

# Puspa Shrestha

Best Quality Resource Site for Class 11 And 12 Students  
(Based on Updated Curriculum 2077)

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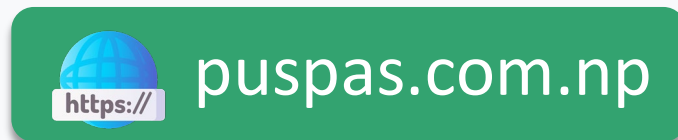


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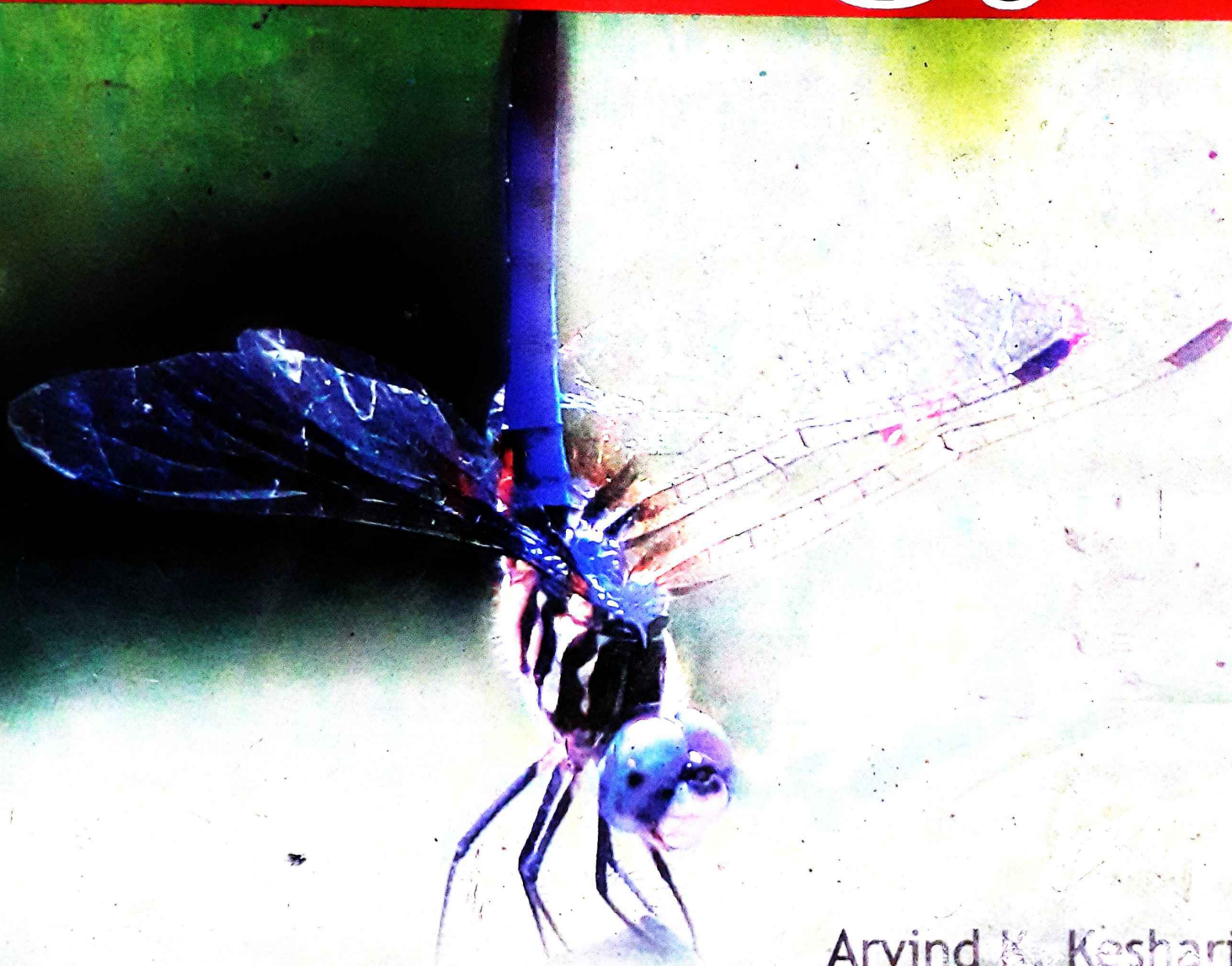
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# Practical Biology

for class XI



Arvind K. Keshari  
Khaga K. Ghimire  
Bijay Shankar Mishra



*Exclusively for the Students of Grade XI Biological Group*

*Samileshya  
karki*

*Revised Edition*

**A textbook of  
PRACTICAL BIOLOGY**

**for**

**Class XI**

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## Preface to the Present Edition

*'PRACTICAL BIOLOGY for Class XI' since its first publication in 2001 has undergone two revisions. The positive and encouraging response has promoted us to undertake yet another thorough revision of the book to cater to the requirement of changed curriculum of HSEB. After incorporating all the required additional materials, the present edition of the book shall fulfill the need of the biology students appearing class XI exam.*

*The major factor of the book to be popular might be the language and content which is simple and lucid thus enabling the biology students easily to comprehend the matter. The diagrams are made very clear and easy to draw. Relevant viva questions are given in the end of the each chapter.*

*The authors have received several words of appreciation and suggestions from the learned teachers and students. We are thankful to them for their kind cooperation and anticipate their continuous support.*

*We have tried to present this revised and update version in simple and lucid manner with many clear and illustrative diagrams. We still solicit the critical comments of the teachers and the students. Any further suggestions for improvement of the book shall be thankfully acknowledged.*

*The authors gratefully acknowledge Mr. Santa Gautam and his publication family. We are equally thankful to Mr. Ganesh Acharya for designing this book and Prem Lamsal for illustrations.*

**Authors**

# SYLLABUS OF HSEB BIOLOGY PRACTICAL - XI

## SECTION A : BOTANY (GRADE XI)

1. Use and maintenance of compound microscope.
2. Study of museum specimen and slides:
  - a. Types of bacterial cells;
  - b. Spirogyra filaments;
  - c. Mucor: Culture to demonstrate mycelium and sporangium; culture of yeast cells.
  - d. Study of vegetative and reproductive structure of Marchantia, Funaria, Dryopteris, Pinus.
3. Study of different stages of mitotic and meiotic cell division through permanent slides and chart.
4. Preparation of temporary slide to study cell structure:  
Onion scale leaf, Leaf of Geranium or Zebrina or Tradescantia or any other locally available leaf.
5. Description of following plants in semi-technical terms with their floral diagrams and formulae and identification and economic importance of at least one plant from each of the following families:
  - a. Cruciferae (Brassicaceae)
  - b. Solanaceae
  - c. Leguminosae - Papilionoidae only
  - d. Compositae (Asteraceae)
  - e. Gramineae (Poaceae)
6. Study of freshwater ecosystem using an aquarium or pond showing a food chain.
7. Study of morphological adaptations of the hydrophytes, mesophytes and xerophytes.
8. Field study: Collection, identification of plants and animals from local area; Preservation of collected organisms in suitable preservatives and maintain a record. The students are also advised to observe different types of environmental pollution during their field study (Jointly with zoology Dept).

## SECTION B : ZOOLOGY (GRADE XI)

1. Study of permanent slide and museum specimen:  
Paramecium, Plasmodium, Sycon, Hydra, Fasciola (Liver fluke), Taenia (Tape worm), Ascaris (Round worm), Pheretima (Earthworm), Hirudinaria (Leech), Palaemon (Prawn), Cancer (Crab), Periplaneta (Cockroach), Pieris (Butterfly), Bombyx (Moth), Aranea (Spider), Palamnaeus (Scorpion), Scolopendra (Centipede), Julus (Millipede), Helix (Garden Snail), Asterias (Starfish), Labeo (Rohu fish), Rana (Frog), Bufo (Toad), Hemidactylus (Wall-lizard), Chelone (Turtle), Columba (Pigeon), Rhinolophus (Bat) and Funambulus (Squirrel).
2. Preparation of temporary slide and their study:
  - a. Striated muscle fibre (thigh) of frog.
  - b. Setae and ovary of earthworm.
  - c. Squamous epithelial cell of human cheek.
3. Study of histological structure through permanent slides of skin, oesophagus, stomach, intestine, rectum, liver, pancreas, lung, kidney, testis and ovary of frog.
4. Study of adaptational features of a primary aquatic animal (Labeo), secondary aquatic animal (Turtle), arboreal (Calotes, Tree frog), primary volant (Pigeon or other birds) and secondary volant (Flying fish, Bat)
5. Dissection of animal provided so as to expose their:
  - a. **Earthworm**: General anatomy, alimentary canal, nervous system and reproductive organs.
  - b. **Frog**: General anatomy, alimentary canal, arterial and venous systems, reproductive organs and brain.

# FORMAT OF MODEL QUESTIONS FOR PRACTICAL EXAM CLASS -XI

## SECTION A : BOTANY (GRADE XI)

Time: 3 hrs.

Full marks: 12.5 marks

Pass marks: 5 marks

1. Taxonomy : Identification of family and plant : 3.5 marks
2. Preparation of temporary slide : 1.5 marks
3. Spotting (6 spotting) : 3 marks
4. Viva-voce : 2 marks
5. Class record : 2.5 marks

-----  
Total 12.5 marks

## SECTION B : ZOOLOGY (GRADE XI)

Time: 3 hrs.

Full marks: 12.5 marks

Pass marks: 5 marks

1. Dissection of animals : 3.5 marks
2. Preparation of temporary slide : 1.5 marks
3. Spotting (6 spotting) : 3 marks
4. Viva-voce : 2 marks
5. Class record : 2.5 marks

-----  
Total 12.5 marks

### Note

1. There will be separate practical exam for Botany and Zoology.
2. Exam time will be of 3 hrs. for each practical exam.
3. Students must pass both the practical exam separately.

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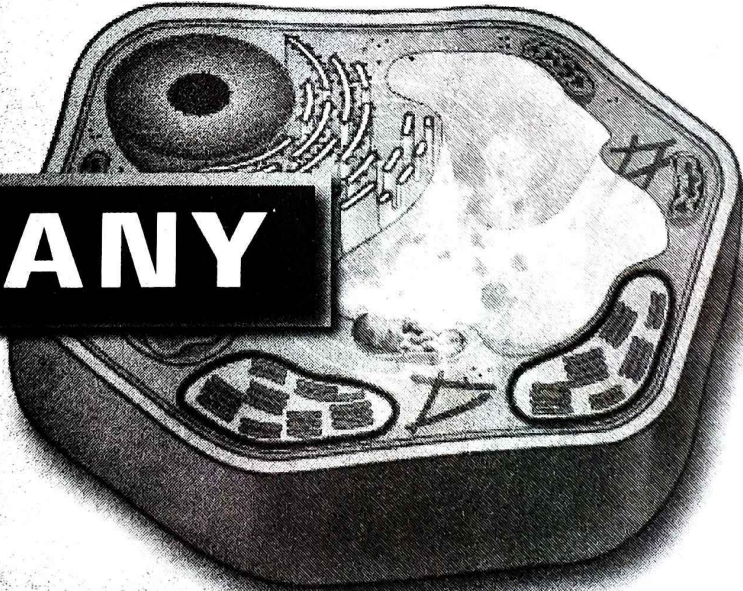
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# Section A

# BOTANY



# LABORATORY PROTOCOL

## Importance of Practical Work

Practical work is an essential part of a course in biology. It is a systematized study based on facts and observation. It helps to understand the theory and verify the facts by actual doing. It provides an opportunity to a student with scientific frame of mind to see and study various aspects of an object under observation. It also removes any doubts and misbeliefs and gives a critical appreciation of how the science of biology is carried out. Practical prepares the students to work systematically, scientifically and understand the concept of biological science in better way.

Almost all the modern inventions and applications of science in daily life are the results of constant experimentation by the scientists and technicians. For the experiment, scientists need a well-equipped laboratory where they perform scientific experiments.

## Safety Rules

1. Perform the laboratory experiments seriously.
2. Before conducting experiments, students must know about the experiment and precautions to be cared.
3. Do not play with any apparatus, microscope, razor, knife, etc.
4. Never talk loudly and run around the lab. Be calm in the laboratory.
5. For any damage or breakage, must inform to the lab incharge or instructor.
6. Use hand gloves for dissection of animals and wash your hands with soap and dettol after dissection.
7. In case of any accident, inform immediately to your instructor.
8. Handle the glassware carefully. Do not eat or drink in the laboratory.

## Students' Biological Practical Assets

While coming to the laboratory for the practical purpose, biological group students are required to bring certain necessary biological assets with them. The important assets are listed below:

1. Practical record book (biological drawing/comments sheets, a cover file and a binding lace)
2. Manual of Practical Biology (A Text Book of Practical Biology - XI)
3. Apron
4. Pencils (HB)
5. Pencil sharpener, eraser and scale
6. Piece of cloth
7. Blotting paper

8. Dissecting set with following equipments:
- Scissors: 2; one fine and pointed, other large blunt
  - Forceps: 2; one fine and pointed, other large and blunt
  - Dissecting needles: 2 (spear headed)
  - Scalpels: 2; one small and one large
  - Fine camel-hair brush: 1
  - Blade: 1
  - Dropper: 1
  - Hand lens: 1
  - Razor: 1
  - Magnifying lens (10X)

### Preparation of Some Useful Reagents

- 30 % or 70% alcohol:** The rectified spirit is 90% alcohol. From it different strengths of alcohol can be prepared:  
 $33 \text{ ml Rectified spirit} + 67 \text{ ml distilled water} = 30 \% \text{ alcohol}$   
 $77 \text{ ml Rectified spirit} + 23 \text{ ml distilled water} = 70 \% \text{ alcohol}$   
 Alcohol is used to store many organisms and to make various reagents.
- Safranin solution:** Dissolve 1 gm of safranin powder in 100 ml distilled water. Keep it for 2-3 days for complete dissolving and then filter.  
 Safranin is a basic dye which gives red colour. It is the most common staining solution. It is used to colour the nucleus and cytoplasm of the cell.
- 5 % KOH solution:** Dissolve 5 gm of potassium hydroxide (KOH) in 100 ml of distilled water. It is used to dissolve the muscles.
- Glycerine:** Generally 20% glycerine is used for mounting.  
 $20 \text{ ml glycerine} + 80 \text{ ml distilled water} = 20 \% \text{ glycerine}$
- Iodine solution:** Dissolve 1.5 gm of potassium iodide (KI) and 1gm iodine crystals in 100 ml of distilled water. This solution is used to stain the nucleus as well as testing starch in green plants.
- Cotton-blue solution:** Dissolve 1 gm of cotton-blue powder in 100 ml lacto-phenol. It is used to stain fungi.
- Gram's iodine solution:** Dissolve 2 gm of potassium iodide (KI) and 1 gm iodine crystals in 200 ml of distilled water. This solution is used to stain bacteria.
- Eosin:** It is prepared by dissolving 0.5 gm. of eosin in 100 ml of water. It is used to stain the cytoplasmic contents.
- Formaline (20%):** Take 20 ml of formaline or formaldehyde and make the volume upto 100 ml. (20 ml formaline + 80 ml water). It is used to preserve the animal or plant materials.
- Benedict solution:** Copper sulphate - 1.7 gm, sodium citrate - 1.3 gm, sodium carbonate (anhydrous)- 10 gm and distilled water - 100ml. It is the reagent for biochemical tests.

11. **Biuret reagent:** Copper sulphate (3%) - 95 ml, potassium hydroxide (10%) - 1000ml. It is the reagent for biochemical tests.
12. **Starch solution (1%):** Take 1 gm of soluble starch and put it in 100 ml of warm water. Leave it overnight on stirring plate. After complete dissolve, filter it.
13. **Fehling solution:** Copper sulphate - 34.65 gm, distilled water - 500ml. It is the reagent for biochemical tests.

## General Instructions to the Students

### 1. Need of practical for the science students

For the science students, practical is very important as they can verify any facts which they study in the theory classes. The students do the practical with their own hand. So that, they understand theory well.

### 2. What is a laboratory?

Laboratory is a place where the necessary apparatus and equipment are kept to perform a certain experiment for the teachers and the students.

### 3. Assets to bring to the laboratory

While coming to the lab for the practical purpose, students of biological group are required to bring necessary biological assets with them. The important assets are listed below:

A manual of practical Biology	A practical note book
An apron	Extra note copy
Pencils (HB), Eraser	Scale
Pencil sharpener	Brush
Dissecting set	A piece of cloth

### 4. Proper care of instruments and equipments

The instruments, apparatus, glassware and other materials must be carefully handled. Students should replace the apparatus back to the same position after use. Students must clean or maintain the apparatus before and after use.

### 5. Punctuality and discipline in the laboratory

A science student must be punctual in the practical class to keep his practical record up to date. Once the practical class is missed, it is difficult for the teacher to repeat it. A student is required a high degree of discipline in the laboratory.

### 6. Maintaining practical record

Biology practical record can be bought from the stationary. Practical paper must be of good quality. Students must maintain their practical record file up to date, neat and clean. The practical should be recorded in your file on the same day. Students must get the practical checked by the teacher.

### 7. Drawing and labeling the diagrams

Diagrams should always be made on clean biology practical sheets. Students must follow the given rules to draw and label the diagrams:

- a. Before sketching the diagram students must leave one-inch margin on the upper side as well as on left-hand side. The upper margin is left to write the title of the experiment. The left-hand margin is left for punching.
- b. Write the date of the practical in the upper left corner.
- c. Draw diagrams proportionate to the size of the paper to avoid the paper looking either too congested or too vacant. Diagrams should not be too large or too small. HB pencil is preferred for drawing and labelling.
- d. Must draw diagram in the center of the paper so that enough space on the sides is available for labelling.
- e. Diagram must be neat, clean and impressive to the teacher.
- f. Avoid over shading the diagram.
- g. Diagram must be well labelled. Labelling is always made on the right hand side. Do not label on left side of the diagram.

#### 8. Writing comments

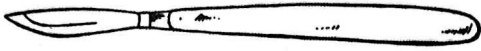
After drawing a diagram, students may use a separate ruled paper to write comments. Comments can be written with pencil or pen. Comments are written in points. Students are advised to see and follow the sample shown by the instructor in the practical exam.

### Dissecting Apparatus

A variety of instruments required depend upon the nature of work. However, there are necessary requirements for the dissection kept in a dissecting box. A dissecting box contains following equipments:

1. **Large forceps:** It has blunt ends used for cleaning and holding.
2. **Small forceps:** It has pointed ends used for cleaning and holding.
3. **Large scissors:** It is used to cut hard part.
4. **Small scissors:** It is used to cut soft part.
5. **Large scalpel:** It is used to cut the hard parts like bones.
6. **Small scalpel:** It is used for shaving and cutting the soft parts.
7. **Needle:** It is used for squashing and mounting.
8. **Arrow headed needle:** It is for piercing.
9. **Brush:** It is used to clean the tissues or organs.
10. **Dropper:** It is used for washing and dropping any fluid.
11. **Hand lens:** It is used for magnification of the objects.
12. **Watch glass:** It is used for keeping the tissues or small organisms or objects.
13. **Blowpipe:** It is used to blow air to clean tissue, suck blood, etc.
14. **Spatula:** It is used to cover vital organs during dissection, especially cover heart while cutting rib case.
15. **Plain slide:** It is a glass slide used for keeping organisms or tissue for microscopic examination.
16. **Cover slip:** It is used for covering the materials on plain slide while microscopic examination.

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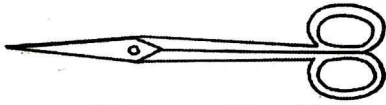
Scalpel



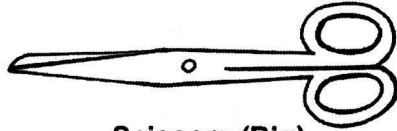
Large Forceps



Pointed Forceps



Scissors (Small)



Scissors (Big)



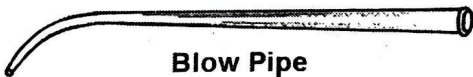
Arrow Headed Needle



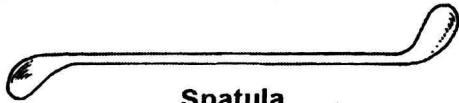
Teasing Needle



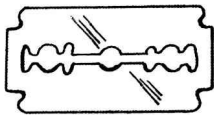
Razor



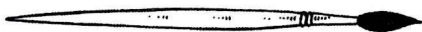
Blow Pipe



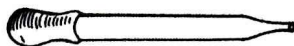
Spatula



Blade



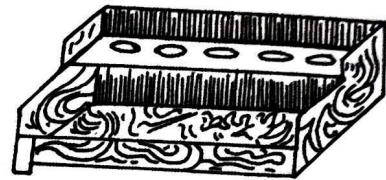
Brush



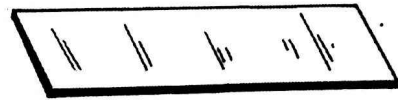
Dropper



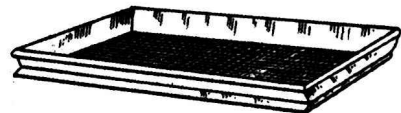
Watch Glass



Staining Rack



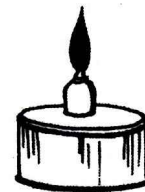
Glass Slide



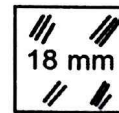
Dissecting Tray



Dropping Bottle



Spirit Lamp



Rectangular Cover Slip



Round Cover Slip

# Laboratory Techniques

## 1. Fixing agents and preservatives

Plants and animals or their parts collected for practical examination are immediately killed and subsequently preserved for long time in the laboratory. These materials are kept completely immersed in the fixing agents or preservatives. These preservatives do not cause any structural disturbances or distortion of the materials. Following are the common preservatives:

- a. Formaldehyde or formaline
- b. Formo-aceto-alcohol
- c. Alcohol (90%)
- d. Picric acid

## 2. Section cutting

Thin sections of the animal organs or plant parts are cut either with the help of microtome or by blade or razor with hand.

For section cutting by hand, especially for the plant materials, keep the materials in your hand in horizontal plane. If material is very soft, use a supporting material like pith, potato or carrot. Hold the razor in right hand with blade facing you and handle at right angled to it. Start cutting transverse sections with uniform motion from outside towards your side. Collect the sections cut on the edge of the blade with the help of drawing brush. Stain and mount them for study under the microscope.

## 3. Staining

It is a process of colouring the cells or tissues. The cells or tissues are stained in various staining chemicals. These staining chemicals make the tissue distinct. Two kinds of stains are commonly used.

- a. **Nuclear stains:** These stain the nuclear part of the cell such as haematoxylin.
- b. **Cytoplasmic stains:** These stain the cytoplasmic components. e.g. borax-carmin and eosin.

However, safranin is considered as the common stain which can stain both cytoplasm and nucleus. It is generally used for temporary preparation of slide.

## 4. Dehydration

It is a process of removal of water from the plant materials which are used in the slide preparation. Presence of water in the tissue can make the tissue decay. Therefore, it is essential to remove water and prevent from decaying. Dehydration is done by passing the mounting material through various grades of alcohol such as 30%, 50%, 70%, 90% and 100%.

## 5. Mounting

It is a process of making the material more visible and clear. The refractive index of a cell is 1.54. Mounting medium should have same refractive index. The mounting chemicals are glycerine and canada balsam. Put a drop of mounting chemical in the center of glass slide and then keep the stained plant or animal material onto the mounting material. In order to avoid the entry of air bubble the cover slip is lowered slowly.

## Section Cutting

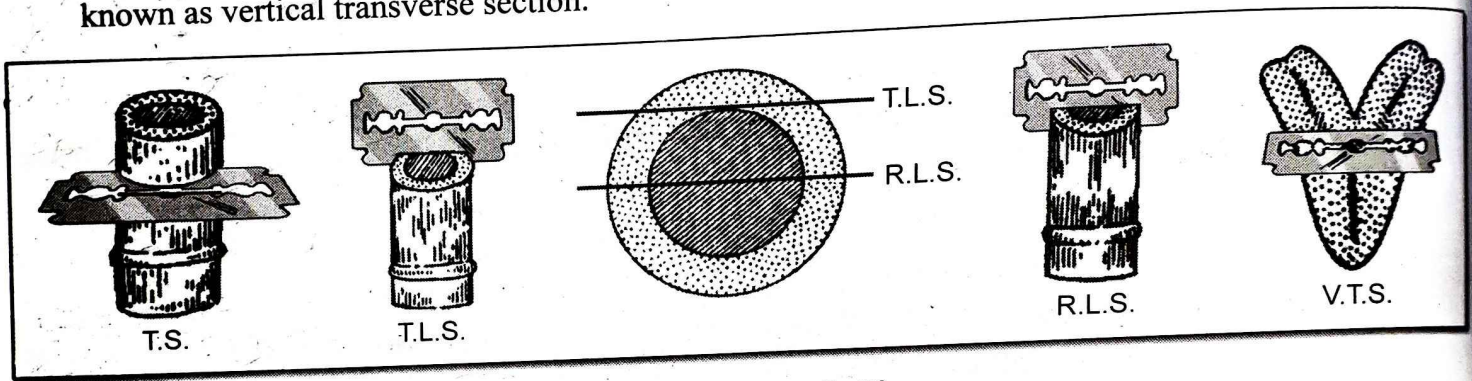
When an internal tissue or anatomical structures of a particular organ is studied, a thin section of the concerned part is taken by freehand. The sections are cut in various planes:

### 1. Transverse section (T.S.)

It is the section that is cut by passing blade edge at right angles to the longitudinal axis of the object. The section of cylindrical organs such as stem and root are cut in this plane.

### 2. Vertical section (V.S.)

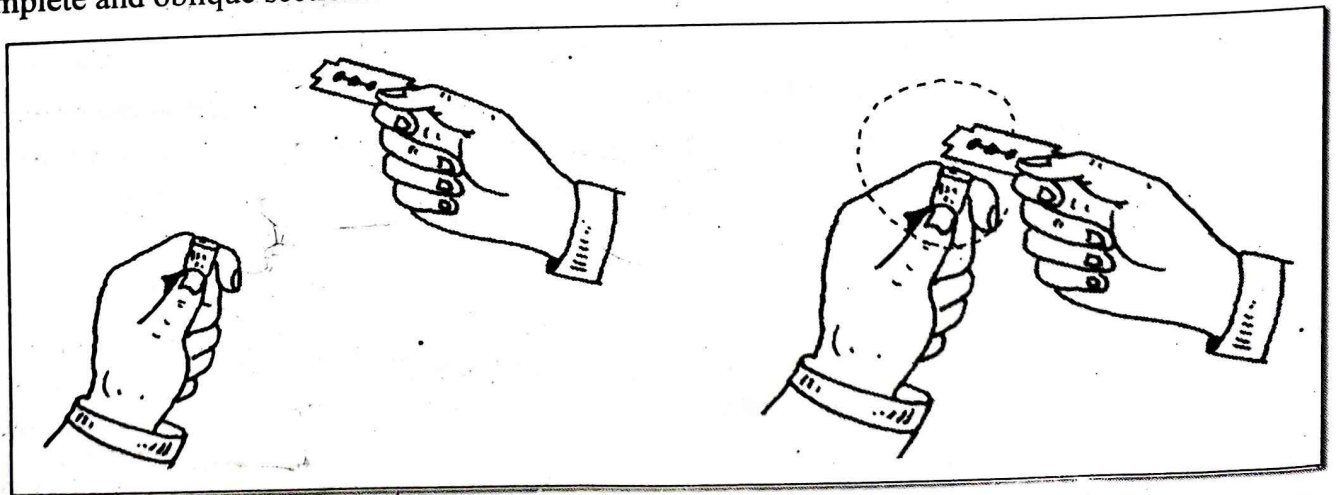
It is the section that is cut by passing blade edge at right angle to its surface. This plane is applied in dorsiventrally flattened leaves and thalloid plants. As the section is cut in vertical plane, hence it is known as vertical transverse section.



Planes for Section Cutting

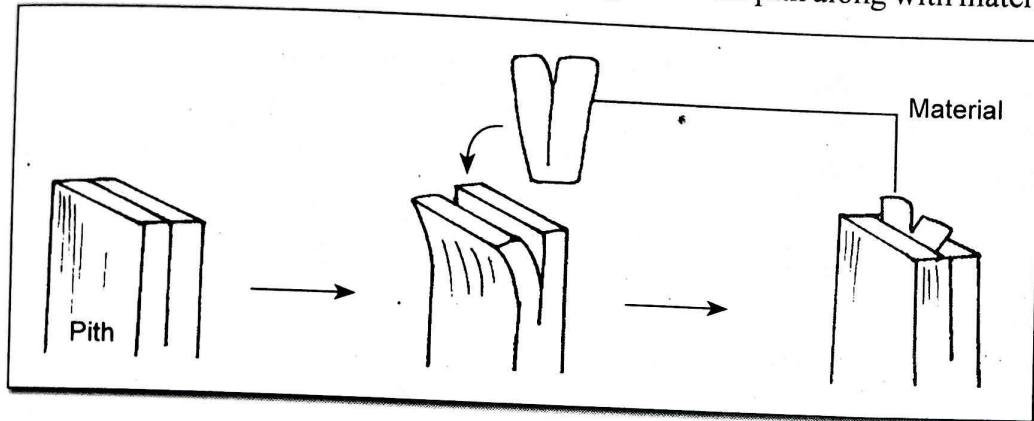
### Technique of free-hand section cutting

The first step of slide preparation is section cutting. Keep all the requirements needed for section cutting such as watch glass, sharp razor or safety blade, slide, brush, needles, water and materials in front of you. Hold the material vertically in between the thumb and fore finger of the left hand in such a way that the material lies at the level of fore finger and the thumb below it. Hold the razor or blade by the right hand. Now, make a horizontal cut to material with a **single stroke**. Repeat the process several times by moving the blade rapidly so as to get a number of sections. Keep all the sections collected on the blade on water into the watch glass. Select a number of thin and uniform sections and place them on the slide with the help of a fine brush. Select under microscope the best thin and unruptured sections from them. Discard the thick, incomplete and oblique sections.



Free-hand section cutting

The material, which is very small or fragile to hold without support, **pith** is used to hold it. Pith is a stiff tissue used to support the soft tissue during the section cutting. Potato, carrot and radish are commonly used as the pith. Take a piece of pith (sized enough to hold by hand) and cut vertically down leaving a portion enough to hold the specimen. Place the material in between two halves of the pith and hold tightly. Now, follow the above mentioned methods of section cutting to cut the pith along with material horizontally.



Section cutting using pith

## Preparation of different types of mount

### Wet mount (wm)

It is the most common type of slide preparation. It is used when the object or material is observed immediately within few minutes after the preparation. This type of mount can't be kept for even an hour. For this type of slide water is used. Put 1 or 2 drops of water on the center of a glass slide. Transfer the material with the help of brush or a forceps and place on the water. Apply the cover slip and remove the excess water along the edge of cover slip with a blotting paper or with a piece of cotton /cloth.

As the water is used as mounting medium, the preparation will get dry very soon due to evaporation. Therefore, the observation should be carried immediately after the preparation.

### Temporary mount

It is also common type of slide preparation. It is used when the object or material is observed for few hours after preparation. It can be kept for few hours. For this type of slide glycerine is used instead of water.

Put one drop of glycerine on the center of a glass slide. Take material with the help of brush or a forceps and place on glass slide. Apply the cover slip over mounting material. Remove excess glycerine using a blotting paper.

### Whole mount (wm)

In this type of slide preparation, entire organism is studied. Put one drop of mounting material (water or glycerine or canada balsam) and transfer the stained or unstained materials on it. Remove excess glycerine with a blotting paper. Whole mount is commonly made for the observation of smaller organisms such as unicellular organisms and thin thalloid materials.

### Permanent mount

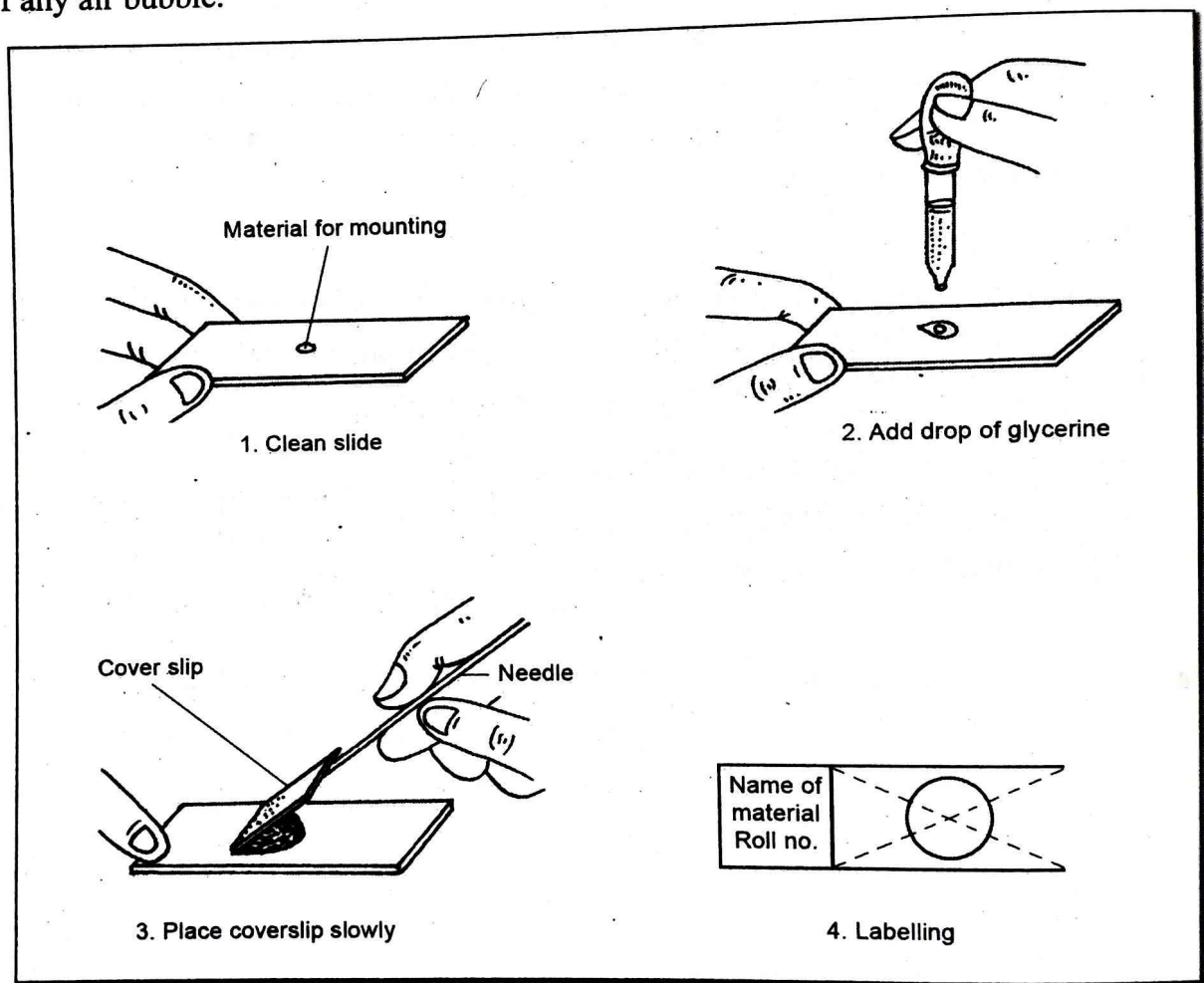
This type of slide is prepared when the material is preserved for long time. It is essential to remove out the water from the materials. The process is called dehydration process. Therefore, the material is required to pass through different concentrations of alcohol (10%, 30%, 50%, 70%, 90%, 100%) for dehydration process.

Put one drop of mounting material ~~canada balsam~~ on a glass slide. Transfer the dehydrated material over the ~~canada balsam~~ and cover it with cover slip. In this way, permanent slide can be kept or stored for years.

## Mounting Technique

Mounting is necessary to properly position an object for clear view. It is the last step in the process of slide preparation. For mounting, put a drop of suitable mounting medium such as water or glycerine or canada balsam on the center of a clean glass slide. Place the material on the mounting material with the help of a fine brush or forceps and finally place a clean cover slip on it. To place the cover slip properly, hold the cover slip with the forefinger and the thumb of the left hand and support it by a needle held in the right hand. Lower down the cover slip slowly and touch one edge of the cover slip obliquely on one side of the mounting liquid. Holding the other edge of the cover slip with a needle point lower it down slowly to avoid air bubbles till it completely touches the slide. Suck the excess fluid outside the cover slip with the blotting paper.

The slide which is without any air bubble is considered as the good slide. Therefore, try to avoid the entrance of any air bubble.



**Method of Mounting Cover slip**

### Significance of Using Cover slip

1. Cover slip is necessary to properly position an object for clear view.
2. It slows down drying of the mounting fluid. Therefore, the slide can be kept or stored for many days.
3. It flattens the material and brings into uniform focal plane.
4. It protects the objective lens by preventing from touching the mounting fluid.
5. It reduces the diffraction of light from the material and the mounting fluid.

## STUDY OF MICROSCOPES

### OBJECTIVE

#### STUDY OF A COMPOUND MICROSCOPE

A compound microscope is a delicate optical instrument consisting of two-lens system [eye piece and objective lens] that magnifies the minute transparent or translucent objects manifold in two steps and enables us to study their minute details. This two - fold magnification is the principle behind the working of the compound microscope. The compound monocular microscope consists of many parts, which are assembled to either mechanical parts or optical parts.

#### Mechanical Parts of a Compound Microscope

1. **Foot:** It is usually a horse - shoe shaped lowermost part. It supports the weight of the microscope.
2. **Pillar:** It is a small vertical stand attached to the base. It supports the movable parts.
3. **Inclination joint:** It is a pivot between the pillar and the arm. It permits the tilting of the upper part of the compound microscope at various angles.
4. **Arm:** It is a curved part of a microscope and its lower end is attached to the pillar and the upper end is joined to the body tube. It is used for handling.
5. **Condenser:** It is a circular chamber with lens system, present below the stage that can be raised or lowered. It is used to concentrate the light rays.
6. **Iris diaphragm:** It is a circular piece with a knob below the condenser. The left and right movements of the knob control the amount of light entering into the microscope on the object.
7. **Stage:** It is usually a rectangular platform having a circular hole in the center to allow the light to pass through. It is used for keeping an object to be magnified.
8. **Clips:** There are two clips attached to the stage, one on each side. These are used for holding the glass slide onto the stage firmly.
9. **Nose piece:** It is a revolving circular disc-shaped metallic structure attached below the body tube. Generally, three objective lenses are screwed to it.
10. **Body tube:** It is a hollow cylindrical metallic tube attached to the upper end of arm and carrying draw tube above and nose piece below.
11. **Draw tube:** It is a small hollow cylindrical metallic tube that supports the eye piece at the top.
12. **Coarse adjustment:** It is large sized screw attached at the upper end of the arm. It can be moved up and down to bring the object into rapid focusing under low power.
13. **Fine adjustment :** It is small sized screw and also attached to body tube. It helps in the adjustment of the sharp focusing. It is used when the object is under high power.

## Optical Parts of a Compound Microscope

1. **Mirror:** It is a plano-concave mirror, with one side plane and other concave. It is attached to the lower end of the arm. It is used for reflecting light rays into the microscope. The plane mirror is used to reflect the rays of light coming from nearby sources such as a bulb or a tube light while the concave mirror is used to reflect the rays of light from distant source i.e., the diffused sunlight.
2. **Objective lenses:** They are attached to the nose piece. Generally the lenses with the magnification power of 5X, 10X, 40X and 100X are available. These lenses magnify the image of the object by the number written on the lens.
3. **Eye piece lens:** It is also called ocular lens and attached to the top of the body tube. It normally ranges in magnification from 5X, 10X and 15X. It is used to magnify the image produced by the objective.

## Magnification of Object

A microscope magnifies an object in two stages. The lens system magnifies the object 5 to 10 times depending on the power of the objective lens. The ocular lens magnifies an object 5 to 15 times. The individual magnification power of the ocular or objective is written on the outside of its barrel. To calculate the total magnification the image with each objective, use the following equation:

$$\text{Total magnification} = \text{Magnification of objective lens} \times \text{Magnification of eye piece}$$

### Magnification of Object

Magnification of Objective	Magnification of Eye piece		
	5 X	10 X	15 X
10 X	50 X	100 X	150 X
40 X	200 X	400 X	600 X
100 X	500 X	1000 X	1500 X

## Handling of Compound Microscope

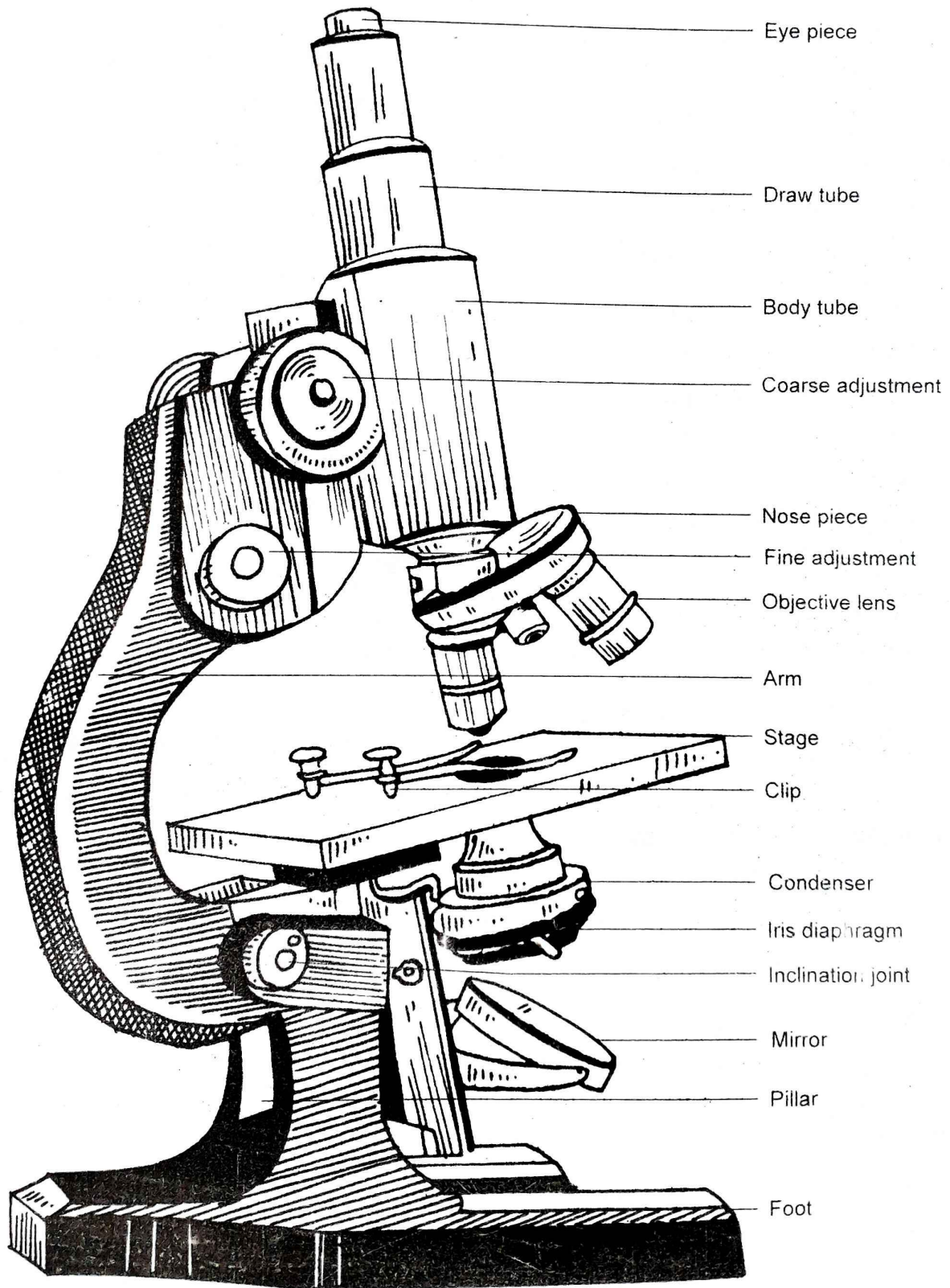
1. Place the microscope on the table by holding the arm at the back with one hand and base with other hand.
2. Fix the lower power objective and adjust the mirror so that light may pass through the objective. When you see a bright round space then you should be sure that light is passing properly through the stage to the objective.
3. Gently place a slide with the specimen over the stage. Use clips to hold the slide firmly.
4. Look through the eye-piece and adjust with the help of coarse adjustment until the object comes in view.
5. Now focus an object fine and sharp with the help of fine adjustment.

