSIFY SPICES AND CONDIMENTS PLANT.**

#### **Material required**

Various ornamental and foliage plants needed for the study.

#### **Theory**

Condiments and spices are substances which are used as adjuncts to food, provide flavour and colour to food. A spice is usually a single unprepared ingredient (e.g., nutmeg, cinnamon, clove, salt, pepper). A condiment is most often something involving some preparation on its own before using, like ketchup, relish, mustard or a special sauce. Apart from adding colour, flavour and taste, consumption of spices provides infinite health benefits.

#### **Procedure**

1. Identified the given plants with their common and botanical name
2. Write about their part use and uses.

#### **Observations**

1. **Common name:** Clove (Laung)  
**Botanical name:** *Syzygium aromaticum*  
**Family:** Myrtaceae

◆

**Part use: Dried unopened flower bud**

**Uses**

1. They are extensively used for **flavouring pickles, curries, sauces, and ketchups.**
2. They are also used for **flavouring puddings, fruit cakes and other desserts**
3. Clove oil (Essential oil) is used in **perfumes, soaps and ingredient of toothpaste and mouthwash.**
4. Clove oil is **important for relieving toothache.**
5. Clove oil rich in eugenol, used in manufacturing of **vanilla and other flavoring compound.**
6. They are also mixed with **tobacco and used in smoking industry.**
7. In biology, **clove oil is used to clean histological sections for study.**

**2. Common name: Cardamom (Eliachi)**

**Botanical name: *Elettaria cardamomum***

**Family: Zingiberaceae**

**Part use: Dried Fruit**

**Uses**

1. Cardamom fruit or seeds are used **whole or fried power form as a culinary spice.**
2. Cardamom may use in preparation of **pickles, sausages, cakes and confectionery.**
3. In India, they are mostly chewed after meal **and also used in pan preparation.**
4. Cardamom oil is used as **condiment and for flavoring of beverages** (preparation of tea, coffee, and cold beverages).
5. Cardamom is used for **digestion problems including** heartburn, intestinal gas, constipation, liver problem and loss of appetite.
6. It is also used for **common cold, cough, bronchitis, sore mouth and throat infection.**

- 7 Due to it is **stimulant and carminative (relieve from gas), in used in ancient medicinal therapies.**
8. A strong cardamom coffee ‘gahwa’ –is Symbol for hospitality among Arabs people.
9. It is used preparation of sweet dishes in many Asian countries. e.g **Elaichi-pista (cardamom and pistachio) kulfi** is a famous summer dessert in India.

**3. Common name: Coriander (Dhania)**

**Botanical name:** *Coriandrum sativum*

**Family:** Apiaceae/Umbelliferaceae

**Part use:** leaves and fruits

**Uses**

1. Leaves are employed for **garnishing meat preparation, sausage and chutney preparation** due to their strong smell.
2. They are used to **flavor curries, soups and curd.**
3. Dried fruit is used as a **constituent of curry (in powdered form) and other spices mixture. e.g. in pickles whole fruit is used.**
4. **Coriander oil** is used for **flavouring perfume, candy, coca, chocolate, tobacco and alcoholic beverages.**
5. Coriander oil is **carminative, tonic and diuretic.**
6. The residue leaf after **extraction of volatile oil is used to feed livestock.**

**4. Common name: Cumin (Jeera)**

**Botanical name:** *Cuminum cyminum*

**Family:** Apiaceae/ Umbelliferaceae

**Part use:** Dried seeds

**Uses**

1. Cumin seeds are used as a **spice for their distinctive flavour and aroma.**
2. It is important ingredient in **curry mixture and used to flavour cheese, pickles, soups, meat dishes, bread and cakes.**
3. **Lassi (churned yogurt)** is often **flavored with this cumin powder-salt mixture in some part of India.**

- 4. Cumin is **stomachic, diuretic, carminative, stimulant and astringent**.
  - 5. They are mostly used in veterinary medicine to **increase lactation and reduce nausea in pregnancy**.
  - 6. It has been shown to be effective in **treating as diarrhea, indigestion, and morning sickness**.
  - 7. The residue leaf after **extraction of volatile oil is used to feed livestock**.
5. **Common name: Asafoetida (Hing)**  
**Botanical name: *Ferula foetida***  
**Family: Apiaceae/ Umbelliferaceae**  
**Part use: Dried resinous gum obtained from root and rhizome**

### Uses

- 1. It is also used as a **flavouring agent in pickles and sauces**.
  - 2. It has been widely used as a **tenderizer and preservative for meat**.
  - 3. It was widely recommended as a herbal medicine for simple **digestive problems such as gas, bloating, indigestion and constipation** in the traditional medicinal systems.
  - 4. It is also helpful in **respiratory problems such as bronchitis, asthma and whooping cough**.
  - 5. It also thins the **blood and lowers blood pressure**.
  - 6. It helps to stimulate nervous system and used to cure **various disorders like hysteria and convulsion**.
  - 7. It is used to cure **headache and migraine problems**
6. **Common name: Pepper (Kaalee mirch)**  
**Botanical name: *Piper nigrum* (Black)/ *Piper nigrum* (White)**  
**Family: Piperaceae**  
**Part use: Dry fruit**

### Uses

- 1. It is an **indispensable component of various preparations such as sauces, soaps, curry power, and pickles**.

2. Black peppercorns along with other spices and seasonings **used to marinate chicken, fish, and meat.**
3. **Mixture of Black piper powder with salt is used as in serving table to sprinkle over vegetable/fruit salads and chats.**
4. Due to **its cooling effect, it is usually added in refreshing drinks.** e.g. **Lassi (churned yogurt) is often flavored with this spice-salt mixture in some part of India.**
5. It is used in medicine as a **stimulant for salivary and gastric secretion.** It enhances digestion, assimilation and metabolism of food.
6. It is known for **detoxifying of lungs; it helps in removing Cold, Congestion and asthma problem.**
7. It also has **Bacteriostatic and fungistatic properties.** e.g. uses in dentistry as an antiseptic remedy for tooth-decay and gum swellings.

### **AIM 29: TO IDENTIFY AND CLASSIFY HERBAL PLANTS.**

#### **Material required**

Various ornamental and foliage plants needed for the study.

#### **Theory**

Herbs are the plants which are useful to human due to their specific properties such as flavor, scent, medicinal and rejuvenating value. These plants are the basis of Ayurveda medicine and useful to human being. Apart from the medicinal uses, herbs are also used in natural dye, pest control, food, perfume, tea etc.

#### **Procedure**

1. Identified the given plants with their common and botanical name
2. Write about their part use and uses.

#### **Observations**

1. **Mint – *Mentha sp.***

**Part used:** Leaves

◆  
**Uses**

1. Its leaves are used for flavouring in soap sauces, beverages, candy and its chutney.
2. Its juice is also given to check vomiting along with onion juice.
3. Its commercial extract is sold as pepper mint which is used in many industries.
4. It is much used as chutney along with coriander leaves or alone with raw mangoes.
5. Pepper mint has a refreshing odour and a persistent cooling taste.

**2. Basil: *Ocimum sanctum***

**Part used:** leaves

**Uses**

1. It is a native of India and is popular because of its aromatic and stimulating properties.
2. The leaves are used for flavoring soups salads and beverages and sauces etc.
3. The golden yellow essential oil extracted from it, is used in perfumery and various beverages.
4. The juice from leaves is used to cure ear infection.
5. The seeds are regarded as refreshing and sedative.
6. Holy basil is used for the common cold, influenza (“the flu”), H1N1 (swine) flu, diabetes, asthma, bronchitis, earache, headache, stomach upset, heart disease, fever, viral hepatitis, malaria, stress, and tuberculosis.

**3. *Aloe Vera***

**Part used:** Leaves

**Uses**

1. Aloe gel is taken by mouth for osteoarthritis, bowel diseases including ulcerative colitis, fever, itching and inflammation, and as a general tonic.

2. It is also used for stomach ulcers, diabetes, asthma, and for treating some side effects of radiation treatment.
3. Aloe latex is used orally for epilepsy, colds, bleeding, and absence of menstrual periods, depression, diabetes, multiple sclerosis, hemorrhoids, varicose veins and other vision problems.

#### 4. **Ginger:** *Zingiber officinalis*

**Part used:** Rhizome

##### Uses

1. Ginger is commonly used to treat various types of “stomach problems,” including motion sickness, morning sickness, upset stomach, gas, diarrhea, nausea caused by cancer treatment, nausea and vomiting after surgery, as well as loss of appetite.
2. Other uses include pain relief from arthritis or muscle soreness, menstrual pain, upper respiratory tract infections, cough, and bronchitis.
3. Ginger is also sometimes used for chest pain, low back pain, and stomach pain.
4. Some people pour the fresh juice on their skin to treat burns. The oil made from ginger is sometimes applied to the skin to relieve pain.
5. In foods and beverages, ginger is used as a flavoring agent.
6. In manufacturing, ginger is used as for fragrance in soaps and cosmetics.
7. One of the chemicals in ginger is also used as an ingredient in laxative, anti-gas, and anti-acid medications.

#### 5. **Lemon grass:** *Cymbopogon citrates*

**Part used:** leaves and stem

##### Uses

1. Lemongrass is a plant. The leaves and the oil are used to make medicine.
2. Lemongrass is used for treating digestive tract spasms, stomachache, high blood pressure, convulsions, pain, vomiting, cough, achy joints (rheumatism), fever, the common cold, and exhaustion.

3. It is also used to kill germs and as a mild astringent.
4. Some people apply lemongrass and its essential oil directly to the skin for headache, stomachache, abdominal pain, and muscle pain.
5. In food and beverages, lemongrass is used as a flavoring. For example, lemongrass leaves are commonly used as “lemon” flavoring in herbal teas.
6. In manufacturing, lemongrass is used as a fragrance in soaps and cosmetics. Lemongrass is also used in making vitamin A.

## 6. Onion: *Allium sativum*

**Part used:** Bulb

### Uses

1. Onion is used for treating digestion problems including loss of appetite, upset stomach, and gallbladder disorders
2. It is also used for treating heart and blood vessel problems including chest pain (angina) and high blood pressure; and for preventing “hardening of the arteries” (atherosclerosis).
3. It is also used for treating sore mouth and throat, whooping cough, bronchitis, asthma, dehydration, intestinal gas, parasitic worms, and diabetes.
4. Some people use it as a diuretic to increase urine output.
5. Onion is applied directly to the skin for insect bites, wounds, light burns, boils and warts.
6. In foods, onion is used in many recipes. And In manufacturing, its oil is used to flavor foods.

## 7. Neem: *Azadirachta indica*

**Part used:** leaves, seeds and bark

### Uses

1. The tender shoots and flowers of the neem tree are eaten as a vegetable in India. A souplike dish as “neem flower rasam” made of the flower of neem is prepared in Tamil Nadu
2. Neem products are believed to be anthelmintic, antifungal, antidiabetic, antibacterial, antiviral, contraceptive and sedative

3. Neem oil is also used for healthy hair, to improve liver function, detoxify the blood, and balance blood sugar levels.
4. Neem leaves have also been used to treat skin diseases.
5. Its twigs are also used as tooth brush. One end is chewed to turn it into soft bristles to clean the teeth by brushing.
6. It is used to kill and to repel insect.

### **AIM 30: TO IDENTIFY AND CLASSIFY FRUITS PLANT.**

#### **Theory**

Fruits and vegetables contain important vitamins, minerals and plant chemicals. They also contain fibre. There are many varieties of fruit and vegetables available and many ways to prepare, cook and serve them. A diet high in fruit and vegetables can help protect you against cancer, diabetes and heart disease.

#### **Procedure**

1. Identified the given plants with their common and botanical name
2. Write about their part use and uses.

#### **Observations**

##### **1. Mango: *Mangifera indica***

**Family:** Anacardiaceae (member of the cashew family)

**Part used:** Fruit (Drupe)

#### **Economic Importance / uses**

1. Mango fruit is one of the delicious fruits mostly **eaten fresh**, but also made into **jam, jellies, and squash**.
2. The green unripe fruits are used in **chutney, sharbats, pickles and curries**.
3. The juice of mango fruit dried in the sun to form a **solid sheet called mango leather or am-papad in India** which is a sour-sweet and pliable product.
4. Mango fruit is a rich source of **fibers, vitamins** including, A, C, and D and minerals like copper, potassium and magnesium
5. Thin **slice of unripe mangoes is dried in the sun** and often mixed with turmeric powder. This is used in powder form (**amchur**) as a souring agent in **soap, chutney and vegetables**.

6. **Leaves** are used to regulate **diabetics and blood pressure**; they are used to **treat stone and diabetics**.
7. **Wood** is extensively used for **low-cost furniture**, floor, ceiling boards, window frames, heavy packing cases, match splints etc.
8. **The bark** contains **mangiferine** and is **astringent** and employed against **rheumatism and hemorrhages** in India.
9. **Dried seeds** are of medicinal value and used for curing **hair (dandruff, hair fall) skin problems (acne) obesity and diarrhea**.

## 2. Papaya: *Carica papaya*

**Family:** Caricaceae (member of the cashew family)

**Part used:** Fruit (Pepo)

### Economic Importance/ uses

1. The fleshy fruit of papaya is high in **vitamins A and C and minerals** (potassium, calcium, and iron) and being **low in calories**.
2. Ripe papaya is usually consumed fresh as a breakfast or dessert fruit; it can also be processed and used in a **variety of products such as jams, fruit juices, and ice cream**.
3. Consumption of the fruit is **reported to aid digestion because of the papain content** and **weightloss**.
4. **Unripe fruits and leaves are consumed as vegetable**.
5. **Papain is milky latex** is either sun-dried or oven-dried and sold in **powdered form**. It is used in **beer clarifiers, meat tenderizers, digestion aids**, textile industry (prevent shrinking of wool and silk), **tooth-cleaning powders**
6. A compound found in **papaya leaf** is acetogenin, **which can help prevent dangerous disease like malaria and dengue**.
7. It is also used in **cosmetic industry** as it removes toxins from skin, provides protection against skin problems **like pimples, freckles and acne**.
8. It is good for **liver, reduce cholesterol and give relief in menstrual pain**.
9. The **seeds** are considered to be anti-inflammatory and analgesic (pain reliever), and they are used to treat **stomachache and fungal infections**.

## Unit-6

# TEMPORARY PEEL MOUNTS

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### **AIM 31: TO STUDY EPIDERMAL CELLS THROUGH TEMPORARY ONION PEEL MOUNT.**

#### **Apparatus and Materials Required**

An onion bulb, slides, cover slips, two watch glasses, needle, brush, forceps, razor blade, blotting paper, safranin (or methylene blue) solution, glycerine, water and compound microscope.

#### **Theory**

All living organisms are composed of cells. New cells arise by the division of pre-existing cells. Cell is the structural and functional unit of life. In plants, cells have an outermost rigid cell wall beneath which cell membrane is present. The cell membrane encloses cytoplasm, cell organelles, and a nucleus. In side nucleus, nucleolus is present. Plant cells is characterized by presence of large vacuole.

#### **Procedure**

1. Remove the scale leaves from the onion bulb and take one fleshy scale leaf of an onion.
2. Break the fleshy scale leaf into two and using a forcep pull out a thin membranous peel adhering to the inner surface of the leaf. This is the epidermal peel.
2. Place the peel in a watch glass containing water and cut it into small rectangular pieces
3. Mix 1 or 2 drops of safranin in a small quantity of water taken in another watch glass and transfer the peels into it. Leave the peels for about 3 minutes. Dip the peel in water to remove excess stain.

4. Take a clean slide with a drop of glycerine in the middle and using a brush transfer the washed and stained peel on to it.
5. Place a cover slip over it by slowly lowering it with a needle. Avoid entry of air bubbles.
6. Remove excess glycerine from the edges of cover slip with the help of a piece of blotting paper.
7. Observe the slide under the microscope, first in low power and then in high power.
8. Draw a labelled diagram of the cells as seen under microscope.

## Results

### A. Under Low power of the microscope

1. The rectangular cells of onion epidermis are seen which are very compactly arranged without any intercellular spaces. The regularly arranged cells have clear outline. The outlines are formed by rigid walls known as Cell Wall.
2. A deeply coloured, round body is seen inside every cell. This is known as Nucleus.

### B. Under the high power of Microscope

1. Nucleus with Nucleolus is clearly visible.
2. A thin layer of less deeply coloured substance along the inner surface of cell wall is seen. It is called Cytoplasm.
3. The central part of the cell, interior to the cytoplasm takes very little stain, this portion is known as vacuole.

## Discussion

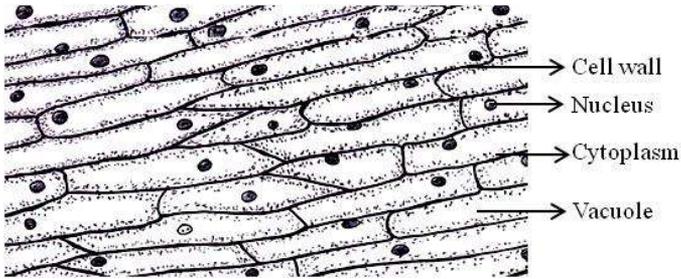
As seen under low and high power of the microscope, the epidermis(peel) of onion scale leaves is composed of cells. Each cell contains cell wall, enclosing the cytoplasm and vacuole. Nucleus with 2-3 nucleolus is found embedded in the Cytoplasm.

## Precautions

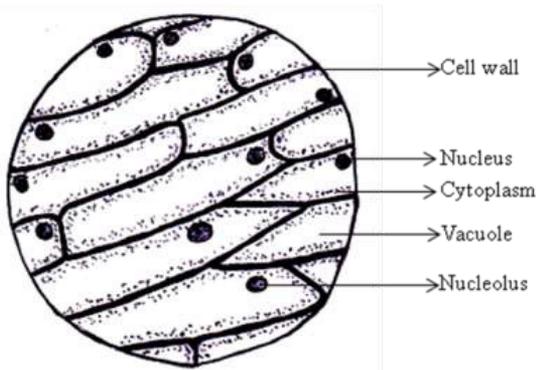
1. Staining of the peel must be appropriate. Excess stain can be removed by rinsing the peel with water taken in a watch glass.
2. Use a brush to transfer the peel on to the slide.

3. While placing the cover slip care should be taken to avoid air bubbles.

### Study of Epidermal Cells through Temporary Onion Peel Mount



Onion Epidermal Peel Mount at Low Magnification (10x)



Onion Epidermal Peel Mount at High Magnification (40x)

**AIM 32: TO STUDY STRUCTURE OF STOMATA THOROUGH TEMPORARY PEEL MOUNT OF RHOEO LEAVES (*TRADESCANTIA PALLIDA*).**

#### Apparatus and Materials Required

Leaf of Rhoeo, forceps, needles, watch glasses, glass slides, a dropper, coverslips, a brush, blotting paper, glycerine and a compound microscope.

## Theory

The continuity of epidermis of leaf is interrupted by minute openings of pores known as **stomata**. They are responsible for exchange of gases, water vapors between the atmosphere and leaves (i.e. transpiration). Each stoma is consisting of an opening surround by the two guard cells. The guard cells have conspicuous nucleus, large number of chloroplast and abundant starch granules. The cell wall of **guards cell** is unevenly thickened, i.e. wall is thicker towards the pore as compared to the peripheral side. The variation in the thickening of cell wall helps in the closing and opening of stomata. The shape of guard cell differs in two group of angiosperms. They are **kidney shaped** in dicot plants and **dumb-bell** shaped in monocot plants. Sometimes, a few epidermal cells, in the vicinity of the guard cells become specialized in their shape and size, known as **subsidiary cells**. The **stomatal aperture, guard cells and the surrounding subsidiary cells** together constitute **stomatal apparatus**

Stomata are found widely scattered on the epidermis of leaves and young stems. They are mostly found in large numbers on the lower surface of a dicot leaf (dorsiventral leaves) as compared to the upper surface. In monocots which have isobilateral leaves arrangement, stomata are evenly distributed on both the surfaces. In hydrophytes, they are present on the upper surface of floating plants and completely absent in submerge plants. Xerophytes sunken stomata are present.

## Procedure

1. Take out the peel from the lower and upper surface of the leaf.
2. Place the peel on a clean glass slide and cut into small piece.
3. Mount the peel (upper and lower) in water or glycerine and place a clean cover slip gently over it with the help of a needle.
4. Remove the excess water or glycerine with the help of blotting paper.
5. Observe the slide under the low-power (10X) and high-power (40X) magnifications of the compound microscope.
6. Observed the stomata, guard cell, epidermal cell and draw a well label diagram.

## Observations

1. **Upper surface:** The epidermal cells are visible. These are irregular in outline and have no intercellular spaces.
2. **Lower surface:** Closely packed irregular shaped epidermal cells are interrupted by many small pores called stomata.
  - (a) Each pore is guarded by two bean-shaped guard cells, each containing chloroplasts and a nucleus.
  - (b) Four subsidiary cell surrounds the guard cells.
  - (c) The inner concave boundary of each guard cell is thick, whereas its outer boundary is thin as seen under 40X. The guard cells regulate the opening and closing of the stomata.
  - (d) The stomata may be open or closed.

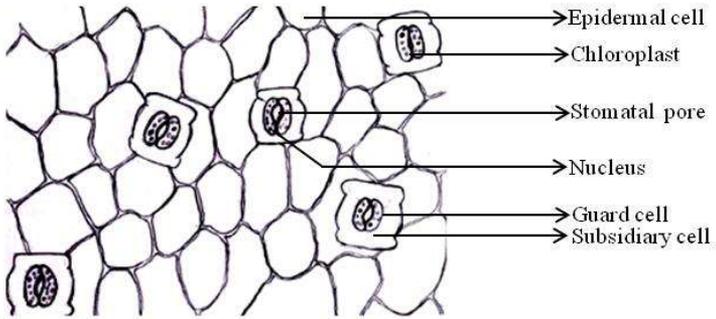
## Results and discussions

Stoma was not observed on the upper surface while they are found in large number on the lower surface. Each stoma was made up of bean shaped guard cell. Some of the cell near to the stomata modified or become distinct as compared to other epidermal cell, these cells known as subsidiary cell, they protect the stomata by regulating the flow of water in the guard cells. Stoma was present in closed and open position. Stomata are present more on lower surface which prevent the loss of water through transpiration. As due to the presence of more stomata on lower surface, the given leaf is identified as dicot leaf.

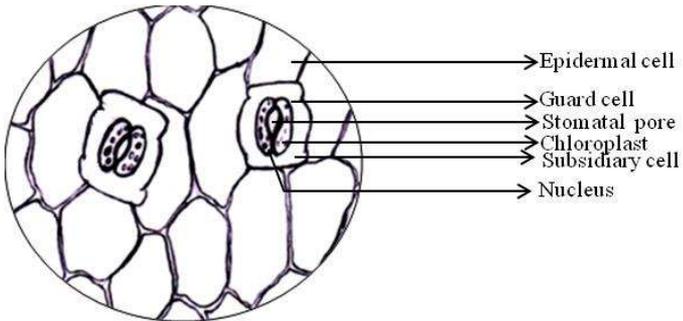
## Precautions

1. Cut the peel to a proper size and avoid folding it.
2. Always place the peel at the center of the slide and hold the slide at the edges.
3. Always handle the peel with a brush as a needle may damage the cells.
4. Do not let the peel to dry.
5. Place the coverslip gently, avoiding any air bubbles.
6. Remove extra water with a blotting paper.

## Study of Stomatal Apparatus



**Rhoeo Leaf Peel Mount at Low Magnification (10x)**



**Rhoeo Leaf Peel Mount at High Magnification (40x)**



# **SECTION-B: ZOOLOGY**

**UNIT-1**

**Classification of Animal Kingdom**

**UNIT-2**

**Economic Zoology**

**UNIT-3**

**Temporary Mounts**



## Unit-1

# CLASSIFICATION OF ANIMAL KINGDOM

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### CRITERIA FOR ANIMAL KINGDOM CLASSIFICATION

1. Levels of organization
2. Presence and absence of body cavity
3. Body symmetry

### IMPORTANT TERMS

#### 1. Levels of organization

**Cellular level of organization:** The cells are differentiated for performing various functions but they do not form tissue. e.g., Porifera.

**Tissue level of organization:** The cells carrying out similar functions are grouped together forming tissues. e.g., Coelenterata.

**Organ level of organization:** Different tissues associated with one function are grouped together to form organ. e.g., Platyhelminthes.

**Organ system level of organization:** cells organized to form tissues, tissues organized to form organs and organs organize to form organ system.

**Germ layers:** There are the primary layers which differentiate in the embryo to form various tissues and organs. Germinal layers can be two or three in number.