## Precautions in Handling the Microscope

1. Do not use strong light that can harm your eyes.
2. Students are suggested to focus first at low power and then slowly change to the high power. Do not focus directly under high power.
3. Never use coarse adjustment screw while focusing the object under high power.
4. Do not put wet or dirty slide on the stage.
5. Clear off dust particles from the lens or other parts of the microscope before and after the use of microscope, as the major enemy of microscope is dust. After use place it in a closed cabinet.

Date

# STUDY OF A COMPOUND MICROSCOPE



A Compound Microscope

**OBJECTIVE****STUDY OF A SIMPLE MICROSCOPE****Comments**

Simple microscope is a very simple optical instrument that is used to observe minute objects during taxonomical studies, the whole mounts, smaller animals like *Hydra*, insects, to perform dissection of small animals, etc. which are large enough to be seen under the compound microscope.

**Parts of simple or dissecting microscope**

Simple microscope has the following parts:

1. **Foot:** It is the base of the microscope which takes its weight.
2. **Stand:** It is small, hollow cylindrical tube like structure. It is attached to the base. It is used to hold the microscope.
3. **Limb:** It is the part of the microscope which is situated above the stand. It can be moved up and down with the adjustment screw for focussing an object.
4. **Arm:** It is attached to the limb with one end. The other end carries a **lens**. As the arm moves, the lens is also moved up and down for focussing. Lens is normally 5X, 10X or 20X.
5. **Mirror:** A double-faced reflecting mirror is attached to the metallic fork at the base. It is used to reflect the light onto the stage.
6. **Stage:** It is a glass plate, rectangular in size. It is attached to the upper end of the stand. Two clips, one on either side of the glass plate, are attached to the stage which are used to hold the slide firmly.
7. **Adjustment screw:** It is bigger sized screw that is used to move the limb up and down for focussing an object.

**Handling of simple microscope**

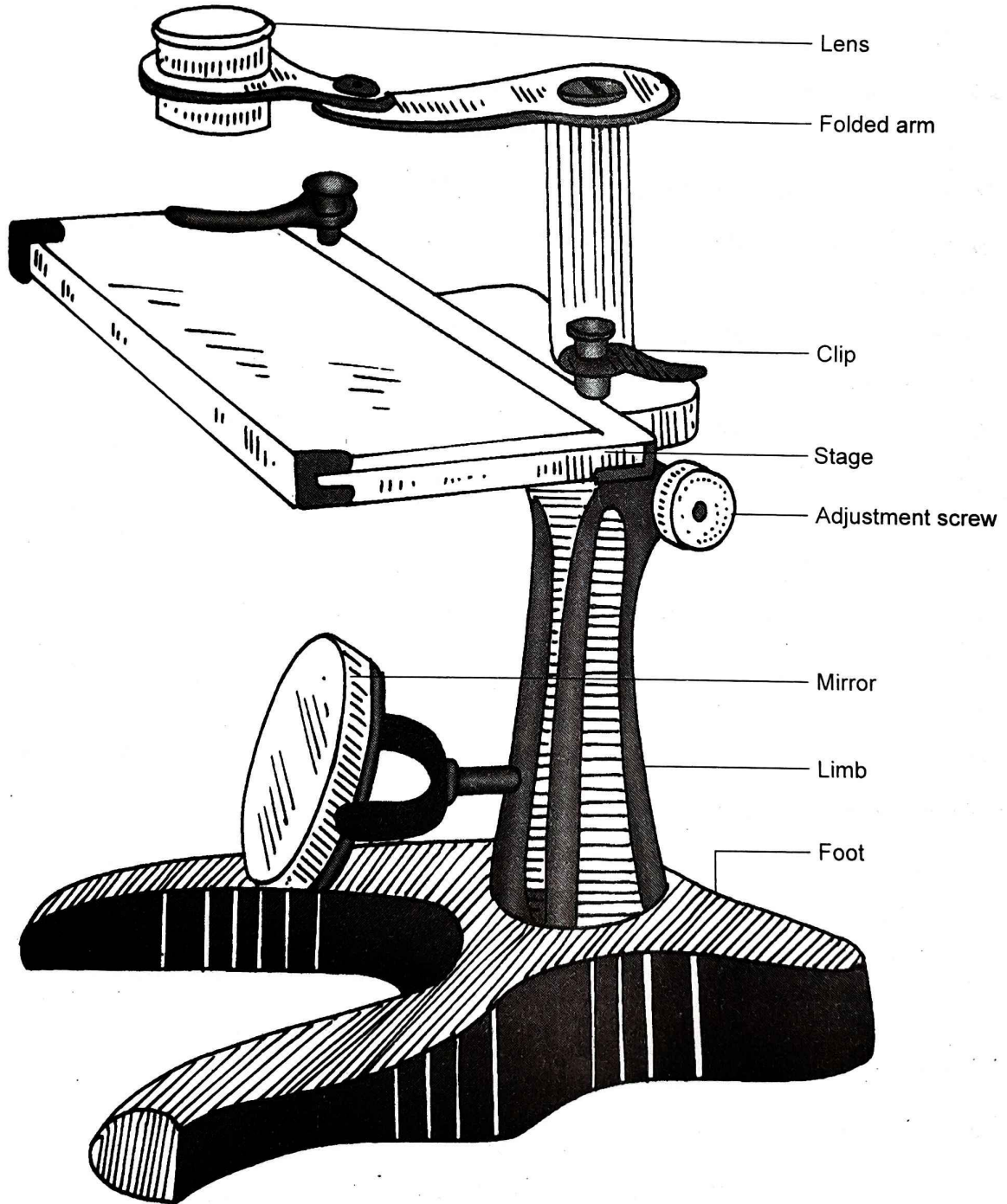
1. Clean the stage and place a slide with the specimen over the stage. Use clips to hold the slide firmly.
2. Place your eyes close to the lens and adjust the mirror so that light may pass through object.
3. With the help of adjustment screw, lens is adjusted to see the object clearly.
4. Always carry the simple microscope in an upright position, holding the arm with right hand and the left hand under the base of it.

**Precautions in handling the microscope**

1. Do not use strong light that can harm your eyes.
2. Do not put wet or dirty slide on the stage.
3. Clear off dust particles from the lens or other parts of the microscope before and after the use of microscope, as the major enemy of microscope is dust.
4. After use cover the simple microscope in a dustcover and place in closed cabinet.

Date

# STUDY OF A SIMPLE MICROSCOPE



A Simple Microscope

## Viva Questions

Students must remember

1. What is microscope?

**Ans:** A microscope is an instrument used to magnify small objects that cannot be seen by naked eye.

2. How many times does a compound microscope magnify?

**Ans:** Magnifying power of a compound is equal to the magnifying power of the objective lens into the magnifying power of eyepiece. It varies from 100 times to 600 times or more.

3. Name the optical parts of a compound microscope.

**Ans:** Eye piece, objective lens and plano-concave mirror.

4. How is object magnified in compound microscope?

**Ans:** The power of eye piece and objective lens magnify the object.

5. Who observed the cells for the first time under the microscope?

**Ans:** Robert Hooke.

6. Name the mounting materials.

**Ans:** Mounting materials for slide preparation are water, glycerine, lactophenol, canada balsom.

7. Why is mounting process essential?

**Ans:** Mounting is essential to make the material more visible and clear.

8. What is dehydration and why is it essential?

**Ans:** It is a process of removal of water from the plant materials which are used in the slide preparation. It is essential for making the slide permanent.

8. Define staining. What are the types of staining fluids?

**Ans:** It is a process of colouring the cells or tissues. The cells or tissues are stained in various staining chemicals. These staining chemicals make the tissue distinct. Two kinds of stains are commonly used:

- a. Nuclear stains: These stain the nuclear part of the cell such as haematoxillin.
- b. Cytoplasmic stains: These stain the cytoplasmic components. e.g. borax-carmin and eosin.

10. How can we de-stain the over-stained materials?

**Ans:** Destaining is a process of removal of excess amount of staining fluid from the plant materials. It can be done by using acid water.

11. Why are the fixing agents or preservatives needed?

**Ans:** The preservatives are the chemicals which are used to preserve the dead or living plants and animals. The preservatives do not cause any structural disturbances or distortion of the materials. The common preservatives are: Formaldehyde or formaline, Formo-aceto-alcohol, Alcohol (90%), Picric acid.

12. How can we cut the plant material which is very fragile?

**Ans:** The material, which is very small or fragile to hold without support, pith is used to hold it. Pith is a stiff tissue used to support the soft tissues during section cutting. Potato, carrot and radish are commonly used as the pith.

# MONERA

The kingdom monera includes all the simplest, prokaryotic and microscopic forms of life. They are thought to be the most earliest and primitive group of organisms.

Monerans are the most numerous living organisms on the earth. They are found everywhere around us in hot springs, under ice, in deep ocean floor, in deserts, on or within the bodies of plants and animals, in soil, in water and air except in the burning fire. A teaspoonful of humus rich soil may contain billion of them.

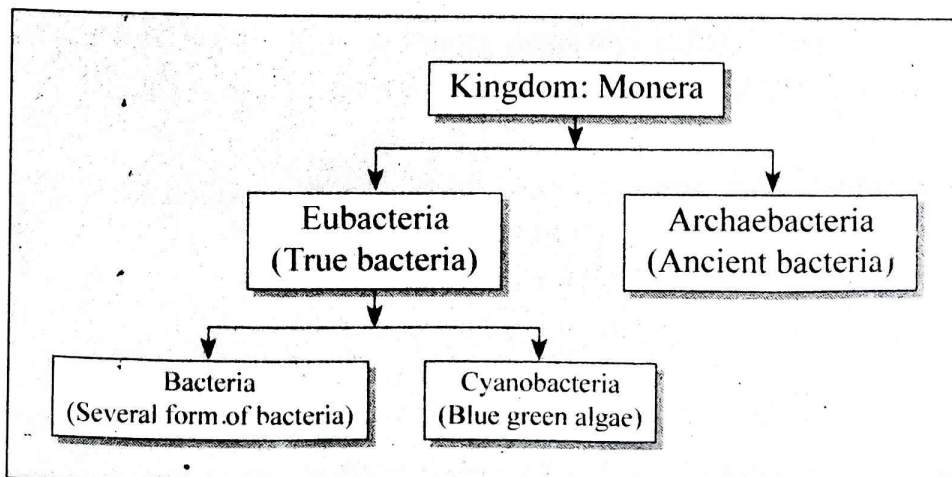
## Characteristics of Monera

1. The kingdom monera includes all the simple, primitive organisms which lack a well-developed nucleus and membrane-bound organelles.
2. They contain circular double stranded naked DNA as the nuclear body in the cytoplasm.
3. They are microscopic and made up of prokaryotic cell.
4. They are cosmopolitan in distribution and found in all types of habitat.
5. Most of them have a rigid cell wall.
6. They have autotrophic and heterotrophic mode of nutrition.
7. They are known as decomposers and mineralisers in the biosphere.
8. Reproduction is primarily asexual.

## Classification of Kingdom Monera

The kingdom monera contains three major groups.

1. Bacteria
2. Cyanobacteria
3. Archaeobacteria



Here, a sub-group eubacteria includes several forms of bacteria and cyanobacteria.

**OBJECTIVE****STUDY OF BACTERIUM AND ITS TYPES****Requirements**

**Apparatus:** Slide, cover slip, brush, dropper, blotting paper, permanent slides of different types of bacterial cells, compound microscope

**Material:** Root of leguminous plant like *Pisum sativum* (Pea)

**Chemical:** Water, crystal violet

**Laboratory work**

1. Take a root nodule of pea and squeeze it to obtain few drops of fluid which contains bacteria.
2. Mount a drop of bacteria containing liquid on a slide. Smear it evenly and make dry. Put one drop of crystal violet over it and stain it for one minute. Wash the slide with tap water and then make dry.
3. Take dry slide and mount it under the high power of the compound microscope.
4. Observe and study the types of bacteria on basis of shape with the help of prepared slide and permanent slide. Also draw each of them and note the features of bacteria.

**Structure**

1. Bacteria occur in soil, water, air, decaying foodstuffs, saliva, fruit and in the body of living organisms.
2. The outermost layer of bacterium is a rigid cell wall. Inner to it, there is a thin plasma membrane.
3. They are extremely simple, microscopic prokaryotic organisms as they lack a well-defined nucleus and membrane-covered cell organelles like mitochondria, plastid, Golgi complex, etc.
4. The cytoplasm contains 70S-ribosomes, stored food materials in the form of lipid, glycogen granules, etc.
5. The nuclear body is represented by a circular double-stranded naked DNA that lies in the cytoplasm.
6. Bacteria may be motile or non-motile as they may either bear flagella or flagella are absent in them.
7. Bacteria reproduce commonly by binary fission.
8. In some bacteria a capsule or a slime layer is found around the cell wall.

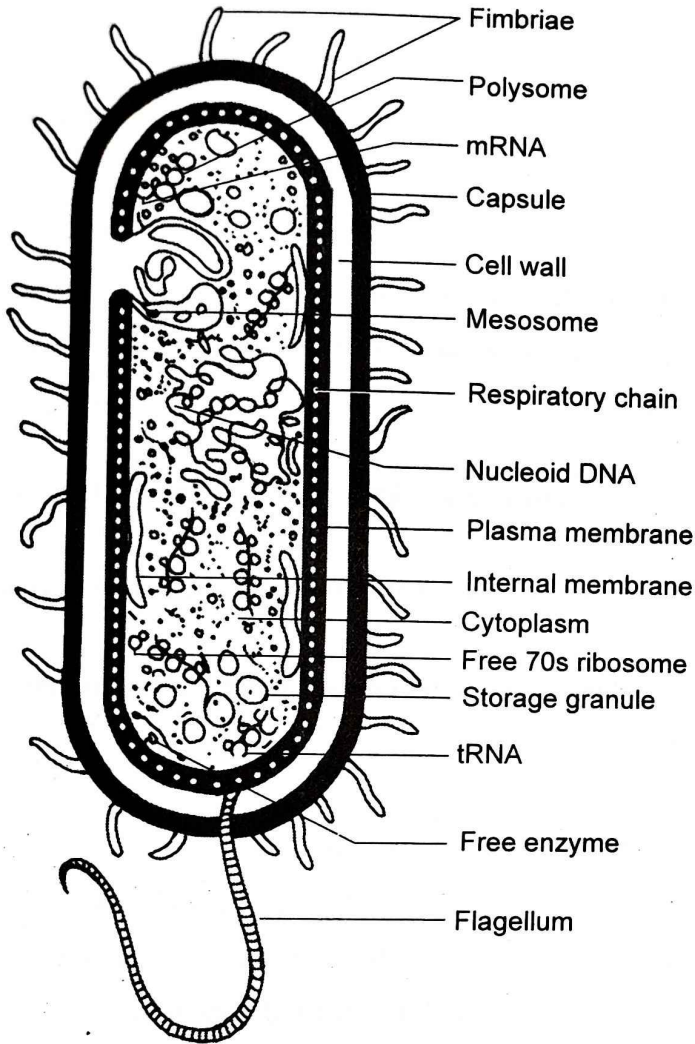
**On the basis of shape of bacteria, they are of following types:**

1. **Cocci (singular-coccus):** They are spherical in shape. They are non-motile as they lack flagella. They may occur singly or may join together into small groups so as to give different shapes. *Monococcus* (single cell), *Diplococcus* (in pairs), *Tetracoccus* (in four), *Streptococcus* (in chain), *Staphylococcus* (in grapes like clusters).
2. **Bacilli (singular-bacillus):** They are rod-shaped, short, straight or slightly curved with blunt ends. Some of them bear flagella and others do not have. They may occur singly (monobacillus), in pairs (diplobacillus) or in chain (streptobacillus). E.g., *Bacillus tuberculosis*, *Bacillus typhosus*, etc.
3. **Spirilla (singular-spirillum):** The spirally twisted bacteria like a cork-screw are called spirilla. They are larger than the cocci and bacilli. They usually bear two or more flagella at one end or both the ends. They occur as single cells or in short chains. E.g., *Spirillum undulatum*, *Spirillum volutans*, etc.
4. **Vibrios:** They are small curved, C-shaped or they are usually motile as they bear flagella at one end. E.g., *Vibrio cholerae*, *Vibrio comma*, etc.

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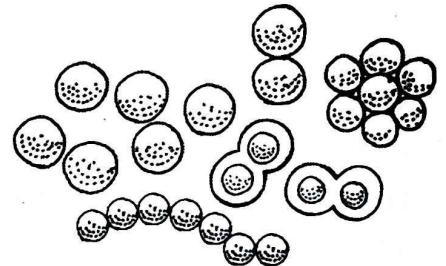
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# STUDY OF BACTERIUM AND ITS TYPES

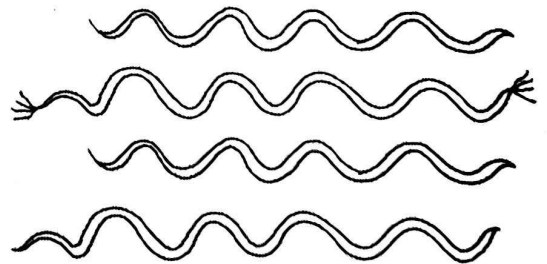


A Bacterium (Ultrastructure)

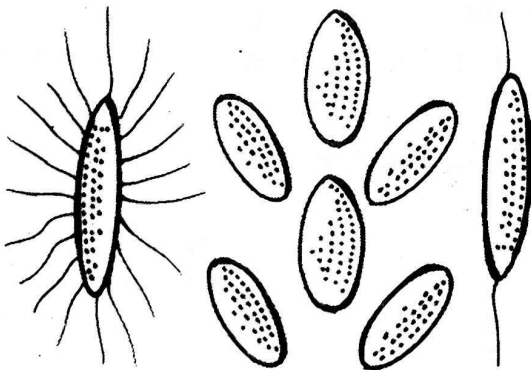
Classification (Five Kingdom)	
Kingdom	- Monera
Division	- Schizophytes
Class	- Schizomycetes
Order	- Pseudomonadales
Family	- Schizomycetaceae
Type	- Bacteria



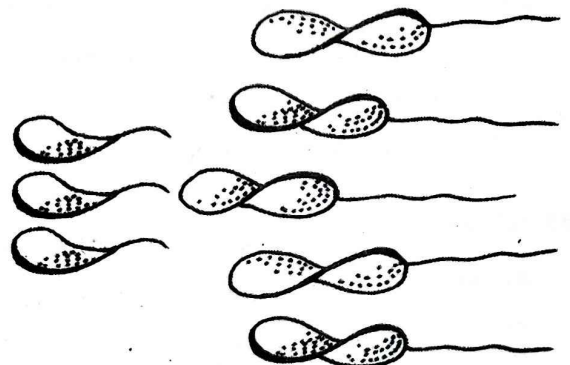
Cocci



Spirilla



Bacilli



Vibrios

**OBJECTIVE****STUDY OF VEGETATIVE STRUCTURE AND REPRODUCTIVE STAGES OF *NOSTOC*****Requirements**

**Apparatus:** Needle, Brush, cover slips, slides, watch glass, compound microscope

**Material:** Colonies of *Nostoc* ( Fresh/preserved), demonstration slides of reproductive stages.

**Chemical:** Safranin, glycerine.

**Laboratory work**

1. Take a ball of *Nostoc* on the watch glass and put few drops of safranin to stain the *Nostoc*.
2. Put a piece of stained *Nostoc* colonies on the slide and separate them into individual filament by using needles.
3. Apply the cover slip over the filaments of *Nostoc*.
4. Observe the prepared slide for vegetative structure and demonstration slides for the study of reproductive stages.
5. Study the *Nostoc* filaments, cell structure and reproductive structure under the compound microscope with low power and high power microscope.
6. Draw the labeled diagram of *Nostoc* colonies, single filament,, cell structure, hormogonium, heerocyst and akinetes.

**Comments**

1. *Nostoc* is a filamentous blue green alga which is present in colonies.
2. They occur in aquatic as well as terrestrial habitats like lakes, ponds, damp soils, etc.
3. *Nostoc* is a simple unbranched filamentous structure without sheath is called trichome.
4. The trichome is made up of oval or spherical cell that gives it a beaded appearance.
5. The trichome with individual hyaline sheath is called the filament.
6. Many *Nostoc* filaments get interwoven with each other forming microscopic ball like colonies embedded in the mucilaginous sheath.
7. Some transparent, thick walled round or barrel-shaped cells are called heterocysts. They are found among the normal cell in intercalary or terminal in position.
8. Each *Nostoc* cell is spherical or oval in shape. The cell wall surrounds the protoplast which is differentiated into peripheral pigmented protoplasm or blue green chromoplasm and granular central body.
9. The cell contains incipient nucleus which is represented by chromatin granules.

**Asexual reproduction**

1. **By Akinetes:** During unfavourable conditions, some of the vegetative cell of *Nostoc* gets enlarged and thickens to form the resting cells called akinetes. The akinetes store abundance food materials. On return of favourable conditions, they germinate into young filaments.
2. **By Hormogonia:** The *Nostoc* filament splits at the junction between heterocyst and the normal adjoining cell to form short segments called hormogonia. Later each hormogonium grows into young *Nostoc* filament.

Date

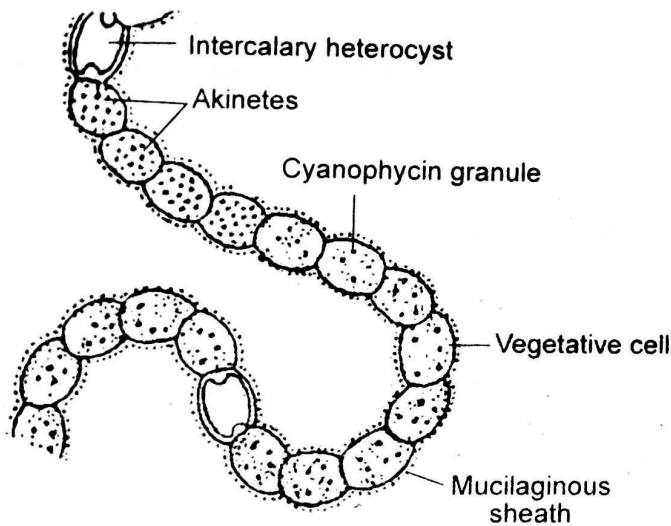
# STUDY OF THE VEGETATIVE STRUCTURES AND REPRODUCTIVE STAGES OF NOSTOC

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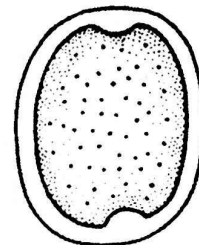


Habit Sketch

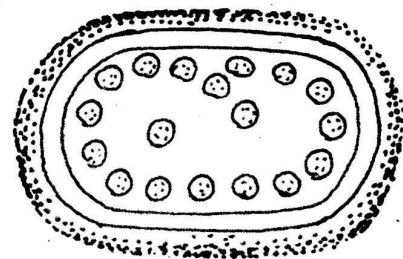
Classification (Five Kingdom)	
Kingdom	- Monera
Division	- Cyanophyta
Class	- Cyanophyceae
Type	- <i>Nostoc</i>



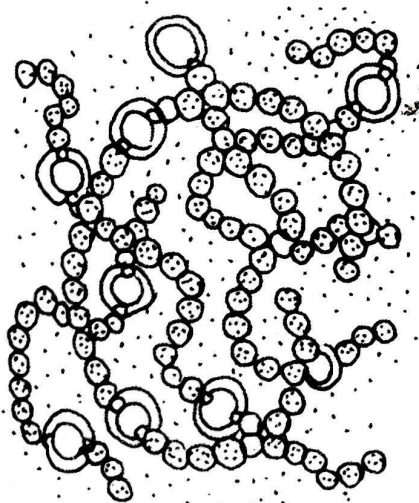
Nostoc- A Filament of Single Trichome



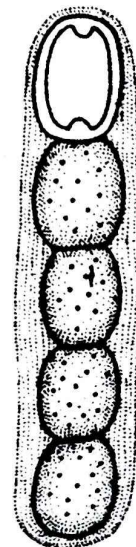
Nostoc- Heterocyst



Nostoc- Single akinete



Nostoc- Colony



Nostoc- Hormogonium

## MYCOTA

Mycota or fungi (sing. *fungus* = mushroom) include about 100,000 known species in the world. Fungi are non-vascular and non green organisms. They are unable to synthesize their own food and therefore, they have parasitic, saprophytic and symbiotic mode of nutrition. They may be colourless or multi-coloured. They range from unicellular to multicellular.

**Mycology** (Gk, *mykos* = fungus; *logos* - discourse) is the branch of biology that deals with fungi. The person who specializes in this branch is called a **mycologist**.

### General Characteristics of Fungi

1. Fungi are non-green organisms and have heterotrophic nutrition. They lead parasitic, saprophytic or symbiotic mode of nutrition.
2. They are non vascular, eukaryotic and multicellular except yeast. Yeast is a unicellular fungus.
3. The vegetative body of fungi is thallus. The thallus consists of long, branched filaments called hyphae. The mass of hyphae is called mycelium.
4. The cell wall of a fungal cell is made up of fungus-cellulose or chitin.
5. The reserve food materials remain in the form of glycogen and oil globules.
6. They reproduce both by vegetative, asexual and sexual methods.
7. The sex organs are usually unicellular.
8. There is no embryo formation after the fusion of male and female gametes.

### Habitat

Fungi are found in all sorts of habitats where organic matter is present. Fungi can be seen growing on leather goods, wood, clothes, preserved pickles, jam, jelly, humus rich soil, dung of animals, etc.

### Nutrition

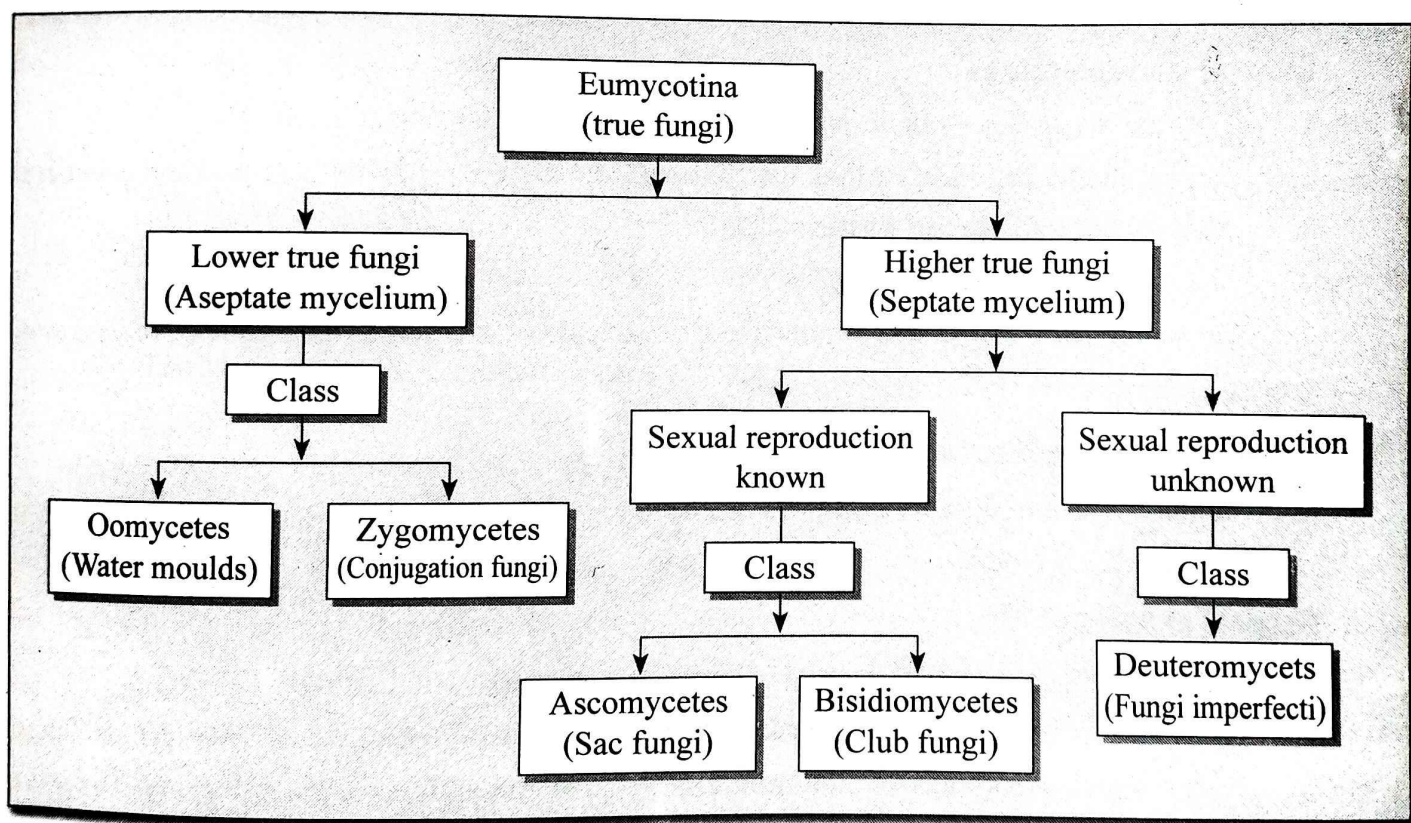
Fungi are heterotrophs. They depend on ready-made food like animals and some bacteria do. They are **chemo-organotrophs** i.e., they derive their energy from oxidation of organic substances. They secrete various enzymes that get released into the substratum and digest it externally. This is known as extracellular digestion. Their nutrition involves the absorption of soluble substances. Fungi have parasitic, saprophytic and symbiotic mode of nutrition.

1. **Fungi as parasitic:** Fungi that obtain their food from the host or the protoplasm of the living plants or animals are called the parasitic fungi. Among the parasites different degrees of parasitism occur. Some parasitic fungi live entirely on the living protoplasm of the hosts and can never grow on the dead tissue, so they die with the death of host and are called **obligate parasites**. Examples-*Erysiphe*, *Puccinia*, *Albugo*, etc. Some other fungi after the death of host are able to take their food from the dead and decaying body. Such fungi are called **facultative saprophytes**. Example - Some smuts.

- Fungi as saprophytic:** Fungi that absorb food from dead or decaying organic matters are called **saprophytic fungi**. Some saprophytic fungi die without decaying organic matters are called **obligate saprophytes**. Example - *Mucor mucedo*. Some other fungi have saprophytic mode of nutrition but can also live parasitically are called **facultative parasites**. Example - *Pythium sp.*, *Fusarium*, etc.
- Symbiotic fungi:** Fungi that grow in the **long lasting** beneficial association with the higher plants are called **symbiotic fungi**. This mutual relationship is termed **mycorrhiza**. The participants are called **symbionts**. They are two types: endomycorrhiza and ectomycorrhiza.

### Classification

On the basis of the organization of vegetative thallus, morphology of reproductive structures, the way of spores production and particular life cycle involved the kingdom mycota is classified into following two divisions: Myxomycotina and Eumycotina. The members of myxomycotina are called slime moulds and do not have cell wall. They reproduce by spores. They are either parasitic or saprophytic. The members of Eumycotina are also known as true fungi.



### 1. Phycomycetes (The Sac Fungi)

Phycomycetes includes simplest type of fungi. It is also called as **Algae-Fungi** because most of the characteristics of them are similar with algae like *Vaucheria*.

#### General characteristics

- They have simple thallus which is **unicellular** or **coenocytic** or **aseptate** filaments.
- They reproduce asexually **by the formation** of zoospores or non-motile spores.
- Sexual reproduction is **isogamous** or **heterogamous** which takes place by gametangial contact.
- The **diploid phase** is represented by zygote.

Phycomycetes has been classified into two sub-classes: oomycetes and zygomycetes.

### I. Oomycetes: (The Water Moulds)

#### General characteristics

1. Oomycetes range from a primitive unicellular thallus to a profusely branched filamentous mycelium.
2. Many members of them are terrestrial and **obligate** parasites.
3. Asexually they reproduce by biflagellate zoospores.
4. Sexual reproduction is oogamy that involves the fusion of female and male gametes to form oospore ( $2n$ ).
5. Oospore undergoes meiosis to produce haploid biflagellated zoospores.

Example, *Phytophthora infestans* (causes potato blight)

### II. Zygomycetes (The Conjugation Fungi)

The group is named zygomycetes because a diploid resting spore called the **zygospore** is formed during the life cycle.

#### General characteristics

1. They are mostly saprophytic, some others are parasites on plants and animals.
2. The vegetative body is mycelium which is well-developed, profusely branched and **coenocytic**.
3. Absence of motile sexual or asexual cells.
4. The asexual reproduction takes place by sporangiospores, aplanospores or by conidia.
5. Sexual reproduction occurs by conjugation of gametangia resulting in the formation of zygospore.

Example - *Rhizopus*, *Mucor*, etc.

### 2. Ascomycetes (The Sac Fungi)

The species of ascomycetes are called the **sac fungi** because they produce sexual spores within the sac like ascus.

#### General characteristics

1. Ascomycetes are mostly terrestrial occurring as saprophytes or parasites.
2. They have well-developed, branched, septate mycelium except yeast. Yeast is a unicellular fungus.
3. Asexually they reproduce by non-motile spores, **conidia**, **oidia** or **chlamydospores**.
4. Sexual reproduction takes place by the fusion of gametangia of opposite mating types.
5. There is absence of motile cells.

Examples - *Saccharomyces cerevisiae*, *Penicillium*, *Aspergillus*, etc.

### 3. Basidiomycetes

The members of basidiomycetes are **saprophytic or parasitic**. The group is named basidiomycetes as they produce the basidiospores at the **club-shaped** basidium during sexual reproduction.

#### General characteristics

1. Mycelium is highly developed, **profusely branched and septate**.
2. The mycelia are differentiated into two mating types: (+ve) and (-ve).

3. There are two kinds of mycelium: **primary mycelium** and **secondary mycelium**.
4. Asexual reproduction takes place by fragmentation, budding, oidia, conidia or chlamydospore.
5. The dikaryotic cell is formed during sexual reproduction.
6. Absence of motile cell throughout the life cycle.
7. Basidiomycetes are the most advanced fungi as their fructifications are often large and prominent.

Example- Mushrooms, *Puccinia* (Rust), *Ustilago* (smut), etc.

#### 4. Deuteromycetes (The Imperfecti Fungi)

Deuteromycetes comprises more than 17,000 species of diverse habits and habitats.

According to Alexopoulos (1962), the fungi-imperfecti is conidial stages of ascomycetes and few cases of basidiomycetes, in which sexual stages have not been discovered or no longer exist. Therefore, the class deuteromycetes is considered as an artificial class of fungi.

##### General characteristics

1. The fungi are saprophytes as well as parasites. Parasitic fungi cause serious diseases to plants, animals including human beings.
2. Some of them are unicellular while others are multicellular.
3. The mycelium consists of well-developed septate; profusely branched hyphae without haustoria. The hyphal cells are multi-nucleate and hyaline to coloured.
4. They reproduce asexually by conidia along with some other types of spores like chlamydospores.
5. The sexual reproduction is entirely absent.
6. The asexual stage or imperfect stage in deuteromycetes is well defined. But, the sexual or perfect stage is absent in the life cycle, therefore, they are called '**Fungi Imperfecti**'

Example: *Alternaria*, *Fusarium*, *Helminthosporium*, etc.

#### Viva Questions

Students must remember

1. What is the reserve food material found in fungi?  
**Ans:** Glycogen and oil globules.
2. Write the name of filamentous branched thallus of *Mucor*.  
**Ans:** In the filamentous branched thallus of *Mucor* is called the mycelium.
3. Write the general habitat of *Mucor*.  
**Ans:** *Mucor* mostly grow on moist bread, leather, jam, pickles, dung and decaying organic matter.
4. Write the common name of Ascomycetes and Basidiomycetes  
**Ans:** The class Ascomycetes is commonly called "the sac fungi" while the class Basidiomycetes is called "the club fungi."
5. Write the main features of Deuteromycetes.  
**Ans:** The class Deuteromycetes is characterized by the absence of sexual perfect stage. Therefore, they are called the fungi imperfecti.
6. What do you understand by mycology?  
**Ans:** The study of fungi.

**OBJECTIVE****STUDY OF VEGETATIVE STRUCTURE AND REPRODUCTIVE STAGE OF YEAST****Requirement**

**Apparatus:** Kuhne's fermentation tube, beaker, forceps, cork.

**Chemicals:** Potassium hydroxide (KOH) stick, 10% sugar solution.

**Material:** Brewer's yeast.

**Laboratory work**

1. Take a Kuhne's fermentation tube to demonstrate fermentation process.
2. Prepare 10% sugar solution in water and mix with brewer's yeast. Make a homogenous mixture by repeated shaking.
3. Fill the mixture of sugar and yeast and brewer's yeast in Kuhne's glass tube from its open end till the vertical tube is completely filled and the bulb is partially filled.
4. Plug the open end of the bulb by cotton or stopper.
5. Allow the experimental set-up in warm place for few hours.
6. Leave the petri-disc at a temperature 25°C for a week.
7. Check the mixture till it gets turbid. Turbidity indicates the multiplication of yeast cells.
8. Take a drop of yeast mixture on a slide. Cover it with a coverslip.
9. Observe the slide under a compound microscope.

**Comments**

After culturing yeast cells, the yeast is identified on the basis of following characters:

1. Yeast is an unicellular fungus. It is spherical or ovoid.
2. Cell wall is thin, delicate and is composed of chitin.
3. Cytoplasm contains a large vacuole, known as nuclear vacuole
4. Cytoplasm contains glycogen, mitochondria, volutin granules, etc are present.
5. A large prominent nucleus is seen at a side of vacuole.
6. The cytoplasm contains, mitochondria, endoplasmic reticulum and ribosomes as cytoplasmic organelles
7. Yeast is a saprophytic fungus as it grows abundantly on organic matter rich substances like juice of fruits, honey or in sugary solution, etc.
8. The reserve food materials is glycogen, oil globules and volutin grains.

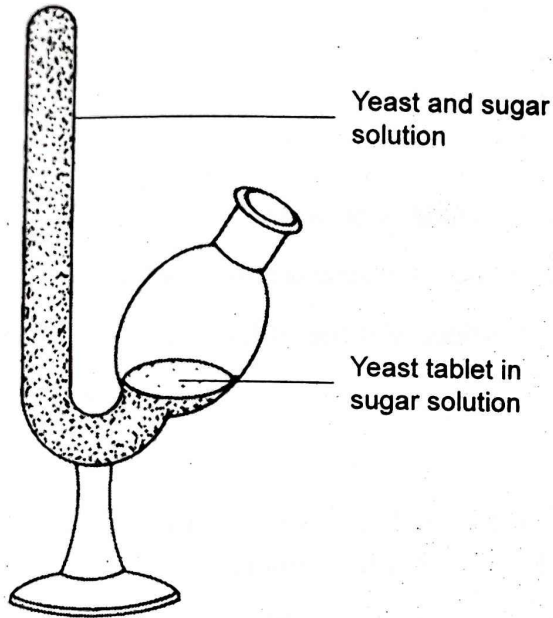
**Reproduction**

*Saccharomyces cerevisiae* or yeast reproduces asexually by budding and fission. The most common method of reproduction of yeast is budding. On the sugary solution, the yeast cells produce small protuberances which are known as buds. The bud may produce additional buds, called daughter buds. These buds on maturity get detached from the original parent cell.

Sometimes the buds are produced rapidly as a result, the buds do not separate at once and they remain attached to the parent cell in the form of long chains. Long chain of yeast is known as pseudomycelium.

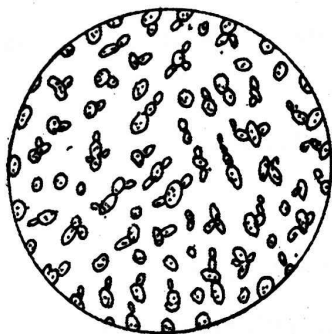
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# STUDY OF VEGETATIVE STRUCTURE AND REPRODUCTIVE STAGE OF YEAST

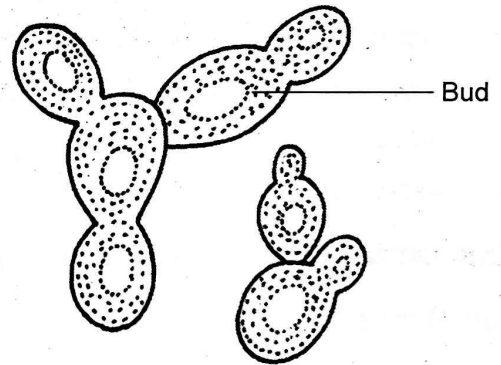


Yeast Culture

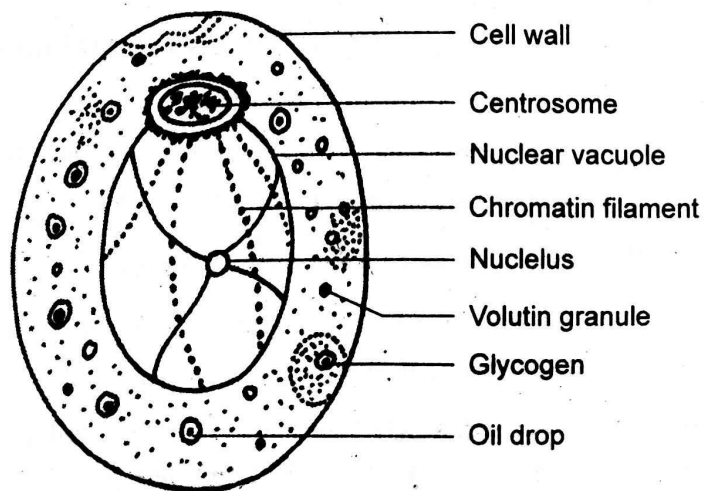
Classification (Five Kingdom)	
Kingdom	- Fungi
Division	- Mycophyta
Class	- Ascomycetes
Order	- Endomycetales
Family	- Saccharomycetaceae
Genus	- <i>Saccharomyces</i>
Species	- <i>cerevisiae</i>



Yeast Cells Under Low Power



Budding of Yeast



A Yeast cell Magnified

**OBJECTIVE****STUDY OF VEGETATIVE STRUCTURES OF *MUCOR*****Requirements**

**Apparatus:** Petri dish, needle, brush, slide, coverslips, watch glass, hand lens.

**Material:** A piece of bread

**Chemical:** Cotton blue, glycerine

**Method of culture**

1. Take a piece of bread (loaf) in a petri dish and sprinkle with water.
2. Cover the bread with bell jar and leave it in ordinary temperature for a week.
3. After a week, the cottony mass with black heads appears at the tip of hyphae.
4. The growing such cottony mass is the *Mucor*.

**Laboratory work**

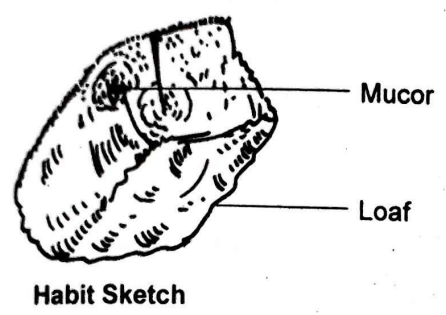
1. Observe the cottony mass on the bread with a hand lens. The black coloured minute swollen structures appear like a pin-head, called sporangia on the tip of sporangiophores.
2. Stain a bit of cottony mass of *Mucor* in watch glass with cotton blue.
3. Mount it on the slide in a drop of glycerine and apply cover slip.
4. Study the mycelium and various reproductive stages of *Mucor* under a low and high power of compound microscope.
5. Draw the diagrams of vegetative structures and reproductive stages of *Mucor*.

**Comments**

1. *Mucor* is a saprophytic fungus that grows on bread, is called bread mold or pin head mold.
2. It is observed as numerous fine, branched white cottony mass with black round head at the tip of erect hyphae.
3. The vegetative thallus is profusely branched structure is known as mycelium. The individual filaments of mycelium is known as hypha.
4. The mycelium is unseptate and multinucleate i.e., coenocytic.
5. The cytoplasm contains reserve food materials like glycogen, oil globules and many nuclei.
6. Hyphae are differentiated into following three types:
  - a. **Rhizoidal or sub-terrestrial hyphae:** These hyphae penetrate into substratum to absorb food as well as anchorage.
  - b. **Stoloniferous or prostrate hyphae:** These hyphae grow horizontally on the surface of substratum. They are comparatively thick and stout.
  - c. **Sporangiospores or aerial hyphae:** These hyphae grow vertically upward from the stoloniferous hyphae to carry the sporangia at the tips.

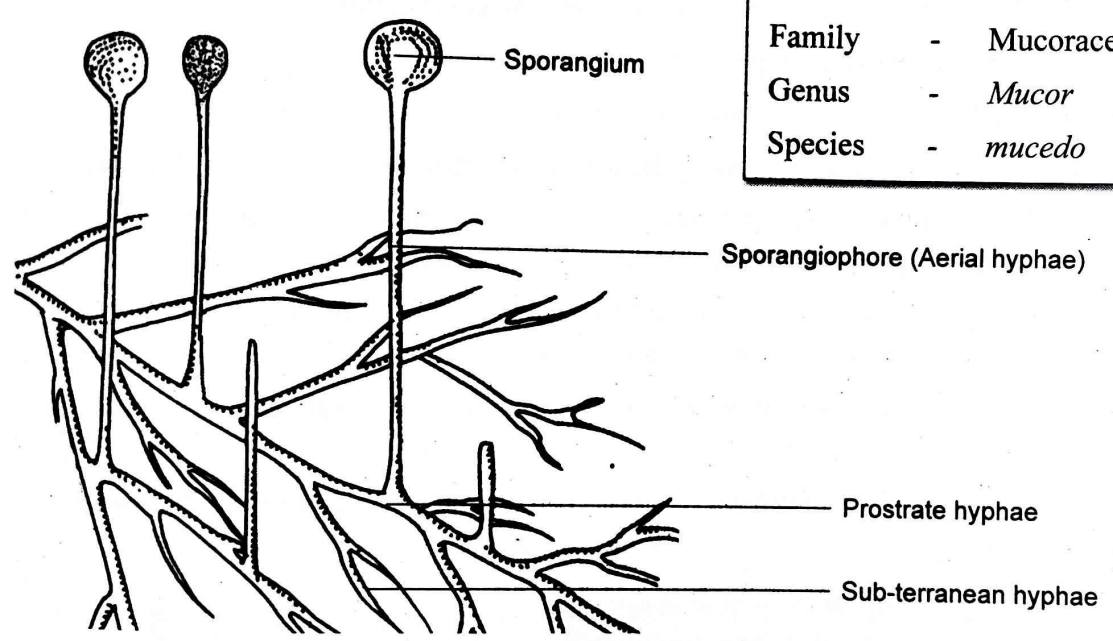
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# STUDY OF VEGETATIVE STRUCTURES OF MUCOR

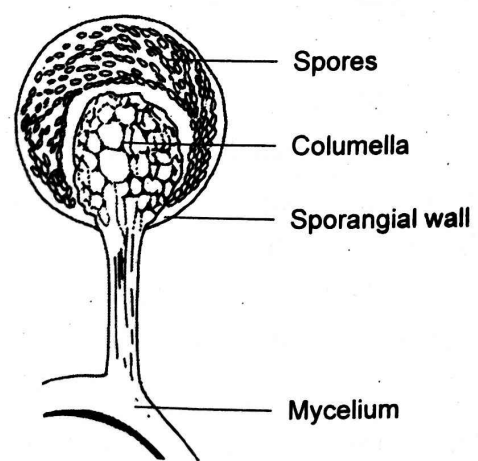


Habit Sketch

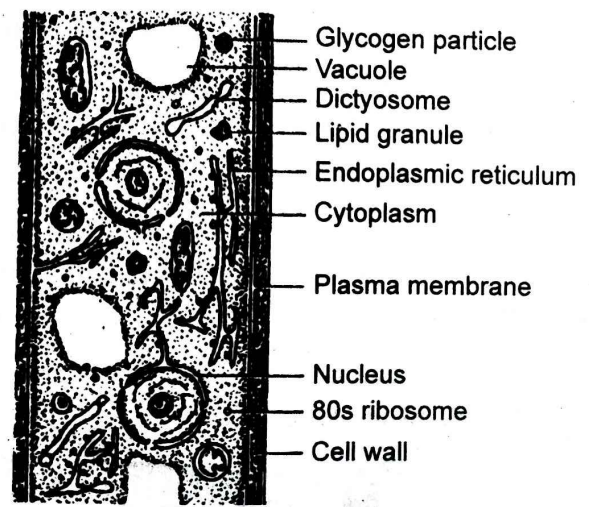
Classification (Five Kingdom)	
Kingdom	- Fungi
Division	- Mycophyta
Class	- Phycomycetes
Sub-class	- Zygomycetes
Order	- Mucorales
Family	- Mucoraceae
Genus	- <i>Mucor</i>
Species	- <i>mucedo</i>



Mycelium of *Mucor* with Sporangium



A Magnified Sporangium



Part of Hypha Showing Detailed Structure

**OBJECTIVE****STUDY OF REPRODUCTIVE STRUCTURES OF *MUCOR*****Asexual reproduction**

1. *Mucor* reproduces asexually by the formation of multinucleate spores developed in knob-like sporangium of sporangiophore.
2. The sporangium has a central vacuolated sterile dome-shaped columella. The multinucleate peripheral fertile portion of protoplasm is called sporoplasm.
3. The sporoplasm later produces multinucleate many spores.
4. The sporangial wall looks spiny due to the formation of crystals of calcium oxalate at maturity.

**Sexual reproduction**

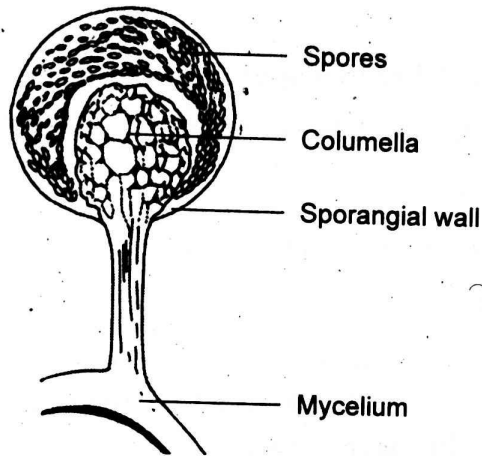
1. *Mucor* is heterothallic and reproduces sexually by conjugation.
2. Reproduction is oogamous type.
3. The two hyphae of opposite strains say (+) and (-) come to close to each other and lie side by side.
4. These two strains have a swelling at the tips which they come in contact, are called progametangia.
5. The distal end of progametangia gets inflated with cytoplasm, nuclei and food. A septum appears in each progametangium that divides it into a basal suspensor and a terminal gametangium.
6. The protoplasm of the two gametangia fuse after dissolving the walls between them and form zygote. The zygote develops a thick black and warty wall of many layers and is called zygosporangium.
7. The zygosporangium undergoes a resting period for a while. After resting period it develops an upright germ tube or hypha is called promycelium.
8. The germ sporangium of promycelium produces uninucleate, non-motile haploid germ spores.
9. Germ spores germinate to produce new mycelium.

**Viva Questions****Students must remember**

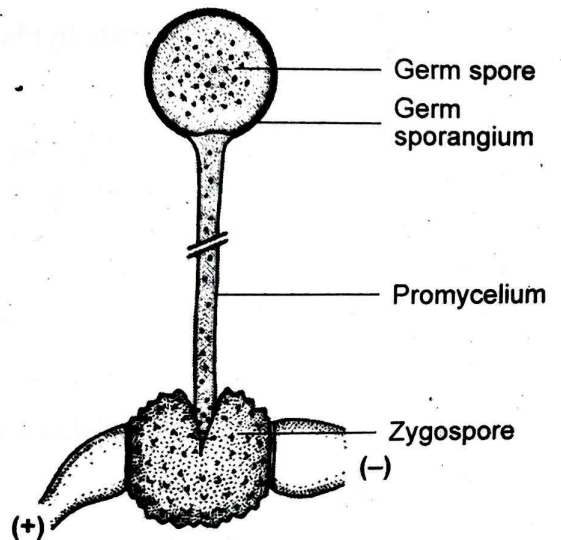
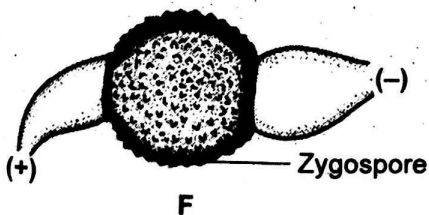
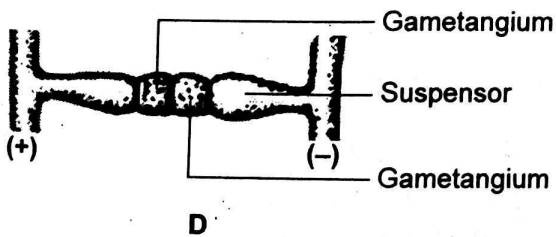
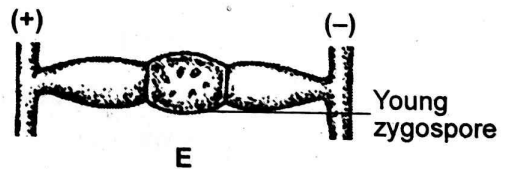
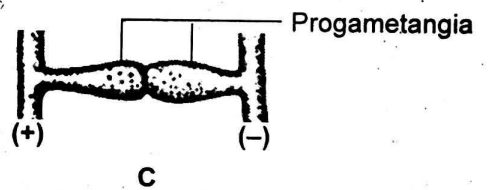
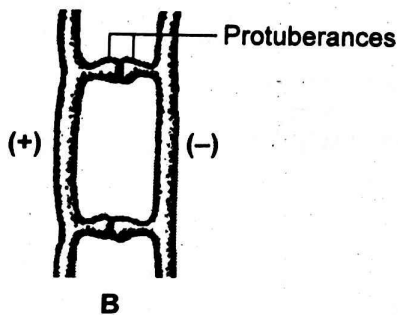
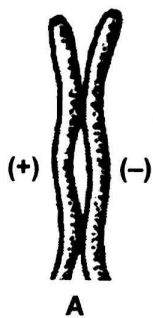
1. Define zoospore.  
**Ans:** It is a thin-walled, flagellated spore produced by aquatic fungi during sexual reproduction.
2. Define sporangiophore.  
**Ans:** The sporangium bearing hypha is called sporangiophore.
3. Fungi have thin soft and delicate hyphae, still they are able to penetrate the hardest wood. How?  
**Ans:** Fungi secrete digestive enzymes into the surrounding wood. The enzymes convert the hard organic material into simple soluble form and fungi easily penetrate the hardest wood.
4. Define hypha.  
**Ans:** The single elongated, filamentous structure, which forms the fungal thallus is called hypha.
5. Define mycelium.  
**Ans:** The branched filamentous body of fungi is called mycelium. It is a network of hyphae.
6. What is the basis of classification of fungi?  
**Ans:** (a) Morphology of vegetative and reproductive structures. (b) Method of spore formation.

Date

# STUDY OF REPRODUCTIVE STRUCTURES OF MUCOR



Asexual Reproduction in *Mucor* : A Magnified Sporangium



## Viva Questions

Students must remember

1. Write the mode of nutrition in fungi.

**Ans:** Saprophytic, parasitic or symbiotic mode of nutrition.

2. What is the reserve food material found in fungi?

**Ans:** Glycogen and oil.

3. Write the name of filamentous branched thallus of *Mucor*.

**Ans:** The filamentous branched thallus of *Mucor* is called the mycelium.

4. Write the general habitat of *Mucor*.

**Ans:** *Mucor* mostly grow on moist bread, leather, jam, pickles, dung and decaying organic matter.

5. What is the economic use of yeast?

**Ans:** Yeast can convert the sugar solution into alcohol and carbon-dioxide by fermentation. Because of this property, it is employed in bread making and brewing beer, wine, toddy, etc. Hence it is popularly known as the brewer's or baker's yeast.

6. Write the common name of Ascomycetes and Basidiomycetes.

**Ans:** The class Ascomycetes is commonly called "the sac fungi" while the class Basidiomycetes is called "the club fungi."

7. What do you understand by mycorrhizae?

**Ans:** The symbiotic association of a fungus with the root of a higher plant is known as mycorrhizae.

8. Give one example of unicellular fungus.

**Ans:** *Saccharomyces cerevisiae*.

9. Why are fungi called natural scavengers?

**Ans:** Fungi decompose dead plants and animals and thus clean the environment, therefore, they are called natural scavengers.

10. Define coenocyte.

**Ans:** The multinucleate, aseptate hyphae is known as coenocyte, e.g. *Mucor*, *Rhizopus*.

11. Define spore.

**Ans:** The spore is a reproductive structure. It is usually unicellular, thin or thick walled, motile or non-motile structure. It is produced by mitotic or meiotic division of the parent cell.

12. Name the following.

**Ans:** Black bread Mold: *Rhizopus*, *Mucor*

13. Define zoospore.

**Ans:** It is a thin-walled, flagellated and motile spore. They are usually produced by aquatic fungi during sexual reproduction.

14. Define sporangiophore.

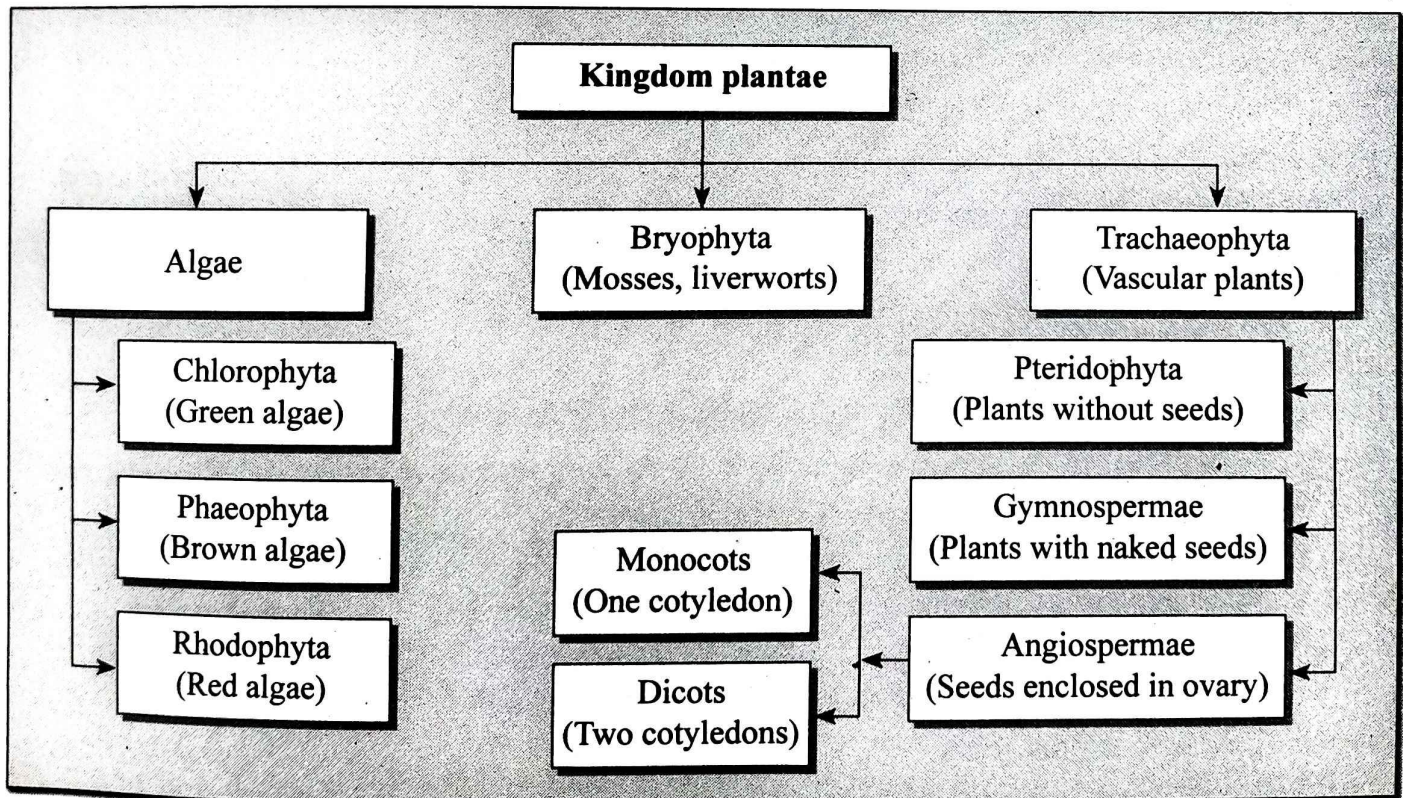
**Ans:** The sporangis bearing hypha is called sporangiophore.

# PLANTAE

The plant kingdom is a phylogenetic group, that includes all the multicellular photosynthetic producers of the biosphere and evolves from different protist ancestors. Though the several groups lack the evolutionary relation they have some features in common.

1. All plants are eukaryotic, multicellular autotrophs and have photosynthetic pigments.
2. They all have a rigid cell wall which is made up of cellulose.
3. They store reserved food materials in the form of starch.
4. They all have two generations in their life cycle - haploid gametophytic and diploid sporophytic generations. These two generations lie alternate to each other.

## Classification of Kingdom Plantae



The multicellular plants evolved from unicellular green algae attached to underwater surface. It seems that transition from aquatic to land life was along two lines. One line led to bryophyta. The bryophytes are the first non-vascular plants which are found in moist places only. They include mosses and liverworts. They are considered as amphibian plants of plant kingdom because they require water medium for fertilization.

The second line led to trachaeophyta. It includes vascular plants which are most predominant group of plants on land. Trachaeophyta shows continuous adaptation through the ages to present day flowering plants with covered seeds. The division trachaeophyta includes pteridophyta, gymnosperms and angiosperms.

**OBJECTIVE****STUDY OF VEGETATIVE STRUCTURES OF *SPIROGYRA*****Requirements**

**Apparatus:** Watch glass, slide, needle, brush, blotting paper, cover slip, microscope, permanent slides of scalariform conjugation and lateral conjugation

**Material:** Fresh or preserved specimen of *Spirogyra*

**Chemical:** Glycerine

**Laboratory work**

1. Take some *Spirogyra* filament in a watch glass and touch it with finger. Feel its texture.
2. Mount few filaments of *Spirogyra* on a slide with glycerine and apply coverslip over it.
3. Observe and study the vegetative structure of *Spirogyra* filament under low and high power of compound microscope.
4. Sketch a filament of *Spirogyra* and enlarged single cell and label the parts.

**Comments**

1. *Spirogyra* is a free-floating fresh water alga found in ponds, pools, lakes, etc.
2. It is commonly known as pond scum or water silk.
3. The plant body is multicellular unbranched filamentous type.
4. Each filament is a long unbranched thread having single row of many cylindrical cells joined end to end.
5. All the cells are rectangular in shape and have thick two layered cell wall. The cell wall is made up of cellulose and pectin.
6. The pectin dissolves in water to form a slimy or mucilaginous sheath and gives the filament a slippery - touch.
7. Each cell has a single central large vacuole, peripheral layer of cytoplasm and a nucleus.
8. Nucleus is **centrally placed and is suspended** in position by **cytoplasmic strands**, which join the peripheral cytoplasm.
9. Each cell contains spirally coiled structures along the length, are called chloroplasts. Chloroplast bears a large number of small rounded pyrenoids. Pyrenoids serve for storage of starch.

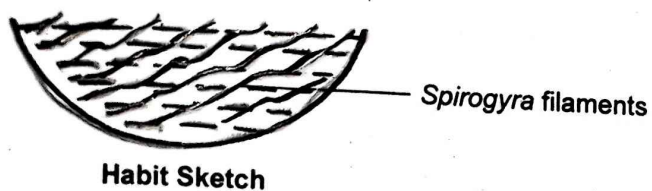
**Viva Questions****Students must remember**

1. Name the plant body of algae.  
**Ans:** Filamentous type.
2. What is the study of algae known as?  
**Ans:** Phycology.
3. Name the cell that helps the *Spirogyra* to get attached to the substratum.  
**Ans:** Holdfast.
4. What is the form of chloroplast in *Spirogyra*?  
**Ans:** Ribbon or spiral-shaped.

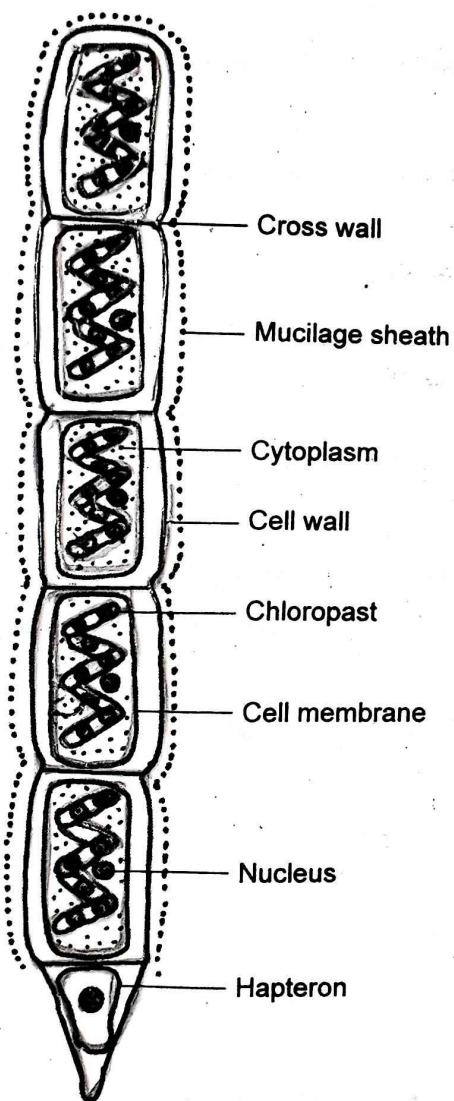
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# STUDY OF VEGETATIVE STRUCTURES OF SPIROGYRA

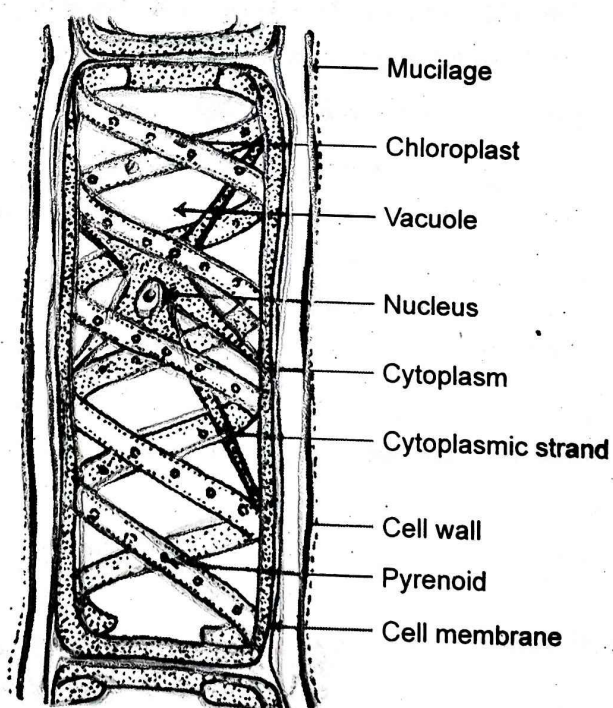
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Classification (Five Kingdom)	
Kingdom	- Plantae
Division	- Chlorophyta
Class	- Chlorophyceae
Order	- Conjugales
Family	- Zygnemaceae
Genus	- <i>Spirogyra</i>



A Portion of *Spirogyra* Filament



Detailed Structure of *Spirogyra*

**OBJECTIVE****STUDY OF REPRODUCTION IN SPIROGYRA****Reproduction**

Sexual reproduction of *Spirogyra* is isogamous type. *Spirogyra* reproduces sexually by scalariform conjugation and lateral conjugation.

**Scalariform conjugation**

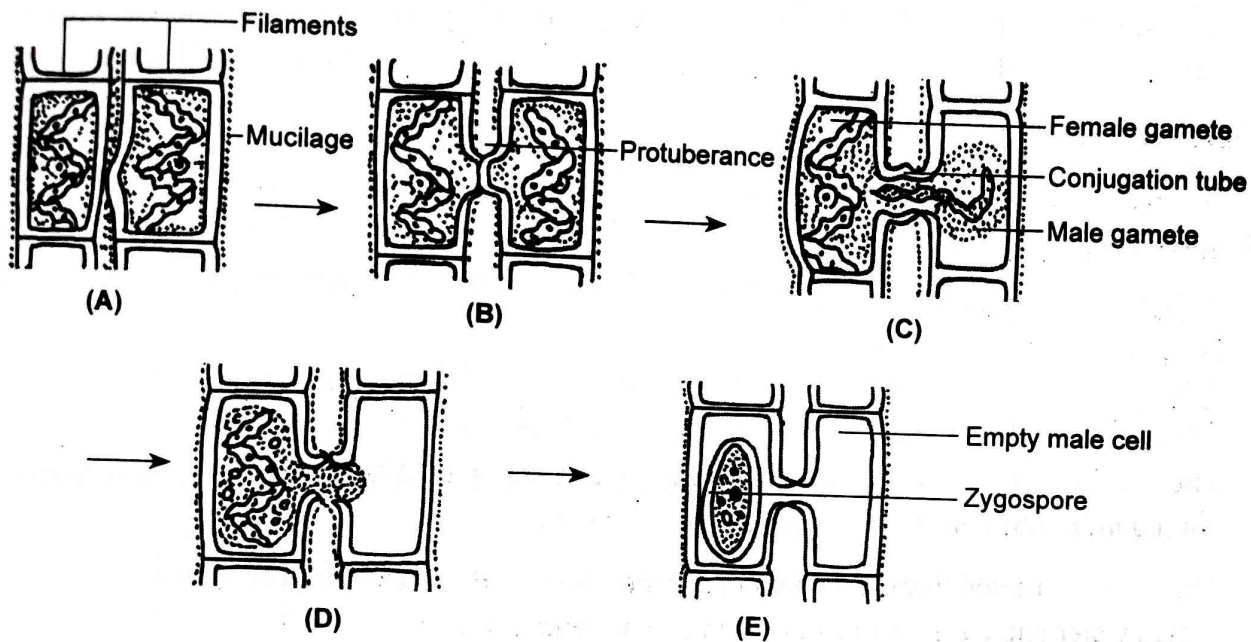
1. It is the common method of sexual reproduction in which two filaments of *Spirogyra* come together and line up side-by-side.
2. A small dome-shaped protuberance called transverse tube appears in their longitudinal walls facing each other.
3. The transverse tubes connect the two filaments and appear as a ladder like structure.
4. The contact wall between the two transverse tubes gets dissolved and forming passage called conjugation tube between the cells of two filaments.
5. The cells connected through conjugation tubes are called gametangia. The protoplasm of gametangia loses water and curls up to form the male and female gametes.
6. Both male and female gametes are naked, non-motile and non-ciliated.
7. The male gamete passes through the conjugation tube into the next filament consisting female gametes. Therefore, the opposite cell becomes empty.
8. The male and female gametes are morphologically alike and are called isogametes.
9. The two isogametes fuse to form a zygospore.
10. The conjugation occurs between two opposite cells of the filaments by forming conjugation tubes between their cells. Then, it appears as a ladder like structure. Therefore it is called scalariform conjugation.
11. Zygospore is circular and dark brown with three concentric layers of cell wall (exine, mesine and intine).

**Lateral conjugation**

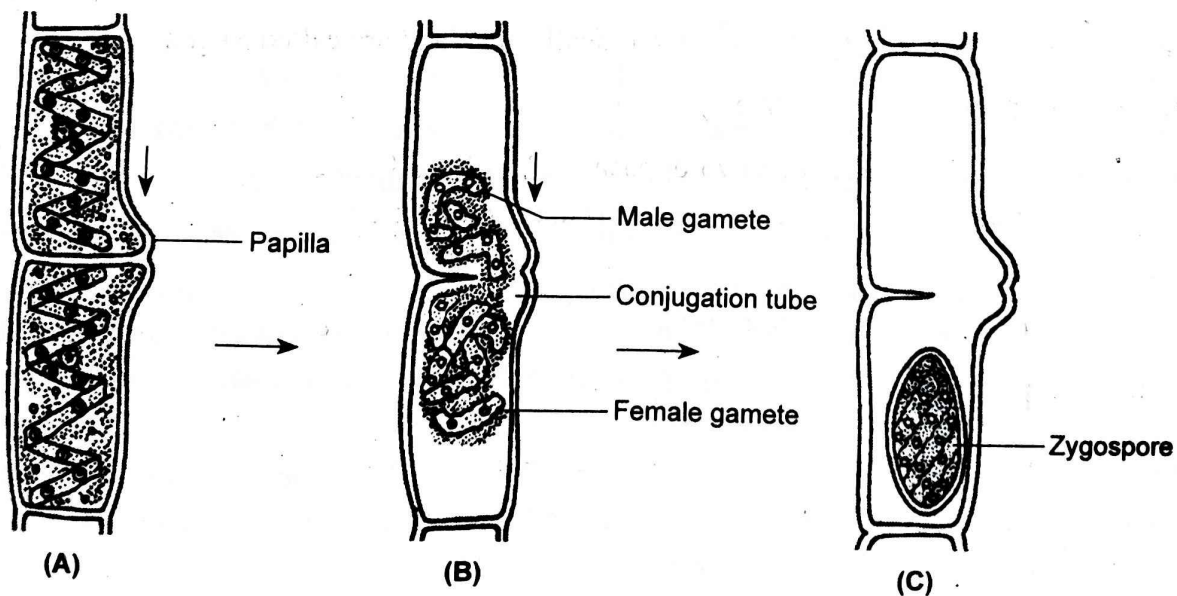
1. Lateral conjugation takes place between the adjacent cells of the same filament.
2. Conjugation tubes are formed between adjoining cells of the same filament. Simultaneously, the two adjacent cells of same filament form the gametes.
3. The gamete, which passes into the another through the conjugation tube is called male gamete while the other which receives the male gamete is called female gamete.
4. The male and female gametes fuse together to form Zygospore.
5. The filament now shows a zygospore in one cell alternating with an adjacent empty cell. Therefore this type of conjugation is called lateral conjugation.

Date

# STUDY OF REPRODUCTION IN SPIROGYRA



## Scalariform Conjugation



## Lateral Conjugation

**OBJECTIVE****STUDY OF VEGETATIVE STRUCTURES OF MARCHANTIA****Requirements**

**Apparatus:** Watch glass, slide, needle, brush, blotting paper, cover slip microscope, permanent slides of V.S. of thallus passing through gemma cup, V.S. of male receptacle, V.S. of female receptacle, V.S. of sporophyte.

**Material:** Fresh or preserved specimen of *Machantia*

**Laboratory work**

1. Take a *Machantia* thallus and observe its different structures like gemma cup, scales, rhizoids, dorsal and ventral surfaces of thallus.
2. Draw neat and sketch diagrams of both ventral (lower) and dorsal (upper) surfaces.
3. Observe and study the male and female thallus with receptacle.
4. Observe and study the V.S. of thallus passing through gemma cup, V.S. of male receptacle, V.S. of female receptacle and V.S. of sporophyte.
5. Draw the necessary diagrams of different reproductive structures of *Marchantia*.

**Comments**

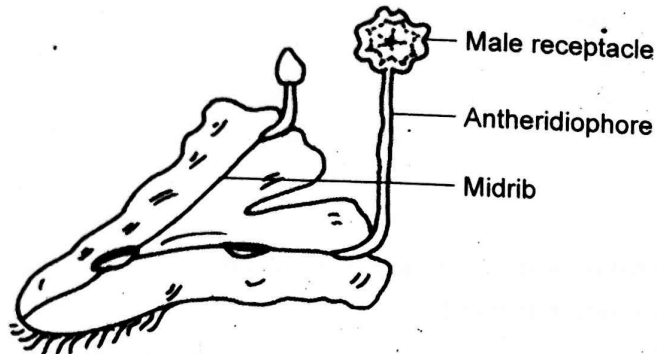
1. *Marchantia* is a common liverwort that grows dense green patches on moist, cool and shady places like rocks, soils, logs of woods, cliffs, tree trunk, bank of streams, etc. It grows well in the burnt soil.
2. *Marchantia* has 65 species and out of which 3 species *Marchantia nepalensis*, *Marchantia polymorpha* and *Marchantia palmata* are reported from Nepal.
3. The plant body of *Marchantia* is a gametophyte which is called a thallus.
4. The thallus is prostrate, dorso-ventrally flattened and dichotomously branched.
5. The thallus is green in colour and has a distinct midrib and an apical notch.
6. The dorsal surface of thallus has conspicuous air chamber and cup like structures the gemma cups.
7. The ventral surface of thallus is provided with two or more rows of scales on either side of the midrib, which protect the growing point. They are two types: ligulate and appendiculated scales. Ligulate scales are smaller, simple without any appendage while the appendiculated scales are larger and bear a small appendage at the broad free end.
8. Rhizoids are unicellular hair like structures with double walled. They are two types: smooth walled rhizoids and tuberculated rhizoids. Smooth walled rhizoids are larger in diameter with smooth walls while the tuberculated rhizoids are smaller in diameter with peg like projections in their inner walls.
9. From the growing point of dorsal surface of thallus, stalked receptacles are borne. The receptacles are of two types. They are antheridophores and archegoniophores that bear corresponding sex organs.

**The Gemma**

*Marchantia* reproduces asexually by special vegetative reproductive bodies, called gemmae. They are produced in large numbers in small gemmae cups. Each gemma has a small stalk and a multicellular, bilaterally symmetrical discoid body. It has two notches on the lateral sides, which are diagonally opposite.

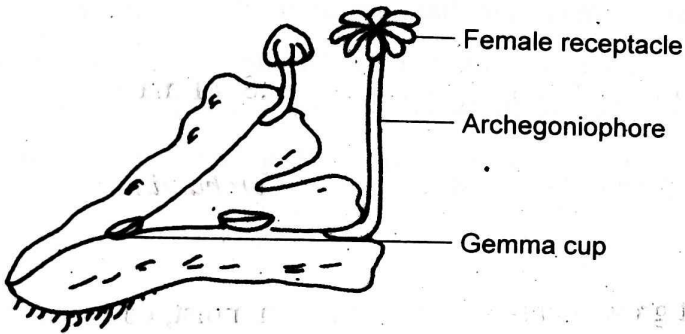
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# STUDY OF VEGETATIVE STRUCTURES OF MARCHANTIA

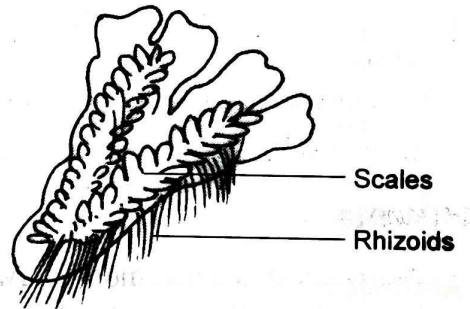


Dorsal Surface of Male Thallus

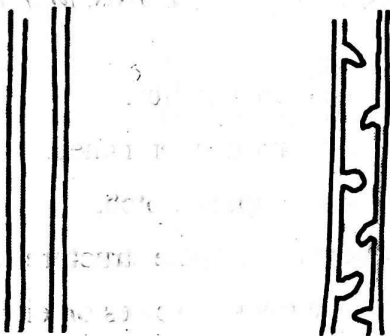
Classification (Five Kingdom)	
Kingdom	- Plantae
Division	- Bryophyta
Class	- Hepataceae
Order	- Marchantiales
Family	- Marchantiaceae
Genus	- <i>Marchantia</i>



Dorsal Surface of Female Thallus



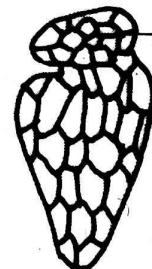
Ventral View of Thallus



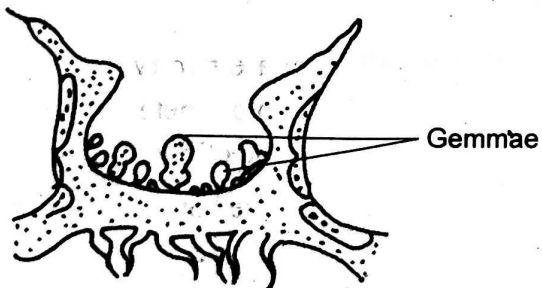
Smooth-walled Rhizoid Tuberculated Rhizoid



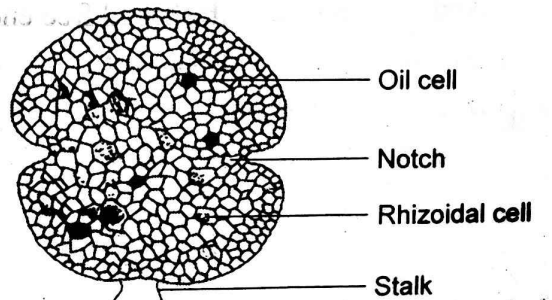
Ligulated Scale



Appendiculated Scale



V.S. of Gemma-cup



Single Gemma

**OBJECTIVE****STUDY OF REPRODUCTIVE STAGES OF MARCHANTIA**

Sexual reproduction of *Marchantia* is **oogamous** type. *Marchantia* are dioecious i.e., male sex organs (**antheridia**) and female sex organs (**archegonia**) develop in separate thalli. The sex organs of *Marchantia* are borne on erect and stalked branches called the gametophores. The gametophore bearing the antheridia is known as **antheridiophore** whereas the gametophore bearing archegonia is called **archegoniophore**.

**Antheridiophore and Antheridium**

1. Antheridiophore has an erect stalk, the tip of which is a flattened, slightly convex, eight lobed peltate disc. Each lobe of the disc has a growing point at its tip.
2. On each lobe of the peltate disc, 10-12 antheridia develop in acropetal succession.
3. The ventral surface of the stalk of antheridiophore bears scales and rhizoids along the two grooves.
4. The internal structure of antheridiophore contains air chambers alternate with the antheridial chamber.
5. Each antheridial chamber is flask-shaped and contains a stalked antheridium, that partially or wholly fills up the chamber. The antheridial chambers open outside by pores called **ostioles**.
6. The mature antheridium is club-shaped and consists of a short stalk and a rounded antheridium proper.
7. The antheridium proper has a single layered jacket. The jacket layer encloses numerous motile, biflagellate antherozoids or male gametes.

**Archegoniophore and Archegonium**

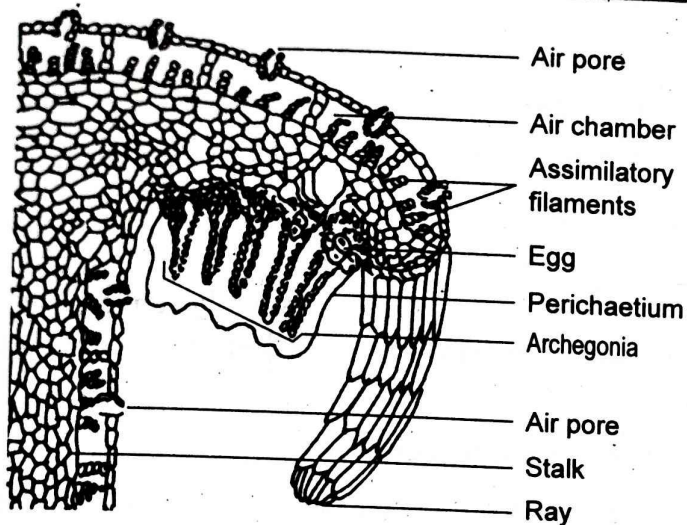
1. The archegoniophore consists of slender stalk and a female receptacle.
2. The stalk of the mature archegoniophore is comparatively longer and stouter than the antheridiophore.
3. The stalk is about 5 to 7 cm long and each surmounted by a lobed disc called the **female receptacle**.
4. The disc is eight-lobed with nine umbrellas like rays drooping down. The archegonia are situated on the dorsal side of each lobe.
5. A vertical section of female receptacle shows the number of archegonia is hanging down in a row.
6. Each lobe contains 11-15 archegonia which are arranged in acropetal succession.
7. All the archegonia are covered by a two-lipped membrane known as **perichaetium** or **involucre**. A cup-shaped outgrowth that surrounds the base of the archegonium is called **perigynium**.
8. The mature archegonium is flask-shaped structure developed on a short stalk. It has swollen **venter** and a long **neck**. The neck enclosing four to six **neck canal cells**. The apical part of neck is covered by four cover cells. The venter has an **egg** and one **venter canal cell**.

**The Sporophyte**

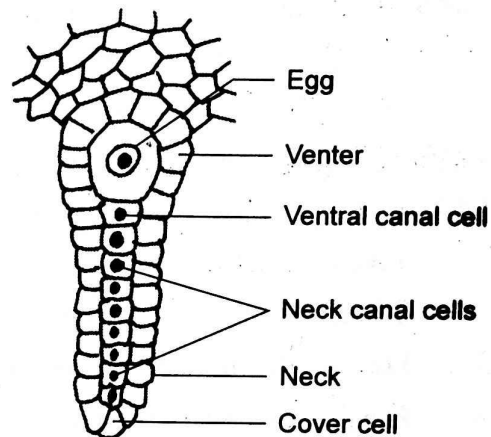
1. The mature sporophyte is an elongated structure that is **differentiated into** definite foot, seta and capsule.
2. Foot is bulbous multicellular expanded structure which is **situated towards** the base of the archegonium.
3. The seta is short, thick stalk and function as **connecting link between** foot and capsule.
4. The capsule is a spherical structure at the **distal end of the sporogonium** and is situated towards the neck of archegonium. It consists of a single **layer thick wall**, the jacket enclosing spores and elaters.
5. The spores are spherical, haploid structures with **two layered** wall the exine and intine.
6. Elaters are long, narrow, spindle-shaped cells with **2-3 spiral bands of thickening** in their inner walls.

Date

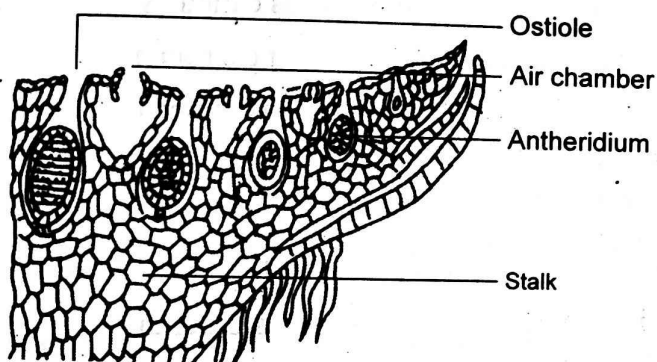
# STUDY OF REPRODUCTIVE STAGES OF MARCHANTIA



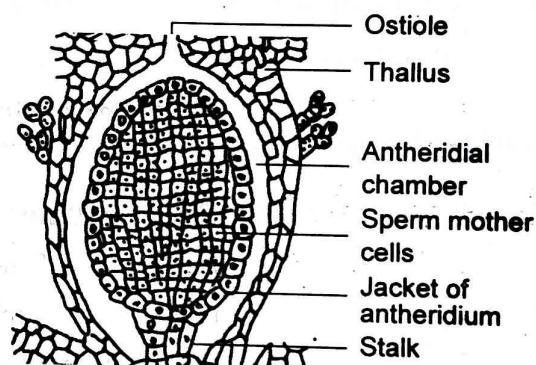
V.S. of Female Receptacle



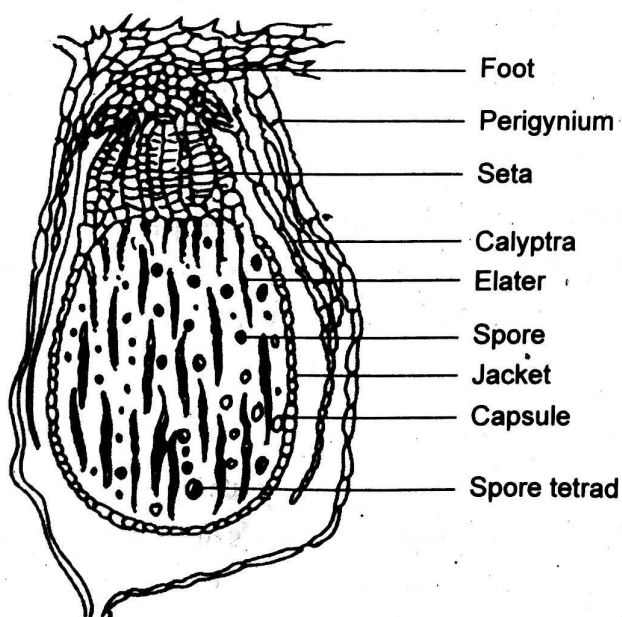
Single Archegonium



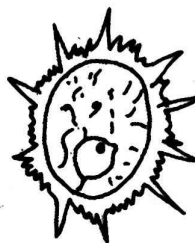
L.S. of Male Receptacle



Single Antheridium



L.S. of Sporophyte



Spore



Elater

**OBJECTIVE****STUDY OF VEGETATIVE STRUCTURES OF FUNARIA****Requirements**

**Apparatus:** Watch glass, needle, brush, dissecting microscope, compound microscope, forceps, permanent slides of V.S. of male shoot, V.S. of female shoot, V.S. of sporophyte.