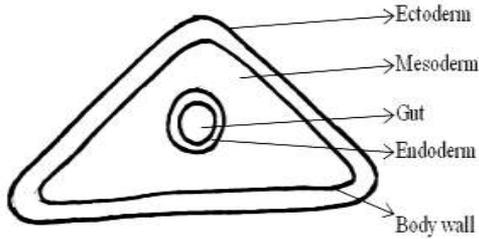
**Diploblastic:** Animals possessing two germ layers.i.e., outer ectoderm and inner endoderm. e.g., Porifera and Coelenterata.

**Triploblastic:** Animals having three germ layers. Outer ectoderm, inner endoderm and middle mesoderm. Platyhelminthes to Chordates.e.g. Annelida

#### 2. Presence and absence of body cavity

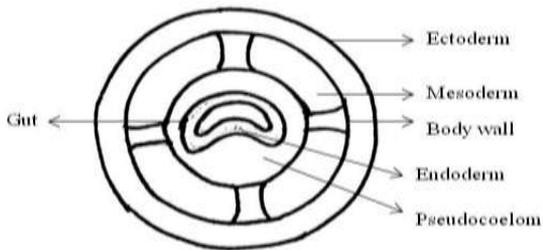
The space between the body wall and the alimentary canal is called body cavity or coelom.

**Acoelomate:** Animals without body cavity.e.g *Amoeba*



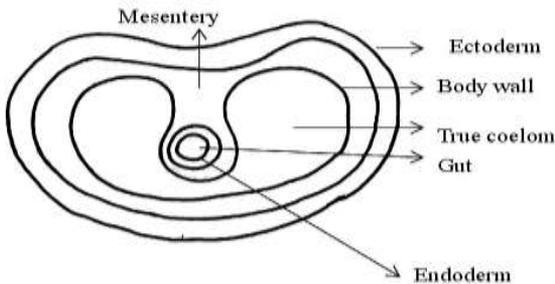
**Acoelomate**

**Pseudocoelomate:** A cavity called pseudocoelom is present which is not lined by mesoderm. Mesoderm occurs in the form of pouches.e.g *Ascaris*



**Pseudocoelomate:**

**True coelomate:** A true coelom is lined by mesoderm.e.g *Earthworm*



**True coelomate**

### 3. Body symmetry

**Asymmetry:** Absence of any repetition or similarity is called asymmetry.e.g.



**Asymmetry**

**Radial Symmetry:** Body can be divided into two equal halves in any plane passing through the middle from top to bottom e.g., Starfish, Jelly fish, Sea Anemone



**Radial Symmetry**

**Bilateral Symmetry** – body can be divided into two equal halves by only one plane that passes through median axis. Body has a head and organs and limbs are paired. e.g. Butterfly, Human beings



**Bilateral Symmetry**

**Difference between chordate and non-chordates**

	<b>Non chordates</b>	<b>Chordates</b>
1.	Notochord is absent.	Notochord is present.
2.	Nervous system is solid and ventral.	Nervous system is hollow and dorsal.
3.	Pharyngeal gill slits are absent.	Pharyngeal gill slits are present.
4.	Post anal tail is absent.	Post anal tail is present.
5.	Vascular system may be open or closed.	Vascular system is closed.
6.	If heart is present it is dorsal	Heart is ventral in position
7.	. e.g. Paramecium, Sponges, Jellyfish, Star Fish etc.	.e.g. Frog, Fishes, Lizard, Man

**AIM 1: TO STUDY CHARACTERISTIC FEATURES OF PROTOZOA****General characteristics**

1. Exhibit in two forms of life: free living dwelling in fresh water, marine water, and damp places or as a parasite on plants or animals.
2. Protozoa are microscopic and acellular.
3. Body is covered by pellicle or naked.
4. They exist in variety of shapes like spherical, oval, elongated.
5. Cytoplasm can be differentiated into outer ectoplasm and inner endoplasm.
6. Nuclei are vesicular (nucleolus encircled by a zone of nuclear sap).
7. Locomotory organs are pseudopodia, flagella, and cilia.
8. Nutrition can be holophytic (plant like) or holozoic (animal like).
9. Respiration by diffusion.
10. Excretion through general body surface or via some temporary opening.
11. Reproduction by sexual (conjugation) or asexual mode (Binary fission or Multiple fission).

## 1. *Paramecium*

1. It is found in freshwater ponds, ditches, streams, lakes, and rivers. It is specially found in abundance in stagnant ponds.
2. Body is elongated, slipper shaped.. Anterior end is blunt and posterior end is pointed
3. Covering of the body is pellicle covered by cilia (hair like projection) which are uniform throughout the body but at posterior end it is longer.
4. Cytoplasm can be distinguished between inner endoplasm and outer ectoplasm.
5. Ectoplasm possesses trichocyst which is discharged for attachment to the substratum and endoplasm possesses macronucleus, micronucleus, and fat, and glycogen food vacuole, anterior and posterior contractile vacuole.
6. Reproduction both sexual (conjugation) and asexual (binary fission).

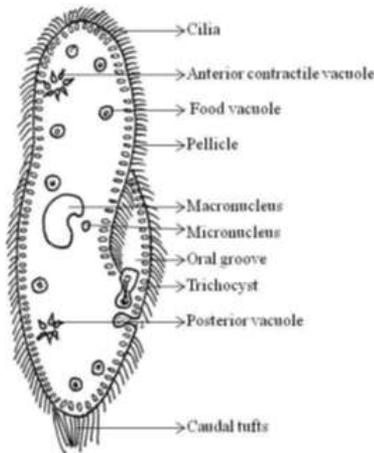
**Interesting fact:** Few species of paramecium produce kappa particles, which kills the other sensitive species of paramecium. It was used to study the maternal inheritance.

Phylum- Protozoa

Class- Ciliata

Order- Hymenostomatida

Genus- *Paramecium*



*Paramecium*

## 2. *Amoeba*

1. Amoeba is commonly found in the mud in freshwater ponds, ditches slow running streams and spring pools.
2. Shape of the body is irregular appears like a colorless gelatinous mass of protoplasm.
3. Body is covered by a very thin, clear relatively tough elastic and semi-permeable layer of protoplasm called plasmalemma.
4. Cytoplasm is distinguished into an outer clear dense ectoplasm and inner granular more fluid portion the endoplasm.
5. Locomotion is by short and blunt pseudopodia.
6. Single small spherical nucleus, a large single contractile vacuole and a variable number of food vacuoles are present in the endoplasm.
7. Reproduction is by binary fission and multiple fission.

### Interesting fact

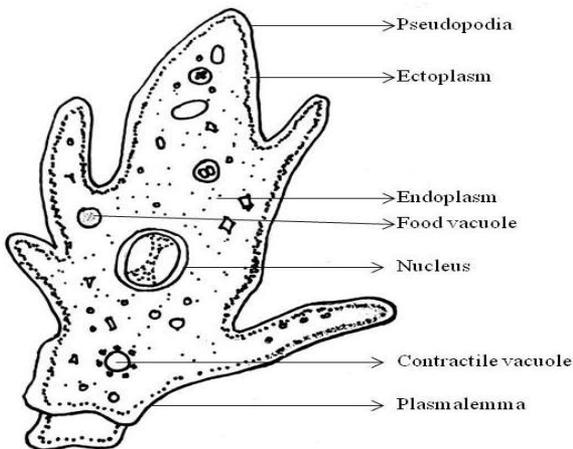
It is referred as immortal animal, have phylogenetic significance. Some species can cause meningo encephalitis.

Phylum-Protozoa

Class- Rhizopoda

Order- Amoebida

Genus- *Amoeba*



*Amoeba*

### 3. *Entamoeba histolytica*

1. *Entamoeba* is cosmopolitan but more frequently found in warm climates where adequate sanitation and effective personal hygiene is not present.
2. *E. histolytica* is a microscopic endoparasite of human and present in mucosa and sub mucosa layers of large intestine.
3. Parasite exists in 2 stages: trophozoite (feeding stage) and cystic stage (non feeding).
  - (i) **Trophozoite:** It is most active, motile and feeding form measuring 20-30 $\mu$  m in diameter. It has thick outer layer of clear translucent endoplasm of single clear pseudopodium, sucking disks, two large nuclei and endoplasm has some ingested RBC and tissue debris.
  - (ii) **Pre-Cystic Stage:** It is smaller in size ranging from 10-20  $\mu$ m in diameter. It is ovoid with blunt pseudopodium. Endoplasm is free of RBC and ingested food particles. It is non feeding and immobile stage.
  - (iii) **Cystic Stage:** During encystment parasite becomes rounded remove food vacuoles and the cyst shape vary from oval to ellipsoid in shape, pearly grey in colour, surrounded by definite wall and about 12  $\mu$  in diameter. Newly formed contains one nucleus and contain food supply in form of vacuole containing glycogen. cyst grow older nucleus divides further and glycogen mass and chromotoid bars are used up and gradually disappear.

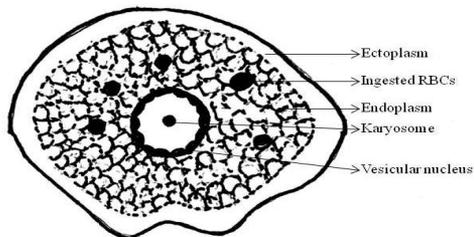
Phylum- Protozoa

Class- Sarcodina

Order-Lobosa

Genus- *Entamoeba*

Species *histolytica*



*Entamoeba histolytica*

#### 4. *Giardia*

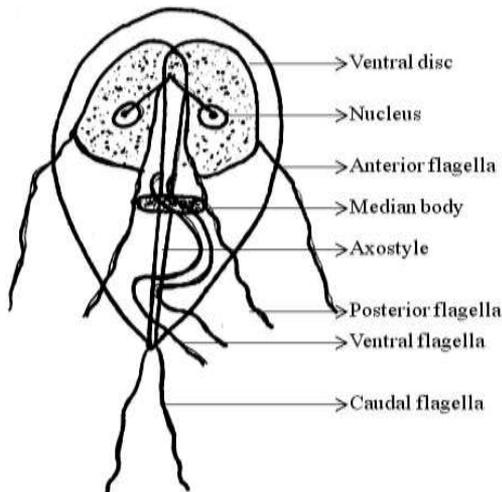
1. It is an ananerobic protozoan found in water source.
2. It occurs in two stages: Trophozoite form and cyst form.
3. Trophozoite- it is pear in shape with broad anterior and tapering posterior. It is 10-12 $\mu$ m and 5-7 $\mu$ m wide, bilaterally symmetrical and has two nuclei. It bears two nuclei, median body, four associated flagella for motility.
4. It is flattened with a large sucking disc on the anterior ventral side which assists in adhesion to the wall of intestine of host.
5. Cyst is a reproductive form and a dormant structure that survive the harsh conditions. It is resistant to desiccation and chemical disinfection. It has two layers outer filamentous layer and inner membranous layer.
6. After encystation each organelle duplicates so cyst contain four nuclei, four median bodies, eight pair of flagella.
7. On excystation each cyst gives rise to two trophozoites.

Phylum- Protozoa

Class- Mastigophora

Order-Diplomonadida

Genus- *Giardia*



*Giardia*

## 5. *Euglena*

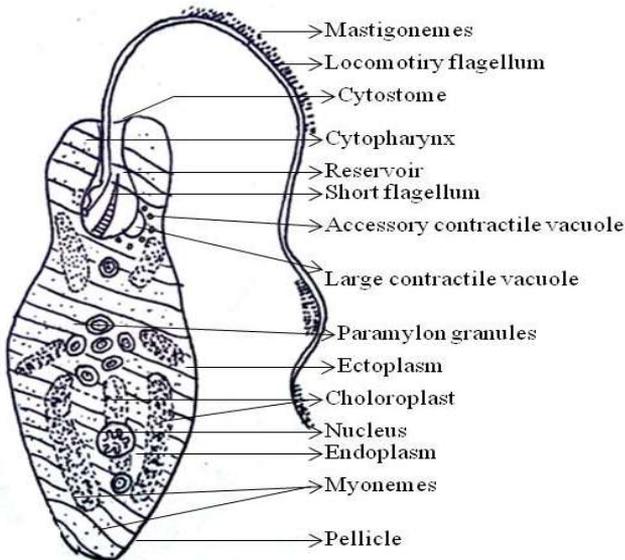
1. It is commonly found in freshwater ponds, ditches, lakes, and streams.
2. It is ovoid, spindle shaped measuring about 50-100  $\mu$  in length and with a rounded anterior end and tapering posterior end. Its body is covered by striated pellicle. The pellicle is pliable.
3. Anterior end of the body possesses a small funnel like cytostome and a tubular cytopharynx which leads into a large spherical reservoir.
4. A single whip like flagellum emerge from the base of the reservoir. Nucleus is visibly clear and located in posterior end of the body.
5. The cytoplasm can be distinguished into ectoplasm and endoplasm. Chloroplasts, paramylon granules, large contractile vacuole encircled by accessory contractile vacuoles are evident in endoplasm.
6. Reproduction is asexual means by longitudinal binary fission. It does not show sexual reproduction.

Phylum- Protozoa

Class- Mastigophora

Order-Diplomonadida

Genus- *Euglena*



*Euglena*

## 6. *Plasmodium*

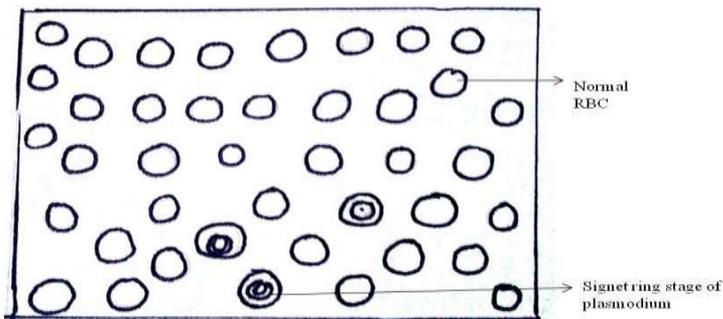
1. It is an intracellular parasite found in the blood of vertebrates. It causes Malaria. There are four species of *Plasmodium*, *Plasmodium vivax*, *P. falciparum*, *P. malariae*, *P. ovale*.
2. Its life history is completed in two hosts i.e. partially in the definite host, the human being, and partially in the intermediate host, the female Anopheles mosquito.
3. Whenever an infected female Anopheles mosquito bites a human being, sporozoites are inserted in the blood from where they reach the liver cell (hepatocytes) through the blood stream and multiply to form merozoites.
4. Succeeding a few schizogony cycles in the hepatocytes the merozoites enter the erythrocytes (RBCs).
5. After 2-8 schizogony cycles, the merozoites change into gametocytes after acquiring certain changes in their shapes.
6. Further development of gametocytes takes place in the gut of the mosquito, therefore they wait for a female Anopheles mosquito to suck the blood with them.
7. When the gametocytes are sucked along with the blood, they undergo sporogony for further development in the gut of the mosquito.

Phylum- Protozoa

Class- Sporozoa

Order- Haemosporidia

Genus- *Plasmodium*



**Peripheral smear of blood showing RBCs infected with plasmodium**

## AIM 2: TO STUDY CHARACTERISTIC FEATURES OF PORIFERA

### General characteristics

1. Sponges can be marine, sessile, or sedentary but some species are found in freshwater also.
  2. Diploblastic (two germ layers), acoelomate (coelom is absent) having pores, with a canal system.
  3. Shape of body can be vase like, cylindrical, asymmetrical or radially symmetrical.
  4. Absence of mouth.
  5. They are found in marine water but few species found in fresh water.
  6. They have a cavity known as spongocoel.
  7. It has a system of pores, canals and chambers through which water circulates with the help of flagellated collar cells known as choanocytes. Water brings food and oxygen.
  8. They have hard skeleton made up of calcium carbonate, silica, or spongin fibers.
  9. Excretion and respiration via diffusion.
  10. Fertilization is internal.
  11. Reproduction by both asexual (budding and gemmule formation) and sexual methods.
- Interesting fact:** Power of regeneration is very well developed.

### 1. *Euspongia* (Common Bath Sponge)

1. It is sedentary form. It is found attached with rocky bottom in warm shallow waters.
2. It is massive and rounded in form; dark black in color provided with large sized pores known as oscula.
3. Skeleton composed of network of spongin fibers.
4. In certain complex sponge increase in size occur by folding of body wall.
5. The bath sponge of household use is prepared by squeezing and bleaching or dying of the sponge.
6. The common bath sponge consists mainly of spongin fibers which possess the capacity of holding water.

7. It is commonly used in offices etc. for wetting postal stamps and counting currency notes or papers etc.

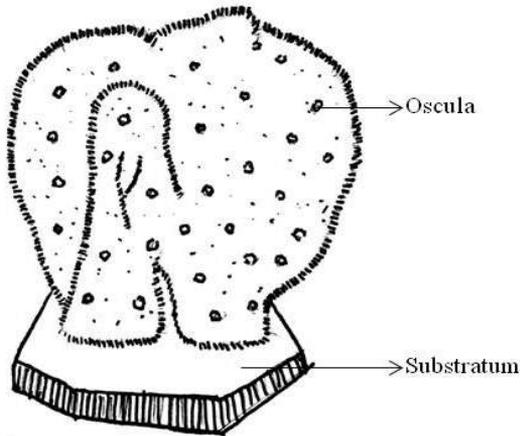
Phylum- Porifera

Class- Calcarea

Order- Ceratosa

Genus-*Euspongia*

(Bath Sponge)

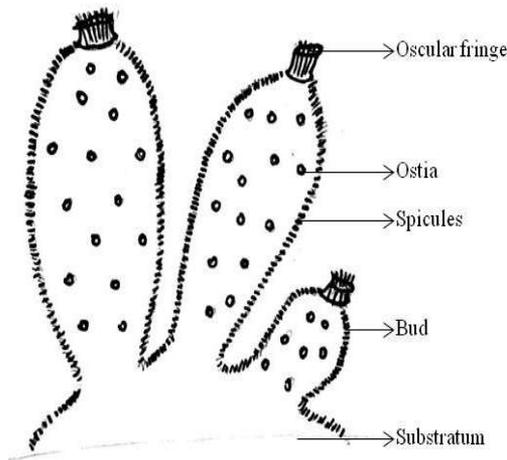


*Euspongia*

## 2. *Sycon* or *Scypha*

1. It is a small solitary or colonial marine sponge, found attached to the rocks and other substrata in shallow water.
2. The body of *Sycon* is slender, vase- shaped cylinder.
3. Each cylinder bulges in the middle and opens to the exterior by an osculum.
4. Body wall is made up of outer dermal epithelium, middle mesenchyme and inner flattened epithelium, lining spongocoel which opens through osculum.
5. The surface of the body is perforated by numerous pores, the ostia or incurrent pores.
6. The chanocytes or flagellated cells are restricted only to the radial canals.

7. Nutrition, respiration and excretion are performed by canal system.
8. Reproduction both sexual and asexual. Asexual by budding and regeneration and sexual by ova and sperms.
9. Hermaphrodite.  
Phylum-Porifera  
Class-Calcarea  
Order- Sycettida  
Genus- *Sycon/Scypha*



*Sycon/Scypha*

### AIM 3: TO STUDY CHARACTERISTIC FEATURES OF COELENTERATA

#### General characteristics

1. Diploblastic (two germ layers). Acoelomate having tissue level organization. gastrovascular cavity.
2. All are aquatic and mostly marine but few are found in fresh water.
3. Have a cavity known as coelenterons (it is enclosed by body wall) or gastrovascular cavity. Its opening serve as mouth as well as anus.
4. They exists in two forms called polyp and reproductive, umbrella shaped is medusa. Polyp lead sedentary life and medusa are free living. This is known as polymorphism.

5. Sessile, asexual form is polyp and reproductive motile medusa alternate with each other during life.
6. They have slender tentacles which are beset with stinging cells called cnidoblasts or nematoblasts. They are used for defensive purpose.
7. Tentacles are used capturing of food, ingestion and defense.
8. Either exoskeleton or endoskeleton is present.
9. Primitive nervous system and brain is totally absent.
10. Respiration and excretion through general body surface.
11. Reproduction is by both sexual and asexual mode.
12. They possess hard skeleton of lime.

**Interesting fact:** Alternation of generation exists where asexual polyp form alternates with medusa.

### 1. *Aurelia* (Jellyfish)

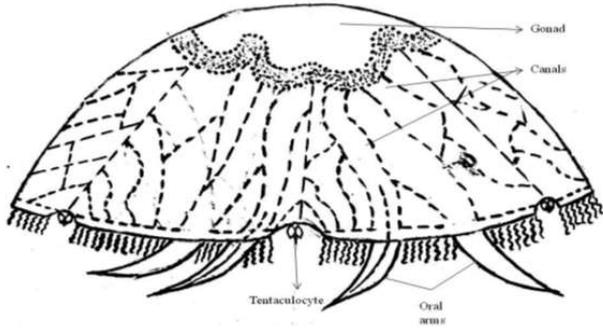
1. It is solitary, and marine, living in coastal water body, is gelatinous, transparent.
2. The medusa or umbrella has a slightly convex upper surface known as exumbrellar surface and a lower concave the subumbrellar surface.
3. Structures like gastric filaments, sub genital pits and velarium can be seen.
4. Sub umbrella margin possess marginal tentacles bearing stinging cells. The margin of the umbrella is divided into eight lobes having sense organs tentaculocysts.
5. Various canals such as inter radial, adradial, and pre radial gastrovascular canals open in a common canal known as circular canal.
6. It eats upon crustaceans, protozoan, nematodes, and mollusks.
7. It is unisexual
8. The mouth is four cornered and each corner is drawn out into a long-frilled tapering process, the oral arms.
9. It swims by rhythmic contractions of umbrella surface.
10. Life cycle represents alternation of generation.

Phylum- Coelenterata

Class- Scyphozoa

Order- Semaestomeae

Genus- *Aurelia* (Jellyfish)

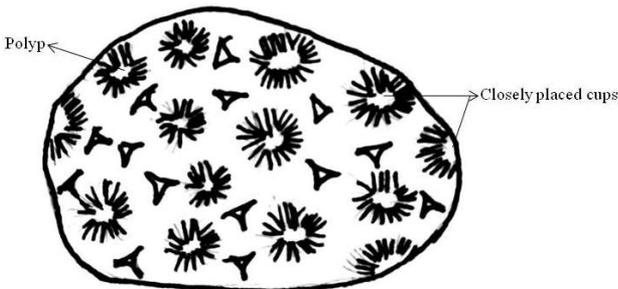


*Aurelia* (Jellyfish)

**2. *Favia* (Coral)**

1. It is a colonial marine and reef building stony coral.
2. The thick and stony skeleton is made by calcareous calcium carbonate skeleton.
3. The surface of the body displays closely set polygonal cups.
4. The thecae of the cups are closely fitted together acquiring common walls.
5. It emerged in Jurassic period and it is living successfully even today.
6. It is an imperforate or pore les coral.

Phylum- Coelenterata  
 Class-Anthozoa  
 Order- Scleractinia  
 Genus- *Favia*



*Favia*

## AIM 4: TO STUDY CHARACTERISTIC FEATURES OF PLATYHELMINTHES

### General characteristics

1. They also known as flatworms.
2. They are mostly endoparasites found in animals, and human beings.
3. They are found in freshwater, saltwater, or terrestrial.
4. They are triblastic and acoelomate, with bilateral symmetry, flattened and ribbon shaped or leaf like or dorso-ventrally flattened appearance.
5. They show organ system level of organization.
6. Anterior part of the body can be distinguished as head bearing mouth.
7. They possess various adhesive secretions and organ of attachment lie hooks for anchoring and suckers.
8. Body cavity or coelom is absent.
9. They possess excretory, nervous, reproductive system but digestive system is absent or incomplete.
10. Respiration is anaerobic as parasites do not get free oxygen.
11. Excretion through protonephridia with flame cells.
12. They are bisexual or hermaphrodite.
13. They possess complex or highly evolved reproductive system.
14. Fertilization is internal.
15. Some organisms of this phylum show great regenerative power.e.g:  
*Planaria*  
Tape worm (*Taenia solium* ), Liver fluke ( *Fasciola hepatica* )

### 1. *Taenia solium* Adult

1. It is an endoparasite which lives in small intestine of human completing its life cycle in 2 hosts: man, and pig or cattle.
2. Adult worm is semi-transparent, whitish or grayish in color. The body is elongated, dorso- ventrally flattened like a ribbon or tape measuring about 4-5 m long.
3. The body can be distinguished into head or scolex, a short-unsegmented neck and a long segmented strobila is composed of 800-900 proglottids or segments.