**Material:** Fresh or preserved specimen of *Funaria* (Moss)

**Laboratory work**

1. Take a moss plant in a watch glass. Observe the vegetative structure and capsule with the help of dissecting microscope and sketch.
2. Identify the male and female plants/male shoot and female shoot.
3. Study and sketch the longitudinal section of head of antheridia and archegonia with the help of permanent slides.
4. Study and draw the vertical section of capsule from permanent slide.
5. Note the structural features of vegetative structures of *Funaria*.

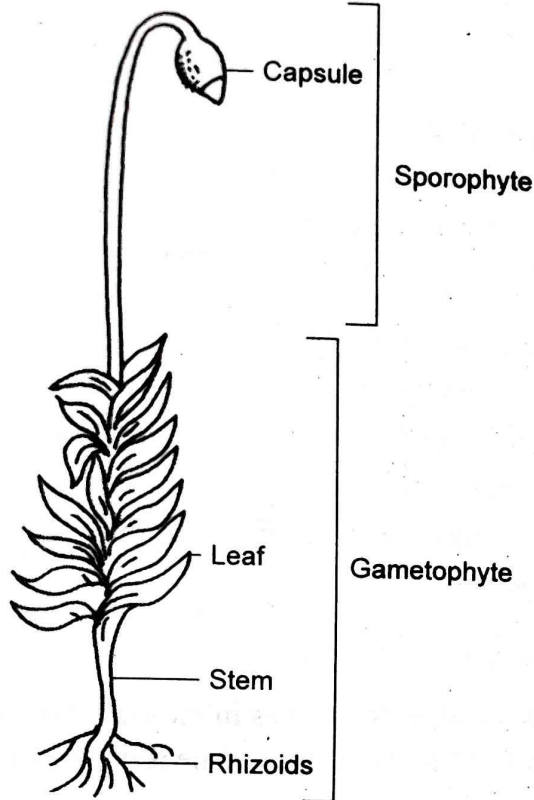
**Comments**

1. *Funaria* is a very common moss which grows luxuriantly in patches in moist, shady places on damp soils, moist rocks, burnt humid soil, and damp walls or on tree trunks in the form of a velvet-like green carpet.
2. The main plant body of moss is gametophyte. The gametophyte has slender, upright, stem like axis which is about 1 to 3 cm long.
3. The plant body is differentiated into rhizoids, stem and leaves.
4. The rhizoids are borne from the basal part of the axis (stem). They are branched multicellular with oblique septa. They are thin-walled and colourless in the young and at maturity they become thick-walled and yellowish brown to dark brown in colour.
5. The main axis or stem is upright, erect, slender and green in colour. A single lateral branch is produced from the lower portion of the main axis. It is surrounded by spirally arranged simple leaves.
7. The leaves are simple, sessile, small and ovate with slightly serrate margins.
8. The leaves are bright green-coloured and spirally arranged on the stem. Each leaf has distinct midrib.
9. The upper leaves are somewhat larger and crowded at the apex of the stem while the lower leaves are smaller and scattered on the stem.
10. The moss plant may be monoecious or dioecious. In case of bisexual plant, the male reproductive organs are borne on the male branch and archegonia on the female branch.
11. The plant bears male and female sex organs in clusters at the tips of the main leafy axis or its branches. The antheridia and the archegonia remain enclosed in the leaves.
12. The mature gametophyte bears a sporophyte. But sporophyte is dependent on the gametophyte.

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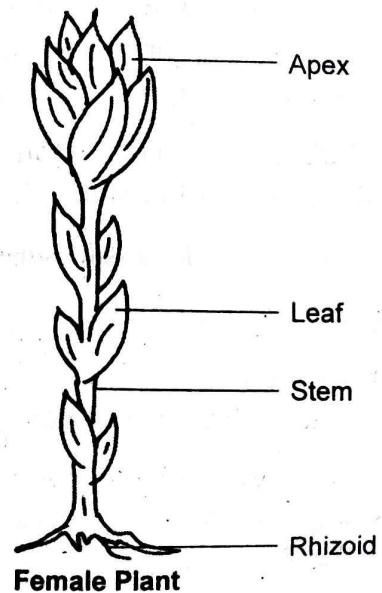
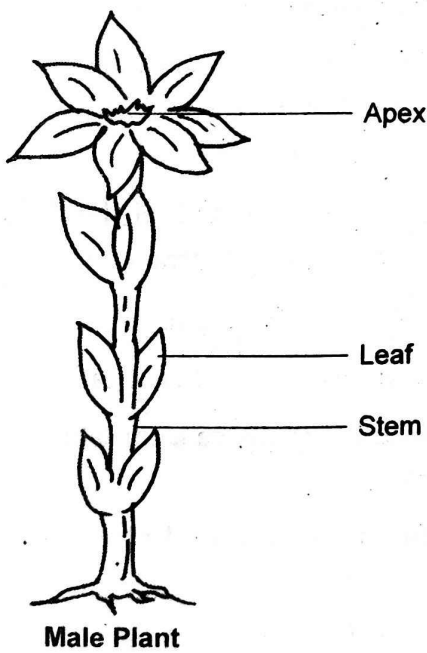
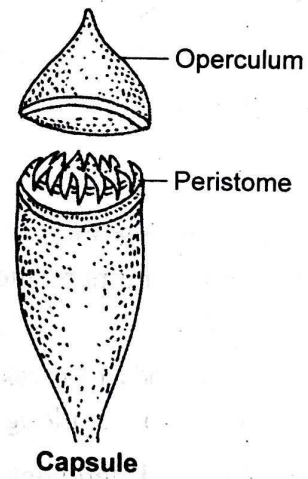
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# STUDY OF VEGETATIVE STRUCTURES OF FUNARIA



Gametophore with Sporophyte

Classification (Five Kingdom)	
Kingdom	- Plantae
Division	- Bryophyta
Class	- Musci
Order	- Funariales
Family	- Funariaceae
Genus	- <i>Funaria</i>



**OBJECTIVE****STUDY OF REPRODUCTIVE STRUCTURES OF FUNARIA****Male branch and Antheridium**

1. Male reproductive organs are the antheridia, which are situated at the apex of male branch and are surrounded by leafy rosettes.
2. The antheridia are intermixed with multicellular hair-like structures called paraphyses.
3. Each antheridium is club-shaped body with a short multicellular stalk and antheridial body.
4. The antheridial wall is single layered which encloses the antherozoids with mucilaginous mass.
5. Antherozoids are minute, spirally coiled and biciliate male gametes.

**Female branch and Archegonium**

1. The female reproductive organs are the archegonia, which are situated at the apex of female branch.
2. Archegonia are interspersed with paraphyses and surrounded by perichaetial leaves.
3. The mature archegonium is a flask-shaped body with a swollen basal venter and long narrow neck.
4. The neck is enclosed by a single layered jacket formed by six vertical rows of neck-cell.
5. The venter contains a naked female gamete, the oosphere and a ventral canal cell.

**The Sporophyte**

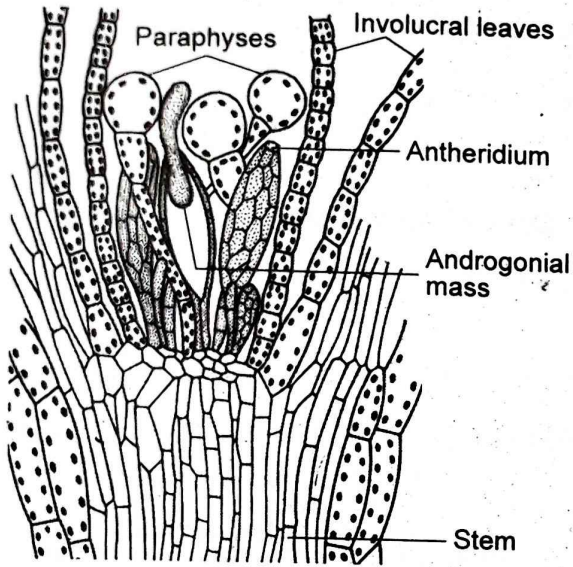
1. The gametophyte bears a partly dependent sporophyte.
2. Sporophyte is differentiated into a conical foot embedded in the tissue of female shoot, a long slender green seta and pear-shaped capsule at the tip. Seta lies in between the capsule and foot.
3. At the apex of the capsule, there is a cap like structure called calyptra.

**The L.S. of capsule shows three parts, i.e., apophysis, theca and operculum.**

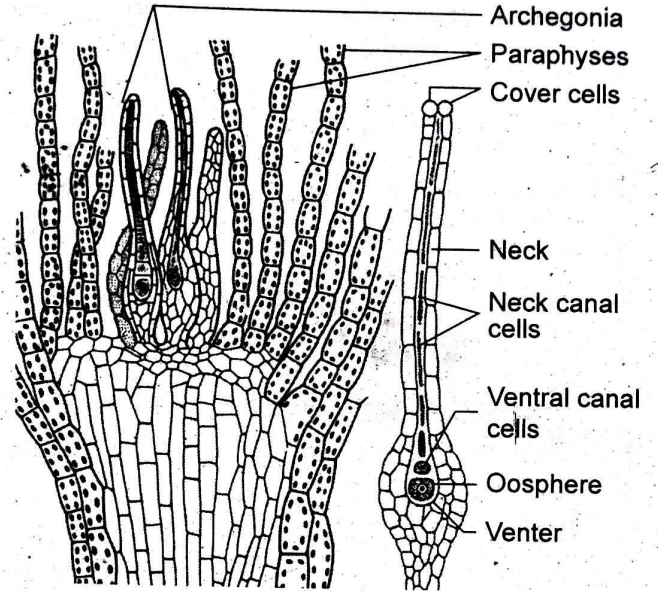
4. Apophysis is the lower region of the capsule which is connected with seta. It has conducting strand and epidermis of this region possesses the stomata. Epidermis is followed by chlorenchyma cells.
5. Theca forms the middle and fertile region of capsule. It consists of following structures:
  - a. Capsule wall: It is made up of single-layered epidermis, two to three-layered hypodermis and few layers of chloroplast containing spongy parenchymatous cells.
  - b. Air space: The spongy parenchymatous tissue is followed by a large cylindrical air-space. It is traversed by branched strands of green cells called the trabeculae.
  - c. Spore sac: It is situated between the air space and columella. The thickness of the wall of spore sac is not uniform. Towards the air cavity, the spore sac is three to four layers in thick while the inner wall is single layered. Spore sac contains haploid spores.
  - d. Columella: It forms the sterile solid central portion of capsule. Its lower portion is in continuation with the apophysis. This region contains colourless parenchyma cells.
6. Operculum is a cap like structure found at the tip of the capsule. It is four to five cells in thickness. It is associated with annulus and peristome.
  - a. Annulus: It is a ring of cutinized epidermal cells, lies between the base of operculum and rim.
  - b. Peristome: These occur below the cavity of operculum and are attached below the edges of rim. These teeth are multicellular and pointing inwards. These peristomial teeth are 32 in number.

Date

# STUDY OF REPRODUCTIVE STRUCTURES OF FUNARIA

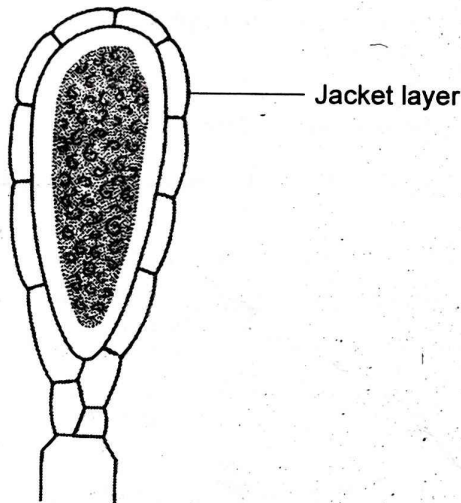


Apex of a Male Shoot in L.S.



Apex of Female Shoot in L.S.

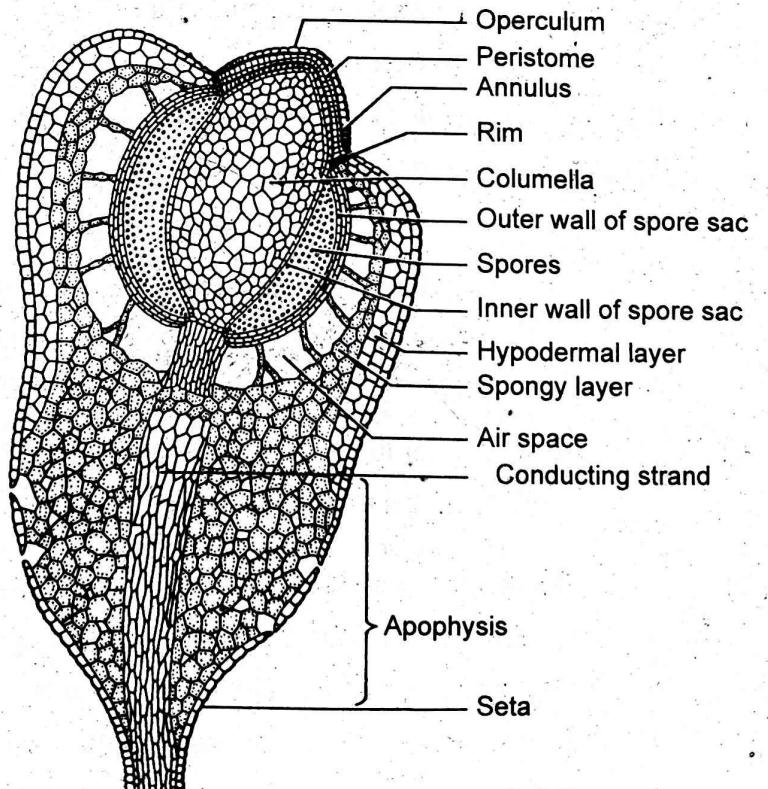
An Archegonium



An Antheridium



Antherozoid



L.S. of Capsule

**OBJECTIVE****STUDY OF VEGETATIVE AND REPRODUCTIVE STRUCTURES OF DRYOPTERIS****Requirements**

**Apparatus:** Watch glass, needle, brush, dissecting microscope, compound microscope, forceps, permanent slides of V.S. of sporophyll through sori, prothallus, antheridium, archegonium.

**Material:** Fresh or preserved specimen of *Dryopteris* (fern)

**Laboratory work**

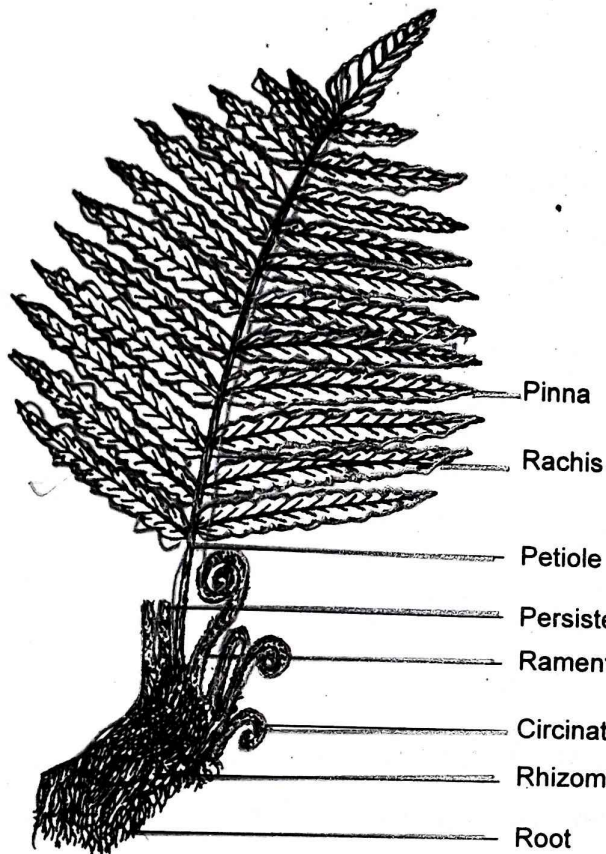
1. Observe a fern plant and sporophyll thoroughly. Draw a labelled diagram of a fern plant and sporophyll.
2. Study and draw a whole structure of prothallus with the help of permanent slide mounted under the dissecting microscope.
3. Study and sketch the antheridium and archegonium with the help of permanent slides.
4. Note all the structural features of vegetative and reproductive stages of fern.

**Comments**

1. Ferns are the first terrestrial land plants that grow in moist, cool and shady moist places both on the hills and plains.
2. The plant body of fern is the sporophyte and differentiated into roots, stem (rhizome) and leaves.
3. The roots are adventitious arising from the lower surface of underground rhizome of sporophyte.
4. The stem is obliquely placed beneath the surface of soil, is called rhizome.
5. The leaves are normally pinnately compound and are borne alternately on the upper surface of a rhizome. Leaves are separated from each other by long internodes.
6. The young leaves show circinate venation and are covered with brownish hairs calledramenta.
7. The fern plant is a sporophyte that reproduces asexually by means of spores.
8. The spores are produced in spore sacs known as sporangia which appear in dark brown structures. The sporangia are found in clusters called sori and develop on the under surface of the leaflets of a leaf. The leaflets contain sori and the leaf with sori is known as sporophyll. A vertical section of sporophyll of *Dryopteris* shows the globular sporangia on placenta.
9. Each dark brown spot under the microscope shows a group of stalked sporangia. The sporangia are present on the placenta.
10. The groups of sporangia are enclosed with a membrane called indusium.
11. Each sporangium consists of a long slender multicellular stalk and a biconvex capsule.
12. The capsule wall is single layered of sterile cells. The capsule wall has ring of specially thickened and cutinized cells running round its margin, this is called annulus.
13. The two ends of the annulus are connected by large thin-walled cells called stomium. A mature sporangium dehisces at the stomium under dry conditions.
14. Each sporangium contains 32 to 64 spores, which are minute, little bit triangular shape and dark brown in colour.

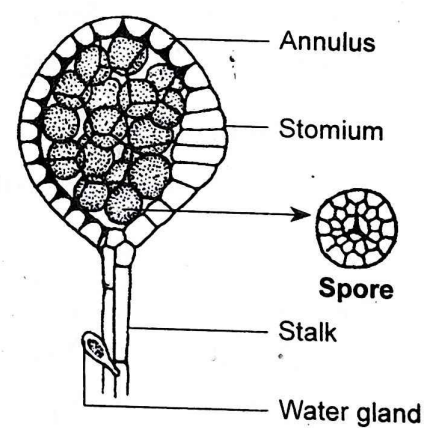
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# STUDY OF VEGETATIVE AND REPRODUCTIVE STRUCTURES OF DRYOPTERIS

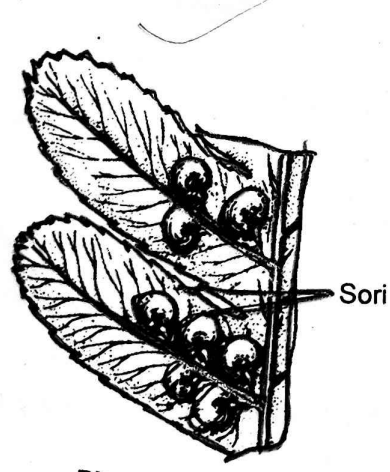


A Sporophyte of Dryopteris

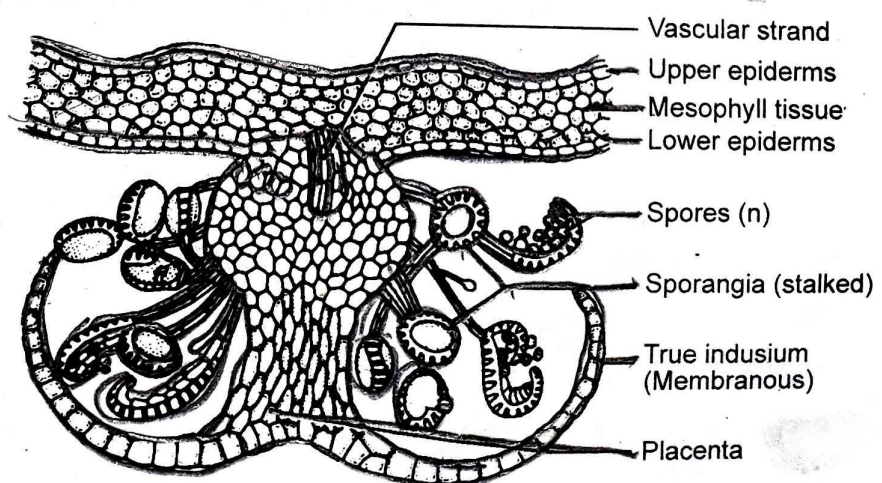
Classification (Five Kingdom)	
Kingdom	- Plantae
Division	- Tracheopyta
Sub-division	- Pteridophyta
Class	- Pteropsida
Order	- Filicales
Family	- Polypodiaceae
Genus	- <i>Dryopteris</i>



A Sporangium



Pinnae with sori



V.S. of Fertile Pinna Showing Sporangia

**OBJECTIVE****STUDY OF REPRODUCTIVE STRUCTURES OF DRYOPTERIS****Prothallus**

1. The prothallus constitutes the gametophyte of the ferns which is a haploid stage.
2. The mature prothallus has several cells thick in the middle region behind the apical notch but the marginal part of the prothallus has one cell in thickness.
3. It is green, heart-shaped, thin, flat and multicellular structure.
4. It contains a deep notch at its anterior end below which lies growing apex.
5. All the cells of prothallus contain chloroplast and can prepare their food by the photosynthesis process. Thus, the prothallus is independent and the mode of nutrition is autotrophic.
6. The prothallus of *Dryopteris* is monoecious i.e, it bears both sex organs, male antheridia and female archegonia.
7. The sex organs and the rhizoids are situated on the ventral side of the prothallus.
8. The archegonia develop near the apical notch and the antheridia develop below the archegonia or near the posterior end where the unicellular, brown tubular rhizoids are present.

**The antheridium**

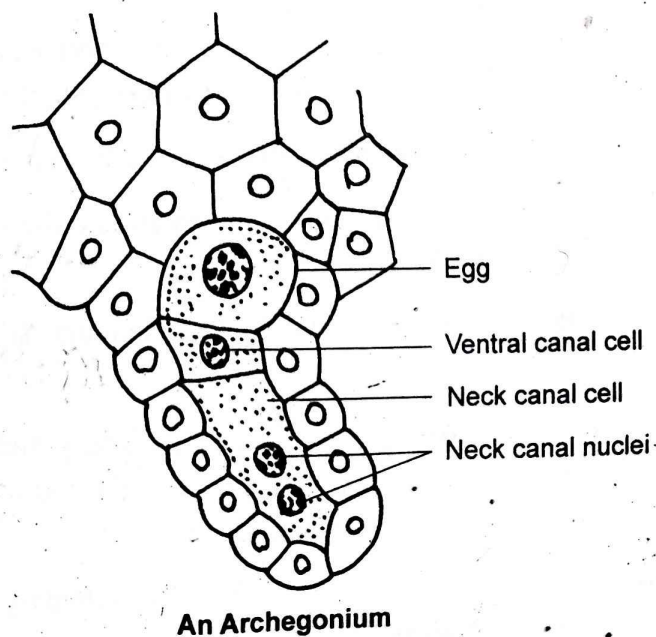
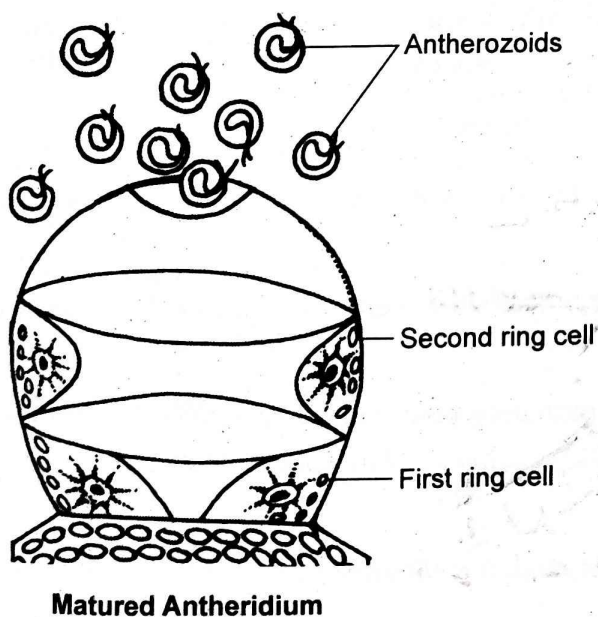
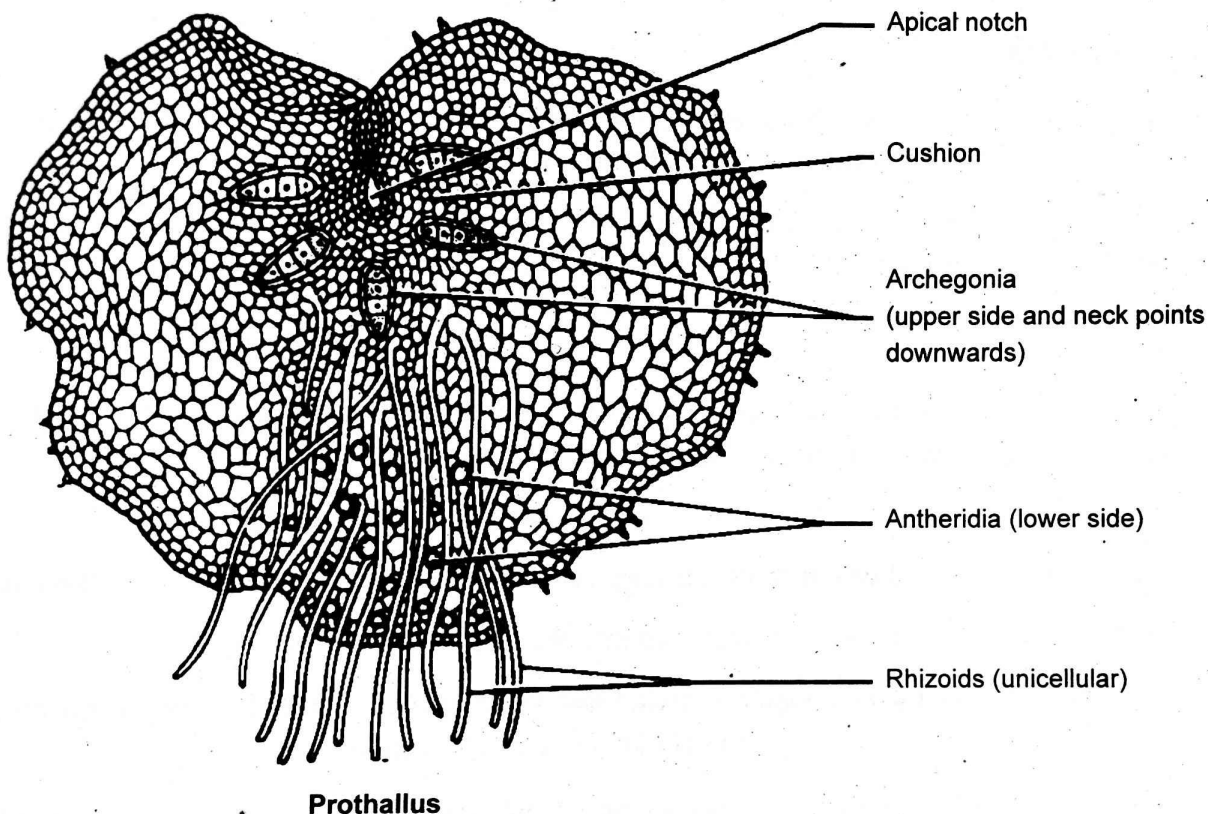
1. The antheridia are the male reproductive organs.
2. Each antheridium is a hemispherical sessile and multicellular structure.
3. The mature antheridium consists of a semi-transparent jacket layer composed of two ring-shaped cells, and either one or two cap cells.
4. Each antheridium consists of a wall made up of three cells surrounding a cavity, in which many antherozoids are found.
5. The antherozoids are large, spirally coiled and bear numerous flagella.

**The Archegonium**

1. The archegonia are the female reproductive organs.
2. They appear on the prothallus later than the antheridia.
3. They appear in a cluster of 4-12 numbers upon the massive cushion just behind the apical notch.
4. The mature archegonium is sessile, flask-shaped multicellular structure with a swollen venter and a short-curved neck.
5. The venter is deeply sunken in the tissue of prothallus. It contains an egg or female gamete and a small ventral canal cell.
6. There is no jacket in the venter of archegonium but the neck consists of a jacket of four vertical rows of cells. It encloses only one binucleated neck canal cell.

Date

# STUDY OF REPRODUCTIVE STRUCTURES OF DRYOPTERIS



**OBJECTIVE****STUDY OF MORPHOLOGICAL STRUCTURES OF *CYCAS*****Requirement**

**Material:** A potted *Cycas* plant, fresh or preserved coralloid root, a foliage leaf

**Laboratory work**

1. Take a potted *Cycas* plant, preserved or fresh coralloid root and a foliage leaf from your locality and observe the different morphological features.
2. Study all the parts of the *Cycas* thoroughly and draw labelled diagrams. Note the important morphological features.

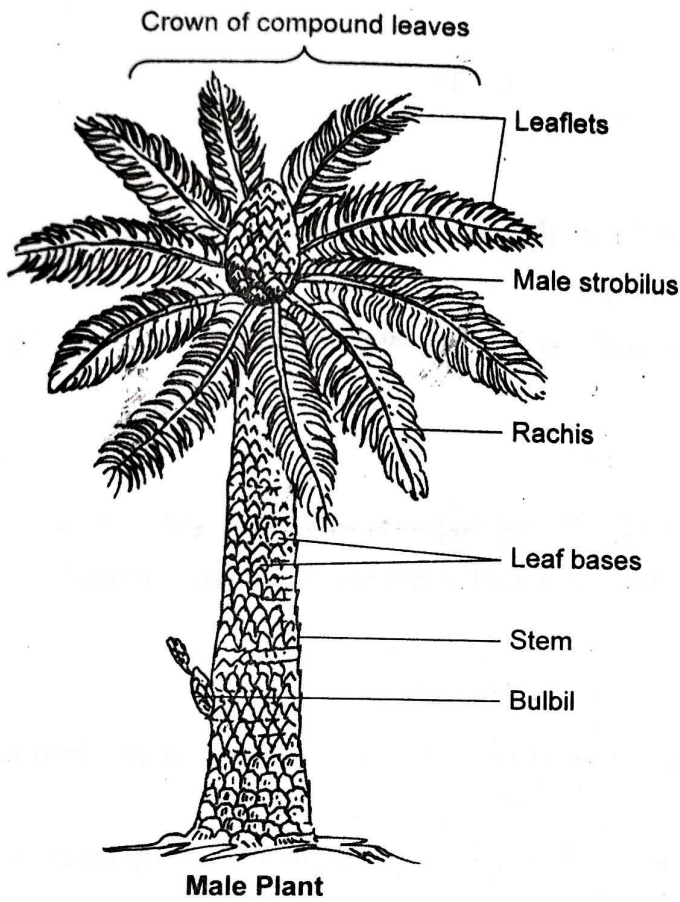
**Comments**

1. The *Cycas* is a slow growing evergreen; shrubby gymnospermic plant grows on wild or cultivated in tropical and sub-tropical regions of the world.
2. The plant is sporophyte ( $2n$ ) and is differentiated into root, stem and leaf.
3. The *Cycas* bears two types of roots: primary or normal root and secondary or coralloid root.
4. The primary root is tap root growing deep into the soil.
5. The coralloid roots are lateral stumpy dichotomously branched, coral like roots. These roots are green in colour and are provided with lenticel like aperture for respiration.
6. Coralloid roots are geotropic in nature as they grow upwards on the surface of soil or parallel to the surface of soil.
7. The stem is stout, erect, columnar, unbranched, woody and arborescent i.e., stem bearing at the apex a crown of leaves in apparent whorls. So, the plant looks like a palm or tree fern.
8. The stem is covered with armour or persistent leaf bases.
9. The leaves are spirally arranged around the stem. The leaves are dimorphic i.e., of two types: foliage leaves and scale leaves.
10. The scale leaves are small, dry, triangular and persistent, covered with brown hairs. They protect the foliage leaves in bud stage.
11. Foliage leaves are green, thick, leathery and pinnately compound and consists of three parts. They are rhomboidal shaped leaf base, thick and woody rachis and lanceolate leaflets or pinnae. The foliage leaves function as assimilatory.
12. The foliage leaves are attached to the stem by expanded leaf bases. It has distinct midrib and numerous leaflets. Lateral veins are absent.
14. The leaflets are attached to the midrib by rachis.
15. The young leaves exhibit circinate venation.

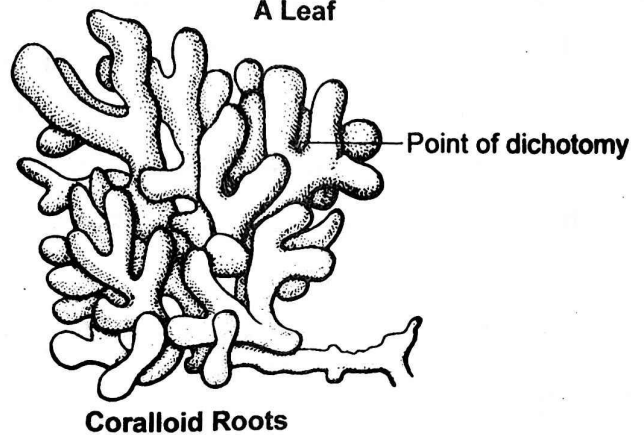
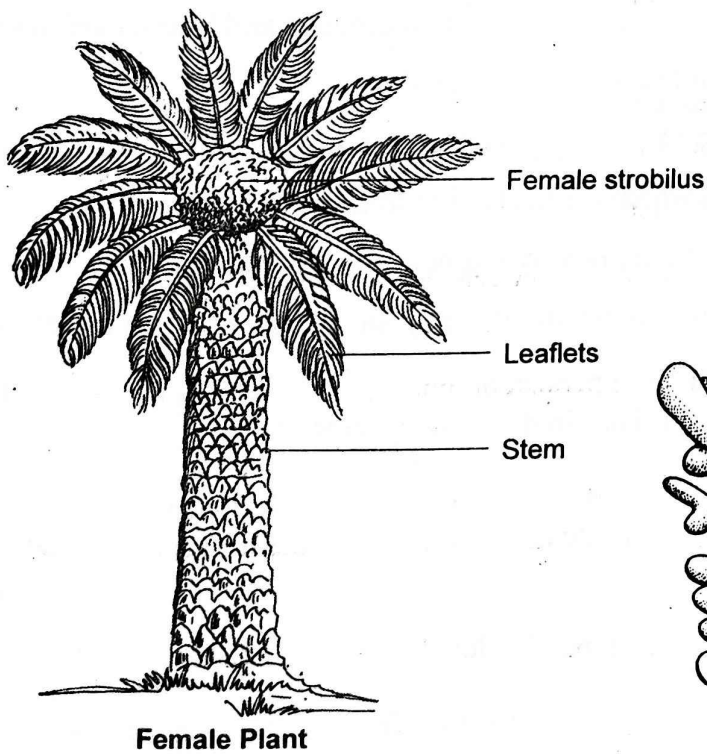
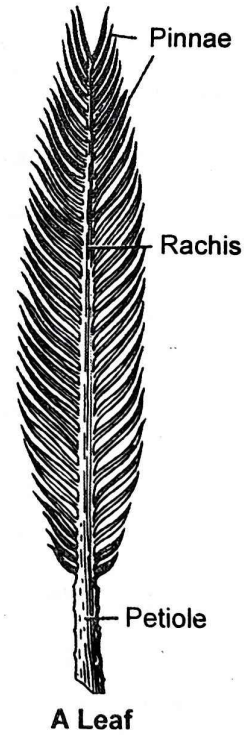
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Date

# STUDY OF MORPHOLOGICAL STRUCTURES OF CYCAS



Classification (Five Kingdom)	
Kingdom	- Plantae
Division	- Tracheopyta
Sub-division	- Spermatophyta
Class	- Gymnospermae
Order	- Cycadales
Family	- Cycadaceae
Genus	- <i>Cycas</i>



**OBJECTIVE****TO STUDY THE MORPHOLOGICAL STRUCTURES OF *PINUS*****Requirements**

**Material:** A young twig of *Pinus* tree

**Laboratory work**

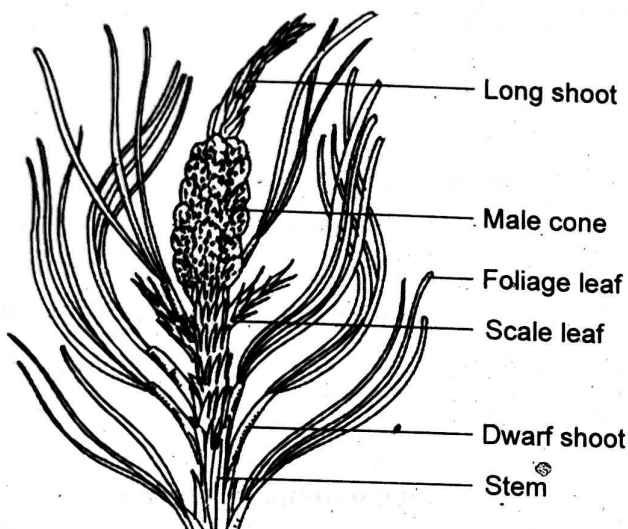
1. Take a twig of *Pinus* plant and observe thoroughly.
2. Separate a dwarf shoot and scales from a twig and observe them.
3. Study all the parts of the *Pinus* thoroughly and draw labelled diagrams. Note the important morphological features.

**Comments**

1. The *Pinus* is a perennial, tall, graceful, xerophytic, evergreen gymnospermous tree.
2. The plant body of *Pinus* is a sporophyte and is differentiated into root, stem and leaf.
3. It has tap root system.
4. The main stem is strong and upright covered with scaly bark.
5. The lateral branches are almost horizontal with gradual decrease in their length from lower to the upper regions giving a cone like appearance to the tree.
6. The stem give off two types of branches: the branches of unlimited growth or long shoots and branches of limited growth or dwarf shoots.
7. Long shoot branches are the main branches which are non-deciduous and bear dwarf shoots.
8. Dwarf shoot branches are deciduous and are shed with needles.
9. The leaves of *Pinus* are dimorphorphic i.e., two types of leaves: foliage leaves and scale leaves.
10. The long shoot bears only scale leaves which are protective in function.
11. The scale leaves or cataphylls are small thin, brown and non-photosynthetic.
12. The foliage leaves are borne only on the dwarf shoot. They are green, long and narrow needle like. They help in photosynthesis.
13. The number of needles in dwarf shoots is fixed in different species of *Pinus*.
  - a. *Pinus monophylla* - One needle
  - b. *Pinus sylvestris* - Two needles
  - c. *Pinus roxburghii*- Three needles
  - d. *Pinus wallichiana*- Five needles:
15. The base of each cluster of needles is surrounded by a thin, dry membranous sheath.
16. The needles are persistent.
14. The *Pinus* is monoecious plant i.e., the male and the female cones are developed in the same plant.

Date

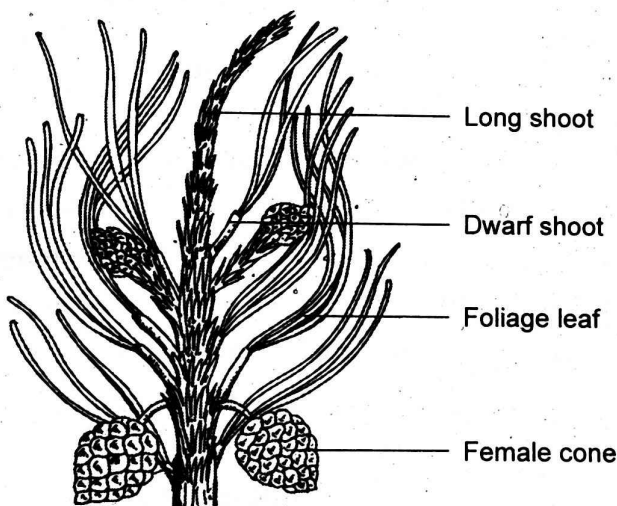
# STUDY OF MORPHOLOGICAL STRUCTURES OF PINUS



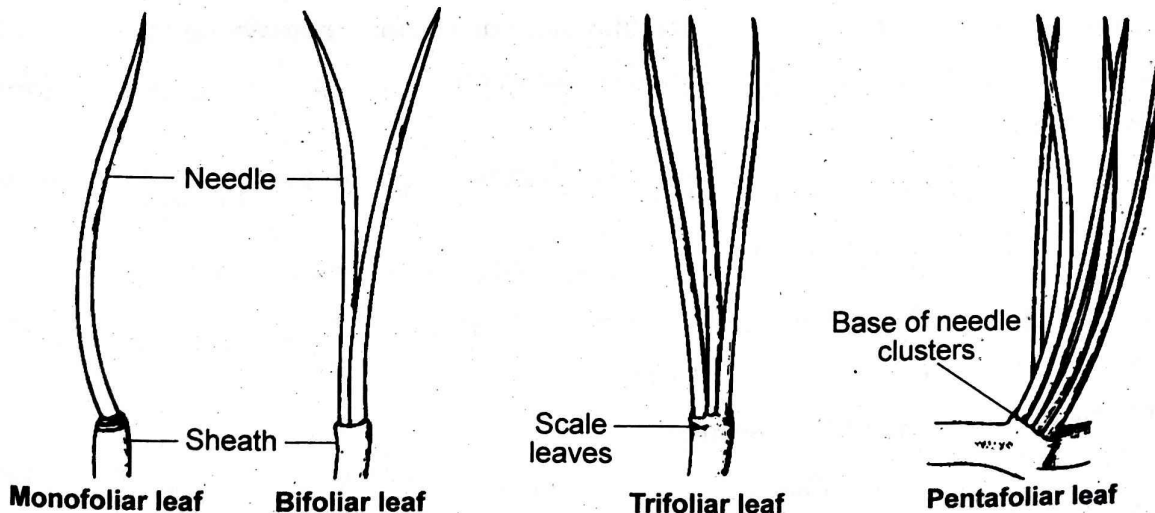
A Twig of *Pinus* with Male Cone

### Classification (Five Kingdom)

Kingdom	-	Plantae
Division	-	Tracheopyta
Sub-division	-	Spermatophyta
Class	-	Gymnospermae
Order	-	Coniferales
Family	-	Pinaceae
Genus	-	<i>Pinus</i>



A Twig of *Pinus* with Female Cone



# LICHENS

The lichens are a distinct group of plants or dual plants having a composite structure consisting of two dissimilar organisms—fungus and alga. These two organisms are associated so intimately so that they appear to be a single organism. The fungus taking part in the formation of lichens is called 'mycobiont' and the algal component is called the 'phycobiont'. Major portion of the lichen thallus is made up of the fungus and the alga is embedded in it. The alga synthesizes organic food for itself and for the fungus. In turn, mycobiont protects the alga, absorbs water and minerals for the lichens and attaches the thallus to the substratum.

## OBJECTIVE

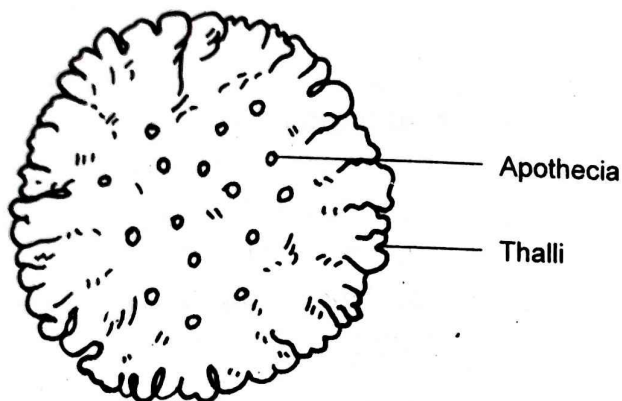
### STUDY OF MORPHOLOGICAL STRUCTURES OF LICHENS

1. Lichens are unique plants composed of algae and fungi. The algae and fungi live together in intimate relationship in lichens. Thus, lichens are dual organism.
3. They are cosmopolitan in distribution found from sea-shore to high mountain in varied climatic range on various substratum like rocks, old walls, branches of shrubs and trees, trunk of trees, soil, etc.
4. They are found in grayish green, greenish-white to yellow, orange, brown, red or black in colour. Some common genera found in Nepal are *Graphis*, *Lecanora*, *Parmelia*, *Cladonia*, *Usnea*, etc.
5. The plant body of lichens is a thallus which is highly diverse in form and habitat.
6. Based on the habit of growth, form and pattern of attachment to the substratum, lichens are;
  - A. Crustose (crustaceous lichens) lichens**
    1. The thallus is flat, thin irregular and poorly developed. This lichen is also called encrusting lichen.
    2. It is just like a crust closely attached to the substratum.
    3. The surface of thallus is usually divided into more or less hexagonal areas called the areolae  
Example: *Graphis*, *Lecanora*, *Lecidea*, *Verrucaria*, etc.
  - B. Foliose (Foliaceous) lichens**
    1. The thallus is flat, broad and much lobed which grows more or less free on the substratum.
    3. It has got distinct upper and lower surfaces.
    4. The thallus attaches to the substratum by rhizoid-like outgrowths called the rhizinae.
    5. The upper surface of the thallus bears a number of cup like fruiting bodies called apothecia.  
Example, *Parmelia*, *Physcia* and *Peltigera*, etc.
  - C. Fructose (Fruticose lichens)**
    1. Thallus is most complex, composed of slender cylindrical or flattened free bushy or erect or pendent branches.
    2. It gets attached to the substratum by a stand of basal hyphae.
    3. The thallus is not differentiated into upper and lower surfaces.
    4. The tip of branches bear fruiting bodies, the apothecia. Example, *Usnea*, *Cladonia* (reindeer moss).

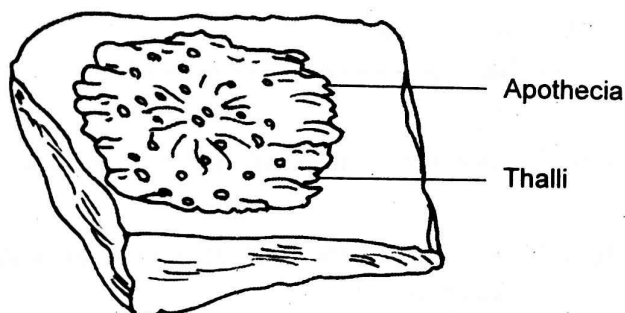
Date

# STUDY OF DIFFERENT TYPES OF LICHENS

## Crustose Lichen

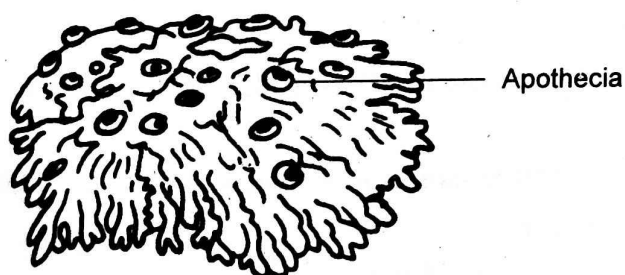


*Graphis*

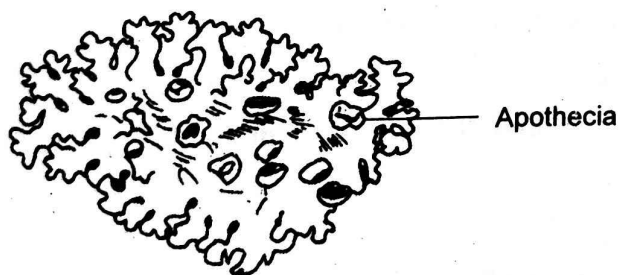


*Verrucaria*

## Foliose Lichen



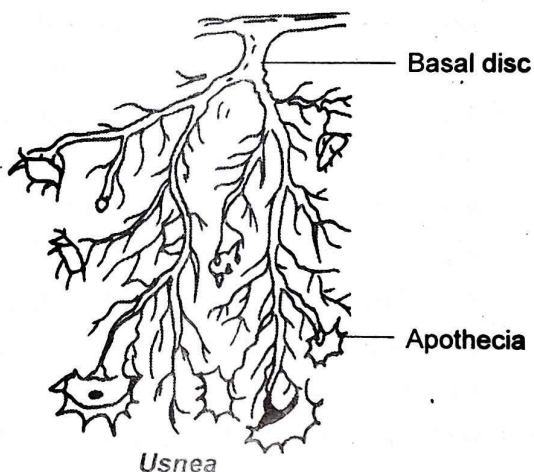
*Physcia*



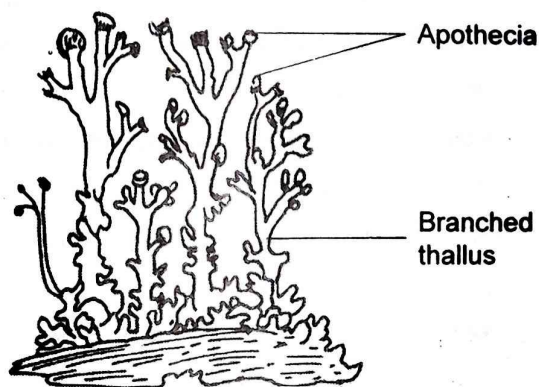
*Parmelia*

Classification (Five Kingdom)	
Kingdom	- Plante
Division	- Lichenes
Type	- Lichens

## Fructose Lichen



*Usnea*



*Cladonia*

## Viva Questions

Students must remember

1. What are the main characteristic features of kingdom plantae?  
**Ans:** The cell wall is made up of cellulose.
2. Write the photosynthetic pigments of chlorophyceae.  
**Ans:** The pigments are chlorophyll -a, chlorophyll -b and small amounts of carotenoids.
3. How does *Spirogyra* get its name?  
**Ans:** *Spirogyra* is common fresh water, green algae, abundantly grow in spring season. It gets its name due to presence of spirally coiled ribbon shaped chloroplast.
4. How does sexual reproduction occur in *Spirogyra*?  
**Ans:** Sexual reproduction in *Spirogyra* takes place by conjugation.
5. Why are bryophytes called amphibian plants?  
**Ans:** Bryophytes are commonly known as "Amphibians plants because they need water for fertilization.
6. Does the life cycle of bryophytes show alternation of generation?  
**Ans:** Yes, the life- cycle of a bryophyte shows regular alternation of gametophyte and sporophytic generation.
7. What is gemma?  
**Ans:** Gemma is a special mode of vegetative reproduction in some *Marchantia*.
8. Write about the plant body of Moss.  
**Ans:** The plant body of Moss is gametophore which is differentiated into rhizoids, axis and leaves.
9. Write about the plant body of fern.  
**Ans:** The plant body of fern is sporophytic. It is differentiated into root, rhizome and leaves.
10. What do you mean by fronds?  
**Ans:** The leaves of fern are long much divided and are usually called fronds.
11. What are first vascular plants?  
**Ans:** Pteridophytes are first vascular plants.
12. How many types of leaves are found in *Pinus*?  
**Ans:** *Pinus* bears two types of leaves (i) Scale leaves and (ii) Foliage leaves.
13. Describe the foliage leaf of *Pinus*.  
**Ans:** The foliage leaves are green, acicular and needle like. It shows xerophytic adaptation.
14. Define thallus.  
**Ans:** A non- vascular, undifferentiated plant body is called thallus.
15. Define zygospore.  
**Ans:** Thick walled, non-motile, diploid spore is called zygospore.
15. Define sporophyll.  
**Ans:** Sporangia bearing leaves are known as sporophyll.
17. Define prothallus.  
**Ans:** A flat, heart shaped gametophyte of fern is called prothallus.
18. Name the three groups in which plant kingdom can be classified.  
**Ans:** Algae, Bryophyta and Tracheophyta
19. Name three types of lichens.  
**Ans:** Crustose, foliose and fructose

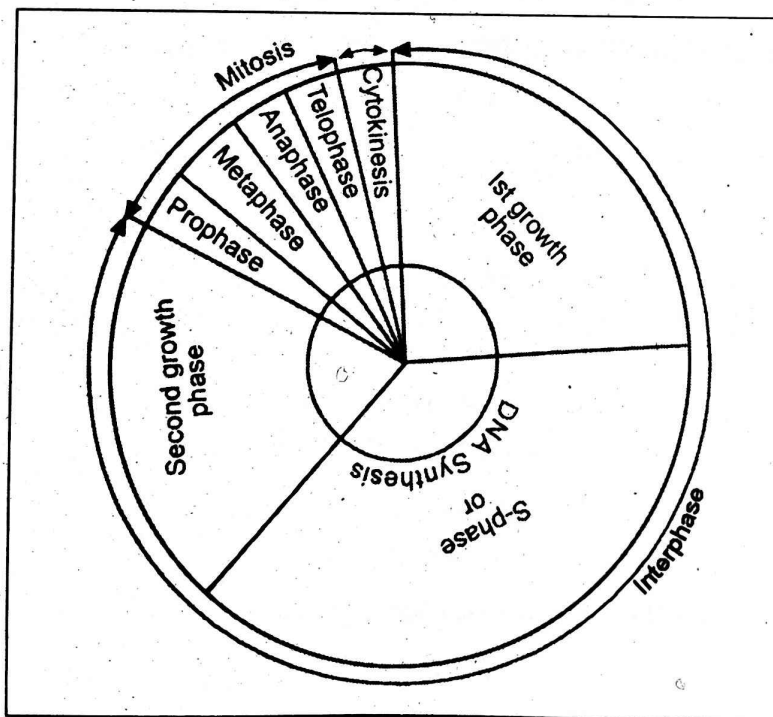
## CELL DIVISION

The cell division is a process by which a mature cell divides and forms new or daughter cells which resemble the mother cell in a number of characters. The division of the cell is achieved by the division of the nucleus, i.e., karyokinesis and the division of the cytoplasm i.e., cytokinesis.

The cell cycle is defined as the history of a cell from the time of its formation by mitosis division to the completion of its own division into two daughter cells. In other word, the cell cycle may be defined as the ordered sets of events which occur between two successive cell divisions. It comprises two phases: Interphase and M-phase.

### Interphase

It is the stage between the ends of one cell division to the beginning of next cell division. In this stage the cell looks restive but metabolically and synthetically very active because the cell prepares itself for next cell division by various biosynthetic activities. On the basis of synthetic activities, interphase can further be divided into three sub-phases.



Cell Cycle

1. **Gap-one or  $G_1$  or First growth phase:** It is also called post-mitotic or pre-synthetic phase. It involves:
  - a. An active synthesis of RNAs, carbohydrates and lipids occurs.
  - b. The nucleus and cell grow in size.
  - c. Cell produces structural and functional proteins.

2. **Synthetic phase or S-phase:** It is characterized by:
- Replication of DNA into daughter DNA molecules. Thus the DNA content gets doubled.
  - Histone protein is synthesized and covers each DNA.
  - Replicated DNA appears as new chromatin fibres, which are actually elongated chromosome.
  - Each chromosome comes to have two chromatids which remain attached at a centromere.
3. **Gap-two or  $G_2$  or 2nd growth phase:** It is characterized by:
- Synthesis of spindle proteins occurs.
  - Synthesis of three types of RNA molecules on DNA.
  - Synthesis and storage of ATP molecules for M-phase.
  - Duplication of mitochondria, plastids and centrioles.

### M - Phase

It represents the phase of actual division. It consists of two phases: karyokinesis and cytokinesis. In karyokinesis, the replication and distribution of chromosomes is completed in four stages. They are prophase, metaphase, anaphase and telophase. In cytokinesis, the division of cell cytoplasm into two daughter cells occurs. After M-phase, exactly same hereditary information is distributed in the daughter cells.

The duration of cell cycle depends upon the type of cell and external factors such as temperature, food and oxygen supply. The duration of cell cycle for some cells is given below.

- Bacterial cells divide in every 20 minutes.
- The epithelial cells of intestinal wall divide in the period of 8-10 hrs.
- The onion root tip cells complete their cell cycle in 20 hours.

This indicates that time required for every stage has been pre-set within the cell.

### Types of Cell Division

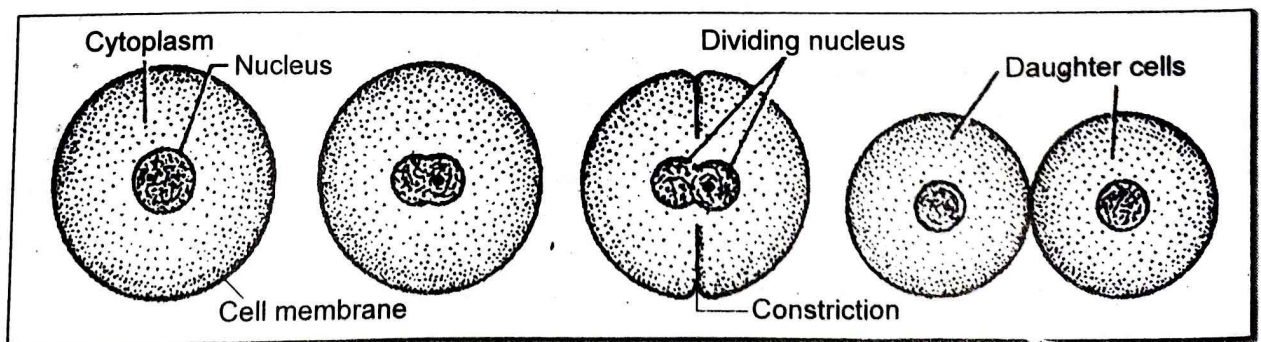
The cells may divide by any of the following three methods:

- Amitosis cell division
- Mitosis cell division and
- Meiosis cell division

### Amitosis Cell Division

It is a simple and most primitive type of cell division. The amitosis is the means of asexual reproduction commonly occurs in some protozoans, bacteria, yeast, etc. Following events occur in this process.

- The nucleus first elongates and constricts in the middle.
- Elongation of nucleus divides it into two daughter nuclei.
- Simultaneously, cytoplasm also divides the cell into two equal or approximately equal halves.



Process of amitosis

**OBJECTIVE****STUDY OF THE MITOSIS CELL DIVISION THROUGH PERMANENT SLIDES**

Mitosis is a type of cell division in which a single cell divides to form two daughter cells, each cell having the same number of chromosomes as present in parent cell. It occurs in vegetative or somatic cells, so it is also called somatic or vegetative cell division. Mitosis is completed in three main phases: interphase, karyokinesis and cytokinesis.

**A. Interphase:** It is the resting phase in which no visible changes occur in the nucleus but cell is metabolically active. The features of this stage are as follows:

1. Cell has a large nucleus with intact nuclear membrane and distinct nucleolus.
2. Chromosomes are not visible because they are uncoiled, long and very fine fibres of granular materials, called chromatin fibres.
3. DNA of chromosome is replicated into exact copies.
4. The size of the nucleus and cell enlarge.
5. The cell is metabolically very active.

**B. Karyokinesis:** It is the division of the nucleus in which a nucleus indirectly divides into two daughter nuclei. It is completed in four stages: prophase, metaphase, anaphase and telophase.

**a. Prophase**

1. Chromatin fibres begin to condense and become visible in the light microscope as chromosomes.
2. Chromosomes become distinct due to shortening and thickening and loss of water.
3. Each chromosome appears to consist of two chromatids due to longitudinal splitting.
4. The chromatids remain attached together at the centromere.
5. Nuclear membrane and nucleolus begins to disorganize and disappear by the end of this phase.

**c. Metaphase**

1. The nuclear membrane and nucleolus disappear.
2. The spindle fibres appearing at two opposite poles and get attached to centromere of chromosomes.
3. All the chromosomes come to lie at the equator of the cell in a single line.
4. Chromosomes are distinctly visible in this phase and thus they can easily be counted and their shape and size can be determined.
5. The centromeres get arranged together to form plate like structure, the metaphase plate, while their arms may extend outside the plate.

**d. Anaphase**

1. The centromeres of chromosomes split longitudinally so that two sister chromatids separate from each other.
2. Each chromatid has got its own centromere and known as daughter chromosomes.

3. Daughter chromosomes migrate towards the opposite poles by the contraction of spindle fibres.
4. The arms of the chromosomes are directed towards the equator and centromeres towards the pole.
5. During their migration, the centromeres again remain foremost so that the chromosomes characteristically appear as J, U, L or V shaped.

In anaphase, the nuclear matter is divided into two equal and similar halves, thus called equational division.

#### e. Telophase

1. All the daughter chromosomes reach to their respective poles and get organized into nucleus.
2. Chromosomes begin to uncoil and they form long thread chromatin fibres due to absorption of water.
3. The spindle fibres disintegrate and the centrioles replicate.
4. Nuclear membrane appears around each group of chromosomes and the nucleoli reappear.
5. Spindle fibres disappear completely around the pole.

Thus, the two daughter nuclei are formed at the end of telophase.

- C. **Cytokinesis:** Cytokinesis is the division of cytoplasm by the formation of cell wall. This stage normally follows telophase and leads interphase. It occurs by the formation of a cell plate in plant cell. After cytokinesis, two daughter cells are formed from single parent cell.

### Significance of Mitosis

1. Mitosis maintains the fixed number of chromosomes in somatic cells.
2. It helps in growth and development of new organs in multicellular organisms.
3. It repairs old cells and regenerates the damaged tissues and organs.
4. It helps in asexual reproduction.

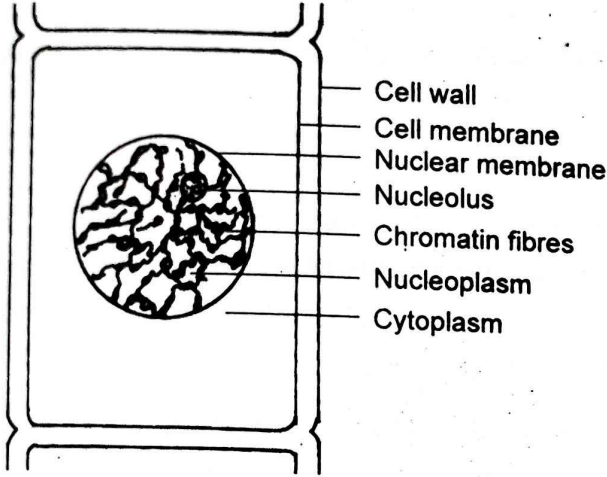
### Viva Questions

Students must remember

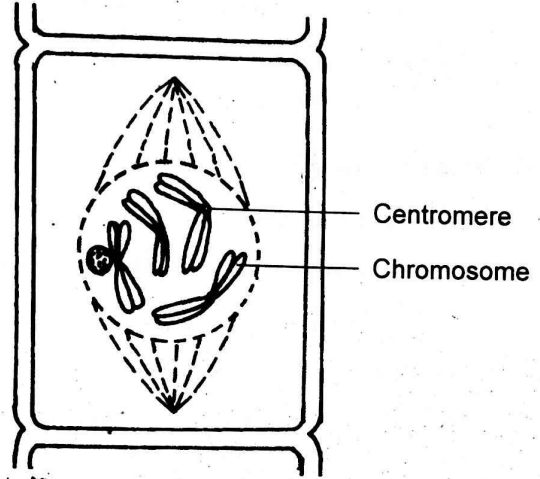
1. Why is mitosis called an equational division?  
**Ans:** Mitosis is called an equational division because the daughter cells have the same number of chromosomes as in mother cell.
2. How is metaphase stage recognized?  
**Ans:** Metaphase stage is recognized only when chromosomes get lined up at the center of the cell forming a metaphase plate.
3. What are spindle fibres made up of?  
**Ans:** Spindle fibres are made up of a contractile protein called tubulin.
4. When does the splitting of centromere take place?  
**Ans:** Anaphase of mitosis and anaphase - II of meiosis.
5. What is point at which chromatids attached?  
**Ans:** Centromere.

Date

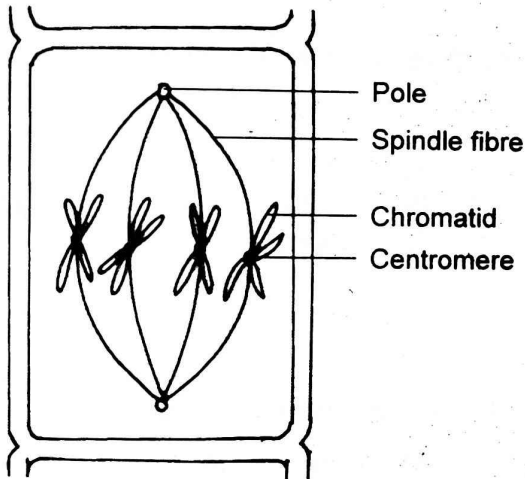
# STUDY OF THE MITOSIS CELL DIVISION THROUGH PERMANENT SLIDES



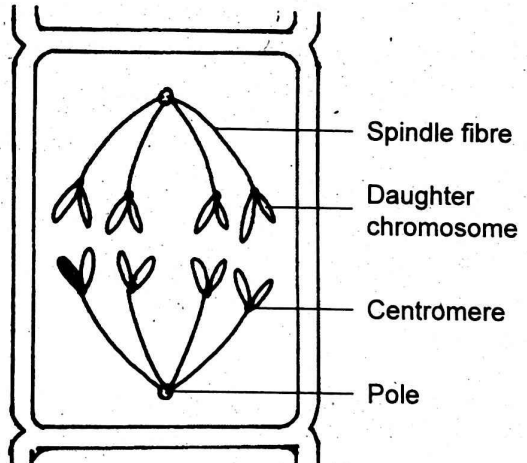
Interphase



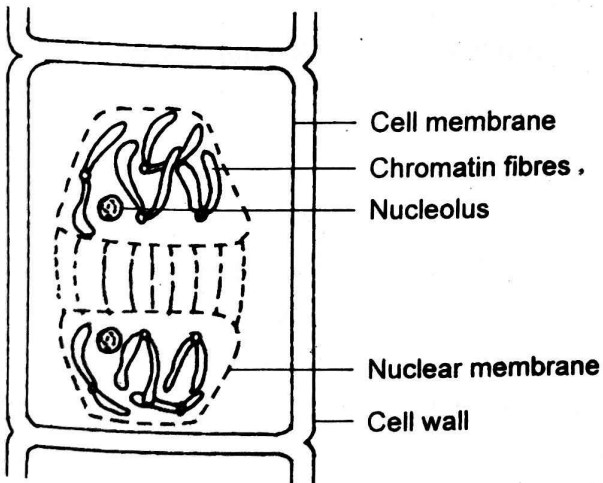
Prophase



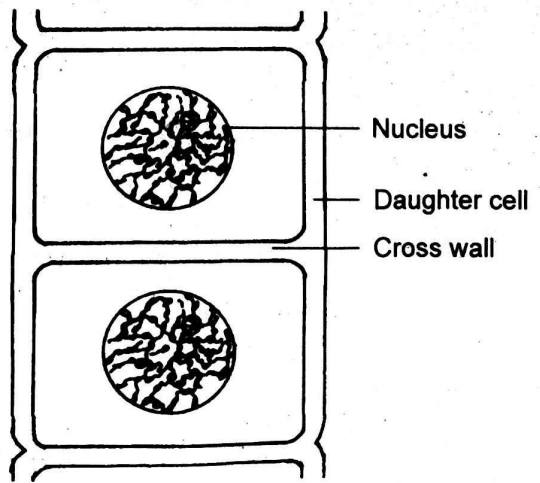
Metaphase



Anaphase



Telophase



Cytokinesis

**OBJECTIVE****STUDY OF THE MEIOSIS-I CELL DIVISION THROUGH CHART**

Meiosis is a type of cell division in which one mother cell produces four daughter cells; each daughter cell bears half the number of chromosome as compared to the mother cell. This cell division is also called reduction division. It is reported in diploid germ cells during gametes and in pollen grains formation. Meiosis occurs in the life cycle of all living organisms. Meiosis comprises of two nuclear divisions: Meiosis first and Meiosis second

**Meiosis First Division**

The meiosis first division is also known as reduction division or heterotypic division as it involves the formation of two daughter cells with just half number of chromosome as that present in the mother cell. It is completed in following stages.

**A. Prophase-I**

It takes long time and involves very complicated changes. It is divided into five sub stages.

**a. Leptotene**

1. The size and volume of nucleus increases.
2. The chromosomes appear as long, uncoiled, single thread like structure due to condensation, shortening and thickening.
3. Each chromosome consists of two chromatids.
4. Chromosomes show beaded structures along the entire length and are called chromomeres (highly coiled regions of DNA alternating with uncoiled regions).
5. The nuclear membrane and nucleolus remain intact.

**b. Zygotene**

1. Chromosomes become more distinct by further shortening and thickening.
2. The initiation of pairing between the homologous chromosomes starts.
3. The process of pairing the homologous chromosomes is called synapsis and the paired homologous chromosomes are called bivalents.
4. Nucleo-proteinous complex, called synaptonemal complex is formed between the homologous chromosomes.
5. The nucleolus increases in size.

**c. Pachytene**

1. The bivalents become shorter and thicker due to further condensation.
2. The nuclear membrane and nucleolus remains intact and prominent respectively.
3. Each homologous chromosome splits longitudinally into two chromatids joined at the centromere and is called a dyad. The bivalent become visible and appear as tetrad with four chromatids.
4. The exchange of chromatid segments of chromosomes takes place by breaking and rejoining between two non- sister chromatids of homologous chromosomes; this is known as crossing over.
5. The regions at which crossing over takes place are known as chiasmata (singular-chiasma).

**d. Diplotene**

1. The homologous chromosomes of each bivalent begin to move away from each other throughout the entire length except at one or two points where two non-sister chromatids of homologous chromosomes are attached.
2. The points of attachment between two homologous chromosomes are called chiasmata.
3. The homologous chromosomes although tend to separate from each other but both remain attached at one or more along the chromatids.
4. The two homologous chromosomes constituting each bivalent become clearly visible.
5. The nuclear membrane remains intact but nucleolus tends to degenerate.

**e. Diakinesis**

1. The chiasma moves towards the end of the chromosome due to contraction of chromosomes. This type of movement of chiasma is known as terminalization. This terminalization of chiasma completed just before this stage, so that paired chromosomes are joined only at the ends.
2. The bivalents move away from each other and spread towards the periphery of cells.
3. The chromosomes become further shorter and thicker
4. The spindle fibres begin to form at the end of this stage.
5. All the chromosomes are surrounded by the matrix.

**B. Metaphase I**

1. The nuclear membrane and nucleolus disappear and the spindle fibres get themselves organized between the two poles of the cell.
2. The bivalents arrange themselves in two parallel metaphase plates.
3. The bivalents are attached to the spindle fibres by their centromeres.
4. Centromeres of bivalents lie equidistant from equator and are directed towards the poles while arms generally lie horizontally on the equator.
5. The centromere of each chromosome is structurally divided into two, but these two parts functionally behave as a single centromere.

**C. Anaphase I**

1. The two homologous chromosomes of each bivalent separate and one chromosome from each bivalent moves apart from each other. It differs from mitotic anaphase, because, the division of centromeres of chromosomes does not occur during this stage.
2. The homologous chromosomes migrate towards the opposite poles of the cell by the contraction of spindle fibres.
2. The two sister chromatids of each chromosome seem to repel each other, so that they are clearly seen as parts of chromosomes.
3. The two groups of haploid chromosomes are formed, one on each pole of the cell. So this phase involves the reduction of chromosome number.
4. The homologous chromosomes at each pole are either paternal or maternal in origin.

**D. Telophase I**

1. Each pole receives one haploid set of chromosome having two chromatids.
2. The chromosomes become long and slender due to uncoiling and form chromatin threads.
3. The group of chromosomes get organized into nucleus.
4. Spindle fibres disappear.
5. Nuclear membrane reappears around the two groups of chromosomes at each pole. The nucleolus also reappears.

Thus two daughter haploid nuclei are formed in a cell at the end of meiosis –I division.

**Cytokinesis**

Cytokinesis may or may not be occurring. If present, it occurs by cell-furrow formation in animal cells and cell plate formation in plant cells.

**Interphase**

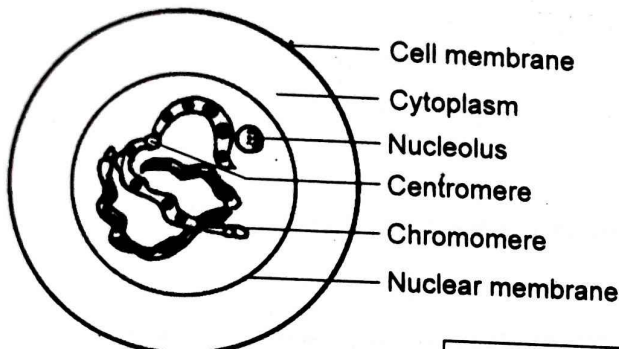
It may be very short or may be absent in some cases at all. During this phase, protein and RNA synthesis occur but the duplication and synthesis of DNA does not take place.

**Viva Questions****Students must remember**

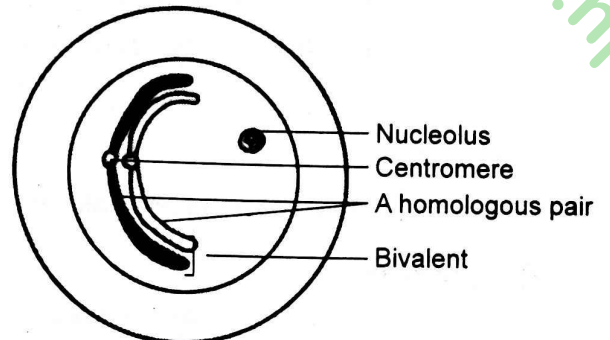
1. Why is meiosis called a reductional division?  
**Ans:** Meiosis is called a reductional division because it reduces chromosome number half in the daughter cells if compared to their mother cell.
2. How many stages are found in prophase first of meiosis first division?  
**Ans:** Five stages. They are leptotene, zygotene, pachytene, diplotene and diakinesis.
3. What is crossing over?  
**Ans:** Crossing over is defined as the exchange of chromatid segments in a homologous chromosome.
4. When does crossing over take place?  
**Ans:** It takes place during pachytene stage of prophase first.
5. In which cells does meiosis take place?  
**Ans:** Meiosis cell division takes place in male and female reproductive cells.
6. Write the significance of meiosis?
  - a. It maintains the chromosome number constant for a generation to generation.
  - b. It causes the genetic variations among the species.
  - c. It forms haploid gametes or spores for reproduction.
7. What is synapsis?  
**Ans:** A close association and pairing of homologous chromosomes during zygotene of prophase first called synapsis.
8. What is karyokinesis?  
**Ans:** The division of nucleus of the cell is called karyokinesis.

Date \_\_\_\_\_

# STUDY OF THE MEIOSIS-I CELL DIVISION THROUGH CHART



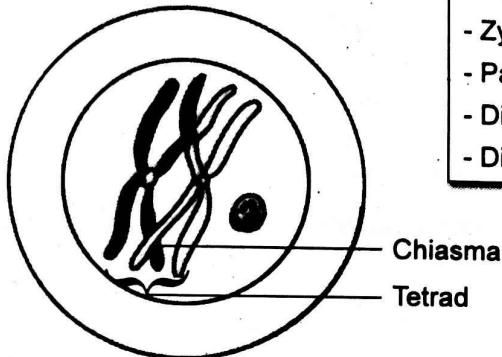
Leptotene



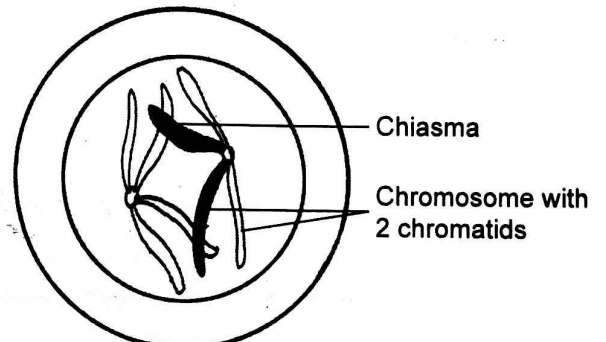
Zygotene

**Prophase - I**

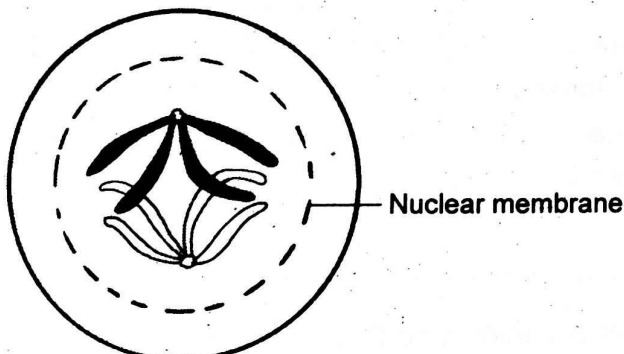
- Leptotene
- Zygotene
- Pachytene
- Diplotene
- Diakinesis



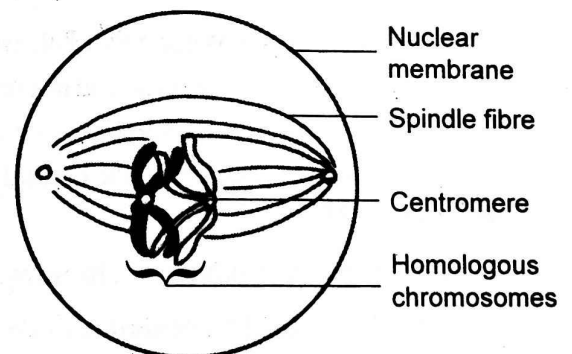
Pachytene



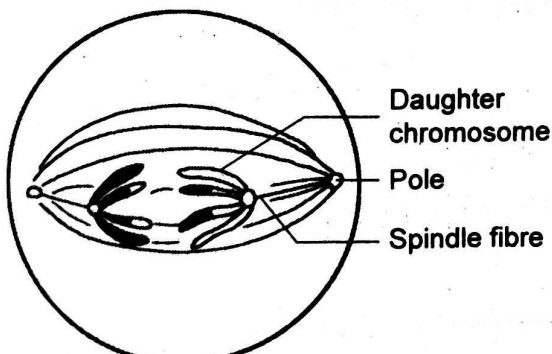
Diplotene



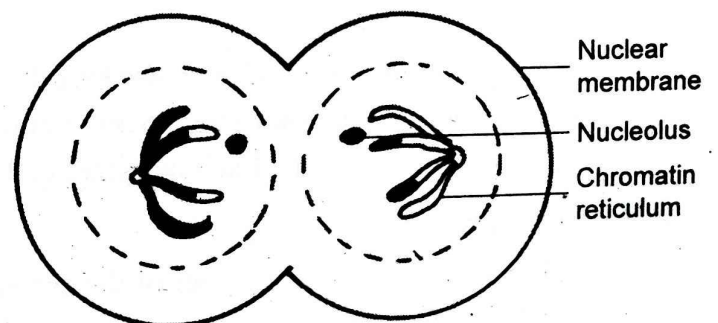
Diakinesis



Metaphase - I



Anaphase - I



Telophase - I

**OBJECTIVE****STUDY OF THE MEIOSIS-II CELL DIVISION THROUGH CHART**

It is a simple mitotic or homotypic division in which two haploid nuclei or cells divide to form four haploid nuclei or cells. It is also called equational division or meiotic mitosis because the number of chromosomes remains the same as after meiosis first. It can also be divided into two parts: Karyokinesis and Cytokinesis.

**A. Karyokinesis**

It is the division of a nucleus into two daughter nuclei. It is completed into following four phases.

**a. Prophase II**

1. The dyad chromosomes become shorter and thicker and are clearly visible.
2. Each chromosome consists of two chromatids, which are attached to the single centromere.
3. The nuclear membrane and nucleolus begin to disappear and the spindle fibres begin to appear.

**b. Metaphase II**

1. Nuclear membrane and nucleolus disappear.
2. The spindle fibres get themselves organized between the two poles of the cell.
3. The centromeres of all the dyad chromosomes are arranged in a single plane at the equator and form a single metaphasic plate.
4. The two sister chromatids of each chromosome are distinctly separated from each other due to repulsion between them.

**c. Anaphase II**

1. The centromere of each dyad chromosome divides in the longitudinal plane and sister chromatids separate to form two daughter chromosomes.
2. The daughter chromosomes move towards the opposite poles due to the contraction of spindle fibre.
3. Anaphase-II ends with the formation of 4 sets of chromosomes, one at each pole of the spindle.

**d. Telophase II**

1. It begins when daughter chromosomes reach the opposite poles and get organized into nucleus.
2. At each pole, chromosomes uncoil, get elongated and form a network of chromatin fibres.
3. Spindle fibres disappear around the pole.
4. The nuclear membrane appears around each group of chromosomes and the nucleolus reappears.

**e. Cytokinesis**

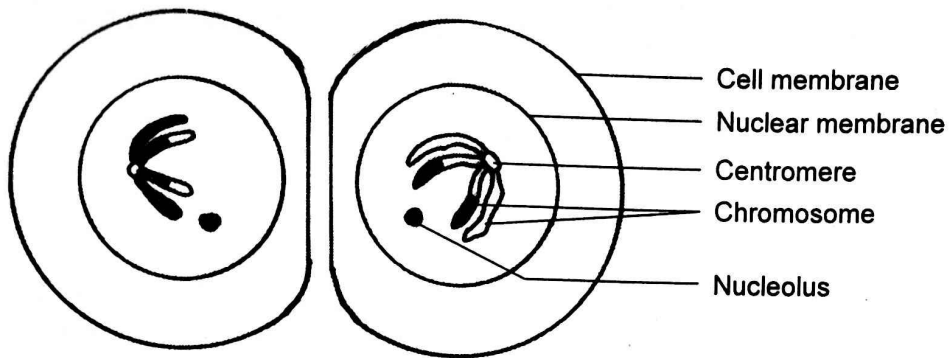
The division of cytoplasm takes place by cell plate formation in plant cells and furrow formation in animal cells is called cytokinesis. As a result of meiosis a diploid mother cell divides twice forming four haploid daughter cells. Each daughter cell has half the number of chromosomes of the parent.

**Significance of Meiosis**

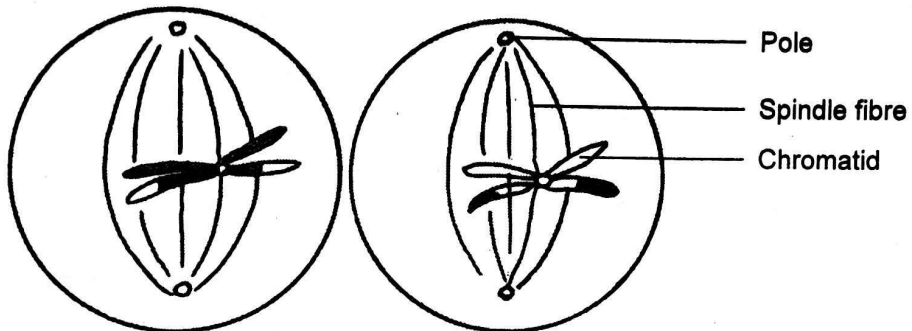
1. It maintains constant number of the chromosomes in the organisms.
2. It causes the genetic variations among the species.
3. It forms haploid gametes or spores for reproduction.
4. It helps in evolution.

Date

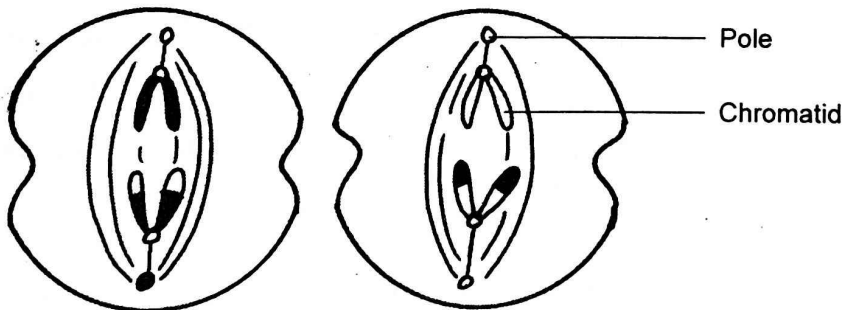
# STUDY OF THE MEIOSIS-II CELL DIVISION THROUGH CHART



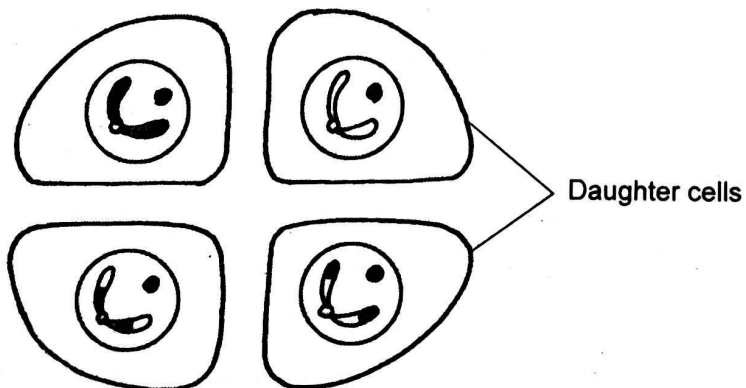
Prophase - II



Metaphase - II



Anaphase - II



Telophase - II

# PREPARATION OF TEMPORARY SLIDES

## OBJECTIVE

PREPARATION OF TEMPORARY SLIDE OF ONION PEEL AND STUDY IT UNDER THE MICROSCOPE

### Requirements

**Apparatus:** Blade, needle, watch glass, cover slip, slide, scissors, dropper, compound microscope.

**Material:** An onion bulb.

**Chemical:** Iodine solution, glycerine, water.

### Procedure

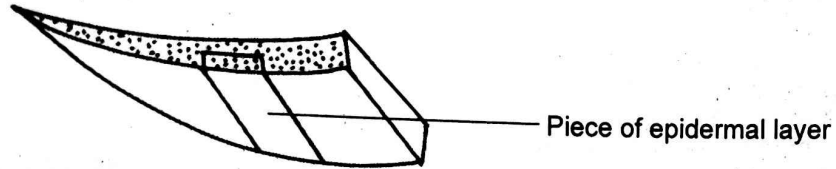
1. Take a piece of an onion scale and turn its concave surface towards outward and snap it backwards.
2. Peel a thin epidermal layer of scale with the help of scissors and forceps.
3. Transfer this thin layer into a watch glass containing water.
4. Cut into about 5 mm sq. piece of different shapes like square or rectangle, using a blade.
5. Dip the piece in iodine solution in a watch glass for about 2-5 minutes to stain the nucleus of the cells.
6. Now wash peel with water and transfer it on a drop of glycerine on the slide. If the peel is folded, straighten with the help of needle and then put the cover slip over it.
7. Observe it under compound microscope with low power and high power.
8. Identify the different structures of cell like cell wall, cell membrane, cytoplasm, nucleus and vacuole.
9. Draw a labelled diagram of onion cell.

### Comments

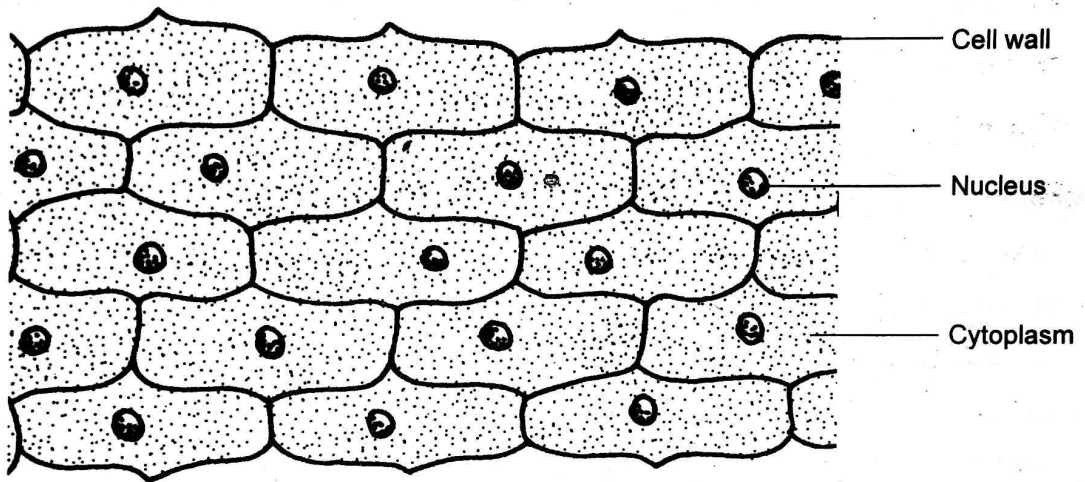
1. The onion cells are rectangular in shape and packed edge to edge without any intercellular space.
2. Each cell is bounded by its own non-living cellulosic cell wall.
3. Protoplasm is the basic unit of life that includes the entire materials inside the cell membrane.
4. Protoplasm can be divided into cytoplasm and nucleus.
5. Cytoplasm is a transparent granular fluid lying in between the cell membrane and nucleus.
6. Nucleus is a large and prominent stained body situated at the center or along the side of the cell.
7. Nucleus contains viscous fluid called nucleoplasm bounded by thin nuclear membrane.
8. A large central vacuole or small sized vacuoles are present in each cell and are filled with cell sap.
9. Stomata are entirely absent in the cells of onion peel.