4. The head bears its curved and pointed hooks (28 in number) arranged in two rows and 4 suckers are buried in the mucous membrane of intestine and the rest of the body is lying free in the lumen of intestine.
5. The strobila has 3 types of segments.
  - (i) **Immature** : proglottid just behind neck, youngest and sexually immature.
  - (ii) **Mature**: has well developed reproductive organs.
  - (iii) **Gravid**-The gravid segments are oldest full of fertilized eggs or oncospheres in branched uterus and are the posterior most. They drop off from the body 4-5 at a time and pass out with the feces of their host. This process is known as Apolysis.
6. Further development of the eggs is feasible only when they are eaten by the intermediate host i.e. pig or cattle.
7. They are hermaphrodite or bisexual.
8. The adult worm in man causes abdominal pain, increase in appetite, anemia, indigestion, weight loss, weakness. The intestinal lining gets damaged. The toxins liberated by the worm cause, serious problems. It causes Taeniasis.

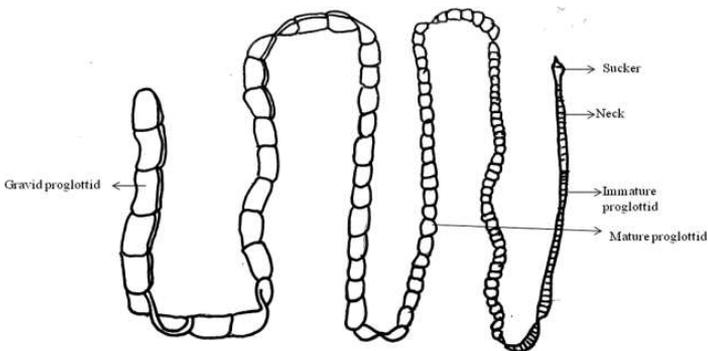
Phylum-Platyhelminthes

Class- Cestoda

Order-Taenioidea

Genus-*Taenia*

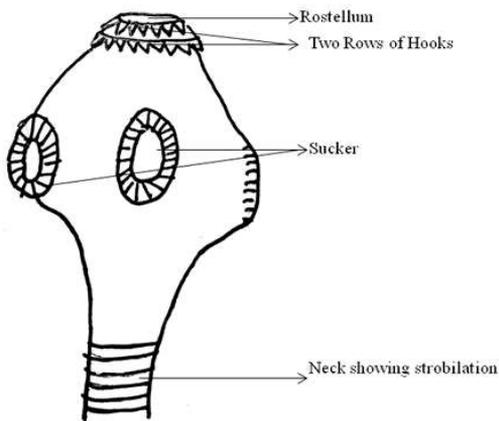
Species-*Solium*



*Taenia Solium*(Adult)

## 2. *Taenia solium* Scolex

1. *Taenia* has enlargement of anterior most part of scolex, small, knob like part of the body measuring 1 mm in diameter.
2. At the top there is a peculiar cone, the rounded structure known as rostellum which is armed with two rows of arched chitinous hooks numbering 28-32.
3. The broadest part of the scolex possess four cups shaped which are slightly muscular
4. The scolex with the help of its hooks and suckers lies embedded in the mucous membrane of the intestine which acts as adhesion part and providing firm adhesion to the body. Thus, it is an organ of anchoring.
5. Scolex is followed by a short undivided neck or region of proliferation or budding zone from which new segment are developed.

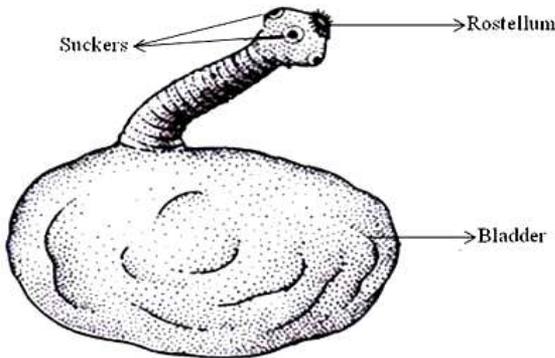


*Taenia solium* Scolex

## 3. *Cysticercus* Larva or Bladder worm

1. It is the larva of *Taenia* found in the flesh of intermediate host, the pig.
2. It develops from oncospheres which is eaten up by pig along the human feces. After passing through various organs, it is attached in the striated muscles where it grows into a cysticercus

3. It takes about 60-70 days for the oncospheres to develop into the bladder worm. It is grossly opalescent, shape is ovoid, bearing a large vesicle filled with fluid and one scolex (inverted) bearing four suckers as adult. It appears as white dot in pork.
4. It remains in the muscles of thigh or shoulder and cannot grow further in pig but can grow further if consumed by final host. It remains viable for several years. Such pig is known as measly pork.
5. When consumed by man (the primary host) along with infested pork, the proscœlex (inverted scolex invaginates in the intestine of man and attaches to the intestinal wall, the bladder is shed away and new segments are budded off from the neck region).
6. It causes cysticercosis. Due to peristaltic movement of intestine, it reaches through intestinal circulation to various vital organs like eyes, brain, liver and get encysted and causes various fatal diseases.

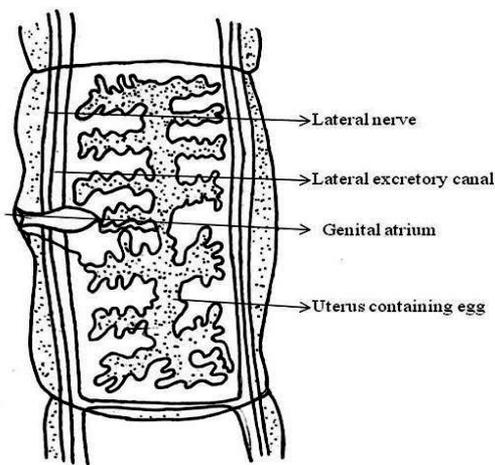


*Cysticercus* Larva or Bladder worm

#### 4. Gravid Proglottid (whole mount)

1. A gravid proglottid is present in the posterior most part of body oldest proglottid and longer than broader about 12 mm x 6 mm in *Taenia solium*.
2. It is completely occupied with a highly branched uterus consisting fertilized eggs or developing embryo around 30,000-40,000.

3. Other male and female reproductive organs of mature proglottid vanish after fertilization having uterus which degenerates greatly to encompass large number of eggs. The number of branches of uterus varies from 7-13.

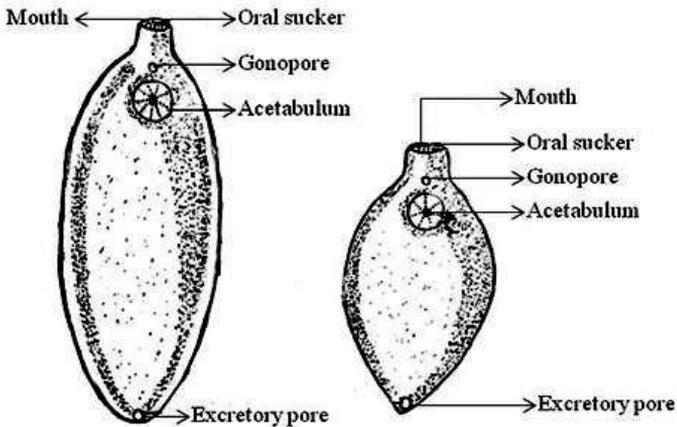


**Gravid proglottid (whole mount)**

### 5. *Fasciola hepatica* (Liver fluke)

1. Its common name is liver fluke. It is an endoparasite found in liver of sheep.
2. The shape of body is like leaf and dorso-ventral flattened with the length 25-30 mm and 4-5 mm in breadth.
3. From anterior end, it is small and conical in shape and posterior end it is large and more rounded.
4. An oral sucker is present at the apex, it also surrounds the mouth and a highly muscular ventral sucker little posterior to the oral sucker.
5. Digestive system is simple, pharynx, oesophagus, and branched diverticulated intestine.
6. In between oral and ventral sucker a gonopore is present through which egg pass to the exterior.
7. Excretory pore is present at the posterior end.

8. Hermaphrodite.
9. Life cycle includes an intermediate host *Lymnea*, a mollusk. It causes a disease known as liver rot.  
 Phylum - Platyhelminthes  
 Class –Trematoda  
 Order- Digenea  
 Genus- *Fasciola*  
 Species- *hepatica*  
 (Liver Fluke)



*Fasciola hepatica*

**AIM 5: TO STUDY CHARACTERISTIC FEATURES OF NEMATHELMINTHS OR NEMATODE OR ASCHELMINTHS (ROUNDWORM)**

**General characteristics**

1. They can be free living, aquatic, terrestrial or parasitic in plants and animals.
2. Possess organ system of organization.
3. They have bilateral symmetry and pseudocoelom.
4. Size of body can be very small or microscopic.
5. Body is cylindrical and tapering at both the ends.
6. Body is covered by a layer known as cuticle which protects roundworms from action of digestive enzymes.

7. They have complete digestive system.
8. Excretion through excretory pore.
9. Fertilization is internal.
10. Sexes are separate.  
e.g: *Ascaris* (Round worm), *Ancylostomata* (Hookworm), *Wucheria bancrofti* (filarial worm)

### 1. *Ascaris lumbricoides*

#### External features of *Ascaris lumbricoides*

1. It is an endoparasite lives in the lumen of the small intestine of man and is more common in children. One gets infected by consuming raw vegetables infested with eggs of ascaris. Around 1000-5000 adult worms may be found in a single host.
2. Body is cylindrical in shape, tapering at each end, pinkish white or white in color covered with a thick layer known as cuticle from outside.
3. Anteriorly, mouth is possessing three finely toothed lips. The digestive and reproductive organs float free within the body.
4. Four longitudinal striations are present on body: one mid dorsal, one mid ventral and two lateral lines extending from anterior to posterior surface.

S. No.	MALE	FEMALE
1.	Males are smaller in length of 15-25cms with a diameter of 3-4 mm. The tail end is curled and in the form of a hook having conical tips.	Females are comparatively longer, robust, 25-40cms long and 5mm wide. The tail end is neither curled nor pointed.
2.	The genital aperture opens into the opening known as cloaca from which two copulatory spicules project out also known as penial setae.	Genital gonopore or vulva and anus are distinct. Anus is sub terminally present and in the form of a transverse slit. The vulva opens at the intersection of the anterior and middle third of the body. The mature female lays 200,000 eggs daily.

5. Life cycle is completed in single host i.e. human being. No intermediate host is involved. The eggs are infective stage. The infection takes place by consumption of eggs through contaminated water or food or unhygienic habits or conditions.
6. The adult worms deprive the host of its food and result in malnutrition, anemia, colic pain and other metabolic disorders. They are monoecious.

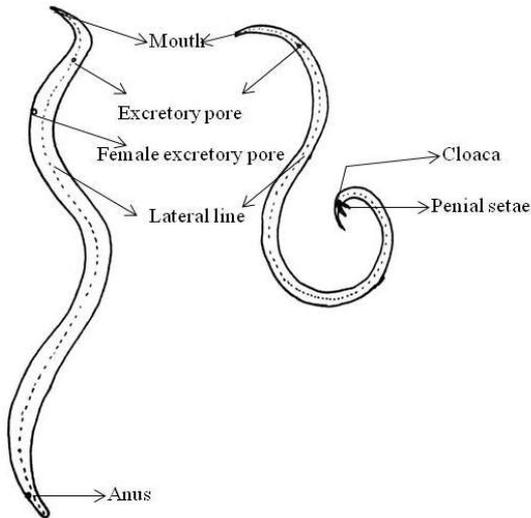
Phylum- Aschelminthes

Class –Nematoda

Order- Ascarioidea

Genus -*Ascaris*

Species - *lumbricoides*

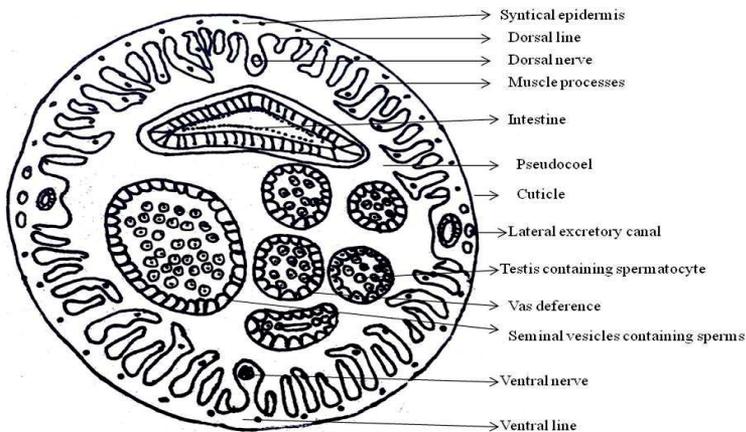


**Female Male**

## 2. Transverse Section of Male *Ascaris*

1. The outer most layer is body wall consists of (i) a thick, tough, resistant layer of cuticle is present (ii) a syncytial epidermis is present (iii) Longitudinal muscles separated into 4 quadrants.
2. Epidermis thickened from inward into a dorsal, a ventral and two lateral lines.

3. Dorsal and ventral lines enfold dorsal and ventral nerve chords; the lateral lines are occupied by lateral longitudinal excretory canals.
4. The section has intestine lined by tall epithelium and the pseudocoel (false body cavity) is occupied by lateral reproductive organs.
5. The given section is that of male *Ascaris* because its pseudocoel is occupied by
  - (i) Several lobes of testes containing spermatozoa in section.
  - (ii) Sections of vas-deferens and seminal vesicle packed with spermatozoa.

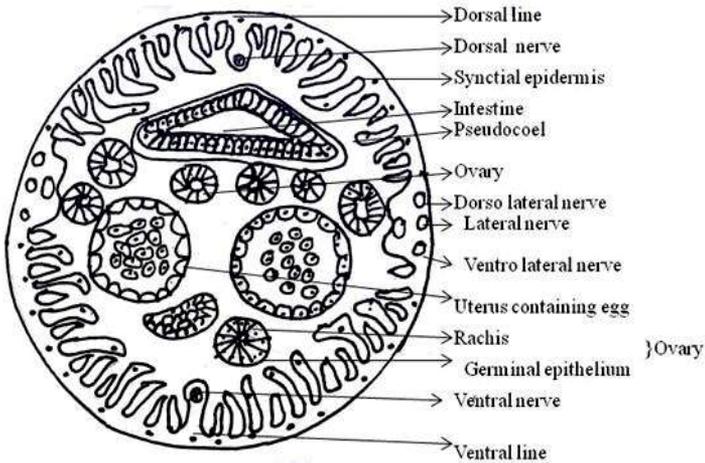


**Transverse Section of Male *Ascaris***

### 3. Transverse Section of Female *Ascaris*

1. The outer most layer is body wall comprising on (i) a thick, tough, and resistant layer of cuticle is present which is (ii) a syncytial epidermis is present. (iii) Longitudinal muscles separated into 4 quadrants.
2. Epidermis thickened from inward into a dorsal, a ventral and two lateral lines.
3. Dorsal and ventral lines enfold dorsal and ventral nerve cords; the lateral lines are occupied by lateral longitudinal excretory vessels.

4. The section has intestine lined by tall epithelium and the pseudocoel is occupied by lateral reproductive organs.
6. The given section is that of female *Ascaris* because
  - (i) Several sections of ovaries and oviducts can be seen. In the ovary's lumen is absent containing a large nucleus and cytoplasm
  - (ii) A pair of uteri packed with eggs having chitinous egg shells.



Transverse Section of Female *Ascaris*

## AIM 6: TO STUDY CHARACTERISTIC FEATURES OF ANNELIDA

### General characteristics

1. They are mostly aquatic, marine, of freshwater forms found in burrows, tubes but some of them are free living forms or sometimes parasitic.
2. True segmented worms. They are soft having long cylindrical body, divided into ring- like segments called annuli.
3. Body is triploblastic, bilateral symmetry, and metameric segmentation is present.
4. They have true coelom or body cavity.
5. Complete alimentary canal.

6. Respiration via skin or gills.
7. Exoskeleton is absent, soft and moist body wall is present.
8. Each segment bears fine chitinous bristles known as setae. They are used for locomotion.
9. Closed type of blood vascular system is present.
10. They possess paired ganglia connected by lateral nerves to a double ventral nerve cord.
11. Nephridia is the excretory organ.
12. Respiration by skin or gills.
13. Sexes are separate.  
e.g: *Pheretima* (Earthworm), *Hirudinaria* (leech)

### 1. ***Hirudinaria* (Indian Cattle Leech)**

1. It is found in freshwater ponds, lakes, slow running streams and swamps. It has Elongated body, dorsoventrally flattened. It is sanguivorous (blood sucking) in habit.
2. Body is divided metamericly into 33 segments each segment is further divided into rings or annuli. Skin is moist and slimy because of excessive mucus secretion.
3. Body can be divided into various regions: cephalic, preclitellar, clitellar, middle and caudal. Dorsal five segments bear five pairs of eyes
4. The anterior and posterior suckers are well developed. Anterior sucker (1-5<sup>th</sup> segment) bears tri- radiate mouth on ventral side. Posterior sucker act as locomotory and adhesive organ.
5. There are 17<sup>th</sup> pairs of nephridiopores are present starting from 6<sup>th</sup> to 22<sup>nd</sup> segment.
6. Male and female genital pores are present in 10<sup>th</sup> and 11<sup>th</sup> segment segregated by five annuli. Anus is present in the 26<sup>th</sup> segment.

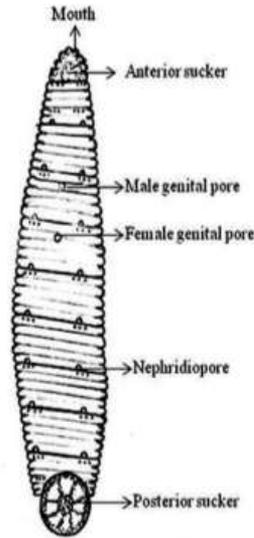
**Interesting fact-** A fed leech can live without blood meal for several months. It also secrets an anticoagulant Hirudin (used for medicinal purposes).

Phylum-Annelida

Class- Hirudinea

Order-Gnathobdellida

Genus-*Hirudinaria* (Indian cattle leech)



*Hirudinaria* (Indian Cattle Leech)

## 2. *Pheretima* (Earthworm)

1. It is found in moist soil, usually, live in the upper layer of slightly damp soil, lawns gardens. It is nocturnal, hermaphrodite
2. Body is long, narrow and cylindrical, 3. Anterior end is pointed, while the posterior end is more or less blunt.
3. First segment also called as prostomium bears mouth on ventral surface and last segment bears anus. On ventral surface except 1<sup>st</sup> and last segment each segment possesses arrow of setae
4. Body is divided by circular furrows into a series of 100 to 200 ring like segments or metameres. Clitellum, a circular band of glandular tissue, is present in 14<sup>th</sup> to 16<sup>th</sup> segments.

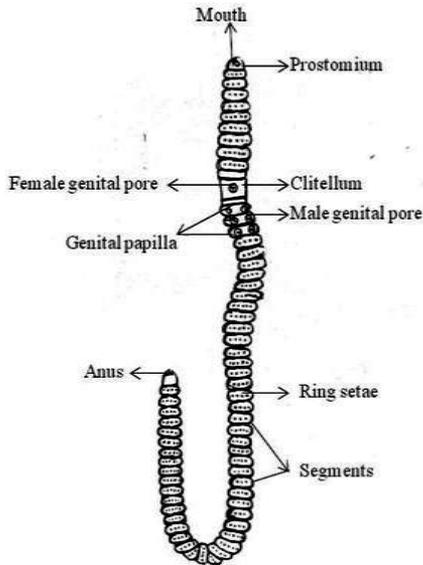
**Interesting features** Very beneficial for agricultural purposes as they eat on organic material and convert them into compost which is rich in nutrients and promotes growth of plants

They also increase permeability of water during rainy season and contribute in mixing of organic debris.

Phylum - Annelida

Class – Oligochaeta

Order-Neoligochaeta  
Genus - *Pheretima* (Earthworm)



*Pheretima* (Earthworm)

## AIM 7: TO STUDY CHARACTERISTICS FEATURES OF ARTHROPODA

### General characteristics

1. It is the largest phylum.
2. Organ system of organization.
3. Possess metamericly segmented body, bilateral symmetry, and are triploblastic.
4. Body is divided into head, thorax and abdomen.
5. They have a hard exoskeleton which is made up of chitin.
6. Complete digestive system is present.
7. **Moulting**- is a process of shedding periodically the outer covering during growth and it is replaced by newer ones.
8. They have jointed appendages.
9. They have a body cavity or blood-filled space known as haemocoel.

10. Open type of circulatory system.
11. They possess Sensory organs like eyes (simple and compound), balancing organ, and antenna.
12. Respiratory system consists of gills, trachea, or book lungs.
13. They have compound eye and antenna.
14. Malpighian tubules or green or coxal glands are present as excretory organs.
15. They may be terrestrial, aquatic, free living or parasitic
16. Fertilization is internal.
17. oviparous.
18. Sexes are separate.  
e.g: *Aranea* (Spider), *Palemon* (Prawn), *Musca* (Housefly) Mosquito, *Periplaneta* (Cockroach)

#### 1. ***Periplaneta americana* (Cockroach) External features of cockroach**

1. Cockroaches are found in dark, damp, warm, moist and dirty places having a typical smell, repulsive appearance. They can be easily seen in cracks, crevices, walkways, basements etc.
2. These are nocturnal in habit, cursorial, and omnivorous in diet.
3. Cockroaches are shining reddish brown or dark brown in color and oval in shape, length is about 29-53mm and width is approx less than one inch.
4. **Head** is triangular in shape attached anteriorly at right angles to the body. It has a pair of long, multi-joined, thread like movable antenna. Head also bears a shield like covering known as Protonum.
5. The dorso- lateral part of the head has two prominent black kidney shaped compound eyes. Each eye is made up of unit known as ommatidia.
6. The head bears biting and chewing type of mouthparts consisting of labrum, a pair of maxillae, and a pair of mandibles, labium and hypopharynx.
7. **Thorax:** It is made up of three parts: **Prothorax, Mesothorax and Metathorax.**

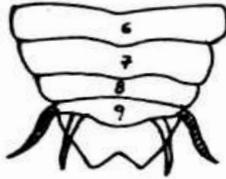
Prothorax have large pale edges and dark spots. As compared to Prothorax, Mesothorax and Metathorax are smaller in size. Thorax have three pairs of walking legs and each leg is attached to the body by a coxa which is in turn jointed to strong femur with the help of trochanter. Femur is followed by long Tibia, ending into tarsus which has 5 segments. Tarsal is composed of fine tarsomeres and the last segment ending in a pair of claws.

8. Two pairs of wings are present on mesothorax and metathorax. Mesothoracic wings or first pair of wings or Tegmina are leather like, dark and opaque and covers the hind wing, second pair of wings are metathoracic wings which are membranous, delicate and folded underneath fore wings.
9. **Abdomen:** Abdomen have eleven segments; 1-7 segments are visible easily and 11th segment is reduced and is represented by a pair of triangular plates at end. On the 8<sup>th</sup> segment there comes out a pair of segmented anal cerci in case of both male and female. On the 10<sup>th</sup> segment a pair of unsegmented appendages known as anal styles are present in case of males only.
10. Gonopore (genital opening) in female is presented on 8<sup>th</sup> segment and in males between 9<sup>th</sup> and 10<sup>th</sup> segments.
11. They can also carry some harmful bacteria and other microorganism and can cause food poisoning. Feces of cockroach can cause some allergic reactions in the body.

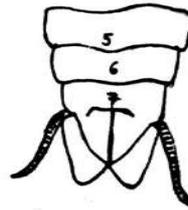
#### Differences between a male and female cockroach

S. No.	Male Cockroach	Female Cockroach
1.	Abdomen is elongated and slender	Abdomen is short and thick
2.	The 7 <sup>th</sup> segment covers only the 8 <sup>th</sup> segment in the abdomen from the dorsal side.	The 7 <sup>th</sup> segment covers both the 8 <sup>th</sup> and 9 <sup>th</sup> segments in the abdomen on the dorsal side.
3.	9 <sup>th</sup> abdominal segment is visible on the ventral side	Only the first seven abdominal segments are visible from the ventral side.

S. No.	Male Cockroach	Female Cockroach
4.	Brood pouch is absent.	7 <sup>th</sup> , 8 <sup>th</sup> and 9 <sup>th</sup> abdominal segments form a brood pouch whose anterior part forms female gonopore.
5.	9 <sup>th</sup> abdominal segment has a pair of anal styles	Anal styles are absent.

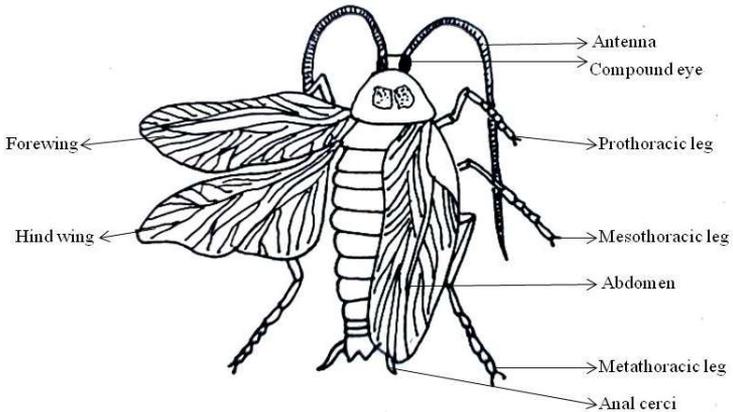


Male

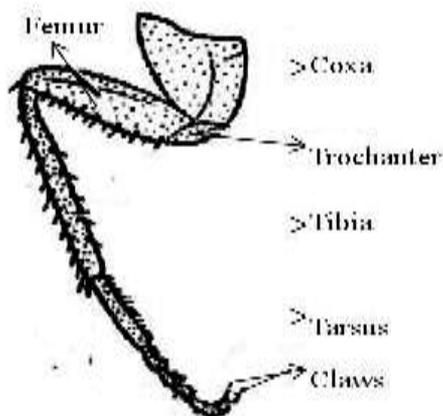


Female

Phylum- Arthropoda  
 Class- Insecta Order- Dictyoptera  
 Genus- *Periplaneta*  
 Species- *americana*



*Periplaneta americana* (Adult)



**Leg of cockroach**

### **Life Cycle of Cockroach**

Development of cockroach is direct with incomplete metamorphosis life cycle has following stages:

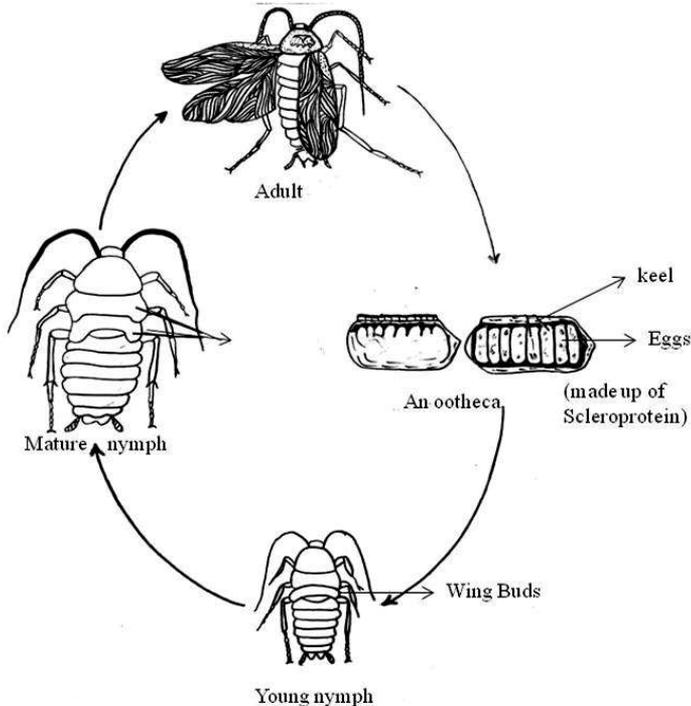
1. Ootheca
2. Nymph
3. Adult

#### **1. Ootheca**

- (a) It is laid 10-15 days after ovulation in warm and secluded places where they are clinging vertically to the surface. Around 90- 100 ootheca are laid by one female during her lifetime.
- (b) On the dorsal side each ootheca has serrated crest with 16 denticles or serrated margins which is known as keel. On the surface of ootheca 8 long raised areas are present on each side.
- (c) It is composed of non-chitinous material known as scleroprotein. It is 0.9cm long.
- (d) It consists of 14-16 eggs arranged in 2 rows like cigarettes are kept in a cigarette case. Eggs hatch in 3 weeks to 3 months' time depending upon temperature conditions and 14-16 nymphs come out from each ootheca when it ruptures.

## 2. Nymph

- (a) It takes about 3 weeks in summer and 3 months in winter from nymph to emerge out from ootheca.
- (b) Newly hatched nymph is delicate, semi-transparent and colorless with black eyes.
- (c) Nymph is identical to an adult cockroach except that is smaller in size devoid of wings and it is sexually immature.
- (d) Total nymph period is around 6-12 months.
- (e) Wing pads appear after 4th or 5th moulting and wings appear after last month which is fully developed. Nymph moults 13 times to become an adult.
- (f) After the nymph development advances, the body increases in size, color become darker, wings appear after last month which are fully developed and their genitalia.



**Life cycle of cockroach**

## **2. *Musca domestica* (Housefly) External Features of Adult Housefly**

Housefly of genus *Musca* is very common in human dwellings, habitation, dirty and filthy places and is especially plenty in number and active during rainy season.

The body is robust, grey colored about 6- 8mm in height and clearly divided into head, thorax abdomen.

### **Head**

It is large and free, mobile. It has two large compound eye laterally and 3 ocelli or simple eyes dorsally on a triangular ocellar plate. In the middle of the compound eye dorsally is a vertex and beneath it is a frons. In front of the head are two small jointed antennae.

Head bears antenna which are 3 jointed with last segment being the largest and bears a bristle called arista. It has sponging and sucking type of mouthparts.

### **Thorax**

The thorax is formed by the extended mesothorax, the pro and meta thorax are greatly reduced. The mesothorax has a pair of transparent wings having minute hair which are folded at rest. The hind wings are modified to form halteres which serve as balancing organs. The thorax bears 3 pairs of legs, segments are- coxa, trochanter, femur, tibia and tarsus. The tarsus ends into claws, below which are 2 pads like pulvilli. The legs possess a large number of bristles.

### **Abdomen**

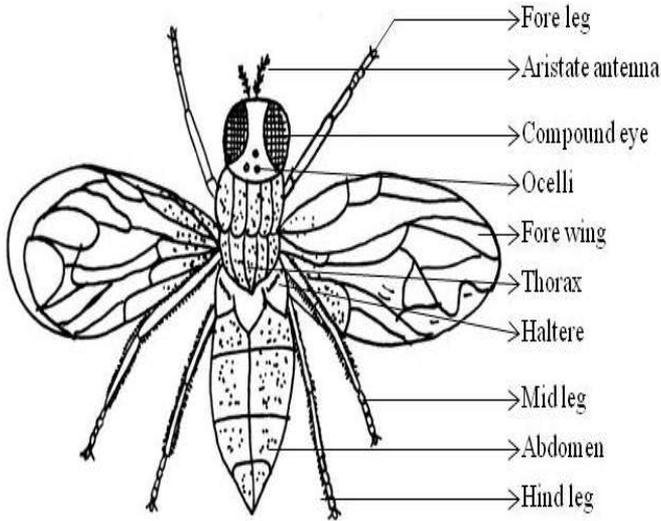
It is broad in the middle and narrow near the end. It has 10 segments of which the third - sixth are well developed and can be seen easily. In the female, segments 7-10 forms the ovipositor which helps in egg laying. The 10<sup>th</sup> segment in both the sexes possesses a pair of cerci. In male, the 9<sup>th</sup> segment has a pair of claspers and genital pouch. In males, ovipositor is absent.

Phylum- Arthropoda

Class- Insecta Order -Diptera

Genus- *Musca*

Species- *domestica*



*Musca domestica* (Housefly)

Metamorphosis is complete and it moults three times. Life cycle is completed in 4 stages i.e.

1. Egg,
2. Larva,
3. Pupa
4. Adult.

**1. Eggs**

- i. Eggs are laid about 4 days after mating in manure, human feces, garbage or decomposing /vegetable material.
- ii. About 120 to 160 eggs are laid at once and a house fly lays eggs 4 to 6 times during her life time depositing about 500 eggs.
- iii. An egg is white in color, cylindrical in shape about 1-2 mm long and has two longitudinal ribs like thickening on one side.
- iv. The incubation period is from 8 to 24 hours depending upon temperature.

**2. Larva**

- i. The first instar larvae come from the eggs in 8 to 24 hours depending upon the temperature conditions.

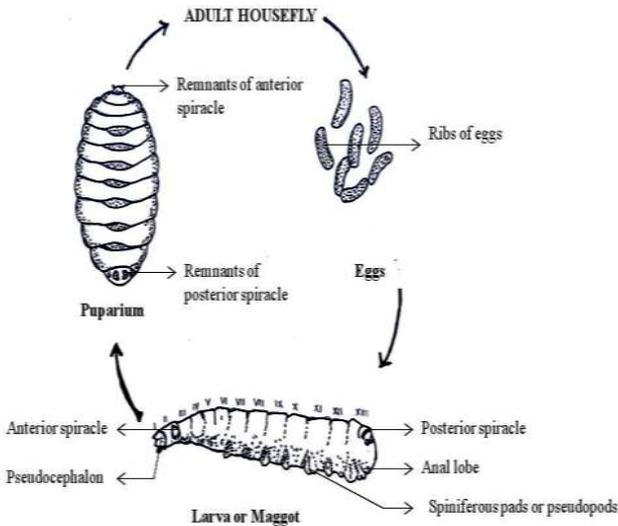
- ii. The larva is known as maggot, a distinct head is absent and the body is covered by thin soft chitin.
- iii. Lymphs are not present and such a limbless larva is called as Apodous.
- iv. The first instar larva length is about 2 mm long and bears only 1<sup>st</sup> pair of posterior spiracles on the last segment. (metapneustic stage).
  - v. The first instar last for 2-3 days during which it feeds on waste, garbage and then moults to transform into the second instar.
- vi. The 2<sup>nd</sup> instar is larger in size as compared to previous one. Along with posterior spiracle, it also develops anterior spiracles.
- vii. After feeding upon decomposing material for about 24 hours it moults once more to form the 3<sup>rd</sup> instar.
- viii. The fully grown 3<sup>rd</sup> instar length is about 12mm. It has a small indistinctive head known as pseudo cephalon (insignificant head), it is followed by 12 segments. The anterior end is narrower but posterior is broader.
- ix. The pseudocephalon bears a mouth and a pair of hooks or mandibular sclerites which help in breaking of food.
  - x. 6 pairs of spiniferous pads or spiny pads or pseudopods are present on segment 6-12. One pair on each segment, they are used in movement.
- xi. The 3<sup>rd</sup> instar lasts for about 3-5 days at the end of which it stops consuming anything and the larva gets prepared for pupation. It moults three times and four larval instar stages are present during life cycle of housefly.

### 3. Pupa

- i. When a larva is prepared to pupate its body contracts to form a pupa. It searches out a dry crevice of the manure.
- ii. The pupa is brownish and barrel in shape. Larval skin hardens to form puparium.
- iii. It does not move externally on segments it shows remnants of larval spiracles and spiny pads.
- iv. The pupa respire with the help of a pair of pupal spiracles present between the 5<sup>th</sup> and 6<sup>th</sup> segment of the puparium.

- v. The pupal stage remains for about 4-5 days.
- vi. During this period complete metamorphic changes take place inside the pupa. These are of 2 kinds.
  - (a) **Histolysis** - Breaking of the larval tissues.
  - (b) **Histogenesis**- formation of new organs of adult.

When both these changes are over the adult develops completely, a blood-filled bag known as ptilinum present on its head and by compressing this against the puparium the adult breaks the puparium and emerges out.



**Life cycle of housefly**

### 3. *Culex/Anopheles* (Mosquito)

Mosquitoes are tiny, soft grayish black insects with 3-4 mm long body covered with small scales. They are found in damp, marshy localities, and temperate, tropics, subtropics regions of country. The body can be distinguished into head, thorax and abdomen. *Anopheles* adult have thin body as compared to that of *Culex* adult. *Anopheles* rest with its body at an angle (45 degree) to the surface, its proboscis being in straight line with the body while *Culex* rest with its body

along the side of surface and its proboscis is not in straight line with its body. *Anopheles* female spreads malaria and *Culex* female spreads filariasis.

## **External Morphology of Mosquito**

### **Head**

1. Head is small rounded, spherical connected by narrow movable neck to thorax. Large legs are present they have well developed kidney shaped compound eyes. There are no ocelli.
2. Antennae have 15 jointed segments. Below the antennae are maxillary palps and proboscis. Palps are shorter in case of females as compared to males.
3. Mosquito can be easily identified and distinguished into male and female by examination of antennae and mouth parts.

### **Abdomen**

1. It consists 10 segments. First vestigial segment is fused to metathorax. Each has a pair of spiracles.
2. In *Culex* female, 10<sup>th</sup> segment is not pointed and bears a pair of cerci between them is a small post genital plate which is a part of 10<sup>th</sup> sternum. In male 9<sup>th</sup> and 10<sup>th</sup> are complicated. A genital pore is present on 9<sup>th</sup> segment.

### **Thorax**

Thorax is domed or curved. Prothorax is smaller in size. Mesothorax is very large consisting of a scutum, a scutellum with three lobes and post scutellum. Thorax bears two pairs of spiracles. A pair of long, narrow membranous wings emerge from mesothorax.

Three pairs of long, thin and delicate legs arise from each of the thoracic segments. Each leg has 5 segments i.e., coxa, trochanter, femur, tibia and tarsus.

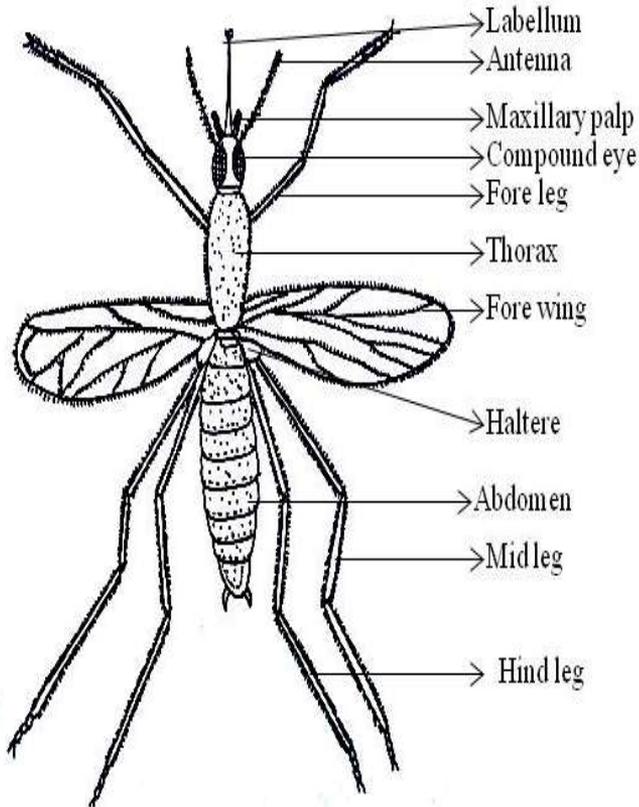
Coxa are short while tarsi are long with 5 joints ending with a pair of claws. Legs have scales and bristles.

Phylum- Arthropoda

Class- Insecta

Order-Diptera

Genus- *Culex/Anopheles*



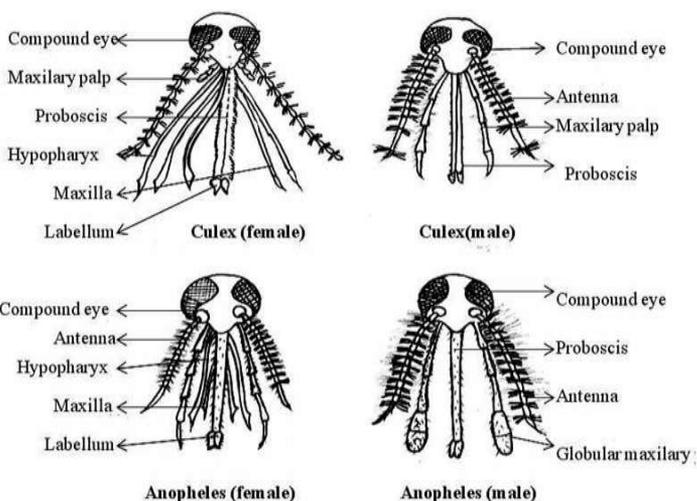
*Culex/Anopheles* (Mosquito)

### Mouth Parts of Mosquito

Mosquitoes have piercing and sucking type of mouth parts.

1. A long proboscis is made by a fleshy labium which has a deep-seated groove on its upper side.
2. At the distal end of the labium is a pair of minute sensory labella which are reduced labial palps.
3. The groove of the labium consist a long pointed stiff labrum.i.e. epipharynx.
4. In the female mosquitoes, the groove of the labium contains 5 needles like stylets. There are 2 mandibles, 2 maxillae and a hypopharynx.

5. The mandibles are finer than the maxilla but both have saw like edges on their tips.
6. The hypopharynx is needle like and has a fine salivary duct running through it and has an opening at the tip. Through this duct saliva is poured to avoid clotting of the blood of the victim.
7. In the male mosquitoes, the mandibles and maxilla are very short and nonfunctional, and the hypopharynx is joined to the labium.
8. In *Anopheles* female, antenna is less bushy. Mandibles, maxillae, and hypopharynx are present as elongated stylets. The maxillary palps are equal to proboscis in length but are clubbed shaped in males and pointed in females.
9. In *Culex*, maxillary palps are longer than the proboscis in males and in females' maxillary palps are shorter. Maxillae and mandibles in the form of elongated stylets which are needle like. Antennae are less bushy.



### Mouth parts of Mosquito *Culex* and *Anopheles* (male and female)

#### Life Cycle of *Culex*

*Culex* undergoes complete metamorphosis during development. Life includes four stages i.e. Egg, Larva, Pupa and Adult.

### 1. Eggs

1. The eggs have cigar shape, tapering at one end and slightly broader at the other end. They are wheatish in color when laid, but soon turn dark grey.
2. The eggs are laid side by side standing upright. These are glued together to form boat shaped raft which can float on water. Generally, eggs are laid on fresh and pure water.

### 2. Larva

1. Larva is about 1 mm on hatching. It swims vigorously on water and feeds on the micro-organisms present in water.
2. Body is distinguished into head, thorax and abdomen.
3. Head bears a mouth, along with rotatory feeding brushes which move rapidly to set up current in water carrying small particles of food to the mouth.
4. Thorax is without segments and broad. Abdomen is slender and has nine segments; the first 7 segments have tufts of bristles. Palmate hair is absent on segments of abdomen.
5. The 8<sup>th</sup> segment has long tubular respiratory siphon at the tip off there are spiracles for respiration.
6. At the end of the 9<sup>th</sup> segment is an anus encircled by four leaf like tracheal gills. The larval life remains from 3-14 days and during this time, it moults 4 times and there are 5 larval instars.
7. Larva feeds on bottom. It comes to the surface to breathe atmospheric air through respiratory tube. The larva is also known as wriggler because of their wriggling movement. It moults four times. Nine abdominal segments possess dorsal and ventral brushes.

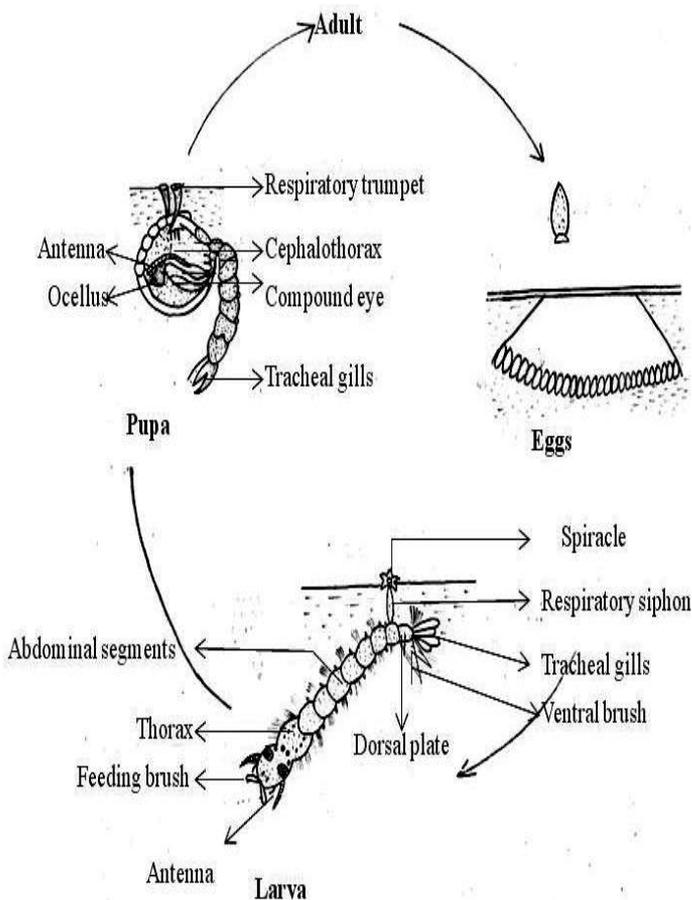
### 3. Pupa

1. It is comma shaped with large cephalothorax (head +thorax) and cylindrical abdomen. They are also known as tumbler.
2. Cephalothorax has a pair of large funnels shaped respiratory trumpets for respiration. Inside the cephalothorax developing organs can be visualized.
3. Abdomen is with segments, palmate hair is absent on each segment and last segment has two leaf like paddles by which the pupa swims.

- Pupa is the resting stage. It does not feed and metamorphosis changes are taking place inside the pupa shell.

**Two types of changes occur**

- Histolysis** by which larval organs are degenerated and broken down.
- Histogenesis** by which new adult organs are formed. When both these changes are over the adult emerges out by breaking the pupal shell and flies off.



**Life cycle of *Culex***

### **Life Cycle of *Anopheles***

Anopheles also shows complete metamorphosis during development as in case of culex.

#### **Egg**

1. Female anopheles lays 40-100 eggs at once. The eggs have tapered ends from both the sides and have two lateral air floats.
2. The eggs are laid singly and lie horizontally on surface of water, they lie in close bunch.
3. Eggs are white in color.

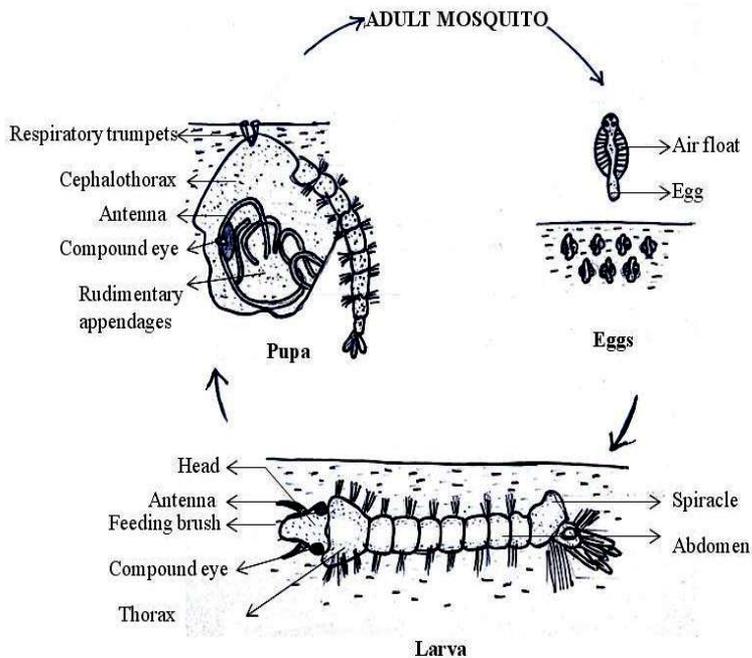
#### **Larva**

- (a) Respiratory siphon are absent in the larva of anopheles. The 8th segment has a raised chitinous quadrilateral plate with two spiracles.
- (b) The larva has palmate bristles or hairs composing a pair of tufts on each thoracic segment and on most of the abdominal segments.
- (c) The larva suspended horizontally from the surface of water by means of palmate bristles and the quadrilateral plate of 8<sup>th</sup> segment.
- (d) The head is longer and less broader and it feeds on the surface of water.

#### **Pupa**

- (a) In Anopheles, the pupal period remains from 2-7 days. The respiratory trumpets are shorter and broader with a large opening at the extreme end.
- (b) Cephalothorax possesses eyes, antennae and short respiratory siphon.
- (c) The abdomen of pupa of anopheles is more strongly arched and possess palmate hair and caudal fins. In anopheles the abdominal paddles and their tips have one large and tiny bristle.
- (d) Anopheles pupa has a pair of peg like spines at the posterior ends of all but not on the last abdominal segments. Two processes occur within pupa

- (i) **Histolysis** by which larval organs are degenerated and broken down.
- (ii) **Histogenesis**- by which new adult organs are formed. When both these changes are over the adult emerges out by breaking the pupal shells and flies off.



**Life cycle of *Anopheles***

**Differences between *Culex* and *Anopheles***

**EGGS**

S.No.	<i>Culex</i>	<i>Anopheles</i>
1.	Eggs are vertically laid in clusters on the surface of the water.	Eggs are laid singly and horizontally on the surface of the water.
2.	Eggs are cigar shaped.	Eggs are boat shaped.