Date

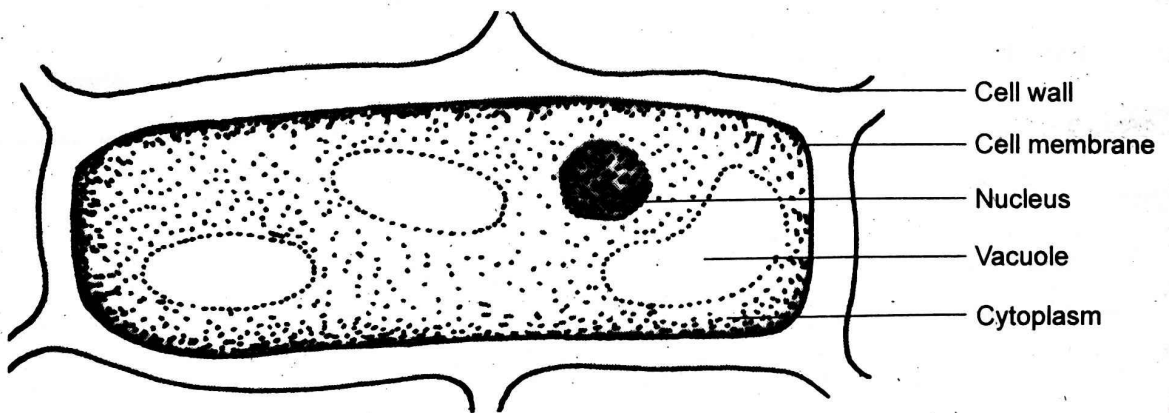
# PREPARATION OF TEMPORARY SLIDE OF ONION PEEL AND STUDY IT UNDER THE MICROSCOPE



Onion Scale



Onion Cells Under Low Power



Single Onion Cell Under High Power

**OBJECTIVE****PREPARATION OF TEMPORARY SLIDE OF TRADESCANTIA LEAF AND STUDY IT UNDER THE MICROSCOPE****Requirements**

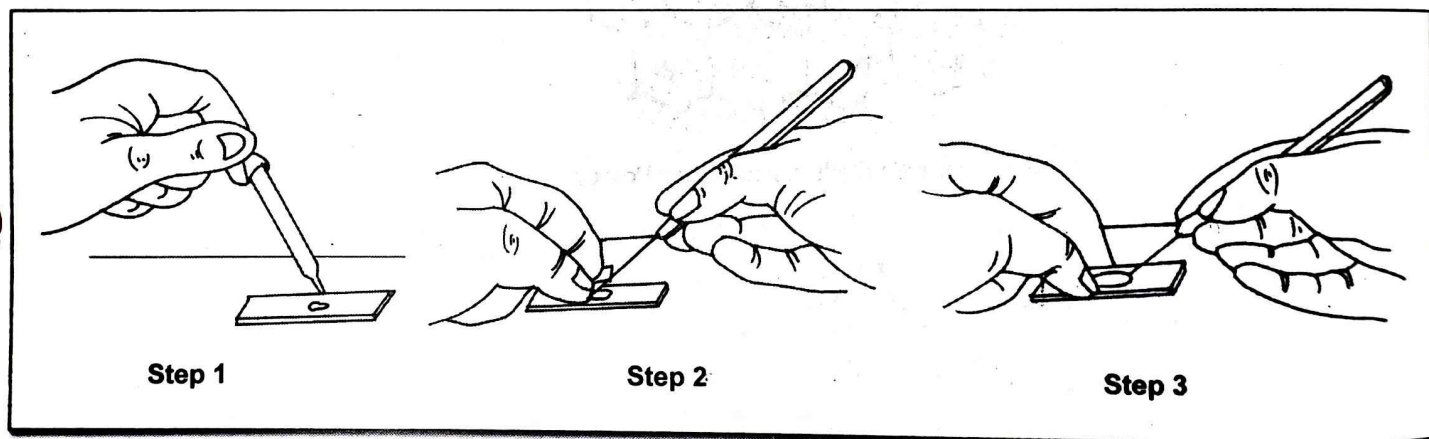
**Apparatus:** Blade, needle, watch glass, cover slip, slide, scissors, dropper, compound microscope.

**Material:** *Tradescantia* leaf.

**Chemical:** Glycerine, safranin, water.

**Procedure**

1. Take a piece of *Tradescantia* leaf and peel a thin epidermal layer with the help of scissors and forceps.
2. Transfer this thin layer into a watch glass containing water.
3. Cut into about 5 mm sq. piece of different shapes like square or rectangle, using a blade.
4. Dip the piece in safranin solution in a watch glass for about 2-5 minutes to stain the nucleus.
5. Now wash peel with water and transfer it on a drop of glycerine on the slide. If the peel is folded, straighten with the help of needle and then put the cover slip over it.
6. Observe it under compound microscope with low power and high power.
7. Identify the different structures of cell like cell wall, cell membrane, cytoplasm, nucleus and vacuole.
8. Draw a labelled diagram of epidermal cells of *Tradescantia* leaf.



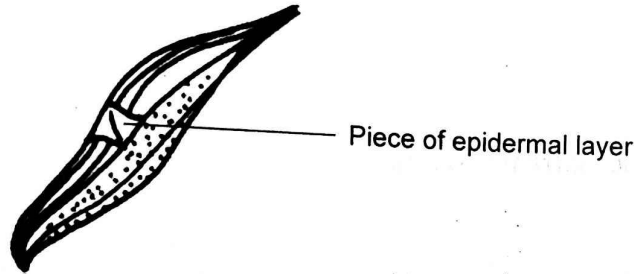
Mounting Procedure of a Slide

**Comments**

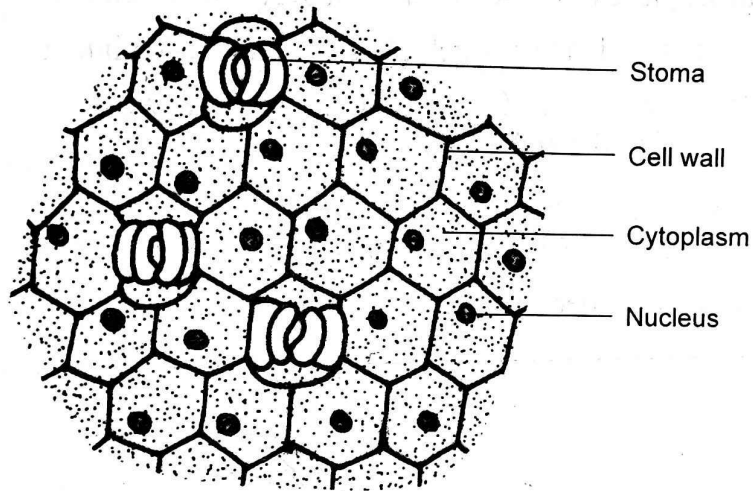
1. The epidermal cells of *Tradescantia* leaf are hexagonal in shape.
2. They are compactly arranged with many scattered stomata.
3. Each cell is bounded by its own non-living cell wall.
4. Cell wall encloses the entire materials called protoplasm that can be divided into cytoplasm and nucleus.
5. Cytoplasm is a transparent granular fluid lying in between the cell membrane and nucleus.
6. Nucleus is a large and prominent stained body situated at the side of the cell.
7. A large central vacuole or small sized vacuoles are present in the cytoplasm.

Date

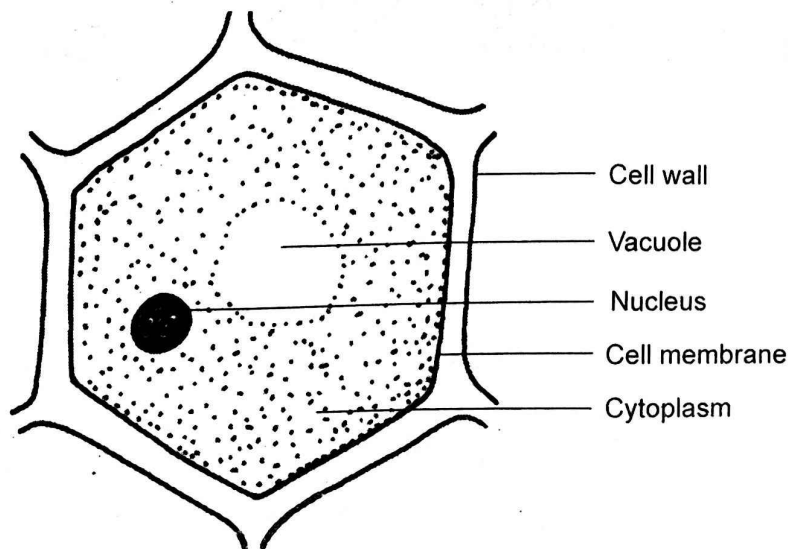
# PREPARATION OF TEMPORARY SLIDE OF TRADESCANTIA LEAF AND STUDY IT UNDER THE MICROSCOPE



*Tradescantia* Leaf



*Tradescantia* Cells Under Low Power



Single *Tradescantia* Cell Under High Power

*Tradescantia* Cells

**OBJECTIVE****PREPARATION OF TEMPORARY SLIDE OF GERANIUM LEAF AND STUDY IT UNDER THE MICROSCOPE****Requirements**

**Apparatus:** Blade, needle, watch glass, cover slip, slide, scissors, dropper, compound microscope.

**Material:** *Geranium* leaf.

**Chemical:** Glycerine, safranin, water.

**Procedure**

1. Take a *Geranium* leaf and peel a thin epidermal layer with the help of scissors and forceps.
2. Transfer this thin layer into a watch glass containing water.
3. Cut into about 5 mm sq. piece of different shapes like square or rectangle, using a blade.
4. Dip the piece in safranin solution in a watch glass for about 2-5 minutes to stain the nucleus.
5. Now wash peel with water and transfer it on a drop of glycerine on the slide. If the peel is folded, straighten with the help of needle and then put the cover slip over it.
6. Observe it under compound microscope with low power and high power.
7. Identify the different structures of cell like cell wall, cell membrane, cytoplasm, nucleus and vacuole.
8. Draw a labelled diagram of epidermal cells of *Geranium* leaf.

**Precautions**

1. The apparatus like needle, forceps, brush, cover slip, slide, etc. should be cleaned.
2. The material should be placed in the center of slide.
3. The air bubbles should be avoided in the glycerine.
4. The material should be covered with cover slip very carefully.
5. The prepared slide should be neat, clean and dry before mount it under the microscope.

**Comments**

1. The epidermal cells of *Geranium* leaf are irregular in shape.
2. They are compactly arranged like segments of a zip or puzzle.
3. Each cell is bounded by its own non-living cell wall.
4. Cell wall encloses the entire materials called protoplasm that can be divided into cytoplasm and nucleus.
5. Cytoplasm is a transparent granular fluid lying in between the cell wall and nucleus.
6. Nucleus is a large and prominent stained body situated at the side of the cell.
7. Many vacuoles are present in the cytoplasm, which are filled with cell sap.

**Viva Questions**

Students must remember

1. What is the shape of the cell you study in *Geranium* leaf?

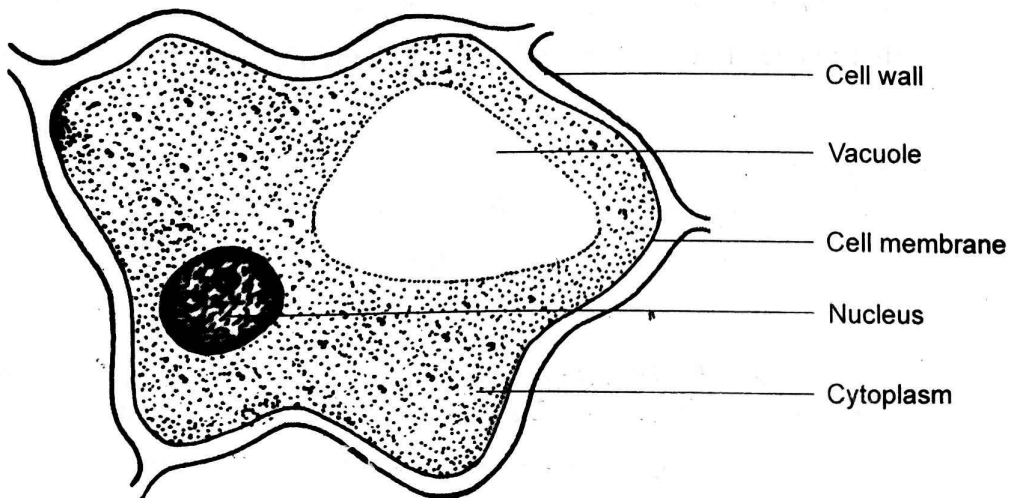
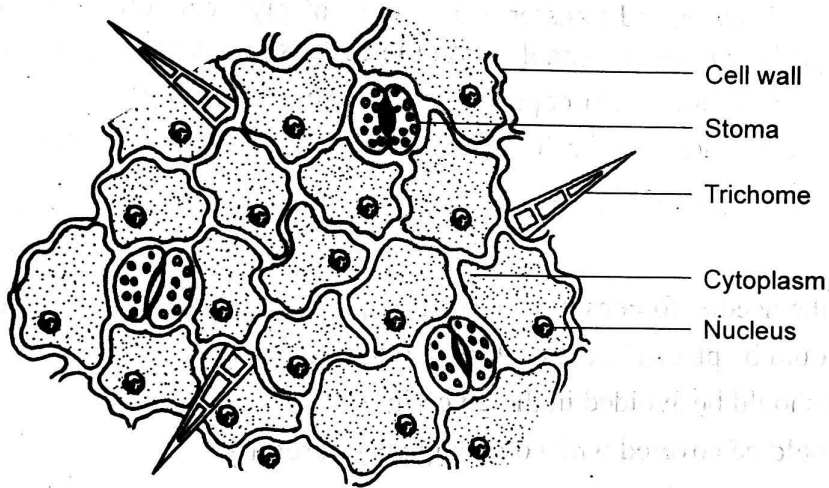
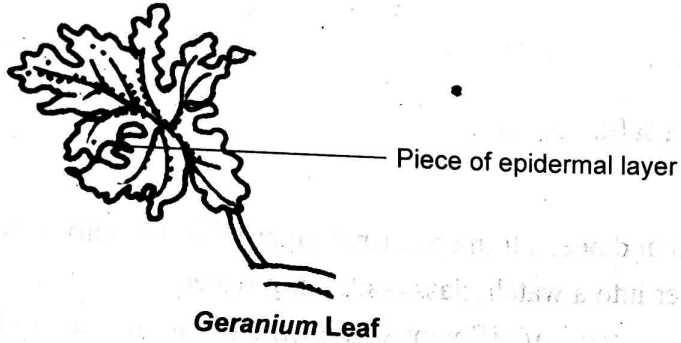
**Ans:** The shape of the cell of *Geranium* leaf is irregular shaped.

2. What is cell wall?

**Ans:** The cell wall is the outermost, rigid, non-elastic protective and supportive layer of plant cell which is made up of cellulose.

Date

# PREPARATION OF TEMPORARY SLIDE OF GERANIUM LEAF AND STUDY IT UNDER THE MICROSCOPE



Single Geranium Cell Under High Power

**OBJECTIVE****PREPARATION OF TEMPORARY SLIDE OF HYDRILLA LEAF AND STUDY IT UNDER THE MICROSCOPE****Requirements**

**Apparatus:** Blade, needle, watch glass, cover slip, slide, scissors, dropper, compound microscope.

**Material:** *Hydrilla* leaf.

**Chemical:** Glycerine, water.

**Procedure**

1. Take a fresh twig of *Hydrilla* plant and pluck up a young leaf with the help of forceps.
2. Transfer this leaf over a drop of *Glycerine* on the slide.
3. Cover the leaf with cover slip.
4. Observe the prepared slide of *Hydrilla* leaf under compound microscope with low power and high power.
5. Observe single cell of a *Hydrilla* leaf with high power magnification.
6. Identify the different structures of cell like cell wall, cytoplasm and nucleus.
7. Draw a labelled diagram of cells of *Hydrilla* leaf.

**Precautions**

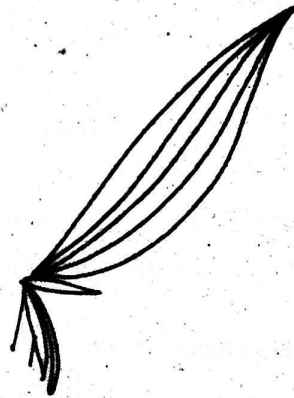
1. The apparatus like needle, forceps, brush, cover slip, slide, etc. should be cleaned.
2. The material should be placed in the center of slide.
3. The air bubbles should be avoided in the glycerine.
4. The material should be covered with cover slip very carefully.
5. The excessive use of glycerine should be avoided in order to come out the cover slip.
6. The prepared slide should be neat, clean and dry before mount it under the microscope.

**Comments**

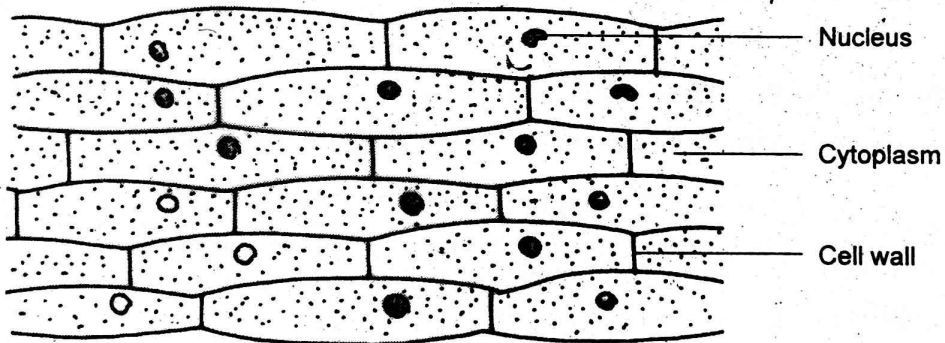
1. The cells of *Hydrilla* leaf are rectangular shaped.
2. The cells are compactly arranged in rows without any intercellular space.
3. Each cell is bounded by its own non-living cell wall.
4. Cell wall encloses the entire materials called protoplasm that can be divided into cytoplasm and nucleus.
5. The cells contain numerous round green structures called chloroplasts. The large number of chloroplasts throughout the cell is the salient features of *Hydrilla*.
6. Nucleus is large and situated at the side of the cell. Sometimes the nucleus remains masked by numerous chloroplasts and makes it invisible.
7. The movement of cytoplasm can be observed due to the flow of chloroplast within the cell.

Date

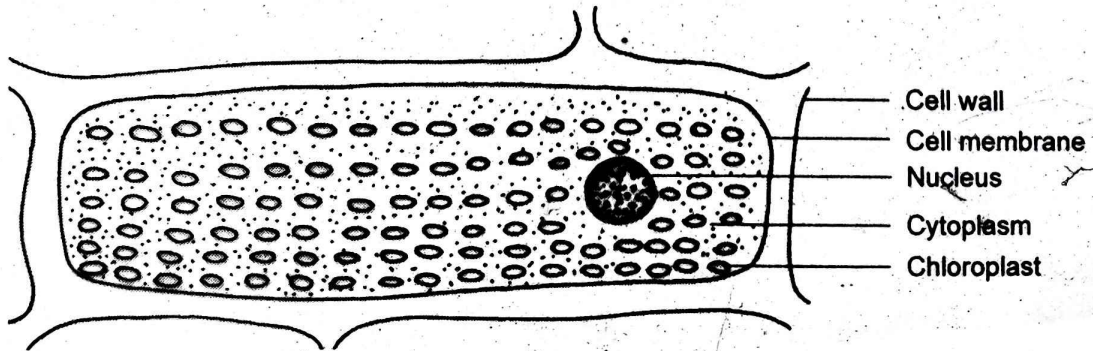
# PREPARATION OF TEMPORARY SLIDE OF HYDRILLA LEAF AND STUDY IT UNDER THE MICROSCOPE



Hydrilla Leaf



Hydrilla Cells Under Low Power



Single Hydrilla Cell Under High Power

Hydrilla Cells

# MORPHOLOGY OF FLOWERING PLANTS

Taxonomy is the branch of biology that deals with the study of classification, description, identification and nomenclature of organisms. To identify the organism correctly, the organisms should be described properly. The varieties of plants are classified on the basis of similarities and differences in their morphological forms. There are many terms regarding to various morphological forms of different parts of plants. Some common terms are discussed below.

## Habit of Plants

Habit of plants is determined by form of stem, height, life span and nature of stem. On the basis of form, the angiosperms are of following types; herbs, shrubs or trees.

- Herbs:** Small and weak plants with soft stems are called herbs. They are usually seasonal. Example- mustard.
- Shrubs:** Medium sized plants give rise to woody branches from the base to form bushy plants are called shrubs. They are mostly perennial. Example- rose.
- Trees:** A tall, woody, strong and perennial plants are called trees. They have prominent trunk which normally give rise to many branches. Example-Banyan

## Lifespan of Plants

On the basis of lifespan angiospermic plants may be annual, biennial or perennial.

- Annual:** Plant that completes its life cycle from seed germination to seed production, followed by death within a single season or year. Example- maize
- Biennial:** It lives for two years to complete their life cycle i.e., growing vegetative parts during first year and fruiting or dying during second year. Example- carrot in colder region
- Perennial:** Plant lives for a few to several hundred of years. Example- mango. Some perennial plants bear flower and fruits every year while some others like bamboo, *Agave*, etc. bear flowers and fruits only once after a vegetative growth of several years.

## Habitat of Plants

On the basis of habitat, angiosperms are of following types:

- Mesophytes:** The plants which are grown in the soils having sufficient moisture and air are called mesophytes. Example- mustard.
- Xerophytes:** The plants which are grown in dry and sandy soils, i.e., in deserts are called xerophytes. Example- *Opuntia*.

- c. **Hydrophytes:** The plants which are grown in water and also in damp and marshy places are called hydrophytes. Example- *Hydrilla*.
- d. **Epiphytes:** The plants which are grown on trees and take support but not live parasitically are called epiphytes. Example- *Vanda*
- e. **Parasites:** The plants that live on or in another plant and absorb food from there are called parasitic plants. Example- *Cuscuta*. The plant on which parasitic plant grows is called its host.
- f. **Saprophyte:** The plants that obtain organic matter from dead and decaying parts of plants or animals are called saprophytes. Example- *monotropa*

**On the basis of labour of division, a flowering plant has root system and shoot system.**

### The Root System

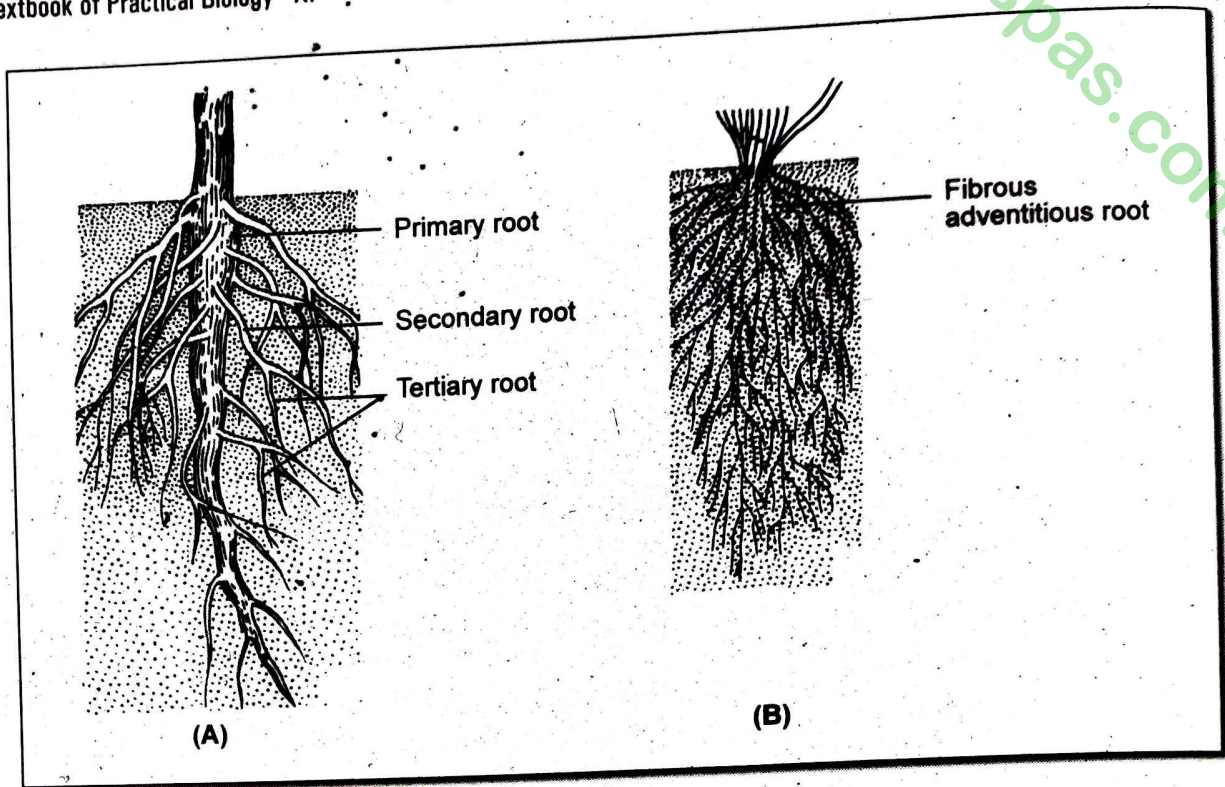
The root is the non green descending part of the vascular plants which grows downward into the soil. It is negatively phototropic but positively geotropic. It helps in fixation and absorption of water and minerals to the plant body. It arises first from the radicle of the embryo of a seed and is called primary seed. After a certain period of growth, it gives out lateral branches called secondary roots. These roots along with their branches constitute the root system.

### Characteristics of the Root

1. The root is the descending portion of the plant body.
2. It is non-green or pale brown in colour.
3. It is not differentiated into nodes and internodes.
4. It does not bear leaves and true buds.
5. Usually the tip of the root is protected by a thimble-like structure, the root cap.
6. The root bears unicellular root hairs.
7. Lateral roots are endogenous in origin.
8. The root is negatively phototropic but positively geotropic.

The root system is generally of two types. They are tap root and adventitious root.

- a. **Tap root:** The root arises from the radicle of seed and develops into a primary root that grows vertically downwards, is called tap root. It persists throughout the life of the plant. The primary root is thickest at its base and gradually thinner towards the apex. It produces many lateral branches of roots are called secondary roots and in turn produce tertiary roots. In short, the whole mass of the roots consisting of primary roots, secondary roots and tertiary roots is called tap root system. Tap root is present in dicot plants like mustard, pea, neem, radish, sunflower, etc.
- b. **Adventitious root:** The root that develops from any part of the plant body other than the radicle is called the adventitious root. This root grows shallow and spread in a larger area rather than depth. It may be underground or aerial. It forms a cluster of roots, which may originate from the same region or point. In monocotyledons the primary root soon disintegrates after germination of seed and a tuft of roots of more or less equal diameter, arising from the base of stem. Such roots are similar and bear smaller lateral branches. Such adventitious roots are called fibrous root. It is commonly present in monocotyledonous plants like wheat, maize, etc.



(A) Tap root, (B) Fibrous adventitious root

### Basic Functions of Roots

1. Root system provides fixation to the plant.
2. Root absorbs water and mineral salts from the soil.
3. Root conducts the water and mineral salts to the base of the stem through xylem.
4. Roots of many plants store food materials.

### Root Modifications

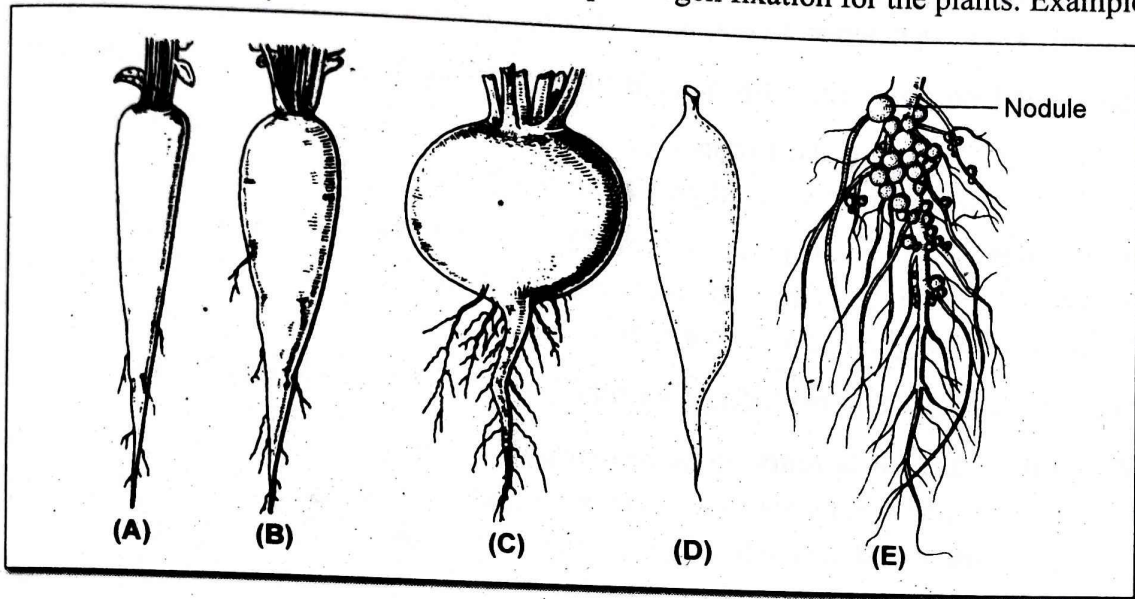
The normal functions of a root are fixation, absorption and conduction. Besides these functions, both tap root and adventitious root are modified structurally to perform specialized functions for the survival of the plant in surrounding environment. Thus, the normal roots that change their shapes and sizes and perform special functions are called modified roots.

#### A. Modification of Tap Roots

The tap roots of many plants are modified to store the reserve food material. It becomes thick and fleshy due to the accumulation of food materials. According to their shape, they are of the following types:

1. **Conical tap root:** The primary root is broad at the base and tapers gradually towards the apex. It looks cone like structure. The broad apex meets with the reduced disc shaped stem. Example- carrot
2. **Fusifform root:** The root is swollen in the middle and tapers gradually at both the base and the apex. It is spindle shaped with reduced disc like green stem at the apex. Example- *Raphanus sativus*
3. **Napiform root:** It is thick, fleshy and almost globular at base and tapers abruptly at the base. The stem is reduced into a disc. Example- turnip
4. **Tuberous root:** The primary root becomes thick and fleshy but has no definite shape. Secondary roots come out from the tuber. Example- *Mirabilis*

5. **Nodulated root:** In legume plants, the secondary roots and sometimes primary roots bear many small or large irregular swellings called root nodules. These nodules contain nitrogen fixing bacteria (*Rhizobium leguminosarum*). These bacteria help nitrogen fixation for the plants. Example- pea.



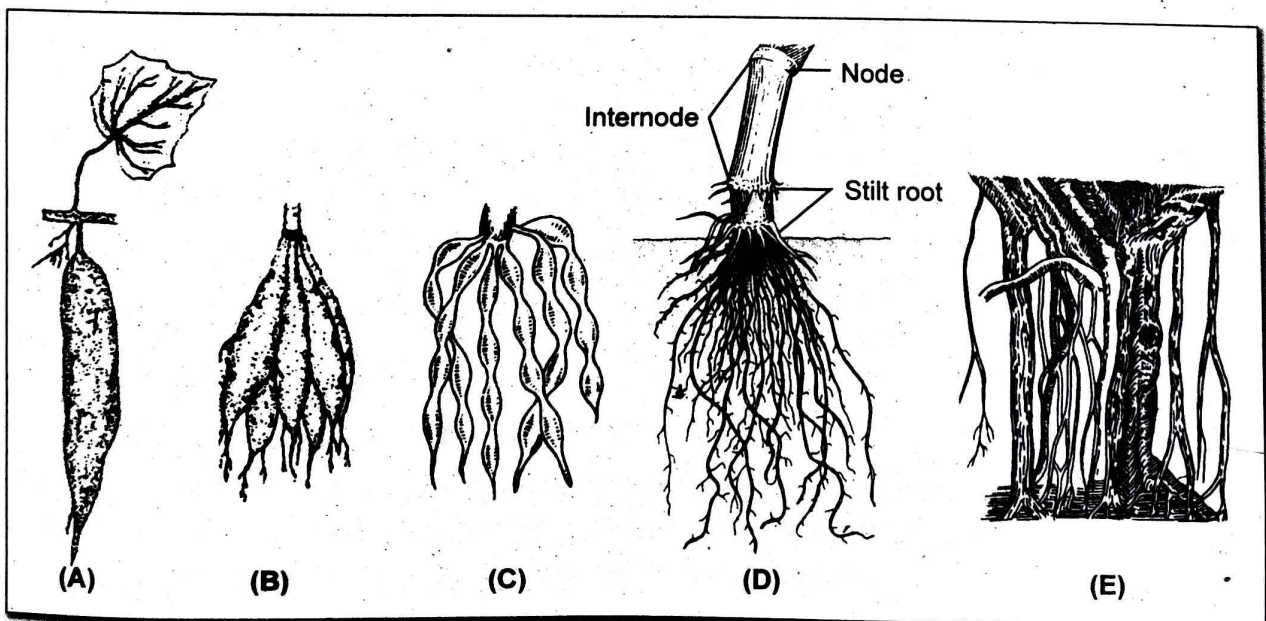
**Modified tap roots**

(A) Conical root (B) Fusiform root (C) Napiform root (D) Tuberous root (E) Nodulated root

## B. Modifications of Adventitious Roots

The adventitious roots are modified into abnormal form and perform various unusual functions such as storage, support, assimilation and other important functions.

- a. **For the storage of food:** In some plants the adventitious roots become fleshy due to the storage of food. They get swollen and appear in following shapes:

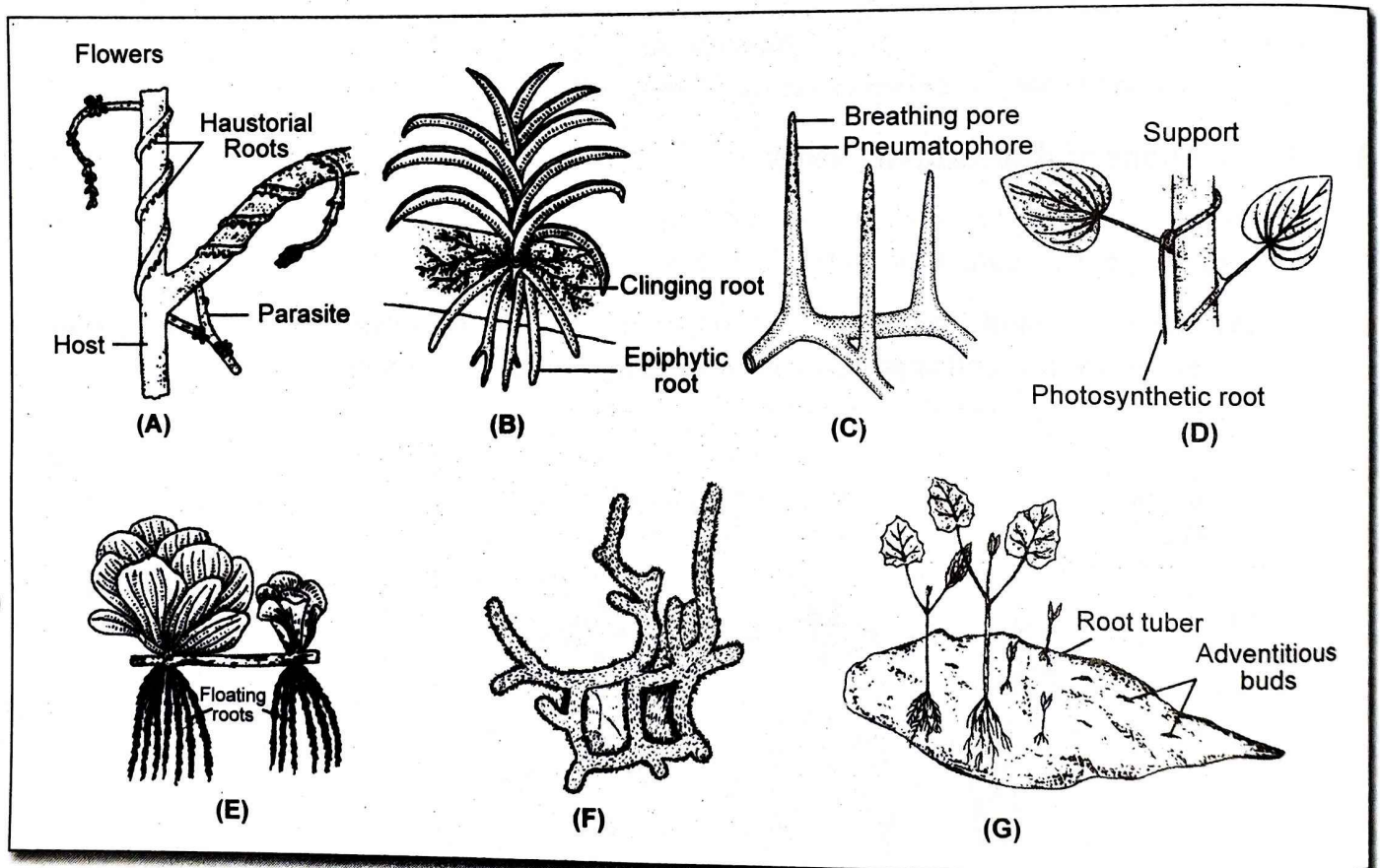


**Modified adventitious root**

(A) Tuberous root (B) Fasciculated root (C) Moniliform root (D) Stilt root (E) Prop root

1. **Tuberous root:** Some of the adventitious roots arise from the node of the horizontal stem and gets swollen without any definite shape. Such types of roots are called tuberous roots. These roots are fleshy and thus they store food. Example- sweet potato

2. **Fasciculated root:** In some cases, tuberous roots occur in clusters at the base of the stem. Example- *Asparagus*, dahlia, etc.
  3. **Moniliform or Beaded root:** In some cases, adventitious roots swell at regular intervals giving a beaded like appearance. Example- *Dioscorea* (yam)
- b. **For mechanical support:** The roots modified for mechanical support are of the following types:
1. **Stilt roots:** These are short roots arise from the first few nodes of the stem. These penetrate obliquely down into the soil and give support to the plant. Example- maize, sugarcane, etc.
  2. **Prop roots:** The roots are pillar like structures hanging vertically downward from branches and penetrate into soil. Gradually, the roots become thick and stout. They give mechanical support to the plant body. Example- banyan tree
- c. **For vital functions:** The roots modified for other vital functions are of the following types:
1. **Parasitic or haustoria roots:** These roots are also known as suckers. They are commonly found in non-green parasitic plants which cannot prepare their own food. The haustoria penetrate the living host tissue and absorb food by sucking. Example- *Cuscuta* (Amar-bel)



Modified adventitious root for vital function (A) Parasitic root (B) Epiphytic root (C) Respiratory root (D) Photosynthetic root (E) Floating root (F) Mycorrhizal root (G) Reproductive root

2. **Epiphytic roots:** Epiphytes are the plants that grow on the trunks or branches of other plants. The roots of epiphytes are called epiphytic roots. These roots are special kinds of aerial roots which hang freely in the air. These roots are covered in **velamen**, which is a dead, hygroscopic and spongy. The cells of velamen absorb moisture from the atmosphere or absorb rain water. The epiphytic roots are mostly found in members of *Orchidaceae*. Example *Vanda* (orchid)

3. **Respiratory roots or pneumatophores:** The roots of some plants growing in saline marsh place suffer from the lack of oxygen. This is due to the water logged condition of the soil. To cope with this situation some root branches grow vertically upwards above the water surface. These roots are soft, colourless, and spongy and have pores in the upper parts. These roots take part in respiration and are called respiratory roots as the gases are exchanged through these pores. Example- mangroove
4. **Assimilatory roots:** These are long slender aerial roots that develop from the branches of certain plants. They are green in colour due to the presence of chlorophyll and perform the function of photosynthesis. Example- *Trapa* (Singada)
5. **Floating roots:** The adventitious roots of some aquatic plants are modified into spongy roots. They store air and make the plant light. They, thus help the plant in floating on the surface of water. Example- *Pistia*, *Eichhornia*, etc.
6. **Mycorrhizal roots:** They may be tap root or adventitious roots. The younger portions of the roots of some plants become associated with fungi. This intimate association of fungus and the roots of higher plants are called *mycorrhiza*. The fungus helps in absorbing water and mineral salts from the soil and in turn the plant roots provide the organic food. Example- *Cycas*, *Pinus*, etc.
7. **Reproductive roots:** The adventitious roots of some plants develop bud which gives rise to leafy shoots. These roots serve as means of propagation. Example- sweet potato

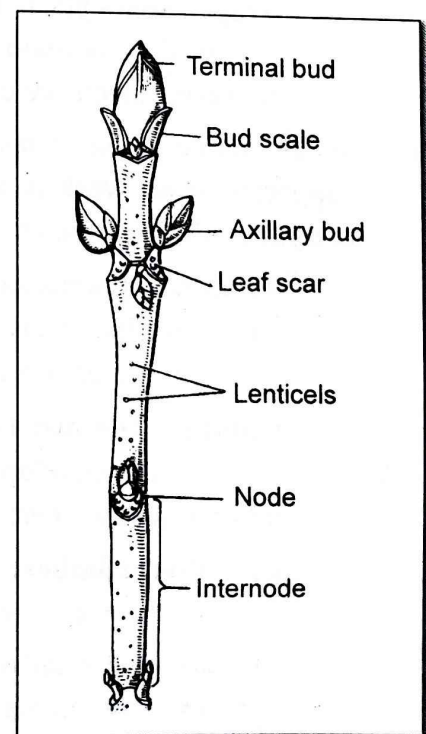
## The Shoot System

The stem is the aerial part of main axis of vascular plants, developing from the plumule. The stem along with the branches, leaves, flowers and other appendages is known as **shoot system**.

### Characteristics of Stem

1. The stem is the ascending part of the main axis of the plant which develops directly from the plumule.
2. The stem grows towards the sun by the activity of terminal bud. It is normally positively phototropic and negatively geotropic.
3. The stem bears nodes and internodes.
4. The branches and leaves arise from the nodes of the stem.
5. The growing apex of stem bears a terminal bud.
6. The stem also bears different kinds of buds. They are terminal bud, axillary or lateral bud and floral bud.
7. The lateral branches are exogenous in origin.

Based on the form of stem, the plants may be erect or weak. The erect plants are normally rigid, strong enough to stand erect by themselves. The plants with weak stems cannot stand erect. They may climb up with the help of support or creep on the ground. Example, pumpkin, watermelon, pea, strawberry, *Cuscuta*, etc.