S.No.	<i>Culex</i>	<i>Anopheles</i>
3.	Eggs of <i>Culex</i> mosquito are not provided with lateral air floats.	Each egg has two lateral air floats, which help them in floatation.
4.	Eggs are laid on dirty water.	Eggs are laid on clean water.

### LARVA

1.	Larva of <i>Culex</i> mosquito is bottom feeder.	Larva of anopheles mosquito is surface feeder.
2.	The respiratory siphon is long.	The respiratory siphon is short.
3.	It forms an angle inside water.	It remains parallel with water surface.

### PUPA

1.	The pupa is colorless.	The pupa is green.
2.	The respiratory trumpets are long and narrow.	The respiratory trumpets are short and wide.
3.	The abdomen is less bent.	The abdomen is more bent

### ADULT

1.	Body is provided with stouter legs	Body is provided with delicate legs.
2.	Wings are transparent and can fly for long distance	Wings are spotted and cannot fly for long distance.
3.	There is presence of small palpi near proboscis	The proboscis and palpi have same length
4.	At rest body lies parallel to the surface.	At rest body is inclined at an angle of 45degrees to the surface
5.	It transmits filarial parasite	It transmits malarial parasite

#### 4. *Scolopendra* (Centipede)

1. It is found in rotten logs and in houses in moist places.
2. It has elongated body, dorso- ventrally flattened with large number of segments.

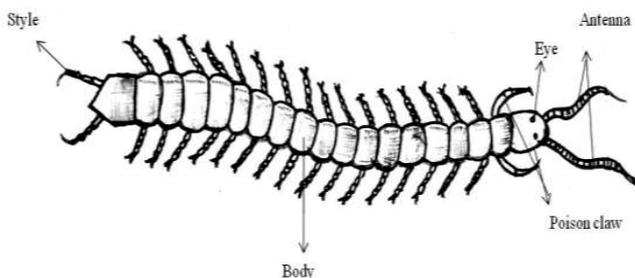
3. One pair of walking legs is present on trunk segment 2-22.
4. Body can be divided into head and trunk. They have simple eye or no eye as they live nocturnal life.
5. Trunk possesses 22 segments and all the mostly alike.
6. Head is peculiar and possess a pair of mandibles for seizing and killing prey and two pairs of maxillae and long jointed antenna for sensing the environment.
7. Sexes are separate.
8. First pair of trunk appendages (maxillipeds) possesses a sharp claw connected with the poison gland.
9. It carnivores, feeds on insects, spiders, worms.
10. Genital aperture is present on the last segment. Respiration through spiracles.

Phylum- Arthropoda

Class- Chilopoda

Order- Scolopendramorpha

Genus- *Scolopendra*( Centipede)



*Scolopendra* (Centipede)

### 5. *Julus* (Millipede)

1. It is found hidden usually in dark and moist places under stones or wood or in decaying leaves. It is also found under stones.
2. Body is prolonged, cylindrical, composed of large number of segments.
3. Body can be divided into head, thorax, and abdomen. Its size varies from 2mm to 35cm.

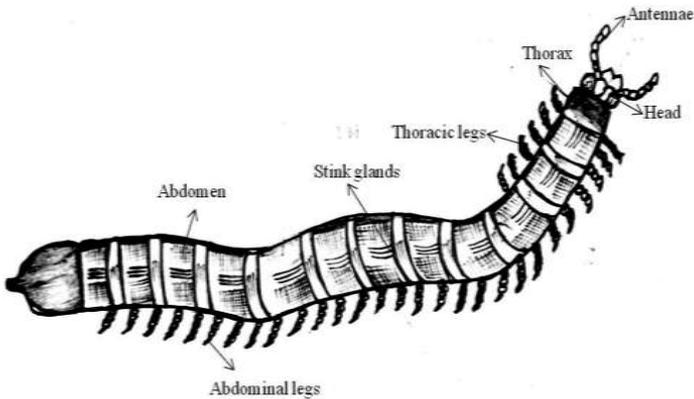
4. Head comprised of five segments, thorax of four segments and an abdomen of 20- 100 segments.
5. Head possess a pair of short seven jointed antennae, a pair of mandibles, and a pair of maxillae.respiration through spiracles.
6. Segments present on thorax bears a pair of legs, while abdominal segments bear two pairs of legs. It is detritivorous.
7. Poison claws are not present.body is covered with chitinous exoskeleton. It consists of dorsal plates(tergite), lateral plates(pleurite),and ventral plates (sternite)
8. Stink glands are present along the sides of the body, secreting toxic substance.

Phylum- Arthropoda

Class- Diplopoda

Order-Juliformia

Genus-*Julus* (Millipede)



*Julus* (Millipede)

#### 6. *Palaemon* (Prawn)

1. It is found in freshwater ponds, lakes streams and rivers.
2. It has extended body, somewhat spindle shaped, and bilaterally symmetrical.
3. Body can be divided into two parts anterior cephalothorax and posterior abdomen.

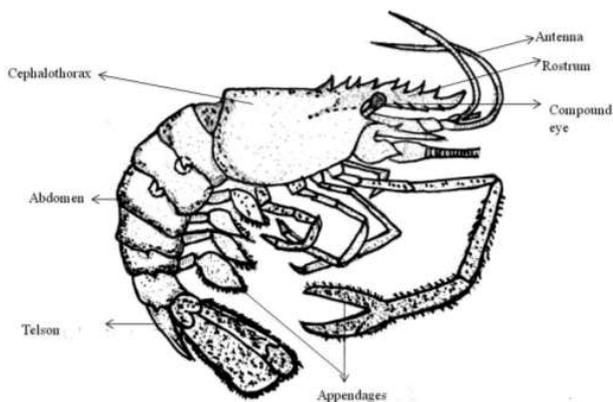
4. The carapace of cephalothorax is anteriorly developed into a saw-toothed rostrum.
5. It has two prominent compound eyes.
6. Cephalothorax is formed by the combination of head comprising five segments and eight segments of thorax.
7. Abdomen consists of six distinct, movable segments, a terminal conical piece, and the telson.
8. The cephalic appendages consist of a pair of antennules, a pair of antennae, a pair of mandibles, a pair of maxillae.
9. There are 19 appendages. Each segment of the body possesses a pair of jointed appendages.

Phylum- Arthropoda

Class- Crustacea

Order- Decapoda

Genus- *Palaemon* (Prawn)



*Palaemon*

## 7. *Aranea* (Spider)

1. They are found in houses, and gardens.
2. Body comprises of prosoma and an opisthosoma, the two are being connected by a narrow pedicel.
3. Prosoma is covered by carapace and possesses eight eyes dorsally and six pairs of appendages.

4. Chelicerae contain poison glands.
5. There are four pairs of seven jointed legs.
6. Respiration occurs by book lungs and trachea.
7. Excretion occurs via malpighian tubules.
8. Sexes are distinct.
9. They are carnivorous, nocturnal, feeds on small insect.

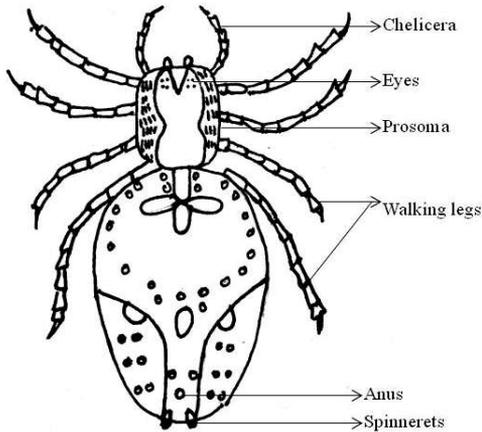
**Interesting fact:** Opisthosoma is unsegmented, bears three pairs of spinnerets which produce thread like structure for making web. It shows mimicry.

Phylum- Arthropoda

Class - Arachnida

Order-Araneae

Genus- *Aranea* (Spider)



*Aranea* (Spider)

## 8. Scorpion

1. It is nocturnal in habit, found under stones; bark of trees, or in burrows.
2. It has extended body, segmented and divisible into anterior prosoma (Cephalothorax), middle mesosoma and posterior metasoma.
3. Prosoma has six segments and possesses a pair of median eyes 2-5 pairs of lateral eyes and six pair of appendages i.e. a pair

of chelicerae, one pair of pedipalpi and four pairs of walking legs.

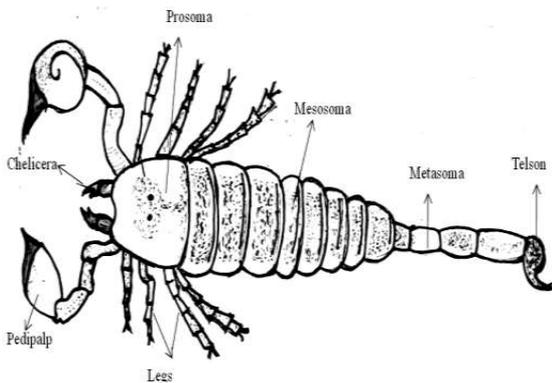
4. Mesosoma is seven segmented.
5. Metasoma comprises of five segments without appendages. it stores poison glands.
6. Last segment of metasoma bears a sting.
7. Respiration via book lungs.
8. Excretion occurs through malpighian tubules.
9. Sexes are separate.
10. Their sting causes severe pain, fever. Sense of smell is very well developed.

Phylum- Arthropoda

Class- Arachnida

Order-Scorpionidea

Genus- Scorpion



**Scorpion**

### 9. *Xenopsylla cheopis* (Rat flea)

1. Adult is a small, ectoparasites of warm-blooded animals like mammals and birds, in which the wings are completely lost due to parasitic mode of life.
2. The body is laterally compressed, the cuticle is strongly sclerotized and the head is attached to thorax neck is absent.

3. Mouth parts are of piercing and sucking type and the fleas suck blood from their hosts.
4. The antennae are short, have 3 segments and embedded in antennal groove.
5. The thorax is comprised of three segments and possesses 3 pair of legs.
6. The legs are large and stout has very large coxae, tarsus is 5 segmented with stout claws.
7. Legs are modified for jumping and fleas can jump up to a height of 65mm and length of about 180mm (i.e upto 200 times the length of their bodies).
8. The abdomen is 10 segmented, 9 segments being clearly visible. Each segment bears one or more rows of backwardly directed bristles that enable flea to cling on to the fur, hair or feathers of its host and the last 3 are modified for sexual function.
9. The 9th segment bears a sensory plate or comb like structure called as pygidium which helps in detecting air currents.
10. The male has an structure known as aedeagus which lies curled up inside the abdomen while the female bears a receptaculum semeniris near the middle of 9th segment.
11. Fleas are vectors of bubonic plague and murine typhus.

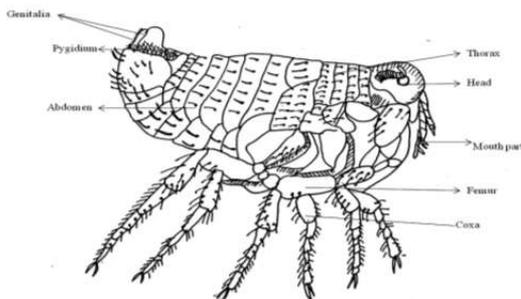
Phylum-Arthropoda

Class- Insecta

Order- Siphonoptera

Genus- *Xenopsylla*

Species- *cheopis*(Rat flea)



*Xenopsylla cheopis* (Rat flea)

## 10. *Microtermes obesi* (Termites)

### Termite winged form

1. The winged adults are the predominant reproductives and all other castes are formed from these. The body is well sclerotised and dark colored compound, and simple eyes are well developed
3. Moniliform antennae are present kind and consist of more segments than in the other castes. The brain in these forms is large, the frontal gland is well developed and the sexual organs are very well developed
4. Thorax bears two pair of large membranous wings, nearly of equal size, the wings are basically similar in form and venation.
5. Both the male and female in the winged forms are modified for a brief aerial life and they are the founders of new colonies. After swarming they shed their wings at the humeral suture and only wing stubs remain throughout the life.

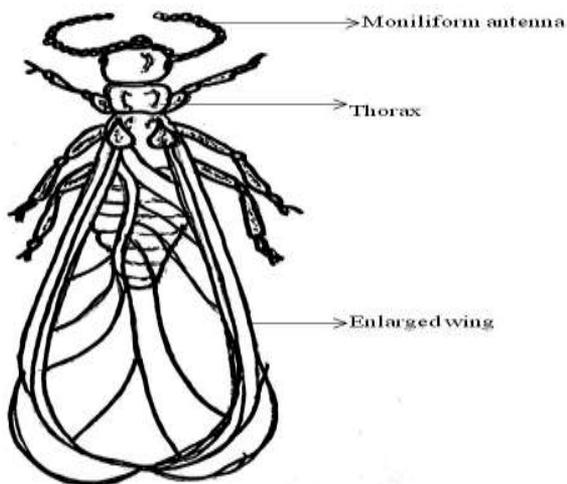
Phylum- Arthropoda

Class- Insecta

Subclass-Pterygota

Division- Endopterygota Order- Isoptea Genus-*Microptermes*

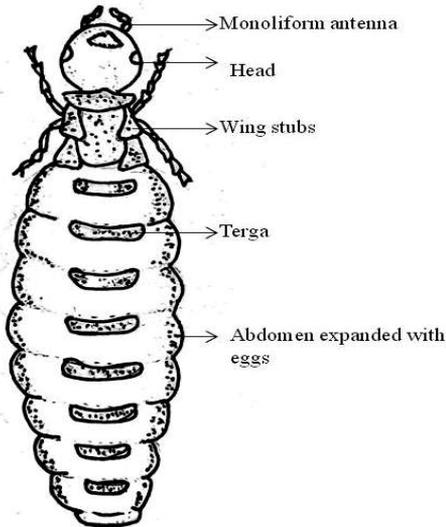
Species-*obesi*



Termite winged form

### Queen Termite

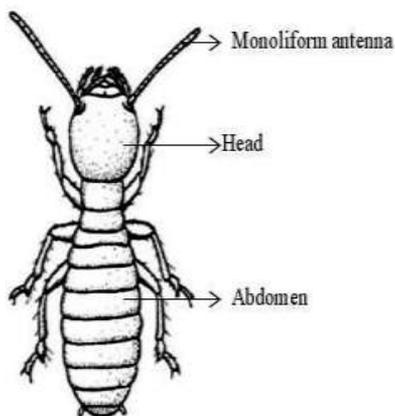
1. The queen is the female, winged form and, a fertile caste of the termite colony. It is about 5 to 7.5 cm long.
2. The body is well sclerotised, dark colored compound eyes are completely developed and mostly 2 ocelli are present, moniliform antennae are present.
3. From thorax two large pair of similar, membranous wings emerges out, these are shed after swarming and mating and only wing stubs remain all through the life.
4. After fertilization, the queen attains huge dimensions. The abdomen enlarges vastly in size due to increase in size of ovary and fat body while the head and thorax remains same in size.
5. The queen lays the first bunch of 10-30 eggs about a week after swarming but later on about 300-3000 eggs are laid per day during her life span of about 5 years, but it may live up to 15 years and lays million of eggs.
6. The queen cannot feed upon any hard matter but is foster upon saliva or fungal hyphae along with saliva by the workers. The job of queen is to lay eggs only.



Queen Termite

### Termite worker

1. Workers are the wingless infertile caste of the termite colony with no or underdeveloped eyes.
2. They are the most numerous, forming about 80% of the colony including male and female both.
3. They are pale in color with some sclerotization and nymph of the other caste, mouth parts are well developed for chewing wood and other vegetable material. Compound eyes are generally not present.
4. The worker execute all other duties like taking care of eggs and young ones, feeding and attending to queen, foraging, planting and cultivating fungus. and building termitadea as well as restoring of the nest.
5. The worker can cause damage to crop, wood because they have well developed chewing and cutting type of mouth parts.
6. The worker termite can digest wood because of the existence of protozoan trichonympha in its alimentary canal, and wood is converted into powder.

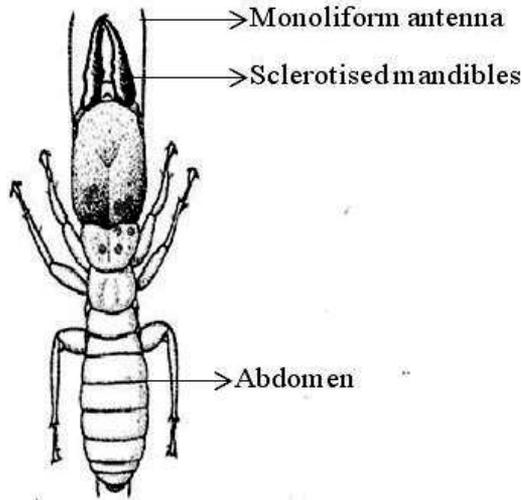


Termite worker

### Termite Soldier

1. Soldiers are infertile, without wings (apterous) and most specialized members of the termite colony comprising both male and female.

2. They are easily identified by the large size and sclerotization of the head.
3. The head has large strong mandibles which facilitate in either driving away or attacking the enemy.
4. Eyes are reduced and are mostly are not present.
5. Antennae are beaded but consist of fewer numbers of segments.



Termite Soldier

## AIM 8: TO STUDY CHARACTERISTICS FEATURES OF MOLLUSCA

### General characteristics

1. They are mostly marine and aquatic but few forms are freshwater and terrestrial.
2. Organ level of organization, possess bilateral symmetry, triploblastic.
3. Presence of coelom.
4. Tongue like organ radula is present.
5. Have soft, unsegmented body, which is enclosed in a fold of skin known as mantle and a hard and brittle shell.
6. Body is divided into three parts head, foot, mantle and visceral mass.

7. Head is significant possessing mouth eyes, tentacles and other sense organs.
8. Body is covered by calcareous exoskeleton.
9. Foot is muscular and ventral in position. It assists in creeping and burrowing, and lies below the visceral mass.
10. Visceral mass consists of vital organs of the body in the compact manner.
11. Respiration by gills, pulmonary sac.
12. Open type of circulatory system.
13. Blood is blue in color due to presence of pigment known as Hemocyanin.
14. Sexes are separate.  
e.g. *Octopus (Devil fish)*, *Pila (Apple Snail)*, *Chiton*.

### 1. ***Octopus (Devil fish)***

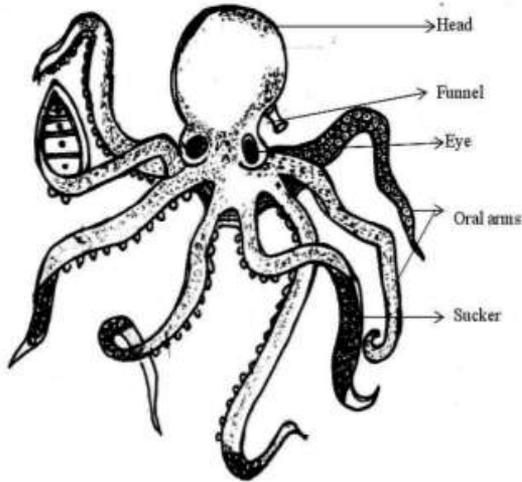
1. It is a marine, bottom living nocturnal animal found easily in rocky crevice, in coral reefs, and understones.
2. Body is globular in shape and like bag with large head and trunk region.
3. Head has a pair of eyes and eight extended equal sized arms which webbed at base and encircles the mouth.
4. Each arm possesses suckers arranged in two rows. Suckers are sessile and enlarged and also act as adhesive organs.
5. No shell.
6. Feeds on crabs, prawns, and fish.
  - **Interesting fact:** It produces an inky fluid which scatters in water and forms smoky effects for defense against enemies.
  - Show camouflage.
  - Most intelligent and behaviorally diverse of other invertebrates.
  - Three hearts are present. Hemocyanin oxygen carrying pigment is present in blood.
  - Show autotomy (detach arms to attract predator) like lizards.

Phylum- Mollusca

Class- Cephalopoda

Order- Octopoda

Genus- *Octopus (Devil fish)*



*Octopus* (Devil fish)

## 2. *Pila globosa* (Apple snail)

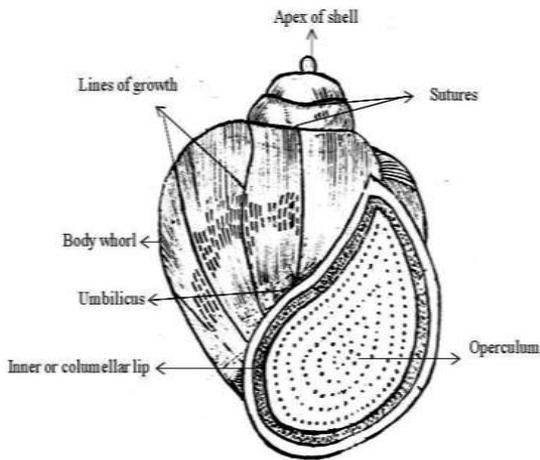
1. It is commonly found in ponds, lakes, tanks etc.
2. The body of the animal is encircled in a shell.
3. Body can be divided into head, foot, mantle and visceral mass.
4. Head lies at the apex and possess two pairs of contractile tentacles and a pair of eye.
5. Muscular foot is present assists in creeping on surface.
6. Spirally coiled shell is present on a axis known as collumella and it opens outside by the mouth.
7. They have thousands of microscopic teeth like structure located on a banded ribbon like tongue called a radula.
8. Mostly herbivores but some of them are omnivores or predatory carnivores. Mostly they feed on rotting material because of their soft teeth.

Phylum- Mollusca

Class- Gastropoda

Genus-*Pila*

Species- *globosa* (Apple snail)



*Pila globosa* (Apple snail)

### 3. *Unio* (Freshwater mussel)

1. It is found at bottom in ponds, lakes, streams, and rivers buried in the sand or mud.
2. They have bilateral symmetry, unsegmented and soft body and flattened and encircled in a calcareous shell.
3. Shell comprises of two plates or valves covering the left and right side of body.
4. Umbo (swelling) is present near the anterior end of the dorsal side.
5. Sexes are separate but shells of both the sexes are similar.
6. Muscular, large foot is present which is wedge shaped used for making burrows in ground.
7. Two valves are united by a dorsal elastic band called a hinge ligament which is continuous with two shell valves.

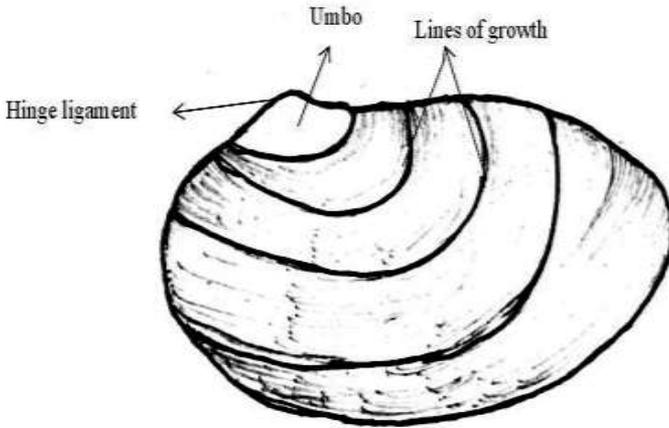
**Interesting fact:** Mantle secretes pearls when any dust or foreign particle lodges between the shell and the mantle and pearls is formed in concentric layers around foreign particles.

Phylum- Mollusca

Class- Bivalvia

Order- Eulamellibranchiata

Genus- *Unio* (Freshwater mussel)



*Unio* (Freshwater mussel)

### AIM 9: TO STUDY CHARACTERISTICS FEATURES OF ECHINODERMATA

#### General characteristics

1. They are the marine forms.
2. Show organ system level of organization.
3. Radially symmetrical, triploblastic, coelomate,
4. Nearly always pentamerous.
5. Head is absent and no segmentation of body.
6. Body has two surfaces oral and aboral surface. Shape of the body can be either spherical, or cylindrical.
7. Body is covered with calcareous spines.
8. Coelom is well developed and presence of water vascular system which consists of tubes of filled with watery fluid.
9. They have tube feet which have suckers on their ends. The tube feet are used for locomotion, attachment to the substratum and for catching the prey.
10. They possess power of regeneration.
11. Fertilization is external.
12. Sexes are separate.  
. e.g: *Asterias* ( Star fish), Sea urchin

## 1. *Asterias* (Starfish or Sea star)

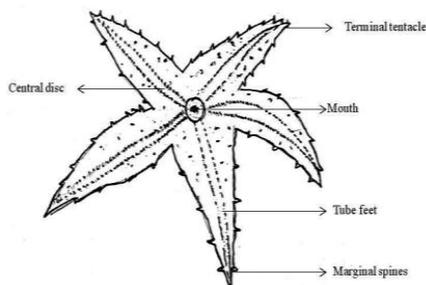
- *Asterias* is a marine form and found in the sandy and rocky parts of the sea.
- The body is star shaped, consisting of a central disc with five radiating arms which are broad at their base and tapering towards their extremities.
- Body surface are distinguishable into an oral surface directed downwards and an aboral surface directed upwards
- Mouth is pentagonal and lies in the centre of the disc on oral surface.
- Water vascular system is well developed. It helps in locomotion and feeding. Tube feet end into suckers.
- Sexes are separate. Fertilization is external.
- Act as keystone species in their marine communities.

Phylum-Echinodermata

Class- Asteroidea

Order- Phanerozoia

Genus- *Asterias* (starfish)



*Asterias* (starfish)

## Phylum chordata

### Characteristics

Dorsal, hollow, nerve cord, it persists throughout the life.

Presence of notochord. In higher animals it is replaced by vertebral column, pharyngeal gill slits are present in the pharyngeal wallet during some stage in life cycle.

Post anal tail is present at some stages of life.

## Vertebrata

- They possess a backbone known as vertebral column.
- Nerve cord is divided into brain, and spinal cord.
- Brain is enclosed in cranium.
- Two pairs of fins or limbs are present.
- Respiration by gills or lungs.

### AIM 10: TO STUDY CHARACTERISTICS FEATURES OF PISCES

#### General characters of Pisces

1. Aquatic freshwater or marine: cold blooded vertebrates.
2. Body is streamlined and covered with scales.
3. Two chambered heart.
4. Unpaired dorsal, caudal, and anal fins and paired pelvic and pectoral fins are present.
5. Oviparous.
6. Locomotion by muscular tail.
7. Limbs are absent. Lateral line sense organs are present.
8. Only internal ear is present.
9. Respiration via gills but other accessory respiratory organs are also present.
10. Presence of swim bladder.
11. Endoskeleton is cartilaginous or bony.

#### Class- Chondrichthyes

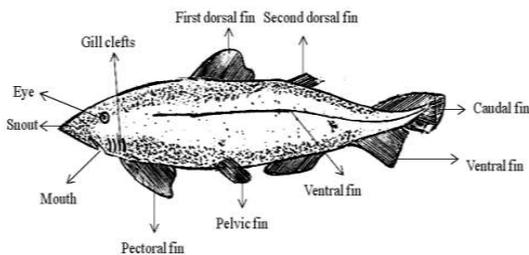
1. Have cartilaginous endoskeleton, ventral mouth and naked gill slits.
2. They are mostly marine.
3. Mouth is ventral.
4. Body is compressed laterally or dorso-ventrally flat.
5. Endoskeleton is made of cartilage.
6. Skin is covered with placoid scales.
7. Gills are not covered with gill cover or operculum.

#### 1. *Scoliodon* (Dog Fish)

1. Lives in sea.
2. Predacious and voracious feeders.

3. The body is elongated, long, laterally compressed and spindle shaped tapering at both ends.
4. The body is divisible into head, trunk, and tail.
5. The head is strongly compressed dorso-ventrally and produced in front into a wedge shape snout.
6. A pair of anterior pectoral fin and posterior pelvic fin and a caudal fin is present on truck region.
7. The trunk is the largest part of the body extending from behind the gill slits up to the cloacal aperture.
8. Five pairs of the gill slits are present on the lateral sides.
9. Shows sexual dimorphism and males possess claspers.
10. A lateral line extends from head to tail.
11. Has educational and experimental value. It is used as food in some parts

Phylum-Chordata  
Subphylum-Vertebrata  
Superclass-Gnathostomata  
Class- Chondrichthyes  
Order-Lamniformes  
Genus- *Scoliodon*



*Scoliodon*

## 2. *Torpedo* (Electric Ray)

1. It is found in Mediterranean Sea, Red sea, Atlantic Ocean, and Pacific Ocean
2. Skin is without scales and smooth
3. Body is dorso-ventrally flattened and disc shaped which is sub circular with the size of 60 cm.

4. Gill slits are ventral
5. Carnivorous
6. Five pairs of gill slits are ventral.
7. It is solitary, nocturnal predator feeds on bony fishes and crustacean.
8. A circular pectoral fin is little larger than second and caudal fin is very well developed which is triangular with blunt corners.
9. The first dorsal fin is little larger than second and caudal fin is very well developed which is triangular with blunt corners.
10. Blue spots are present on back but their number varies depending on the species.

**Interesting fact:** A pair of large kidney shaped electric organs is present which gives electric shock of up to 200 volts.

Phylum- Chordata

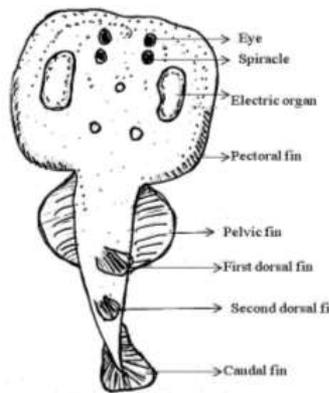
Subphylum-Vertebrata

Superclass-Gnathostomata

Class-Chondrichthyes

Order Torpediniformes

Genus-*Torpedo* (Electric Ray)



*Torpedo* (Electric Ray)

### Class- Osteichthyes

1. Bony fishes have bony endoskeleton, anterior mouth, operculum covering gill slits and has air swim bladder.
- 2 They are found in fresh and sea water.

3. Mouth is in terminal position.
4. Have endoskeleton of bones.
5. Body is covered with cycloid, ganoid, and ctenoid scales.
6. They possess 4 pairs of gills. Gills are covered by operculum.
7. Air bladder helps in maintaining the buoyancy.

### 3. *Exocoetus* (Flying fish)

1. It is found from Indian Ocean to the China seas.
2. Body is moderately extended, flattened, and covered with scales.
3. Pectoral fins bear black spots.
4. Mouth is broad bears the teeth in upper and lower jaw.
5. Presence of air bladder
6. Oviparous.
7. Pectoral fins are vastly elongated to form wing like structures. They act as parachute to assist fish in its gliding leaps.
8. It is considered as good palatable fish and contribute fishery in certain seasons.

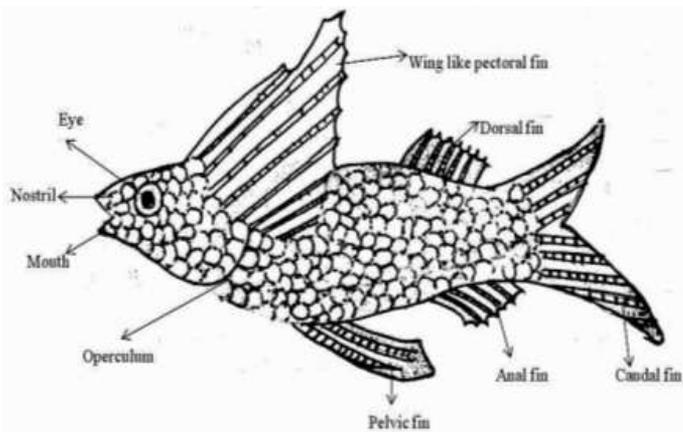
Phylum- Chordata

Subphylum-Vertebrata

Superclass- Gnathostomata

Class- Osteichthyes

Genus- *Exocoetus* ( Flying fish )



*Exocoetus* (Flying fish)

#### 4. *Hippocampus* (Sea Horse)

1. Found in tropical and temperate seas.
2. Body is more or less elongated having an exoskeleton of rings.
3. Mouth is at the extremity of an elongated tubular snout.
4. Trunk is compressed, somewhat elevated with 10-20 rings.
5. Their size may vary from 1.5-35.5cm.
6. They feed on crustacean (crabs, lobsters, shrimps)

**Interesting fact:** Male possesses a brood pouch on their abdomen.

In the brood pouch eggs are retained until they hatch as young ones.

Tail is prehensile are used for coiling around the sea weeds.

They are poor swimmers.

Phylum- Chordata

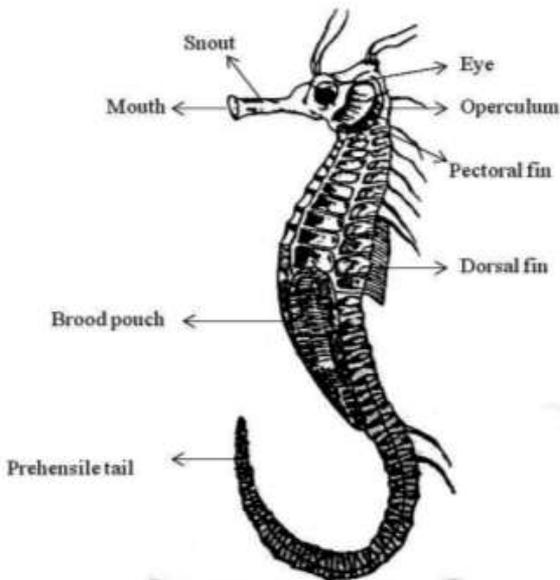
Subphylum-Vertebrata

Superclass- Gnathostomata

Class- Osteichthyes

Order-Syngathiforms

Genus- *Hippocampus* (Sea Horse)



*Hippocampus* (Sea Horse)

## **AIM 11: TO STUDY CHARACTERISTIC FEATURES OF AMPHIBIA**

### **General characteristics**

1. They are amphibious.viz. They live on land as well as in water.
2. Amphibians are cold blooded animals.
3. Skin is moist and without scales. They have large number of mucous glands which keep the skin moist.
4. Respiration takes place via gills, lungs and skin.
5. Three chambered heart is present.
6. Nictitating membrane is present. External ear is present.
7. Amphibian bears two pairs of pentadactyl limbs.
8. They are oviparous.Fertilization is external.

### **1. *Bufo* (True Toad)**

1. It is found all over the world except Australia and Madagascar.
2. Skin is rough, dry and warty on the dorsal surface of the body and possesses parotid and few mucous glands.
3. Body is divisible into head and trunk.
4. Head possess mouth, large eyes, nostril and tympanum.
5. Eyes are large and nostrils are very small.
6. Hind limb possesses digits with four claws and thumb pad.
7. Tympanum is very well developed.
8. Paired parotid glands are present behind the tympanum. These glands secrete poison fluid which is irritating and can cause nausea, respiratory and muscular disturbance.
9. Both forelimbs and hind limbs are shorter in length.
10. Pigmented Eggs are laid in water long with gelatinous string.

Phylum- Chordata

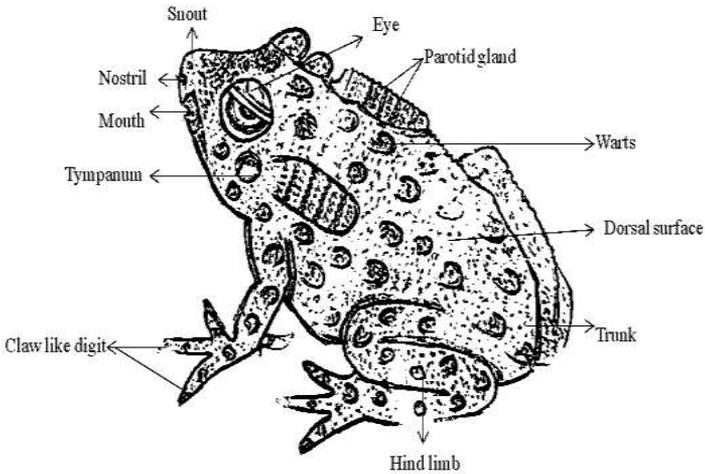
Subphylum-Vertebrata

Super-class-Gnathostomata

Class- Amphibia

Order- Anura

Genus -*Bufo* (True Toad)

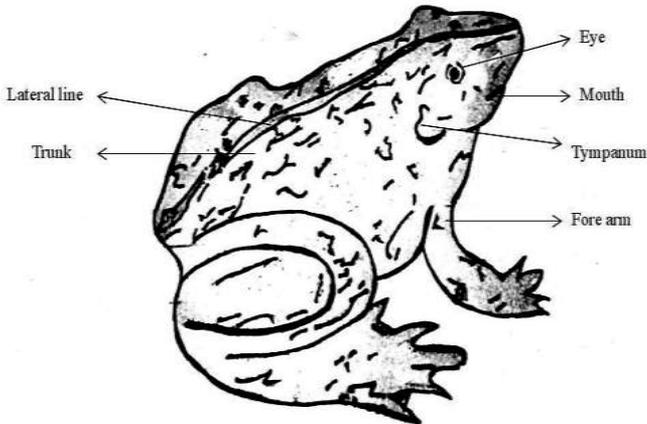


*Bufo*

## 2. *Rana* (Frog)

1. Lives in freshwater, dry land, some are adapted on to live underground or in trees.
2. Skin is glandular, moist and has respiratory and protective function. Head is flat and more or less triangular.
3. Head is flat and more or less triangular. Body is green with black patches. Limbs are pentadactyle
4. External nostrils are on the dorsal surface of the snout, one on each side of the median line. On lower jaw teeth are absent. Large, bifurcated muscular tongue is present.
5. Eyes are large and placed behind the nostrils and provided with eyelids. Tympanum lies behind the eyes. It feeds on small aquatic insects worms, slugs etc.
6. Produce wide variety of vocalization during breeding season to attract mate and to warn off predators.
7. Rasping mouth adapted for herbivorous, omnivorous or planktivorous diet.
8. Adults are carnivorous or omnivorous and without tail.
9. Lays eggs in water. Aquatic larvae are called tadpoles.

Phylum-Chordata  
Sub-phylum-Vertebrata  
Super-Class-Gnathostomata  
Class- Amphibia  
Order- Anura  
Genus- *Rana* (Frog)



*Rana* (Frog)

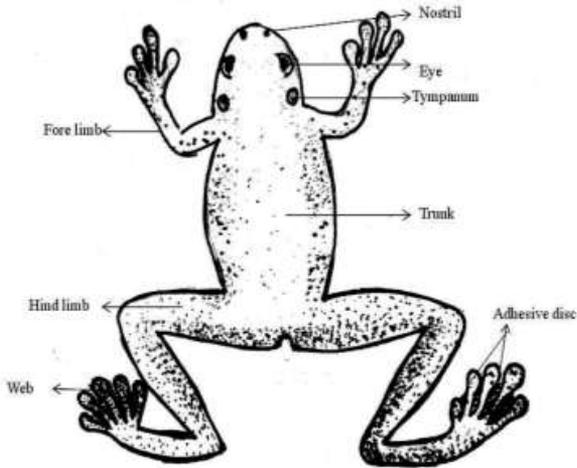
### 3. *Hyla* (Tree frog)

1. It shows arboreal habits.
2. The size of the body varies from 2.5 to 7.5 cm in length.
3. Eyes, nostril and tympanum are well developed.
4. Fingers and toes possess adhesive or discs for sticking on the smooth surface.
5. Mouth bears teeth only on upper jaw but not on lower jaw.
6. They display mimicry.
7. Vocal cords are very well developed and can make powerful sound.
8. Skin is smooth on dorsal surface.

Phylum-Chordata  
Sub-phylum-Vertebrata  
Super-Class-Gnathostomata  
Class- Amphibia

Order-Anura

Genus- *Hyla* (Frog)



*Hyla* ( Tree Frog)

## AIM 12: TO STUDY CHARACTERISTIC FEATURES OF REPTILIA

### General characteristics

1. First terrestrial animals. They are creeping, and burrowing cold blooded vertebrates bearing epidermal or horny scales.
2. Skin is dry and rough and without glands.
3. They respire through lungs.
4. Reptiles bear two pairs of pentadactyl limbs. Each digit ends in claw.
5. Heart is three chambered except four chambers in crocodile ventricles are incomplete.
6. Sexes are separate. Fertilization is internal. Eggs are laid on land

### 1. *Chamaeleon*

1. Skin is covered with minute granules. Body and head are laterally compressed and can be divided into head, neck, truck and tail.
2. Head bears mouth, large eyes, and small nostrils. It is an arboreal reptile.

3. Large eyes with glandular lid meant for binocular vision each eye work independently while catching the prey. Eye can achieve visual field of 180 degrees and together both eyes provide visual field of 360 degrees. Able to detect ultraviolet rays
5. Tongue can be drawn several inches beyond the mouth in order to catch the prey.
6. The tip of the tongue is coated with mucus in order to make it sticky and thereby helps in quick catching of prey. It is Insectivorous
7. Forelimb and hind limb are adapted for holding the branches of tree firmly.
8. Tail is long and prehensile adapted for coiling around branch of tree.

**Interesting fact:**

- It has power of changing color according to the surrounding cells are equipped with pigment used for color change are called chromatophores..
- Males are ornamented with horns, spikes, and nasal protrusions as compared to the females. All these features are used while defending their territory.

Phylum-Chordata

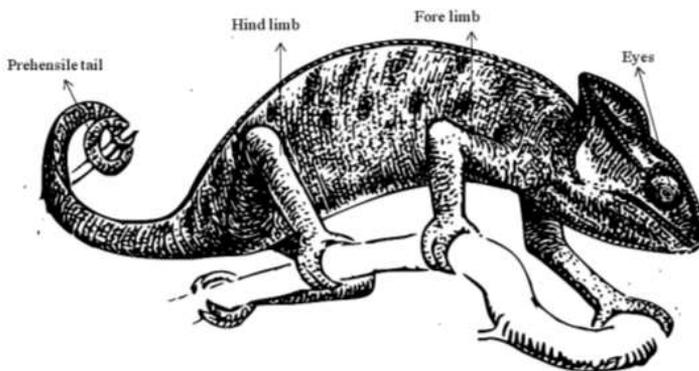
Sub-phylum-Vertebrata

Super-Class-Gnathostomata

Class-Reptilia

Order- Squamata

Genus-*Chamaeleon*



*Chamaeleon*

## 2. *Naja* ( Indian Cobra)

1. Lives in holes, under stones, mud walls,
2. Body is elongated measuring one and a half to two meters in length. It can be divided into head, neck trunk and tail.
3. Head bears mouth eyes and nostril.
4. Mouth possesses poisonous fangs followed by smaller one to three teeth.
5. The color of the body is brown or blackish.
6. Body is covered with smooth oblique scales.
7. Tail is cylindrical and tapering posteriorly.
8. The expansion of the neck and cervical ribs form the hood which contains binocellate, monocellate mark on dorsal surface.
9. Oviparopus.
10. Carnivorous feeding on frog, lizards rats, and other snakes.
11. It is deadly poisonous and its venom is neurotoxic and fatal.

Phylum-Chordata

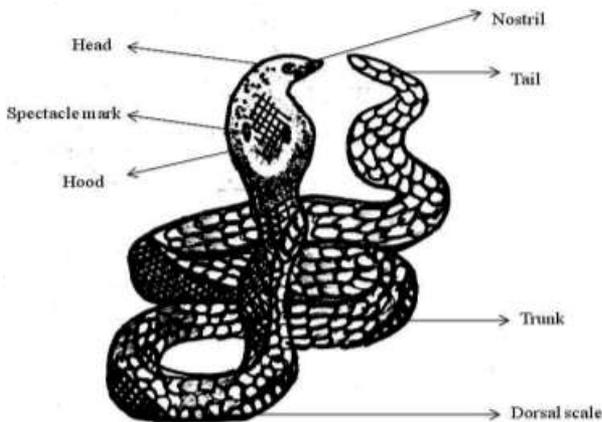
Sub-Phylum-Vertebrata

Super-Class-Gnathostomata

Class-Reptilia

Order- Squamata

Genus- *Naja* (Indian Cobra)



*Naja* (Indian Cobra)

### **AIM 13: TO STUDY CHARACTERISTIC FEATURES OF BIRDS/AVES**

#### **General characteristics**

1. Body is streamlined to reduce air resistance during flight.
2. Warm blooded.
3. Fore limbs are modified into wings which are covered by feathers, each possessing three clawless digits.
4. Hind limbs have four clawed digits which are best suited for walking, swimming.
5. Bones are light in weight and spongy due to presence of air cavities (pneumatic bones)
6. Beak is present and teeth are absent.
7. Four chambered heart with two auricles and two ventricles.
8. They possess well developed lungs which have air sacs attached to them.
9. They produce voice by a special organ known as syrinx instead of larynx. It is present at the base of trachea.
10. Oviparous.
11. Sexes are separate.
12. Fertilization in internal.  
Parental care well developed.

#### **1. *Passer (House Sparrow)***

1. It is distributed worldwide except the Andaman and Nicobar.
2. Body can be divided into head, neck, back, breast and abdomen.
3. In males the upper surface is earthy brown streaked with blackish throat and under parts and whitish abdomen is present.
4. Females are ash white in color. Feathers of tail are elongated.
5. Head bears small eyes and conical short beak.
6. Food consists chiefly of seeds and grain. Foot modified for perching.
7. Folded wings and wing feathers are present all over the body.
8. Four clawed toes in each leg. Three toes in front side and one at back.
9. Nesting is practiced throughout the year.
10. Young ones are without feathers at birth need parental care before becoming independent.

11. They are useful to agriculture by destroying large no of insects.

Phylum-Chordata

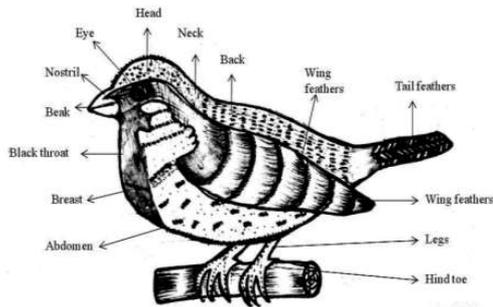
Sub-Phylum-Vertebrata

Super-class-Gnathostomata

Class-Aves

Order- Passeriforms

Genus-*Passer* (House Sparrow)



*Passer* (House Sparrow)

#### AIM 14: TO STUDY CHARACTERISTIC FEATURES OF MAMMALS

##### General characteristics

1. These are warm blooded animals and highly evolved.
2. Possess milk producing mammary glands for the nourishment of young ones.
3. Possess external ear or pinna.
4. Two pairs of limbs are present.
5. Four chambered heart with two auricles and ventricles.
6. Presence of Oil glands (sebaceous glands) and sweat glands are present in the skin.
7. Forelimb and hind limb have five digits.
8. Penis is present in males.
9. They are viviparous i.e. adult female will give rise to young ones

##### 1. *Rattus rattus*

1. It is found throughout the world. It prefers warm and dry climate. Lives in holes and burrows in houses.

2. The body is sander with thick set fine fur mixed with stiff hairs.
3. Body is divisible into four distinct regions head, neck, trunk and tail
4. Head bears sharp eyes, nostril, snout, external ear and moustache.
5. It is usually grayish or brownish in color and tapering anteriorly to a terminal nose.
6. Next to neck is trunk which is the largest part and bears two pairs of limbs) fore limbs and hind limbs. Incisors are used for cutting and absence of canines in mouth.
7. Tail is extended, cylindrical and longer than body. Hair are present on tail and it is covered by vestigial scales. It is also act as a balancing organ.

**Interesting fact**

- They are used for experimental studies, in order to understand genetics, diseases and the effects of drugs and other topics that provide a great benefit for the health and well being of humankind.
- Viviparous act as a carrier of disease like plaque and typhus fever.

Phylum-Chordata

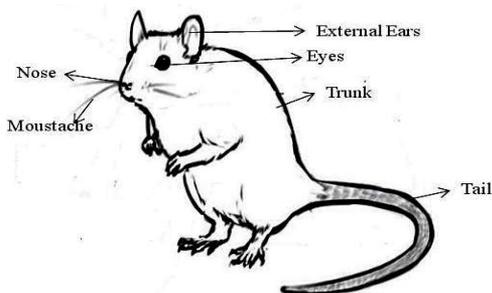
Sub-phylum-Vertebrata

Super-Class-Gnathostomata

Class-Mammalia

Order-Rodentia

Genus- *Rattus rattus*



*Rattus rattus*

**2. *Desmodus* (Bat)**

1. Cosmopolitan in distribution. Nocturnal is habit. Gregarious living in colonies of thousands.

2. Small in size and the body is covered with soft fur. Snout is short. Head bears external ears, large eyes, snout and small teeth. Eyes are small and the vision is weak
3. During resting time they hang themselves in downward position and covers entire body by wings. Only known flying mammals
4. Insectivorous though occasionally frugivorous or sanguivorous (blood sucking)
5. Forelimbs are modified into wings. Hind limbs are with clawed toes.. Small tail
6. Wings are formed by fold of skin or Patagium. Only first and second finger are clawed.

• **Interesting facts**

- Their feces can be used as fertilizer.
- They have well developed sonar system. They produce ultra sonic sound waves from their vocal cords which after striking on the solid objects are reflected back and are picked up by their ears, guiding in their flight.
- Act as reservoir for a large number of pathogen including rabies, Ebola virus.
- Help in pollinating flowers and dispersal of seeds.