Terminal and axillary bud

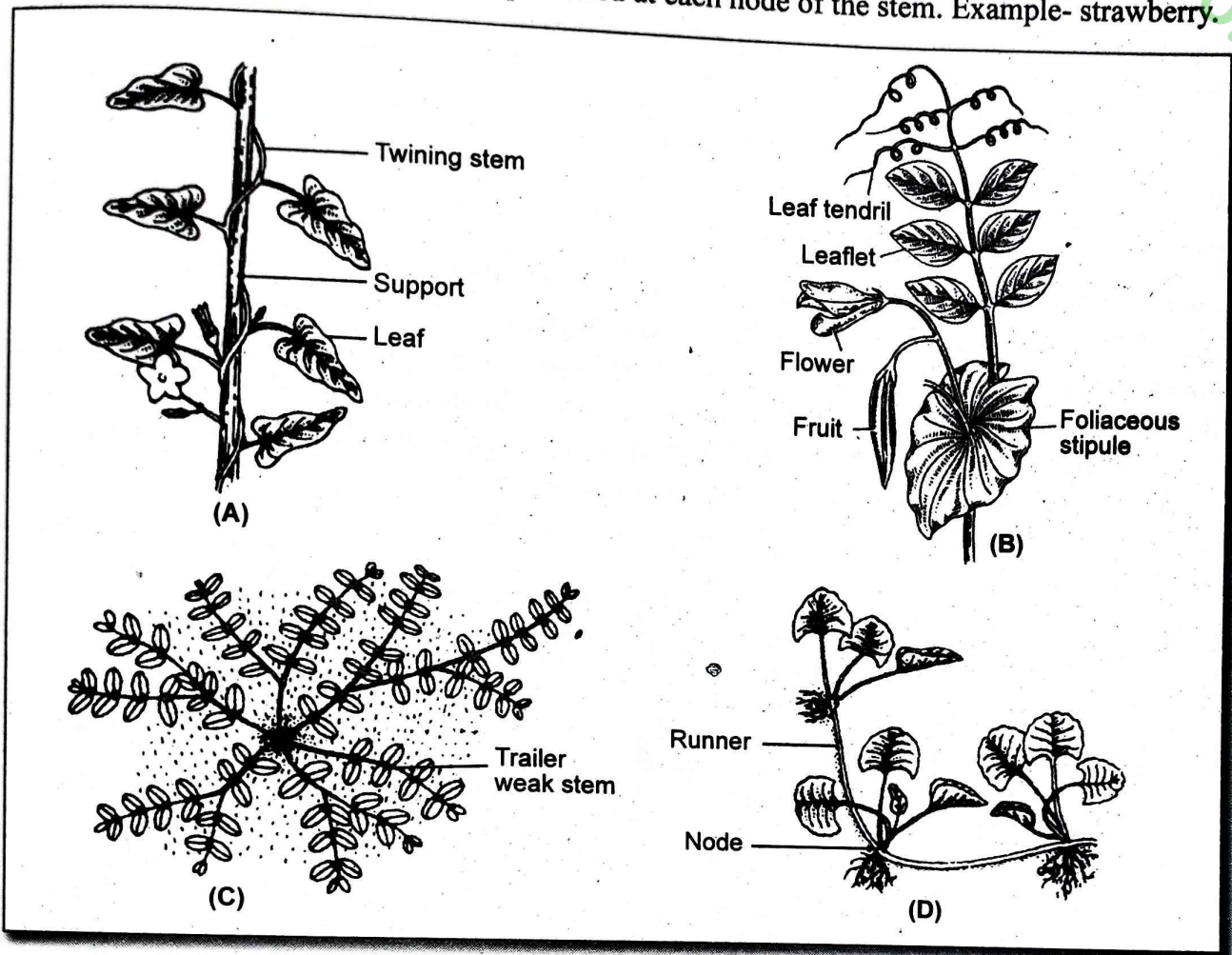
## Basic Functions of Stem

1. The stem supports the leaves and branches and holds them in such a position as to expose maximum sunlight for photosynthesis.
2. It conducts water and mineral salts from root to the other parts of the plant.
3. It also supplies the food materials from leaves to the other parts.
4. The green stems carry out photosynthesis as well.
5. It bears flowers and fruits.
6. Stem of some plants take part in vegetative propagation.
7. It serves as storehouse of the food material.

## Types of Stem

- a. **Erect stem:** It is the common type of aerial stem that is enough strong to remain erect or upright without any external support. Example- maize. Erect stems may be of following:
  1. **Caudex:** Some plants have long and unbranched erect stem with a crown of leaves at top. Such stem is called caudex. Example- *Cocos nucifera* (coconut)
  2. **Excurrent:** Some trees bear single main trunk with smaller lateral branches. In such trees, the terminal shoot grows faster and indefinitely and the lateral branches develop in a acropetal succession. Such type of growth of trees is called ex-current. Example- Fir (*talis patra*)
  3. **Deliquescent:** In most of the deciduous and broad leafed trees the main stem is prominent and remains distinct up to certain height and bears lateral branches. These branches grow more vigorously and give a wide spreading in all directions. Such type of tree is called deliquescent. Example- mango
  4. **Clums:** The cylindrical stem of some plants have distinct nodes and internodes. The internodes of such plants are hollow and the nodes are solid. Such growth of stem is called culm. Example -bamboo
  5. **Scape:** Some plants have underground stem with rosette of radical leaves. During flowering season they develop an erect unbranched aerial stems and bear flowers at their tips. Such flowering stems are called scape. Example - onion.
- b. **Weak stems:** These stems are thin, soft and weak. They cannot stand erect and therefore, need a support to grow. Weak stems may be upright or prostrate. Plants with weak stems are classified into twidders, climbers, trailers and runners.
  1. **Twinner:** The weak stem is long, flexible and sensitive. It coils itself round a upright support and climb up without any organs for attachment as in simi, is called twinner. The twining of stem may be clockwise or anti-clockwise. Example- *Lablab*
  2. **Climber:** The stem is weak, long and flexible. It is unable to coil around an upright support by itself. Thus it develops special clinging structures for climbing like tendrils in pea. It is classified into following types:
    - (i) **Root climber:** The weak stem produces adventitious roots from its nodes which acts as holdfast in fixing the climbers to the support. Example- Betel
    - (ii) **Tendrill climber:** Tendrils are green thread like sensitive structures that can around a support and help the weak-stemmed plants to climb up. Example - pea
  3. **Trailers:** The prostrate plants having weak, long and slender stems are called trailers. They trail along the ground but do not try to climb up. Example- *Tribulus*, *Protulaca*

4. **Runners:** The weak stemmed plants that creep on the ground are called runners. They are fixed to the soil by adventitious roots produced at each node of the stem. Example- strawberry.



Some plants with weak stem (A) Twiner (B) Climber (C) Trailer (D) Runner

### Some Taxonomical Terminology Used for the Description of Stem

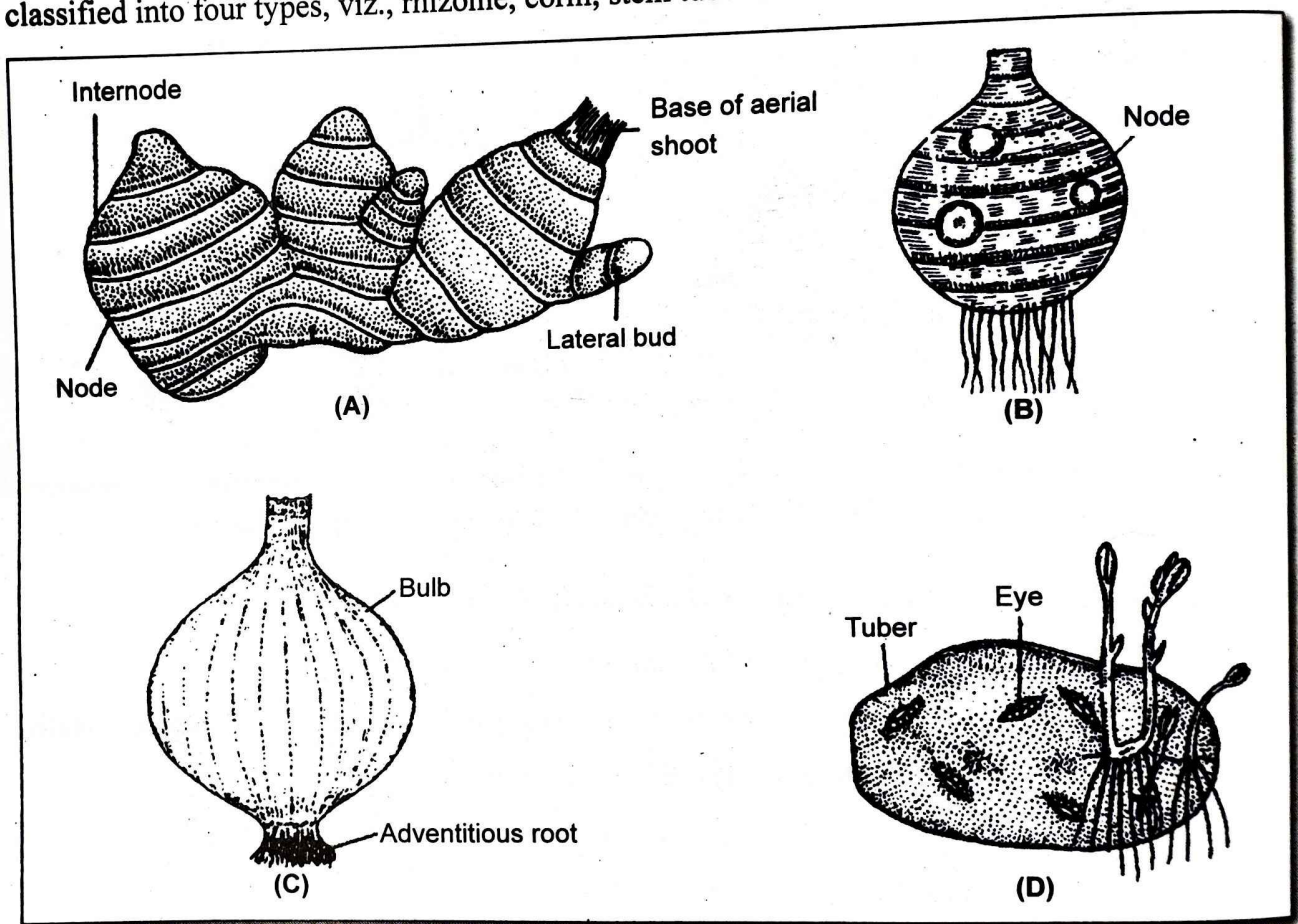
1. **Erect:** Plants stand upright. Example - maize
2. **Creeping:** Plants growing horizontally along the surface of the ground. Example - oxalis
3. **Branched:** Main stem with branches. Example - mustard
4. **Unbranched:** Main axis of the plants having no branches. Example - rice
5. **Cylindrical:** Rounded stem. Example - mustard
6. **Angular:** Plants with ridged stem. Example - marigold
7. **Solid:** Internally stem is filled with compact cells. Example - maize
8. **Fistular:** Hollow stem. Example - pea
9. **Herbaceous:** Weak, annual herb plant. Example - pea
10. **Woody:** Strong and hard stems of shrubs and trees. Example - china rose
11. **Glabrous:** Smooth stem or stem without hair. Example - wheat
12. **Hairy:** Stem with hairs. Example - sunflower
13. **Glaucous:** Smooth and shiny stem. Example - *Citrus*

## Stem modifications

The stems of many plants exhibit different modifications to perform different functions. The modified stems perform three different functions. They are perennation, vegetative propagation and storage of food. Based on the habit, the stem modifications can be classified into the following three categories:

- Underground stem
- Sub aerial stem
- Aerial stem ( Epiterranean stem)

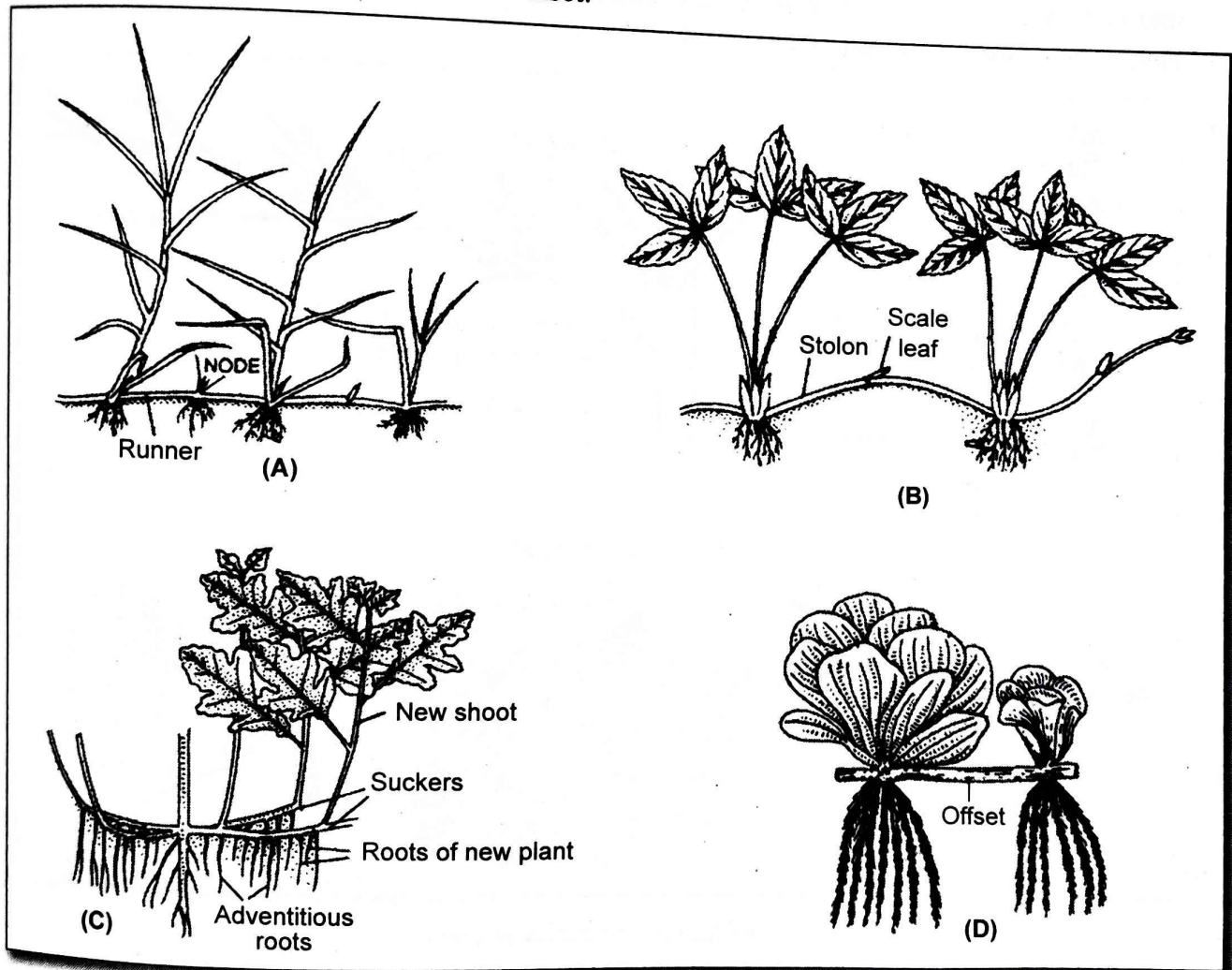
**a. Underground stems:** In many plants the stems develop non-green underground perennial stems. They store plenty of food material, propagate vegetatively and are adapted for longer time. The underground stems resemble roots in their general appearance in being underground and non green. But they can be identified as stems because of the presence of nodes, internodes, scale leaves, buds, branches, etc. Based on the type of growth and the part that stores food, the underground stems are classified into four types, viz., rhizome, corm, stem tuber and bulb.



Different modifications of underground stem (A) Rhizome (B) Corm (C) Bulb (D) Tuber

- Rhizome:** Rhizome is stout, horizontal, thick and fleshy underground stems. It contains dry scale leaves which protect the axillary buds. Nodes and internodes are distinct. The presence of buds help in the vegetative propagation of the plant. Example- ginger, turmeric, etc.
- Corm:** Corm grows vertically at a particular depth in the soil. It is a short, stout, solid and fleshy underground stem. It bears scale leaves at each node. It has distinct nodes and internodes. Nodes bear one or more buds in the axil of scale leaves and some of these buds grow up into aerial flowering shoots. The base of corm bears the annual adventitious roots. Example- *Colocasia*

3. **Bulb:** The bulb is shortest and somewhat disc-like underground stem that bears rosette of fleshy leaf bases or fleshy scales. It has terminal bud which develops into aerial shoot. It bears adventitious roots on the lower surface. The nodes and internodes are not differentiated in the bulb. Bulb stores food materials and water in the leaf bases or scale leaves. Example- onion
4. **Stem tuber:** Stem tuber is a swollen underground stem. It occurs under the soil at any depth. It has distinct nodes and internodes. An eye bearing a scale leaf and one or more axillary buds represent each node. The 'eyes' with buds take part in vegetative propagation. The stem tuber stores a large amount of food material in the form of starch. Example- potato, yam
- b. **Sub-aerial modifications:** The sub-aerial modifications are found in many herbaceous plants with a thin, delicate and weak stem. In such plants a part of the stem lives underground whereas remaining part of the stem is aerial. These plants bear adventitious roots and aerial branches at nodes. Such plants propagate vegetatively by means of small fragments of modified stem branches. Based on the type of growth and part of the plant that produces them, the sub-aerial stems are divided into four types namely runner, stolon, sucker and offset.

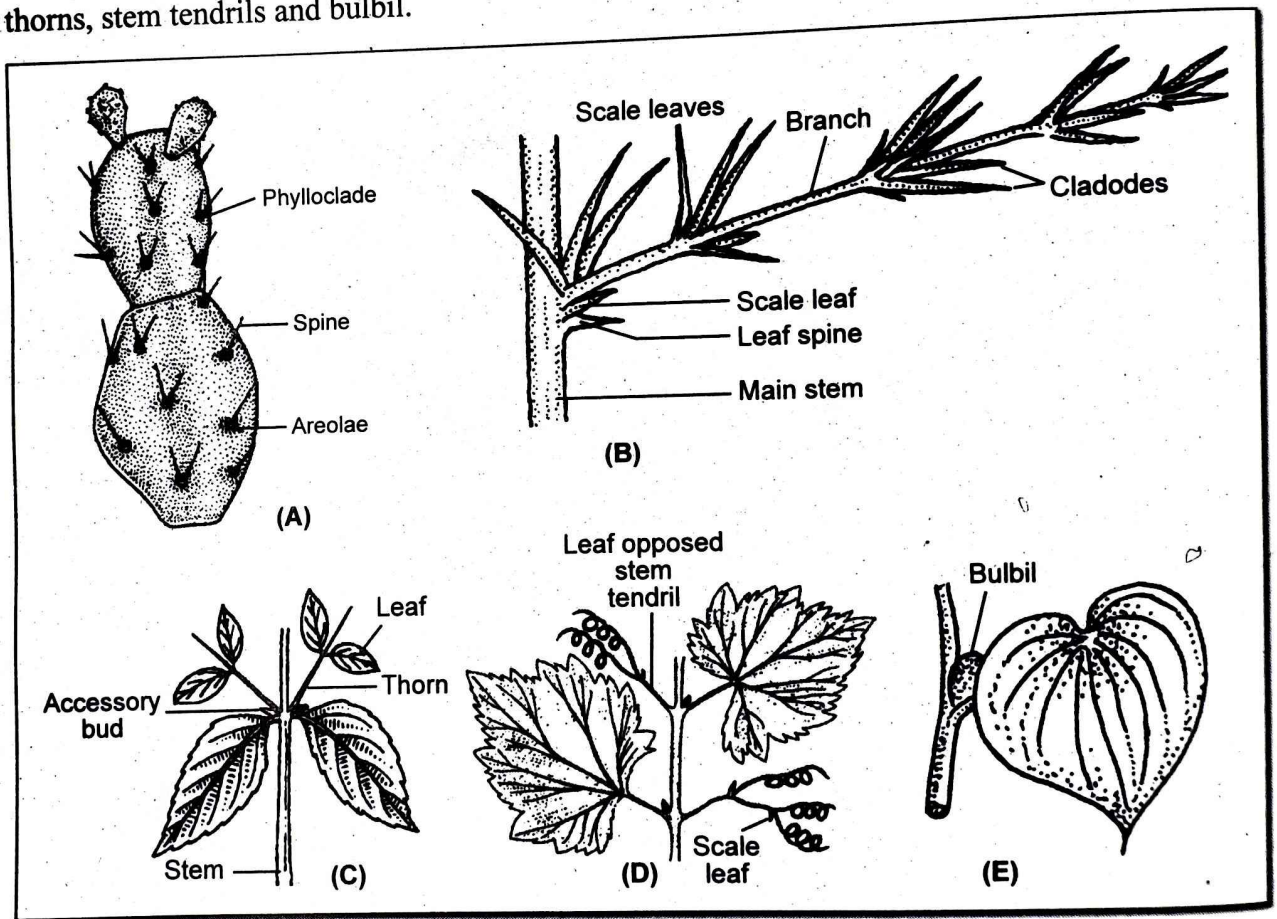


Sub-aerial modifications of stem (A) Runner (B) Stolon (C) Sucker (D) Offset

1. **Runner:** Runner is a specialized weak stem that has long and thin internodes and the branches creep over the surface of the soil. The branches develop adventitious roots from the lower sides of each node. The aerial branches develop from the axil of scale leaves at the nodes. The runner gives rise to new plants either from axillary or terminal buds. Example- mint, *Cynodon dactylon* (Doobo).

2. **Stolon:** Stolon is a thin lateral branch which grows horizontally outwards and bears nodes and internodes. It produces adventitious roots at the point of contact with the soil. Leaves are distributed all over the stolon due to normal apical growth. Example- strawberry
3. **Sucker:** It is a lateral branch which develops from the axillary bud of an underground part of the stem. It grows obliquely and gives rise to leafy shoot. The adventitious roots develop at the base of nodes of underground part of the sucker. Example- *Chrysanthemum*
4. **Offset:** Offset is also known as condensed runners. It is weak, elongated, horizontal branches at one internode that arise in the axil of leaf. An offset produces a tuft of leaves above and a cluster of roots below. The offset may break off from the parent plant and acts as an independent plant. Example- *Pistia*

c. **Aerial modifications:** The aerial stems are exposed to different environmental conditions. Hence, they exhibit many modifications. The vegetative and floral buds of many plants instead of growing into branches and flowers modify to new structures. Such new structures are phylloclade, cladode, thorns, stem tendrils and bulbil.



Aerial modifications of stem

(A) Phylloclades (B) Cladodes (C) Thorns (D) Stem tendrils (E) Bulbil

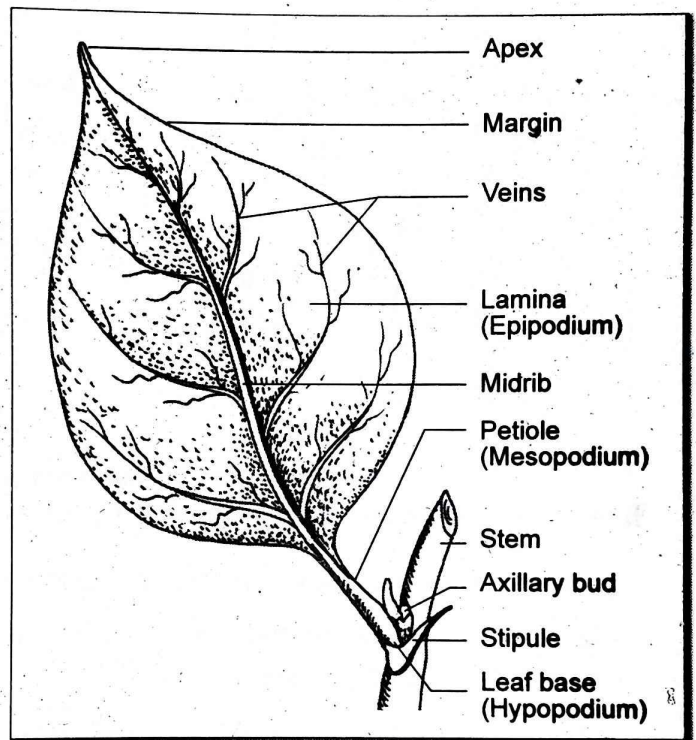
1. **Phylloclades:** They are green, flattened, or cylindrical stems. They bear distinct nodes and internodes. Their leaves are reduced to spines to reduce the transpiration rate. The stem takes part in photosynthesis. It is the characteristics of xerophytic plants. Example- *Opuntia*
2. **Cladodes:** They are short, green, cylindrical or flattened stem branches of limited growth. They arise from the node of stem in the axil of reduced scaly leaf. They may have one or two internodes only and help in photosynthesis. Example- *Asparagus*

3. **Thorns:** Thorns are straight pointed, often hard and woody structures. They are structures of defence against browsing animals. They are modifications of axillary or terminal buds. They may bear leaves, flowers and fruits. They may be branched. Example- *Duranta*, *Bougainvillea*
4. **Stem tendrils:** Stem tendrils are thin, thread like spirally coiled leafless structures which act as climbing organs of the plants. They help a weak plant to climb. Example- Grapevine
5. **Bulbils:** Bulbils are modified axillary buds which are meant for vegetative propagation of the plant. They develop from axillary buds, which become swollen and fleshy with food and drop off to form new plants. Example- *Agave*

## The leaf

The leaf is a thin, flattened, green outgrowth of the stem or its branch, borne at a node and having a bud in its axil. It carries physiological functions like photosynthesis and transpiration. A typical leaf has three main parts. They are leaf base, petiole and lamina.

1. **Leaf base:** The leaf base is the lowermost part of the leaf. It helps the leaf for attachment with the stem. In dicot plants the leaf base usually bears two lateral appendages called the stipules. These may vary in form and size. These are generally absent in monocot.
2. **Petiole:** Petiole is the stalk of the leaf. It helps in exposing the lamina to light. A leaf is said to be sessile, if the petiole is absent. The leaves of monocots are usually sessile.
3. **Lamina:** It is also called leaf blade. It is the terminal part of the leaf. It has two surfaces: upper surface and lower surface. The dicot leaves are dorsiventral whereas the monocot ones are of isobilateral types. It is green in colour due to the presence of chlorophyll in the cells, so it is the main sites of photosynthesis. There are many minute pores found on the leaf are called stomata through which the exchange of gases takes place between the leaf and atmosphere during respiration and photosynthesis. It also helps in transpiration. The lamina consists of central strong prominent midrib in the middle, which gives rise a number of lateral thin veins and veinlets traversing through its surface.



A typical leaf

## Duration of leaves

The mature leaves fall away after functioning for one or more seasons. This measures the duration of the leaves.

**Caducous :** Leaves fall down soon after the growth of axillary bud. Such leaves are called caducous.

**Deciduous:** Leaves fall down annually or after the growth of one season. Such leaves are called deciduous.

**Persistent or perennial:** If the leaves remain live and attached to the plant more than own seasons or one year, such leaves are called persistent or perennial.

## Insertion of leaf

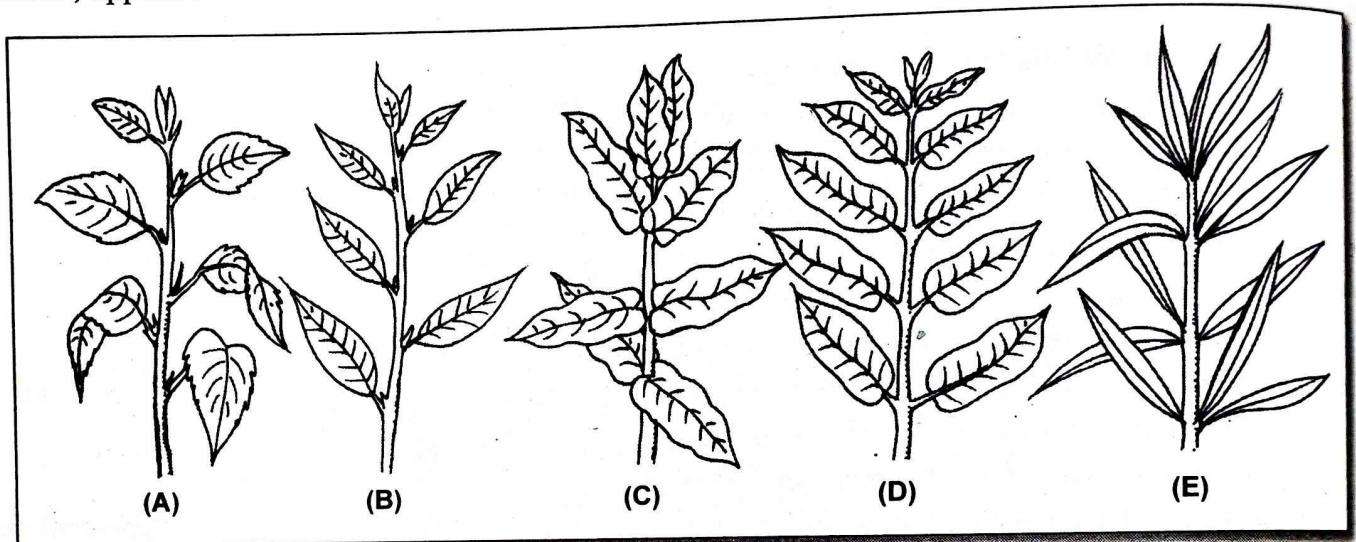
**Radical** : Leaves arising from or near the root. Example-onion

**Cauline** : Pertaining to the stem. Example - palm

**Cauline and ramal** : Pertaining to the main stem as well as its branches. Example - mango

## Phyllotaxy of leaf

The arrangement of leaves on the stem and branches is known as phyllotaxy. It is of three types: alternate, opposite and whorled.



Phyllotaxy of leaves (A), (B) Alternate (C) Opposite decussate (D) Opposite superposed (E) Whorled

**Alternate (spiral)** : A single leaf arising at each node. Example- *Hibiscus rosa-sinensis*

**Opposite**: Two leaves arise at each node opposite to each other. It is of two types. They are opposite decussate and opposite superposed.

**Opposite decussate**: The upper and lower leaves are found in pairs in nodes but arrange at right angles to one another. Example- *Calotropis*

**Opposite superposed**: When a pair of opposite leaves in the upper and lower nodes lies in the same plane is known as opposite superposed. Example- guava

**Whorled**: In this arrangement, two or more than two leaves arise at each node and form whorl around it. Example- *Oleander*

## Leaf base

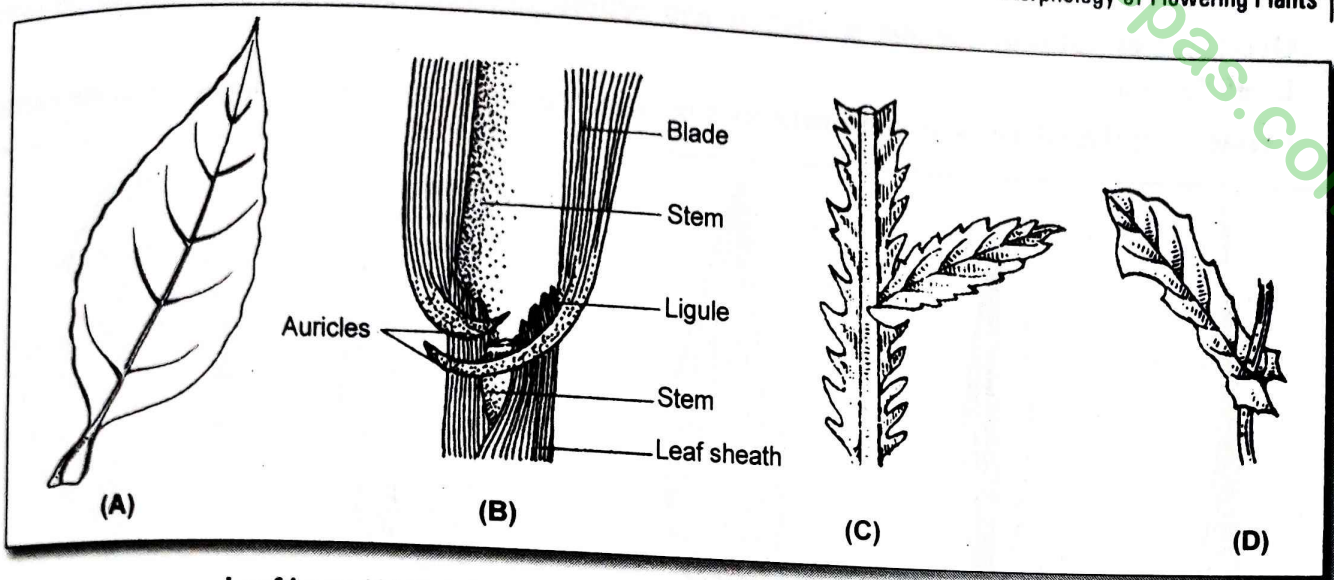
Leaf base is the part of a leaf attached to the stem or branches. It is of following types: pulvinus, sheathing, decurrent and amplexicaul.

**Pulvinus**: The petiole of the leaf has a swollen base. Example -mango

**Sheathing**: Leaf blade becomes broad and flat and covers a part of the node of stem. Example - banana, maize, etc.

**Decurrent**: Both the petiole and leaf base become broad; flat and winged that ensheath the upper part of node. Example - *Crotolaria*

**Amplexicaul**: The sheathing leaf base clasps and surrounds the stem completely. Example - *Polygonum*.



Leaf base (A) Pulvinus (B) Sheathing (C) Decurrent (D) Amplexicaul

### Stipules

Stipules are the lateral appendages of leaf at the leaf base. Stipules may be leafy (foliaceous), e.g., *Lathyrus*; free lateral, e.g., china rose

**Exstipulate** : Leaves without stipule. Example - mustard

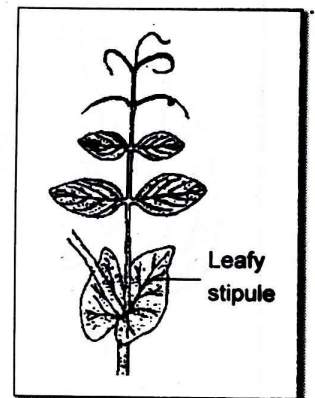
### Petiole

Petiole is a stalk of leaf. It connects the lamina with the stem or branch.

**Petiolate** : A leaf blade is situated on the petiole. Example - sunflower

**Sessile** : Leaf without a petiole. Example - maize

**Sub sessile** : Having a short petiole at the base of leaf. Example - guava



Leafy stipule

### Lamina or Leaf blade

Lamina is the most important green and flattened part of the leaf, which is mainly concerned with the preparation of food. According to the shape, apex, margin and venation, lamina shows many variations.

### Shape of lamina

**Acicular** : The lamina is like a needle. Example- pine

**Linear** : Lamina is longer and narrow. Example-wheat, rice, etc.

**Lanceolate** : Lamina is like a lance, i.e., broader in the lower middle part and pointed at the ends. Example- bamboo

**Oblong** : Lamina is long, broad with a round apex. Example-banana

**Ovate** : Lamina is egg-shaped. Example- china rose

**Cordate** : Lamina is heart-shaped with a deep notch at the base. Example- betel

**Sagittate** : Lamina is arrow-shaped with two basal lobes pointing towards the base. Example- *Arum*

**Reniform** : Lamina is kidney-shaped, rounded above with a deep notch at the base. Example- *Malva*

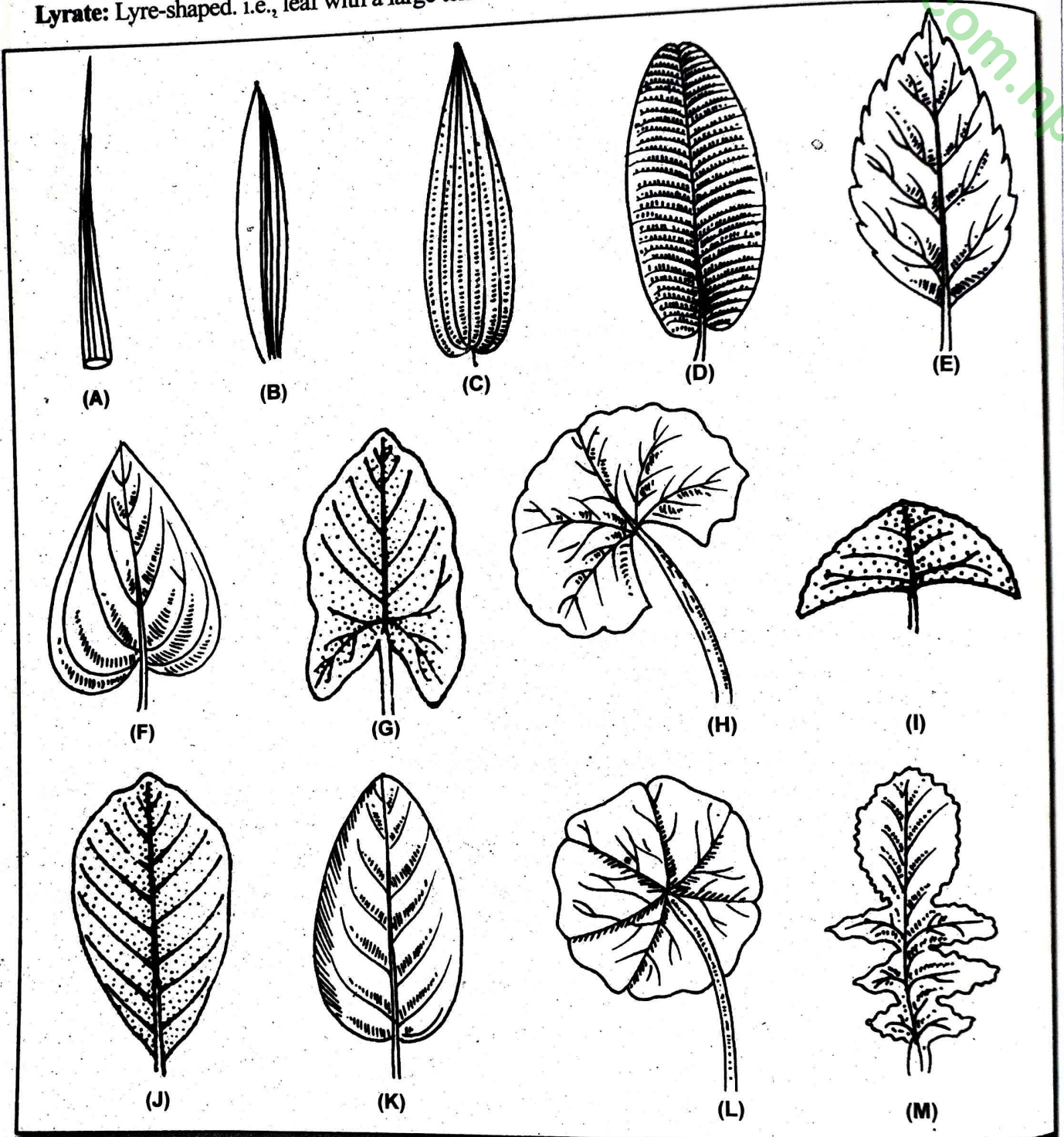
**Lunate** : Lamina is semicircular like a half moon with two pointed basal lobes. Example- *Adiantum*

**Obovate** : Apex of lamina is broader than the base. Example - Jack-fruit

**Oval or elliptical** : Lamina is oval shaped. Example- guava

**Orbicular or rotund:** Lamina is circular and petiole attached below the lamina near its centre.  
**Example-**lotus

**Lyrate:** Lyre-shaped. i.e., leaf with a large terminal lobe and some smaller lateral lobes. **Example-**mustard



Shape of lamina (A) Acicular (B) Linear (C) Lanceolate (D) Oblong (E) Ovate (F) Cordate (G) Sagittate (H) Reniform (I) Lunate (J) Obovate (K) Oval (L) Orbicular (M) Lyrate

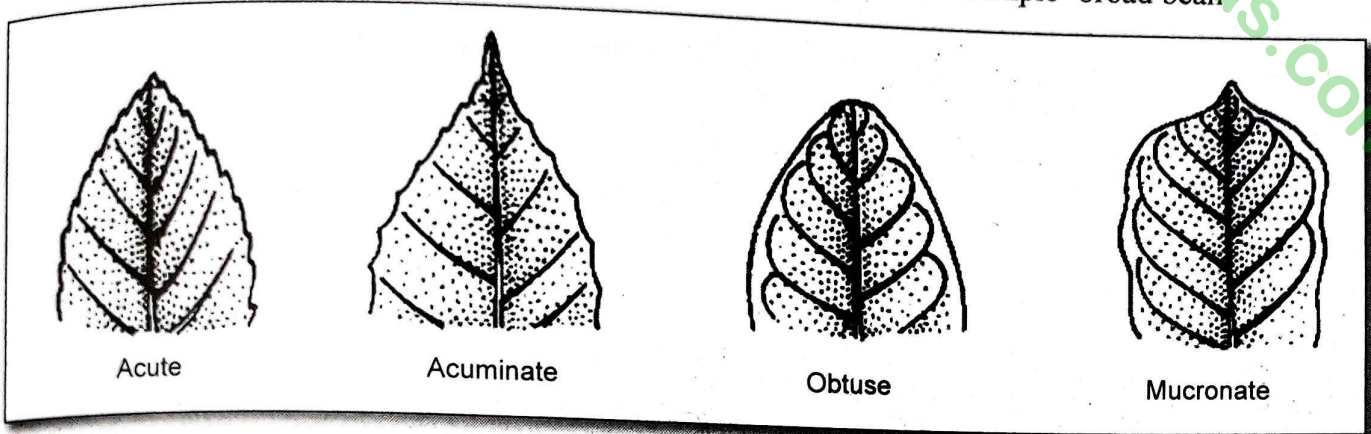
**Apex of Lamina**

**Acute:** Apex of lamina is pointed and narrow. **Example-** *Hibiscus rosa-sinensis*

**Acuminate:** Drawn out into long pointed apex. **Example-** peepal

**Obtuse:** Apex is broad, round and blunt and both margins of lamina make an angle of more than 90°  
**Example -** banyan

**Mucronate:** The apex is broad and round with a small projection. Example- broad bean



Apex of lamina

### Margin of lamina

**Entire:** The margin of the leaf is smooth and straight i.e., not incised. Example- *Nerium*

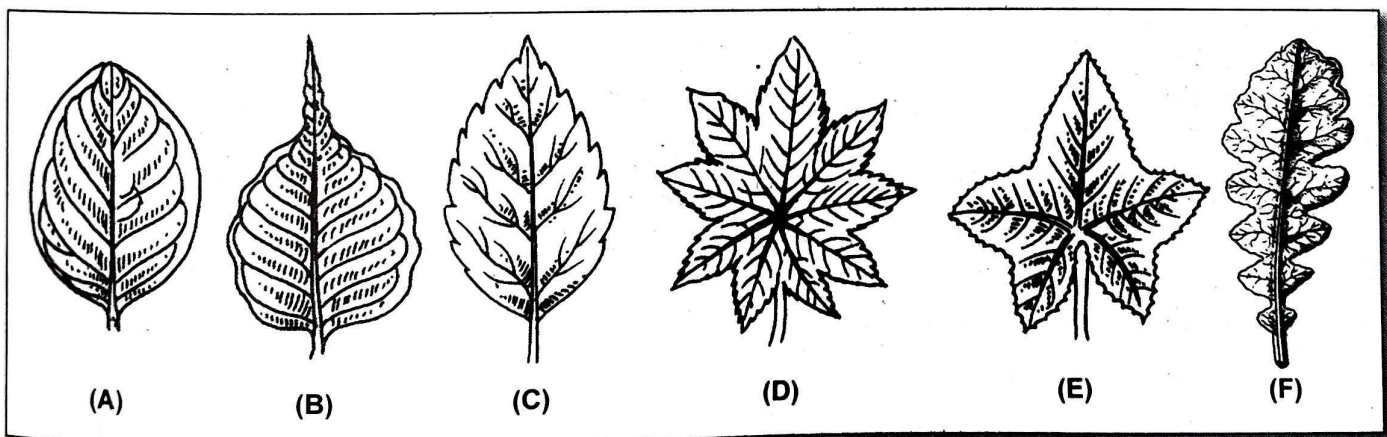
**Wavy:** The margin of the lamina with shallow or deep undulations. Example- Ashok tree

**Serrate:** The margin of the lamina is incised like a saw and all the teeth are directed upward. Example- rose

**Biserrate:** The margin is toothed but the teeth are again dentate. Example - elm tree

**Dentate:** The margin of lamina is serrate but teeth make right angle with the margin and are directed outwards. Example- water lily

**Lobed:** In this type, margins are incised up to various depths and divided into small lobes. Example - mustard



Margin of lamina- (A) Entire (B) Wavy (C) Serrate (D) Biserrate (E) Dentate (F) Lobed

### Venation

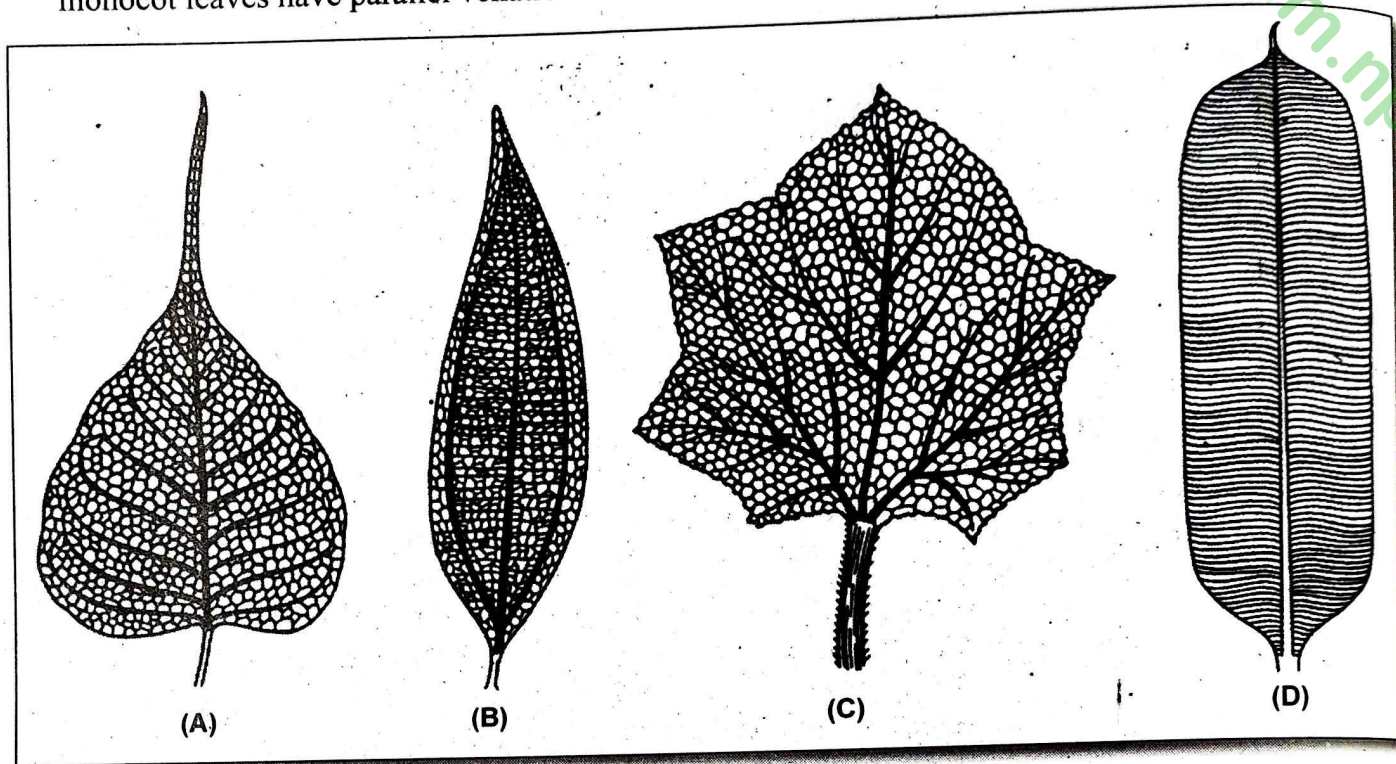
The arrangement of veins and veinlets in the leaf lamina is called venation. It is of two types: reticulate and parallel.