Phylum - Chordata

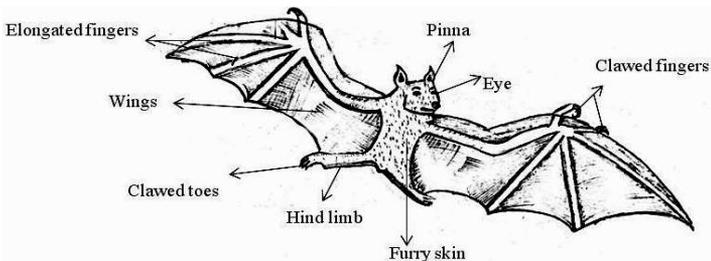
Sub-phylum-Vertebrata

Super-class- Gnathostomata

Class- Mammalia

Order- Chiroptera

Genus- *Desmodus* (Bat)



***Desmodus* (Bat)**

## Unit-2

# ECONOMIC ZOOLOGY

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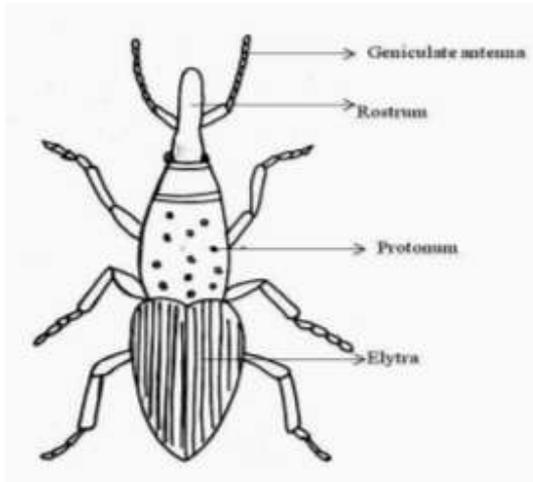
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### AIM 15: TO STUDY STORED GRAIN PESTS

#### 1. *Sitophilus oryzae* (Rice weevil)

1. The rice weevil breeds from August and November and hibernation takes place in winter as an adult inside cracks and crevices and under wheat bags in godowns.
2. The adult rice weevil is cylindrical in shape and about  $1/6^{\text{th}}$  inch in length. It is dark brown or reddish brown in color. It feeds on wheat, corn, macaroni, oats, barley, sorghum,, brick wheat and other grains and grain products
3. An elongated snout extends downwards from the front of head for distance of about  $1/4^{\text{th}}$  length of body. It helps in piercing of grains. It is also known as rostrum.
4. Genuiculate type i.e. elbow shaped antennae are present and 10-12 segmented. The first segment is long and other 10 are smaller.
5. Elytra covers entire body abdomen and is marked with light reddish or yellowish spot. The metathoracic wings are fully developed. They are good known fliers can move from godown to nearby fields.
6. During active season, the females lay eggs on grain by making a hole with help of their mandibles. After an egg has been laid hole is covered with gelatinous secretion. A single female may lay as many as 400 eggs which hatch in 6-7 days time.
7. Males have shorter and broader rostrum as compared to females. Stout mandibular jaws are present. Females are larger as compared to males.

Phylum- Arthropoda  
 Class- Insecta  
 Order- Coleoptera Genus-*Sitophilus*  
 Species- *oryzae* ( Rice weevil)



*Sitophilus oryzae* ( Rice weevil )

## 2. *Trogoderma granarium* (Khapra Beetle)

1. It is active from April to October. Its color is blackish brown and is 1/10 inch long.
2. It has a rounded rostrum, which is insignificant, has reduced compound eyes. Mouth parts are biting and chewing type which is highly reduced. Antennae have 10-11 segments and are clubbed shape which, fit into groove in the side of pronotum. Head is concealed.
3. Pronotum is well developed with reddish marking have a shape of dome. Mesothorax is fused. Males are darker than female. Adults are covered with hair. Legs are short and robust. Tarsus has four joints
4. Two pair of Hind wings which are membranous, delicate folded underneath the forewing known as elytra. Elytra covers the whole abdomen and is quite solid.
5. Abdomen has ten segments, without any appendages and covered by elytra which is tough and forewing. Female is larger than male

6. Life span is 2-3 yrs. Adults does not feed. Entire body of adult is covered with fine hairs.

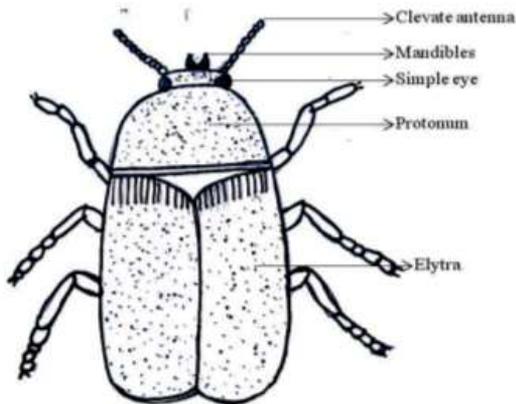
Phylum- Arthropoda

Class- Insecta

Order- Coleoptera

Genus-*Trogoderma*

Species- *granarium* (Khapra Beetle)



*Trogoderma granarium* (Khapra Beetle)

### 3. *Callosobruchus chinensis* (Cowpea weevil)

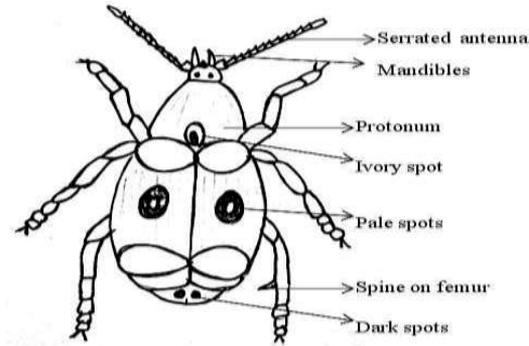
1. The adult comes out of grain by making a small hole in grain.
2. The females are larger in size as compared to males measuring 3-4 mm in length and 2-3 mm in width. The average life span of adult is 5-20 days.
3. The insect undergoes 7-8 overlapping generation in a year. Along with temperature, the nature of grain has effect on duration of its life cycle.
4. On *Cajanus cajan* the life cycle occupies a maximum of 43 days in January and February and a minimum of 25 days in March and April.
5. Antennae are serrated in female and pectinate in males, reduced mouthparts, and presence of ivory spot.
6. Elytra does not cover abdomen completely dark patches present on elytra. 10 The adult are capable of flight and can disperse to other field.

7. The abdomen of female is slightly longer than the elytra and it is whitish in color have grey and black patches.

Phylum- Arthropoda

Class- Insecta Order- Coleoptera Genus- *callosobruchus*

Species -*chinensis* (Cowpea weevil)



*Callosobruchus chinensis* (Cowpea weevil)

## AIM 16: TO STUDY APICULTURE

### *Apis* ( Honeybee )

Bees are gregarious and diversified insects living in colonies in honey comb. There are different castes in colony, workers, drones, and queen

### Apiculture

It is a scientific method of rearing honeybee to produce honey called apiculture. Basic principle involves use of artificial hive which provide facilities for building combs by the bees in controlled manner where they can produce maximum quantity of honey.

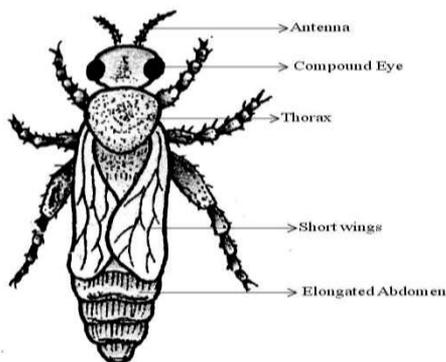
Apiary- the person who looks after the bees in his group of hives is called apiary or beekeeper.

### 1. Characteristic features of queen, workers and drones

#### Queen

1. The queen is the only fertile female member in a bee hive, quite larger in size

2. The queen is longer, 15-20mm long and easily distinguished by her long, tapering abdomen, short legs and wings are present.
3. Mouthparts are shorter, a sting is present to fight with rival queen but it has no barbs.
4. The queen comes from a fertilized egg; the larva is fed basically on royal jelly. It performs the function of laying eggs.
5. It is not able to produce wax or honey or perform any job like nest construction, collection of pollen or nectar other than laying eggs.



**Queen**

### **Worker**

1. The worker bee is the smallest sized member of colony and makes up the largest no. of population in colony.
2. It is blackish or brownish in color with body densely covered with hair.
3. The worker performs all the jobs of the colony. It feeds the young larvae and taking after them, it makes the hives and builds and repairs the combs & it collects pollen and nectar to convert it into honey.
4. The body is distinguished into 3 parts head, thorax and abdomen.
5. The head is wide and triangular. It has a pair of compound eyes, three ocelli, a pair of short, antennae has 12 joints and mouth parts are chewing and lapping type.
6. The thorax is divided into 3 parts prothorax, mesothorax & metathorax. Each of these has a pair of legs & wings which are

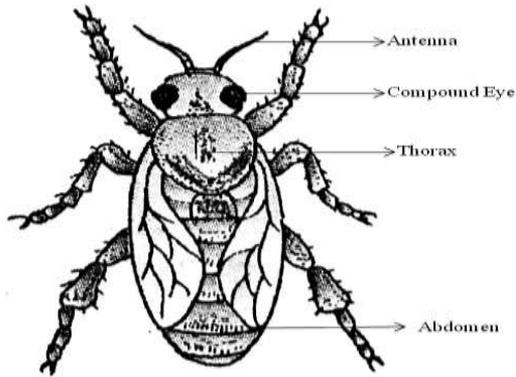
present on the mesothorax and metathorax. The wings are tiny, narrow, membranous and transparent. The hind wings possess on each side a row of minute hooks known as hamuli.

7. The abdomen has six segments & bears the wax glands on ventral side & the sting which is the modified ovipositor. A pollen basket is present on her hind leg.

Phylum- Arthropoda

Class- Insecta Order- Hymenoptera

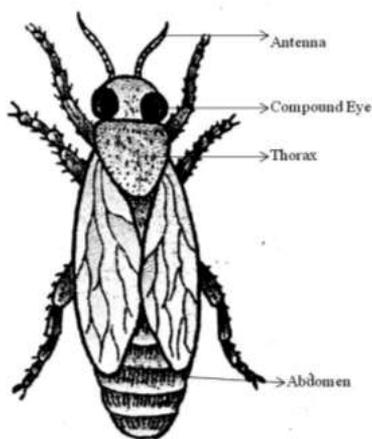
Genus- *Apis*



**Worker**

### **Drones**

1. These are the male bees of colony.
2. There are about 100 drones are present in a colony.
3. They are mid in size but larger than workers, about 15-17mm long but noticeably stouter and broader.
4. They have very large eyes which meet in the center (holoptic) and cover most of the surface of head and small pointed mandibles are present.
5. Wax producing glands, pollen collecting apparatus and sting are not present.
6. They develop from unfertilized eggs and perform the function of mating and fertilizing the queen.

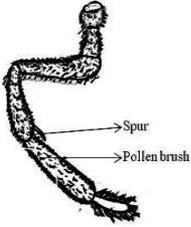
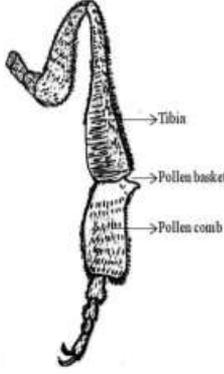


**Drones**

## 2. Legs of honey bee

There are three pairs of legs which are heavily covered with hair, which along with walking it carries out collection of pollen and are variously adapted. Each leg consists of five parts i, e., coxa, trochanter, femur, tibia, tarsus (five jointed) terminating in a pair of claws and pulvillus.

<p><b>Prothoracic leg</b></p>		<p>Each prothoracic leg consists of row of stiff bristles or hair on tibia forming an eye brush for wiping the compound eyes. Tarsus bears a semicircular notch called antennal notch or antennal comb at the distal end. This comb along with tibial velum forms the antenna cleaner that performs the cleaning of antenna drawn in between them. Long bristles on the tarsus form a pollen brush for detaching pollen from the front part of the body.</p>
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<p><b>Mesothoracic leg</b></p>	 <p>The diagram shows a mesothoracic leg with two main features labeled: a 'Spur' at the distal end and a 'Pollen brush' on the tibia.</p>	<p>It is the mid leg bearing same segments. Each mesothoracic leg bears a pollen brush on the tarsus, the end of the tibia has a spur like a spine for separating pollen from pollen basket.</p>
<p><b>Metathoracic leg</b></p>	 <p>The diagram shows a metathoracic leg with three main features labeled: the 'Tibia' (the large upper part), the 'Pollen basket' (a pocket on the tibia), and the 'Pollen comb' (a structure at the distal end of the tibia).</p>	<p>Each metathoracic or hind leg has a large tibia with a pocket in the outer surface with rows of curled bristles forming pollen basket or corbicula used for keeping pollen during collection. At the distal end, tibia bears a row stiff bristles known as pecten below which is a flat plate, known as the auricle. The auricle and pecten constitutes a wax pincher for separating wax from the abdomen of workers. The outer surface of the tarsus has a pollen combs or bristles possessing rows of stiff spines. The pollen combs separate pollen from the body and fill it in pollen basket.</p>

**3. Artificial beehive**

Langstroth is the most popular hive in the USA and world national is the popular in UK.

The basic components of artificial bee hive are following:

**Stand**

Stand is strong, firm and with four legs about 6 to 9” inches high. The main function is to avoid contact between ground and beehive and check dampness.

### **Floor or bottom board**

It forms the base of the hive and has an entrance 3 inches long.

### **Brood chamber**

It is rectangular box with no floor or top. It is the main house of bee colony. It possesses number of frames and each frame has four sided wooden support for wax comb foundations. These foundations are composed of pure bee wax. It is mostly wired to give it structural support.

### **Queen excluder**

It is composed of metal rods fitted close to each other in a wooden frame. The main function of this part is to keep queen and drone down in brood box and only workers can enter through these rods and fill the super with honey.

### **Super**

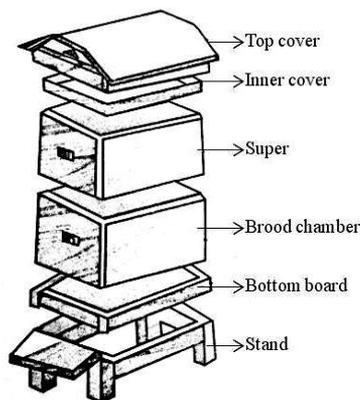
It is another rectangular box with frames. But frames are superficial and extra space for expansion is available.

### **Crown board**

The main role of this board is to absorb moisture and condensation does not occur. Bees can't be seen in this box.

### **Roof or top cover**

It keeps the rain water off and provides some space for ventilation of the hive. It is made up of thicker wooden board covered with a zinc sheet.



**Artificial beehive**

## AIM 17: TO STUDY SERICULTURE

### Life cycle of Silk moth

#### Adult

1. It is paler and creamish in color having a plump and body is robust which is covered by hair with reduced mouth-parts and pectinate antennae.
2. There are 3 pairs of legs which are hairy and 2 pairs of medium sized folded wings having faint and dark stripes on their surface. In resting position wings lie in horizontal position.
3. Females are much larger in size as compared to males.
4. The main target is to produce its own species.
5. It has short life, lives only for 7-8 days during this time it takes no food its main target is to continue its own species.
6. Female lay around 400-450 eggs on the leaves of mulberry plant during its life span.
7. A small larva comes from each egg within 4-5 days depending upon climatic conditions and food material available.

#### Egg

1. Minute, sub spherical white eggs laid by female on leaves of mulberry.
2. The weight of the newly laid 2000 eggs is about 1 gm.
3. With increase in time after laying, eggs become darker in color.
4. Two types of eggs are found **Diapause** type (hibernating) which undergo diapauses and hatch out only in next spring and **non-diapause** (non- hibernating eggs) type they do not undergo diapauses within a a year.

#### Larva

1. Each newly hatched caterpillar larva is 2 mm in size and the full grown is 7.5 cm long and become darker in color.
2. Head has a pair of short antennae and two small black eye spot on each side of head.
3. The labium bears a pair of opening of silk gland.
4. 3 segments immediately behind the head are slightly crumpled and swollen. These constitute the thoracic segments.
5. 3 Pairs of hook-like true legs, one pair on each segment are present on the underneath of thorax.

6. The abdomen is segmented.
7. Ventrally 5 pairs of pseudo-legs are present on the abdominal segments.
8. 9 pairs of spiracles are present, 1 pair on the thorax and 8 pairs on either side of first eight abdominal segments.
9. The larval period is 42 days and there are 5 larval instars and it moults 4 times.
10. During the 5<sup>th</sup> instar stage, the caterpillar eats voraciously on mulberry silk and grows very rapidly. After this, the larva spins a silken cocoon around its body.
11. The little caterpillar larva instantly after hatching from egg begins to feed on mulberry leaves and grows rapidly.
12. The larval period is 42 days and during duration there are 5<sup>th</sup> instar and 4 moulting. During the 5<sup>th</sup> or last stage, the caterpillar has a length of 4-5 cm or more.
13. After a week, color of larvae changes to yellow. The larva is now prepared extrusion of silk from silk glands which open in the labium.

### **Pupa**

1. The full-grown larva becomes restless, and tries to find a dried and bushy area as it finds such place it starts to spin its cocoon around itself.
2. The cocoon is formed from secretion of silk glands.
3. The temperature and humidity affect the speed of spinning and quality of silk.

### **Cocoon**

1. From the labial glands or silk glands, the larva secretes a silken case around itself.
2. Secreted fluid comes out through spinneret (a narrow aperture present on the hypopharynx) and takes the form of long fine thread of silk which hardens on exposure to the air and enfold around the body of the caterpillar in the form of a covering called as Cocoon.
3. It takes around 3 days to spin silken cocoon by the caterpillar.
4. Each cocoon is composed of several layers of silk deposition.
5. After a week or 10 days, the adult moth comes out of the cocoon by making a small hole.

6. Single caterpillar give 1000 to 13000 m of continuous silk without any break. If is discontinuous than it is of no use.

Within a cocoon pupa reduces in length but expands in width specially in the middle of the body. Its proleg is shrinked up and 3 legs are curled inwards, and change into adult.

### Types of species of silk moth

Best quality of silk is mulberry silk is produced from *Bombyx mori* which is a small creamish-white moth. In India, *B. mori* is cultivated by human in Karnataka where the temperature ranges from 16-31°C, throughout the year, whereas in West Bengal, the multivoltine silk-worm raising is exercised even under harsh conditions of temperature. In Jammu and Kashmir, the rearing of silk-worms is carried out once a year (**Univoltine**) during May-June.

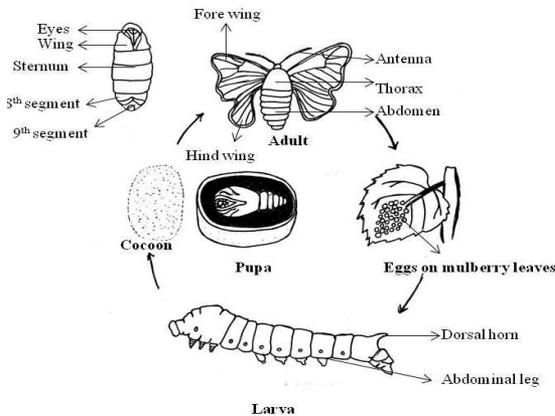
Short description of main species of silk-worms found in India is as follows.

The worms are generally reared in cold climatic conditions.

Those worms whose two generations grows in a year are known as **Bivoltine**.

Similarly, worms producing more than 2 generations in a year are known as **Multivoltine**.

Multi and Bivoltine silk-worms are reared in tropical reasons. Multivoltine species develops in 5-6 weeks. Though, the life-time can be increased by increase or decrease in temperature.



**Life cycle of Silk moth**

**AIM 18: TO STUDY VERMICOMPOSTING AND ITS APPLICATIONS**

Vermicompost can be also defined as organic matter of plant or animal origin consisting of earthworm casting, material due to interactions between microorganism, earthworm as the material passes through the gut of earthworm

Vermiculture is a process of artificial rearing or culturing of worms (earthworms) and the technology is the scientific process by using them to obtain a sustainable harvest for betterment of human beings. Earthworms feed upon a heterogeneous mixture containing cow dung or farm-yard manures along with the other worms of the wastes and pass it through their body and in the process change it into a “vermicompost” which is rich in nitrogen and other minerals.

**Steps of making vermicompost pit**

1. To start with, we need 5 basic ingredients i, e., a container, bedding, water, worms and farm waste. The container depth or pit depth should be 0.9 to 1.5 m width and 0.25 to 0.3 m height and it should not be very deep because the worms eat in top layers of the bedding.
2. The bedding for vermicomposting should be able to retain both moisture and air so that worms can survive they respire through their skin if surface is wet and moist, they can live for long. For moistening of bedding dechlorinated water is better.
3. Some suitable sources of bedding are: cardboard pieces, shredded newspaper (paper), hay moss horse manure, leaves, saw dust.
4. The water is required to moisten the bedding. Water is allowed to be absorbed by the bedding as much as possible before placing it in the container. Add some soil to the bedding as it will add microorganisms.
5. The worms which are commonly used in vermicomposting are called as red worms or *Eisenia foetida*, manure worms or red wigglers on scattering immediately move down as the worms' skin is easily affected by sun light. The kitchen waste including fruits, vegetables, is fed to the worms.
6. They don't break the material vigorously. They should be released on upper layers of bedding. About 1kg of worms are introduced.
7. Bed of material should be turns once after 30 days for proper aerobic condition and decomposition of organic matter.

- ◆
8. In around 40 days, about 60 cm of the bed is converted into vermicompost and is collected.

### **Advantages of vermicomposting**

1. It is rich in all plant essential nutrients like nitrates, potassium, calcium, Magnesium etc.
2. Helps in excellent plant growth. It promotes the growth of new shoots leaves and enhances the quality and shelf life.
3. It is free flowing easy to handle and store.
4. It enhances the soil texture, aeration, waterholding capacity and prevent soil erosion.
5. It is devoid of harmful chemicals pathogens and toxic elements, weed seeds.
6. It promotes the decomposition of organic matter in soil.
7. It consists of various vitamins and nutrients and plant hormones.
8. It reduces the incidence of pest and diseases.
9. It is a process of breaking down of organic matter through the use of earthworms, bacteria and fungi.
10. The end product is a vermicomposting is a vermicompost or worm castings. It is nutrient rich material that can be added to soil to increase its efficiency.

### **Disadvantages of Vermicomposting**

1. Worms apparently do not breed in organic waste and will move away from the food to breed.
2. Requires time to stabilize the pH (acidity).
3. Optimum temperature has to be maintained.
4. Worms need care, food, heat and moisture.
5. Odor due to anaerobic environment.
6. All species are not suitable for making vermicompost.
7. Earthworm feed on a suitable diet including fruits, vegetables, bread etc, and face problem in digesting dairy products and meat etc.

### **Types of vermicomposting**

The types are based upon the amount of production and structure of compost

**Small scale composting:** it is done for meeting personal needs and farmer can harvest 5-10 tonnes of vermicompost each year. Usually, kitchen and garden waste is used.

**Large scale vermicomposting:** is done at a commercial level by recycling large amount of organic waste with the production of about 50-100 tones each year.

### Methods of vermicomposting

**Bed method-** In this method composting is done by making a bed (6x2x2 feet size) of organic mixture on the pucca/kachcha floor.

**Pit method** –in this method pits (5x5x3feet) are created. This pit is covered by grass, thatch, leaves etc.

It has more disadvantages as cost of production is high, chances of water logging at bottom, and aeration is poor.

### Best species

*Eisenia foetida* (Red earthworm), *Eudrilus eugeniae* (night crawler), *Perionyx excavatus* etc

### Why worms are used?

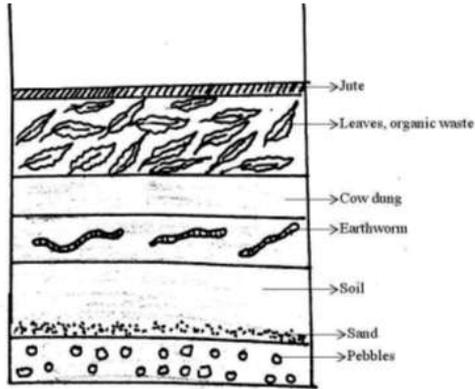
**Manure worms (red worms)** and earth worms all have a long, rounded body with a pointed anterior end and posterior end is less pointed. The body is moist and soft, bears rings or annuli. The rings help the worm to twist, turn, and move through the ground. This is required as the worm does not have a backbone or legs.

The body does have setae or bristles along it to assist the worm move back and forth, or scrawl', through the ground. Worm respiration is cutaneous or through skin, absorbing oxygen and releasing car-bon dioxide into the atmosphere.

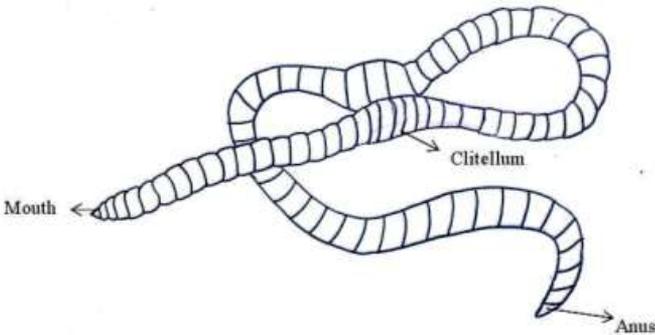
Food is taken in through the mouth and passes to pharynx where it is lubricated by mucus after this it reaches oesophagus and then reaches crop where it stores temporarily and finally reaches the gizzard.

Earthworm do not possess teeth but the in-gizzard muscles of gizzard assist in churning of food as well enzymes secreted by walls of gizzard contributes in further breakdown of material with the help of ingested stones and further grinding takes place.

The material then passes through the intestine where it releases fluids to aid digestion and have blood vessels where digested food is absorbed, and the rest is excreted through anus.



Vermipit



Earthworm

**AIM 19: TO STUDY PEDIGREE ANALYSIS FOR AUTOSOMAL TRAITS AND SEX-LINKED TRAITS**

- Family information is presented orderly by pedigree chart
- First step involves study of inheritance of characters
- This chart is significant in predicting genetic risk

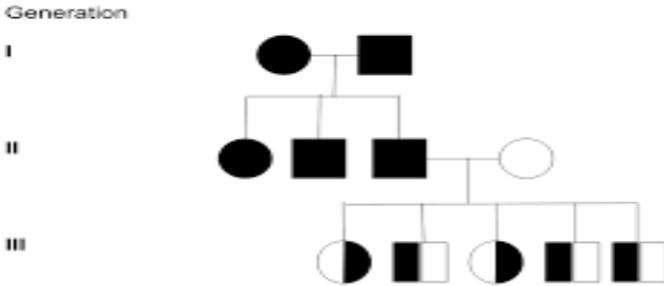
Autosomal Recessive Trait- example Sickle Cell Anemia

- If both the parents are affected, the offspring are also affected
- the Expression is equal in males and females

The below given pedigree chart is of the autosomal recessive disease- sickle cell anemia

**Comments**

1. Sickle cell anemia is autosomal recessive trait. If both the parents are carriers, this can be transmitted to offspring. If both the parents are affected the offspring will be affected.
2. HbS HbS genotype causes sickle cell anemia, individuals with HbA and HbS genotype are carrier but apparently appear unaffected.
3. Sickle cell anemia is a classic case of point mutation, which is caused by the substitution of Glutamine by valine at the sixth position of the beta chain of the hemoglobin molecules.



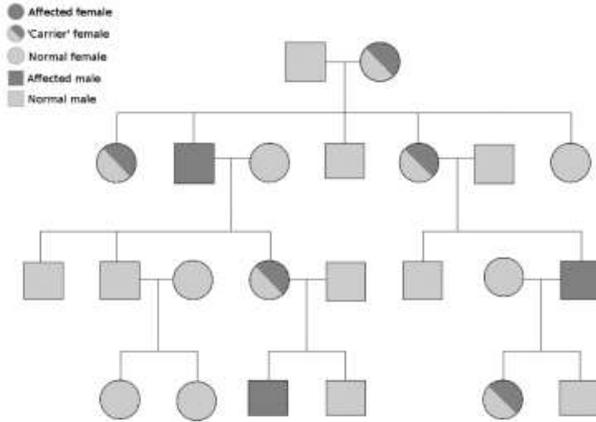
**Autosomal Recessive Pedigree [1]**

X – Linked Disease - Example Haemophilia (Bleeder’s Disease)  
The given pedigree chart is of Haemophilia, X linked disease.

**Comments**

1. Haemophilia or bleeder’s disease (Royal disease) is the most tarnished of all sex-linked diseases. The person suffering from this disease bleeds for a long period (30 minutes to 24 hours) during injury due to the failure of blood coagulation.
2. It is caused by a recessive X – linked gene more common in men than women.

3. The females are carriers of the disease and would transmit the disease to 50% of their sons even if the male parent is normal.
4. It follows criss – cross or zig – zag pattern of inheritance (i.e., grandfather transmits his X linked character to his grandson through carrier daughter).



**Sex Linked Inheritance [2]**

## Unit-3

# TEMPORARY MOUNTS

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### **AIM 20: TO PREPARE A TEMPORARY MOUNT OF HUMAN CHEEK EPITHELIAL CELLS FROM BUCCAL SMEAR, AND TO STUDY ITS CHARACTERISTICS.**

#### **Theory**

The body of all organism including humans is composed of cells. In animal cells cell wall is absent. The outermost covering of an animal cell is known as plasma or cell membrane. The cytoplasm, nucleus and other cell organelles are enclosed within it. Epithelial tissue is the outermost covering of most organs and cavities present in an animal body.

#### **Material required**

Methylene blue stain, a compound microscope, slide, cover slip, a clean spatula or a toothpick, a brush, a needle, and a piece of blotting paper

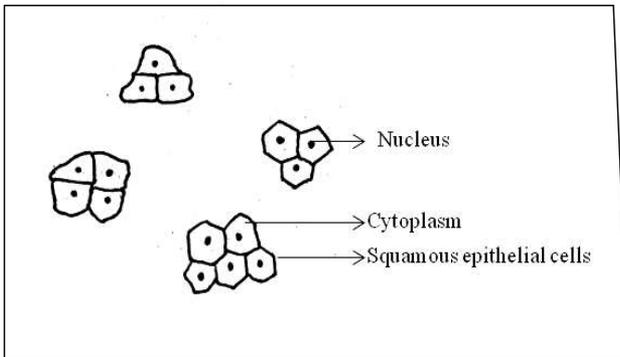
#### **Procedure**

1. Rinse your mouth with fresh water.
2. With the help of a clean spatula or a toothpick, gently scrap the inner side of your cheek.
3. Transfer the scrapped material into a drop of water taken on a clean slide
4. With the help of a needle spread the material uniformly
5. Add a drop of methylene blue stain. Leave it for 2- 3 minutes
6. Place a clean cover slip over it. Remove the excess stain from the edges of cover slip with the help of a piece of blotting paper.

7. Examine the slide under microscope, first under low power and then under high power.
8. Draw diagrams of cells as seen under the microscope. Observe and record the following features

**Observations**

Observation	Present	Absent
Nucleus		
Cytoplasm		
Plasma membrane		
Cell wall		



**Microscopic view of cheek cells under 10X**

**Results and Discussion**

Epithelial cells are small, thin, and polygonal in shape with prominent nucleus and compactly arranged to form a continuous layer. The cells are without cell wall. Cell membrane encloses a distinct nucleus and a vacuole. Epithelial tissue forms the outermost covering of almost all the organs and various cavities present in animals and human body. These are squamous epithelial cells.

**Precautions**

1. Cheeks should be scrapped gently and carefully to prevent injury.

2. Spread the material on the slide so that it forms a thin uniform layer
3. Avoid over staining or under staining) of the material.
4. While mounting the cover slip, avoid entry of air bubbles.
5. Use clean spatula or tooth pick.
6. Always use the blunt end of toothpick.

### **AIM 21: TO PREPARE A TEMPORARY STAINED MOUNT OF NERVE FIBERS AND NERVE CELLS FROM THE SPINAL CORD OF GOAT.**

#### **Material required**

Spinal cord of frog or goat, slide, cover slip, petridish, forceps, scissors, needle, brush, methylene blue, glycerine, etc.

#### **Procedure**

1. Take a small piece of tissue from the centre of spinal cord and tease it on a slide with the help of needles. Now keep rest of it in saline water (0.9%) in a petridish.
2. Add few drops of methylene blue to stain.
3. After staining the tissue again tease it with needles so that nerve cells and nerve fibers are well separated.
4. Remove the excess of water and stain with the help of blotting paper, if any surrounding the tissue. Now put the coverslip. Now do the tapping with the blunt object in order to spread the tissue properly on slide.
5. Examine the slide under the microscope first under 10 X.

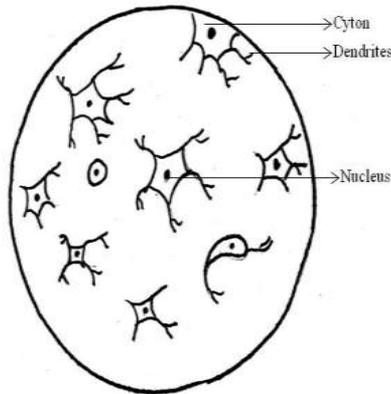
#### **Observations**

1. A nerve cell or a neuron has a large cell body known as **cyton or soma** with a peculiar nucleus.
2. A cyton or cell body comprising of cytoplasmic projections called dendrites, nucleus and other cell organelles. One of the projections is longest and is known as **axon**.
3. A group of axons combined together by a connective tissue is known as nerve.
4. When a myelin sheath is present over the axons known as myelinated nerve fiber. A membrane known as neurilemma surrounds the myelin sheath. At the node of Ranvier myelin sheath is not present.

**Unipolar neuron** is a type of neuron in which consists of only one protoplasmic process extends from the cell body.

**Bipolar neurons** that have two main extensions of similar lengths extending from main body.

**Multipolar neuron** is a type of neuron that possesses a single (usually long) axon and many dendrites.



**Microscopic view of nerve cells**

### Precautions

1. Avoid overstraining and under staining of slide.
2. Teasing of nerve fibers should be done properly with the help of needles.
3. Remove extra stain with the help of filter paper.
4. Tapping of material should be done with the blunt object.
5. Always clean the slide with filter paper and keep cover slip gently over the material to avoid entry of bubbles.

### AIM 22: TO MAKE A SLIDE OF PERIPHERAL BLOOD SMEAR AND STUDY VARIOUS TYPES OF HUMAN BLOOD CELLS

Human blood consists of the following types of cells:

1. **Red blood cells (RBC) or Erythrocytes** are circular biconcave enucleated disc like structures. They do not possess other cytoplasmic organelles like ribosome, endoplasmic reticulum, mitochondria. The

cells contain an red colored iron pigment known as hemoglobin which carry oxygen and collects carbon dioxide. Total number of RBC is approx. 5-6 millions/ml of blood in males and 4-5 millions/ml of blood in females. Average life span of a RBC is about 120 days. It also has antigens on its surface.

2. **White blood cells (WBC) or leucocytes** are larger in size as compared to RBC and are with a nucleus. They do not contain any pigment like hemoglobin but granules are present in cytoplasm of cells. Total number of WBC is approx. 5000-9000/ml of blood. Its life span is 3-4 days. They are mainly of two types:

(i) Granulocytes

(ii) Agranulocytes

(i) **Granulocytes**- possess granules in their cytoplasm. They contain multilobed nuclei. They constitute 70 % of the total leucocytes. They are of the following three types:

(a) **Basophils** - the nucleus is bilobed. The cytoplasmic granules are large. They release histamine and heparin (anticoagulant).

(b) **Acidophils or Eosinophils** - the nucleus is multi lobed. The granules are also stained using acidic dye as they are acid loving cells. It helps in killing parasitic worms.

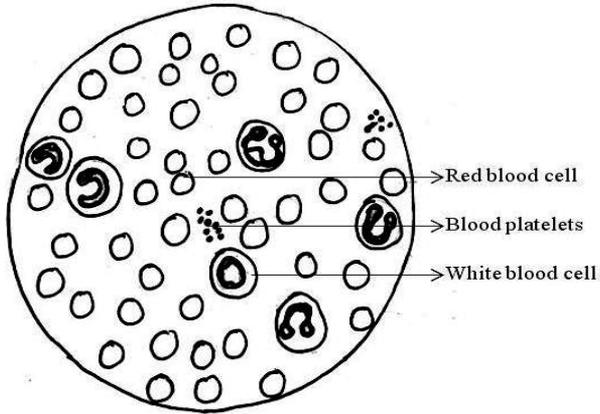
(c) **Neutrophils**- these are multilobed. Significant cytoplasmic granules are present.

(ii) **Agranulocytes** have clear cytoplasm and do not have granules. They have single spherical nucleus. They are 30% of the total leucocytes. They are of the following two types:

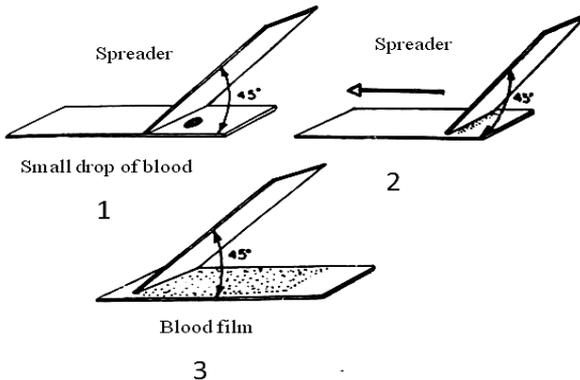
(a) **Lymphocytes** have a large spherical and prominent nucleus that covers the most of the cytoplasm. It is stained dark purple in color.

(b) **Monocytes** are large mononuclear cell and have a kidney shaped nucleus. It is also stained dark purple in color.

3. **Blood platelets** are small irregular-shaped non nucleated bodies. They appear as violet granules under the microscope. Their number is about 250,000/ml to 300,000/ml of blood. They help in the clotting of blood.



Microscopic view of blood cells under 40X



Steps for making blood peripheral blood smear

### Precautions

1. Clean and dry slides should be used.
2. Blood film should be drawn immediately after the blood is taken out of from the finger otherwise blood will clot.
3. The edge of the slide should be smooth with which the blood film is to be drawn, otherwise smear will not be smooth.

4. Always sterilize the finger and needle with spirit or alcohol before and after taking out the blood from finger.
5. The slide should be kept on some hard and uniform surface or on the table while drawing the blood smear.
6. A very large drop of blood should not be taken to draw the blood smear.

### **AIM 23: TO DETERMINE THE BLOOD GROUPS OF THE GIVEN BLOOD SAMPLES**

#### **Requirements**

Disposable needles, cotton, alcohol, antisera A, B and D, slide, toothpicks.

#### **Theory**

The ABO blood group system was given by Karl Landsteiner. In humans, four kinds of blood groups under the ABO system are:

1. A (A antigen, B Antibody)
2. B (B antigen, A Antibody)
3. AB (both A and B agglutinin present)
4. O (none present).

An **antibody** (Ab), also known as an **immunoglobulin** (Ig), is a large, Y-shaped protein molecule produced mainly by plasma cells that is used by the immune system to detect and destroy pathogens such as bacteria, protozoa and viruses.

There are five different classes of antibodies IgG, IgA, IgD, IgE, IgM,

**Antigen**- an **antigen** is any substance that stimulates an immune system to produce antibodies against it.

These are also proteins or large polysaccharides having a large molecular weight.

There are two main agglutinogens- A and B and there are two complementary agglutinin  $\alpha$  and  $\beta$

There are four types of blood groups A, B, AB, O in accordance with the nature of agglutinogens found on the surface of RBCs as suggested by Landsteiner.

Agglutinogens a and b are polysaccharide. A is N-acetyl  $\beta$  galactosamine and B is a  $\alpha$ -D galactose.

Another important agglutinin- Rh antigen known as D is demonstrated on human red corpuscles, discovered by Landsteiner and Weimer in Rhesus monkey in 1940.

Persons of blood group AB+ have no circulating agglutinin and can therefore, be given blood of any type without developing a transfusion reaction and are called **universal recipients**

Persons having blood group O- contain no agglutinin and can give blood to anyone because their RBC 's are not agglutinated by the recipient 's group and are called **universal donors**.

**Erythroblaois foetalis** also referred to as Hemolytic disease of new born (Hdn)

If mother is RH negative and foetus is RH positive, serious complications may occur RBC; containing "d" antigen may pass the placenta from the foetus to the mother, either during pregnancy or small amount of foetal blood leaks into maternal circulation at the time of delivery. The mother responds by forming anti D which returns to foetal circulation and tends to destroy foetal RBCs. The changes in the foetus are termed Hemolytic disease because they are due to the destruction of RBCs by maternal Anti D.

Rh hemolytic disease can be prevented by administering a single dose of anti- Rh antibodies in the form of Rh- immune globulins soon after the childbirth, which will prevent active antibodies formation by the mother.

S. No.	Blood type	Antigen on RBC	Antibody in serum	Can donate blood to	Can receive blood from
1	A	A	Anti-B	A, AB	A, O
2	B	B	Anti- A	B, AB	B, O
3	AB	A,B	NONE	AB	A, B, AB,O
4	O	NONE	Anti A and Anti-,B	A, B, AB, O	O

### Procedure

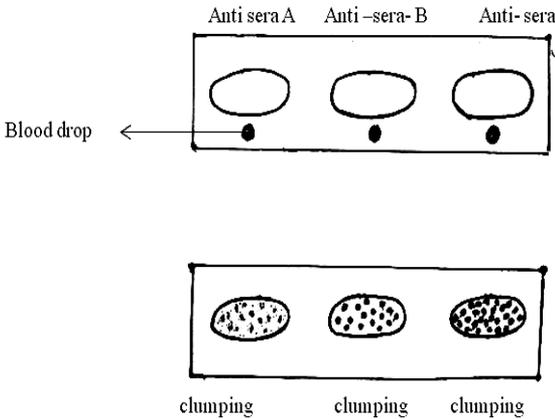
1. A clean glass slide was taken and anti A, anti B and anti D regions were marked on it.
2. One drop of each anti A, anti B and Anti D sera was put on their respective marked regions.

3. The tip of the middle finger was cleaned with alcohol and was pricked with a sterile disposable needle.
4. A drop of blood was placed in each region of the slide.
5. The blood was mixed properly (using toothpicks) with the anti-sera.
6. The slide was carefully observed for agglutination reaction.

**Observation**

Agglutination was observed in all the three with anti A sera and anti B sera and anti D sera.

S. No	Name of student	Agglutination with ANTI-A	Agglutination with ANTI-B	Agglutination with ANTI-D	Blood group



**Agglutination was observed in all the three blood drops after mixing with ant-iseras**

For e.g. Percentage of A+ Blood Group =  $\frac{6}{20} \times 100 =$   
 Percentage of B+ Blood Group =  $\frac{12}{20} \times 100 =$   
 Percentage of 0+ Blood Group =  $\frac{4}{20} \times 100 =$   
 Percentage of AB+ Blood Group =  $\frac{3}{20} \times 100 =$   
 Percentage of A- Blood Group =  $\frac{1}{20} \times 100 =$

## Result

The blood group was found to be AB.

## AIM 24: TO STUDY MEIOSIS IN GRASSHOPPER TESTIS

### Theory

The process of meiosis takes place in reproductive tissues. The chromosome number becomes half, and the diploid ( $2n$ ) cells undergo division to form haploid ( $n$ ) cells.

### Procedure

In animals, the stages of meiosis can be studied in grasshopper testis. The procedure is as follows:

1. Acquire testis of grasshopper fixed in ethanol: acetic acid (v/v) in the ratio of 3:1, beforehand as well as stored in alcohol (70%)
2. Wash grasshopper testis under water.
3. Tease the testis with dissection needle to release the lobules
4. Take stain acetocarmine (1%) on watch glass and transfer the tubules on it. Keep in stain for 10-15 minutes.
5. Pick 1-2 lobule and transfer on to a clean slide. Place one drop of acetic acid (45%) over lobule and cover with coverslip. Using filter paper clean the excessive acetic acid.
6. Take two filter paper sheets and place the slide between them. Use the thumb to apply pressure or use the flat end of pencil to gently tap the slide.
7. The pressure causes cells and chromosomes to spread. Seal coverslip edges using nail enamel.
8. Observe slide under compound microscope.

### Observations

The different stages of meiosis are observed along on the basis of the following features.

Meiosis I  
Prophase I

Condensation of chromosome and their movement towards centre of cell. There are 5 sub stages

- Leptotene – Replication of homologous chromosomes.

- Zygotene: Homologous chromosomes start pairing; the process is known as synapsis. The pairing of chromosomes start at many points and these chromosomes are known as bivalents. The synaptic chromosomes are cemented by synaptonemal complex that facilitates crossing over.
- Pachytene: The chromatin threads coil and condense and thus become short and thick. Each bivalent has four chromatids, configuration is known as tetrad.
- Diplotene: Synaptonemal complex disassembles and chiasmata appear which is the representation of site of exchange of the parts between two homologous chromosomes
- Diakinesis: Thick, short and prominent, homologous pair of chromosomes. Chiasmata still observed.

Metaphase I- The paired chromosomes get arranged on the equator of the cell. The chromosomes are maximally concentrated at this stage and can be counted easily.

Anaphase I- separation of homologous chromosome occurs and their movement towards opposite poles. This movement results in reduction of chromosome number to half.

Telophase I- The chromosomes at two poles decondense, result in formation of two nuclei.

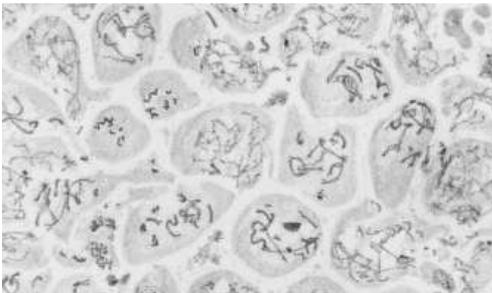
#### Stages of Meiosis II

Prophase II- In this stage, chromosomes are seen as rod shaped.

Metaphase II -The chromosomes are arranged on the metaphasic plate

Anaphase II The two chromatids of each chromosome undergo separation and move towards two opposite poles.

Telophase II The separated chromosomes decondense and form nuclei.



**Meiosis: Grasshopper testis [3]**

**AIM 25: TO STUDY DIFFERENT STAGES OF MITOSIS FROM TEMPORARY MOUNT OF ONION (*ALLIUM CEPA*) ROOT TIP CELLS.****Theory**

All living organisms are composed of cells. Cells divide and new cells are produced from pre-existing cells. New cells are made for maturation and maintenance of tissues and growth of organisms. Mitosis and meiosis are the two methods of cell division. In mitosis, eukaryotic cell nucleus divides into two, and then parent cell undergoes division to form two daughter cells.

Cell division has two events- karyokinesis, division of nucleus as well as cytokinesis division of cytoplasm.

**Materials and methods**

Root tips of onion, acetocarmine stain, 1N HCl, slide, coverslip, compound microscope, forceps, clean blade, hotplate/ spirit lamp.

**Procedure**

1. Take the tip of onion root, by excising tip at 5 to 8 mm from the root and wash it under water. Place it on clean slide
2. Put a drop of 1 N HCl on root tip and 2-3 drops of acetocarmine stain over it
3. Place the slide on a hot plate or gently warm the slide on spirit lamp. Care should be taken that stain should not dry up.
4. Remove the excess stain using blotting paper.
5. Put a drop of water and place coverslip, while avoiding bubbles.
6. Take two filter paper sheets and place the slide between them. Use the thumb to apply pressure or use the flat end of pencil to gently tap the slide.
7. The pressure causes cells and chromosomes to spread. Seal coverslip edges using nail enamel.
8. Observe slide under compound microscope.

**Observations**

The different stages of mitosis are observed along on the basis of the following features.

Prophase I- In this stage, outline of nucleus is seen intact. Chromatin is in the form of fine threads. In early prophase, chromatin is very fine

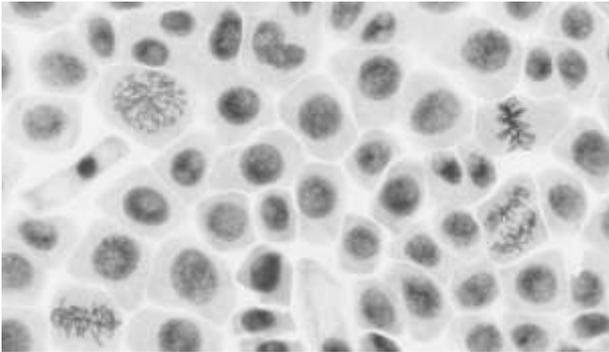
while in late prophase these might be visible as thick. Also, nuclear membrane will not be seen in late prophase.

**Metaphase I** - The thick chromosomes are arranged on the metaphasic plate. For each chromosome, two chromatids are visible, joined at centromere.

**Anaphase I** - The two chromatids of each chromosome undergo separation and move towards two opposite poles. Each chromatid appears as separate chromosome, at this stage.

**Telophase I** - The separated chromosomes decondense and form nuclei and appear as chromatin mass.

**Cytokinesis:** after telophase, in plants, a cell plate is formed at the middle. On the other hand, in animal cell. Constrictions are seen at two sides of cell. These constrictions grow inwards and divide the cells into two daughter cells.



**Onion root mitosis [4]**

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