**Reticulate:** When veins and veinlets are irregularly distributed without a definite pattern in the lamina forming a network, is called reticulate venation. It is of two types: **unicostate** (having only one principal vein) and **multicostate** (having many principal veins). This type of venation is found in dicot leaves.

**Divergent :** When main vein diverges towards the apex of leaf. Example- china rose

**Convergent:** When veins converge towards the apex of leaf. Example - *Cinnamomum*

**Parallel:** When all veins run parallel or roughly parallel to another in the lamina is called parallel venation. In this, the veinlets are not conspicuous and do not form network in the leaf. Most of the monocot leaves have parallel venation.



Venation of leaves—(A) Unicostate reticulate (B) Multicostate convergent  
(C) Multicostate divergent (D) Parallel unicostate

### Leaf surface

**Hairy:** Leaf surface is covered with fine hairs. Example - radish

**Glabrous:** Leaf surface without hairs. Example- china rose

**Glaucous:** Shiny green leaf surface. Example - Orange

**Spiny:** Leaf surface with spines. Example - *Argemone*

### Texture

**Coriaceous:** Leathery. Example - *Calotropis*

**Fleshy:** Soft and thick. Example - *Spergula*

**Succulent:** A fleshy leaf with full of juice or sap. Example - *Aloe*

**Membranous:** A thin leaf like membrane. Example- *Solanum nigrum*

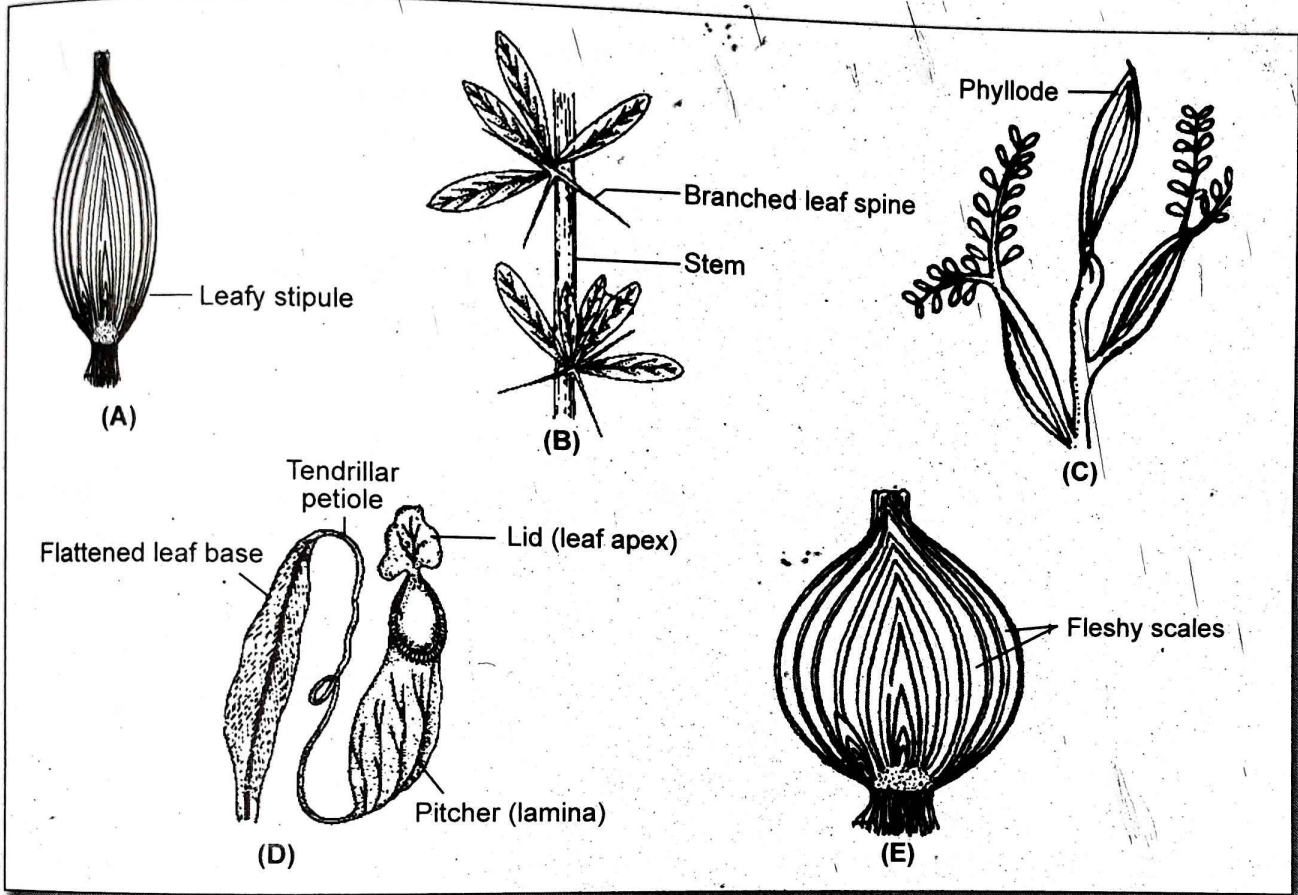
### Modified leaves

Leaves of many plants are often modified into some specified structures to do various specialized functions. Some of the modified leaves are as follows:

**Leaf tendrils :** The leaf or the leaflets are modified into slender branched or unbranched thread like structures which are sensitive called tendrils. They help in climbing. Example- pea.

**Leaf spines:** Leaves get modified into sharp-pointed structures for defensive purposes are known as spine - Example- *Argemone*

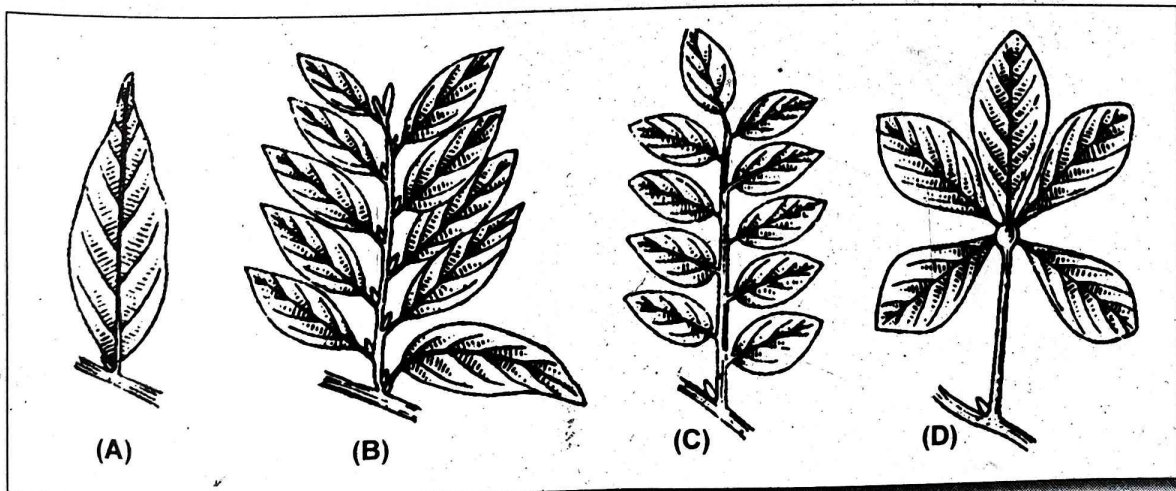
**Phyllode:** Petiole flattened to form leaf like structure called phyllode. Example- *Acacia* (Gum tree)  
**Leaf pitcher:** Some plants growing in soil deficit in nitrogen, leaves of them are modified into a peculiar structure- the pitcher. Example- *Nepenthes* (an insectivorous plants)  
**Scale leaves:** These are thin, dry, stalkless, membranous structures. Usually they are brownish or sometimes colourless. Example - onion



Modification of leaves (A) Leaf tendrils (B) Leaf spines (C) Phyllode (D) Leaf pitcher (E) Scale leaves

### Types of Leaves

On the basis of the number of leaf blades, the leaves are classified into two types: simple and compound leaves.



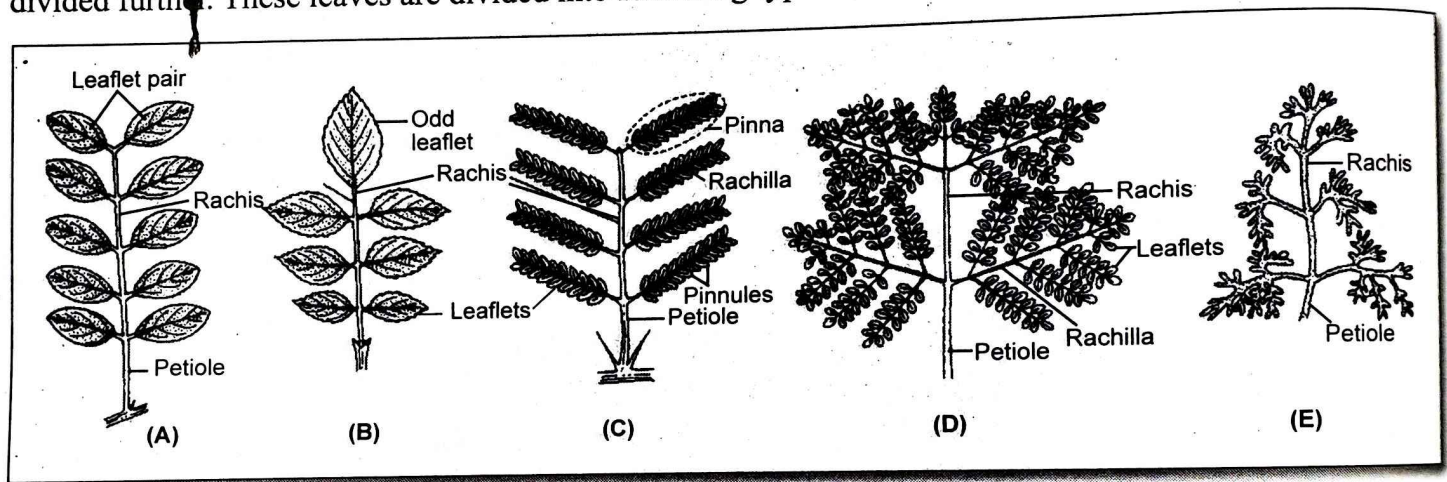
Simple and compound leaves: (A) Simple leaf (B) a branch (C) Pinnately compound leaf (D) Palmately compound leaf

**Simple leaf:** A leaf is said to be simple when its lamina is entire or incised to any depth but not up to midrib or petiole. The lamina may have various types of incisions. The pattern of incision depends upon the type of venation. Leaf axil always possesses an axillary buds. Example- mango

**Compound leaf:** A leaf in which the leaf lobes cut deep up to mid rib and the leaf blade is divided into a number of separate parts, the leaflets is called compound leaf. The compound leaves may be large or small. Though, leaves are divided into many leaflets which act as single entities. These leaflets are borne on a common axis and do not bear any axillary buds in their axil. Each leaflet also divided into base, stalk and lamina. Example- pea. There are two types of compound leaves: pinnately compound leaves and palmately compound leaves.

### Pinnately Compound Leaves

A compound leaf bears leaflets or pinnae laterally on rachis (the continuation of petiole, equivalent to mid rib) arranged alternately or oppositely. The leaflets in pinnate leaf may be sessile and may be subdivided further. These leaves are divided into following types.



Pinnately compound leaves (A) Unipinnate- Paripinnate (B) Unipinnate- Imparipinnate (C) Bipinnate (D) Tripinnate (E) Decompound

**Unipinnate:** A leaf having leaflets on each side of rachis. It is of two types: Paripinnate (leaflets are in even number) e.g. rajbrikchhya (*Cassia sp.*) and imparipinnate (leaflets are in odd number) Example- rose

**Bipinnate:** In it, the leaf is twice pinnate i.e., the rachis or mid-rib branches and the branches bear leaflets. Example - *Acacia*

**Tripinnate:** The leaf is thrice pinnate i.e., the branches of rachis produce branches further and bear the leaflets. Example - *Moringa*

**Decompound:** A leaf is called decompound when the leaf is more than thrice pinnate. Example-carrot

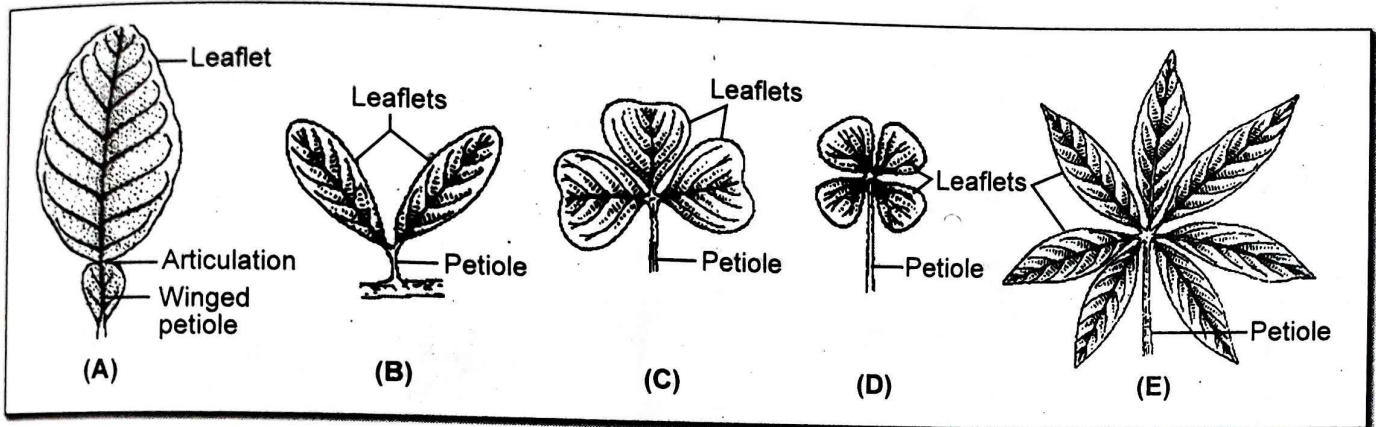
### Palmately Compound Leaves

The leaf blade of palmately compound leaves is dissected below up to the tip of the petiole. In palmately compound leaves, the leaflets arise from the tip of the petiole as fingers arising from palm. Leaves may be petiolate or sessile. The leaves are divided into following types.

**Unifoliate :** It looks like a simple leaf. The leaflet is reduced to single structure and a petiole bears single terminal leaflet. Example - shaddock (Bhogate)

**Bifoliate:** A pair of leaflets is borne on petiole. Example- *Balanites*

- Trifoliolate:** Compound leaf having three leaflets growing from petiole. Example- *Trifolium repens*
- Quadrifoliolate:** Compound palmately leaf with four leaflets arising at a common point of petiole. Example- *Marsilea*
- Multifoliolate:** Compound palmate leaf with five or more leaflets arising from tip of petiole. Example- *Gynandropsis pentaphylla*, simal, etc.



Palmately compound leaves– (A) Unifoliolate (B) Bifoliolate (C) Trifoliolate (D) Quadrifoliolate (E) Multifoliolate

## Inflorescence

The mode of arrangement of flowers on the floral axis or on the peduncle is called inflorescence. The stalk or floral axis of the inflorescence is called the **peduncle**. It may be branched or unbranched. A flattened peduncle is known as receptacle. The inflorescence is the characteristics feature of many angiosperms. The type of inflorescence is useful in identification of plants. On the basis of the nature of peduncle, the arrangement of flowers and the opening of flowers, inflorescence is of five types: solitary, racemose, cymose, mixed and specialized.

### A. Solitary Flowers

Flowers occur singly or are separated from other flowers in the same plant by vegetative parts. Solitary flowers are two types:

- Solitary terminal:** Single flower occurs at the tip of the main stem and its branches. Example- poppy
- Solitary axillary:** Single flower occurs in the axil of foliage leaves. Example- shoe flower

### B. Racemose Inflorescence

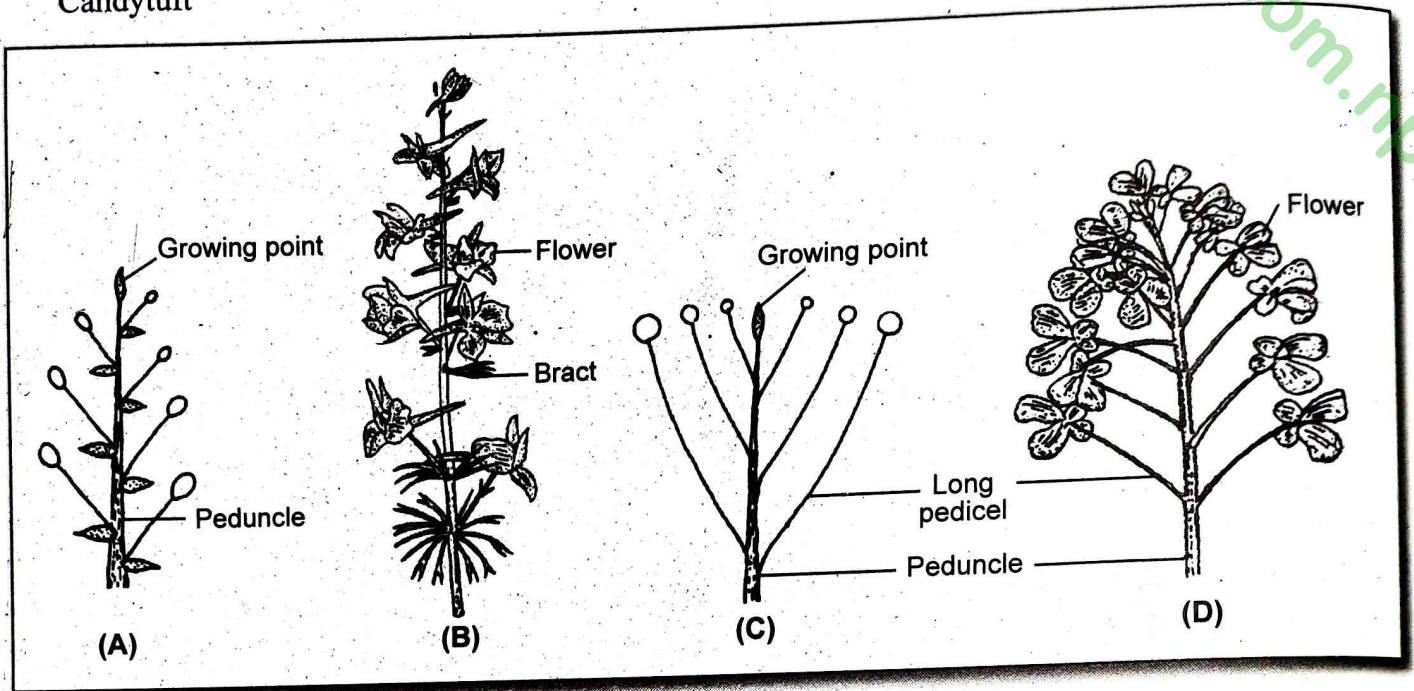
The racemose inflorescence is an indefinite inflorescence which shows unlimited growth of peduncle and bears a number of flowers due to the presence of active growing point. The arrangement of flowers is either acropetal succession ( i.e., older flowers are present at the base and the younger flowers towards apex) or centripetal succession (i.e., older towards the periphery and younger towards the centre). Racemose inflorescence is of two types: simple and compound.

#### I. Simple racemose inflorescence

Simple racemose inflorescence is that indefinite inflorescence in which the peduncle is unbranched. It is of the following types:

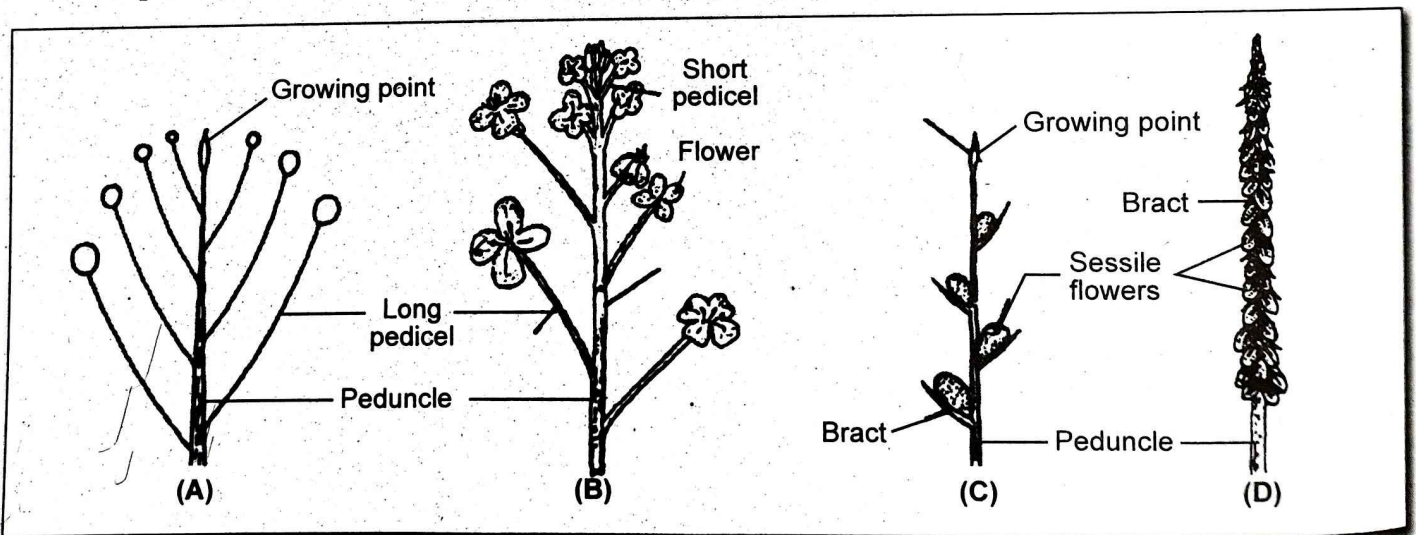
- Raceme:** In this type of inflorescence, an unbranched elongated peduncle bears pedicellate flowers in an acropetal fashion. Example- mustard

2. **Corymb:** An unbranched peduncle bears pedicellate flowers in an acropetal fashion but the pedicel of the lower flowers are longer. In this way, all the flowers come to lie at the same level. Example- Candytuft



Racemose inflorescence (A), (B). Raceme (C), (D) Corymb

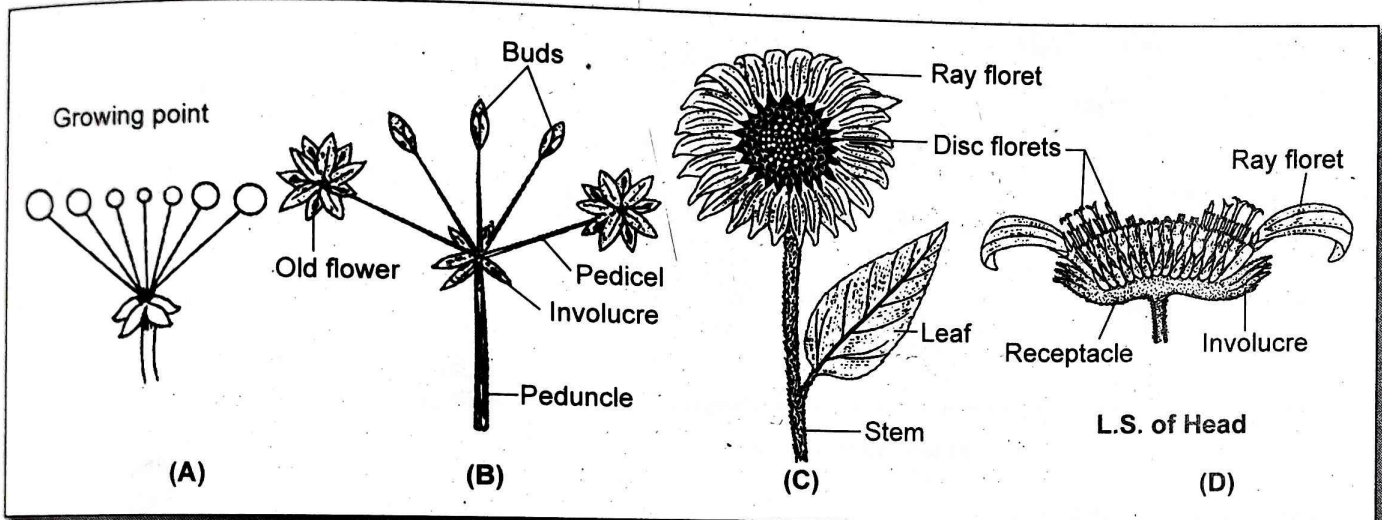
3. **Corymbose raceme:** The young flowers appear to be arranged like a corymb but in mature state the longer pedicels of the lower flowers do not bring them to the level of upper ones. Example- mustard
4. **Spike:** An elongated unbranched peduncle bears bracteate sessile flowers in an acropetal fashion. Example- *Achyranthes*



Racemose inflorescence (A), (B) Corymbose raceme (C), (D) Spike

5. **Umbel:** All the pedicellate flowers arise from a single point in a centripetal fashion because the peduncle is reduced to a short axis. An involucre or a whorl of bracts is often present at the base of flowers Example- hydrocotyle (*Centella*)
6. **Head or Capitulum:** The peduncle is somewhat flattened to form a receptacle that bears small sessile small flowers called florets. The florets are of two types: disc florets and ray florets. The small and tubular disc florets are borne on the central part of the receptacle whereas the large and ligulate ray

florets are borne around the disc florets. The whole inflorescence at the base is surrounded with a number of green involucre of bracts. The disc florets are actinomorphic, tubular and bisexual. The ray florets are zygomorphic, ligulate and unisexual (pistillate). This inflorescence is the characteristics of the family *compositae*. Example- sunflower. Besides this general arrangement, there are two kinds of head. They are homogamous head and heterogamous head.



Racemose inflorescence (A), (B) Umbel (C), (D) Capitulum

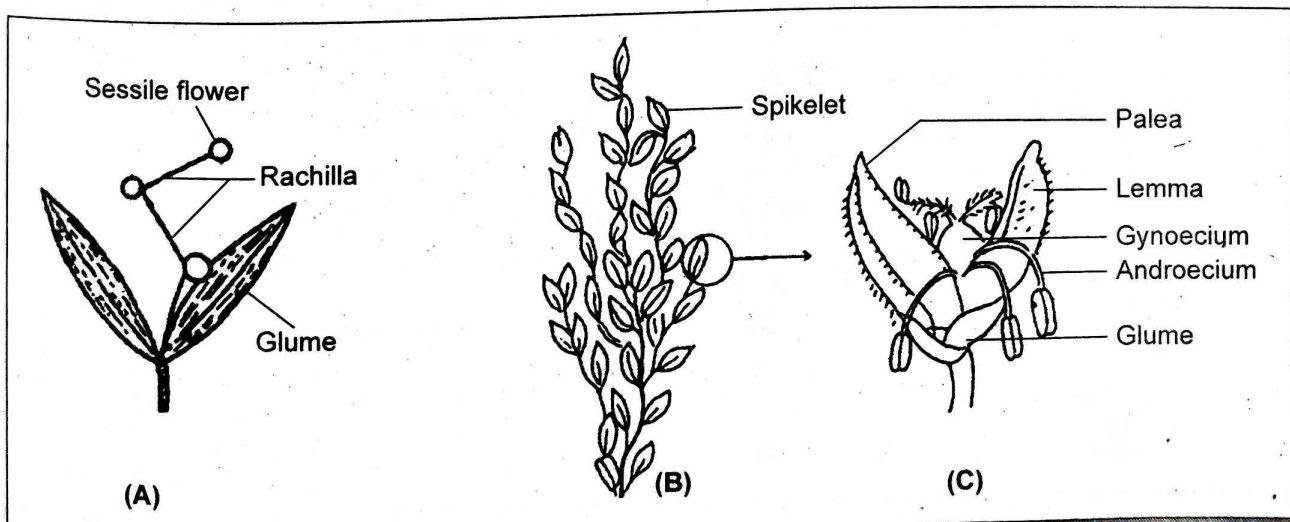
**Homogamous head:** The head with one type of florets is called homogamous head. Example- *Ageratum*, *Vernonia* (all disc florets) *Zinnia* (all ray florets).

**Heterogamous head:** The head with two kinds of florets i.e., ray florets and disc florets is called heterogamous head. Here, the disc florets are at the centre and ray florets are at the periphery of the inflorescence. Example- *Helianthus*

## II. Compound racemose inflorescence

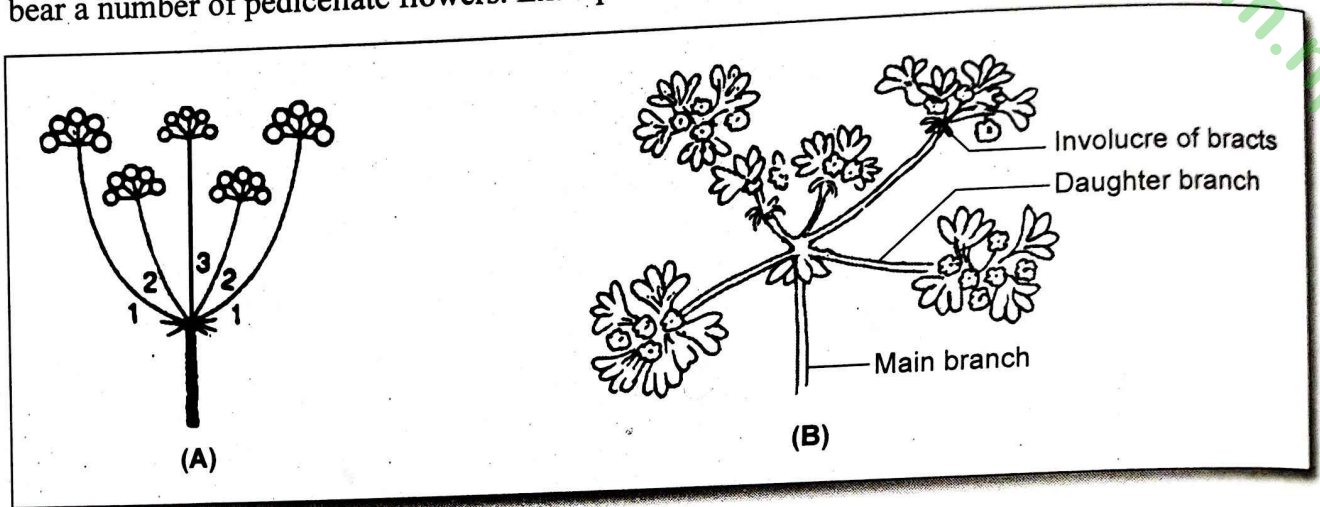
It is an indefinite or indeterminate inflorescence in which the peduncle is branched and each branch bears flowers in acropetal or centripetal fashion.

1. **Spikelets:** The spikelets are very small spikes with a few sessile florets. Each spikelet bears two sterile glumes. The flowers are borne at the axil of fertile bract, the lemma, lying opposite the small bracteole, the palea. Example- wheat



(A), (B) Spikelet (C) Single spikelet

2. **Compound corymb:** The branched peduncle and its indefinite growth appears like a simple corymb. A compound corymb is a corymb of corymbs. Example- cauliflower
3. **Compound umbel:** The main axis branches into a number of daughter branches whose tips, in turn bear a number of pedicellate flowers. Example- coriander

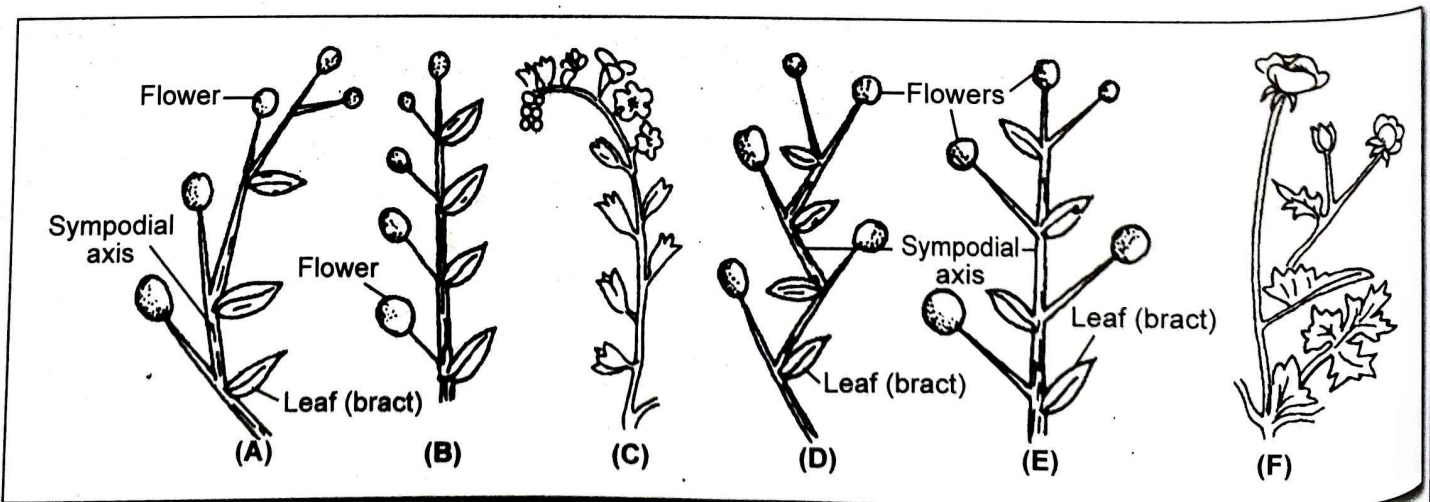


(A) Compound umbel (B) Compound umbel—coriander

### C. Cymose Inflorescence

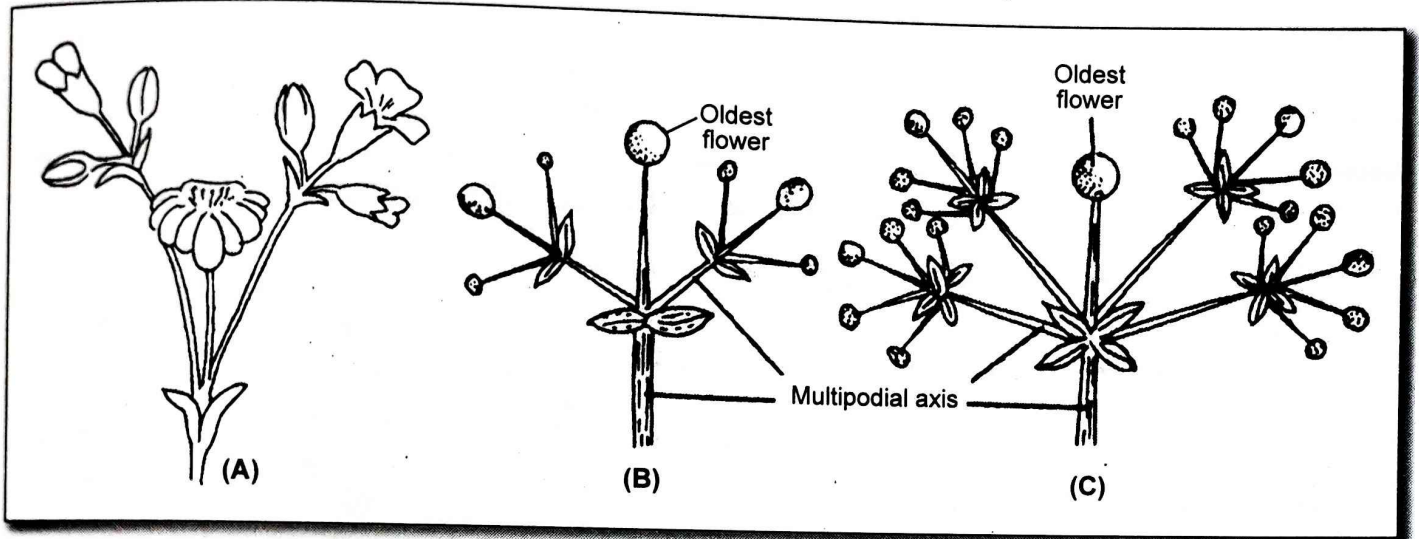
The main axis is shortened due to the development of terminal flowers. The flowers are arranged either in basipetal succession, ( i.e., the terminal flowers are the oldest and the lateral ones are the youngest) or centrifugal (i.e., opening of flowers proceeds from centre of the inflorescence to periphery). The cymose inflorescence is of following types.

1. **Solitary cyme:** An inflorescence with a single flower is called solitary cyme. Here, the peduncle ends with a flower and therefore, its further growth is checked. The solitary cyme may be axillary (e.g. *Hibiscus*) or terminal (e.g., *Datura*).
2. **Monochasial cyme:** The peduncle ends in a flower and a lateral branch is developed only on one side which again forms a terminal flower and subsequently a lateral branch develops. This process continues. The monochasial cyme is of two types namely helicoid cyme and scorpioid cyme.
  - i. **Helicoid cyme:** All the flowers are borne on the same side forming a sort of curve. Example- *Begonia*
  - ii. **Scorpioid cyme:** All the flowers are borne in one plane. Example- *Solanum nigrum*.



Cymose inflorescence (A), (B), (C) Uniparous helicoid cyme (D), (E), (F) Uniparous scorpioid cyme

- Dichasial cyme:** In this type, the peduncle ends in a flower and lateral branches are given to act on both sides. Both the lateral branches end in a flower and forming two lateral branches. Example - *Dianthus*, *Bougainvillea*, etc.
- Polychasial cyme:** In this type, the peduncle ends in a flower. Then three or more lateral branches arise in the axils of bracts present below the first flower. These branches also end with flowers. Each branch repeats the same type of branching pattern. Example - *Calotropis*



Cymose inflorescence – (A), (B) Dichasial or Biparous cyme (C) Polychasial or Multiparous cyme

#### D. Mixed Inflorescence

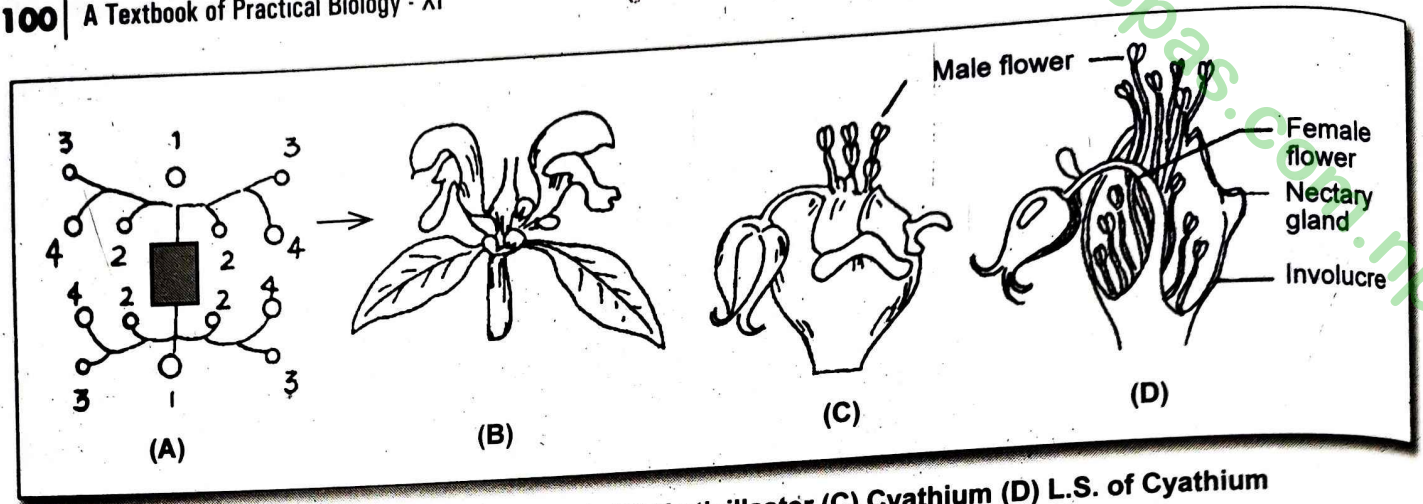
Inflorescence showing the characteristics of both racemose and cymose inflorescence is called mixed type of inflorescence.

- Mixed panicle:** In this type, basic pattern is racemose inflorescence but the branches show cymose inflorescence. Example - *Ligustrum*
- Cymose umbel:** In this type, cymose flowers are arranged in an umbellate manner on the top of the suppressed peduncle. Example- onion
- Mixed spadix:** In this type, the cymose types of flowers are arranged acropetally on the fleshy axis. Example- *Musa*
- Thyrse:** It is mixed inflorescence in which the peduncle grows indefinitely and a clusters of cymose flowers are arranged in acropetal succession. Example- *Ocimum*

#### E. Special Types of Inflorescence

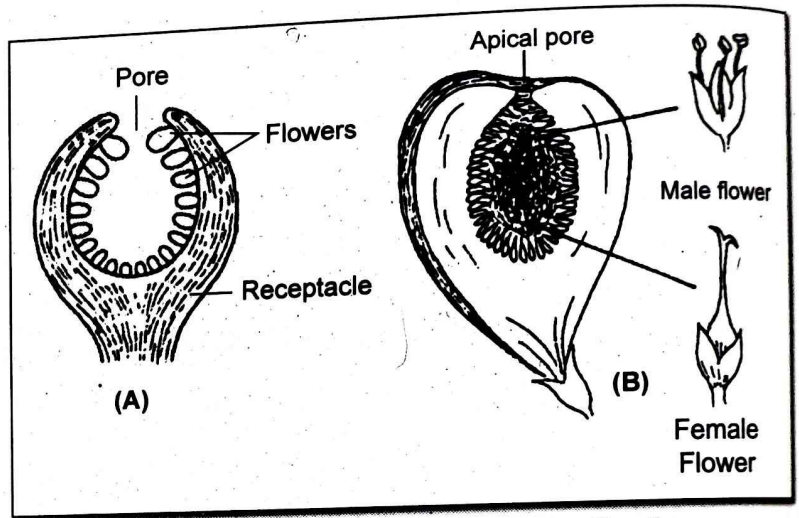
Some inflorescence undergoes modifications. It results in peculiar arrangement and opening of flowers. Such inflorescence is called special type. Some special types of inflorescence are verticillaster, cyathium and hypanthodium.

- Verticillaster:** It is a condensed form of cymose inflorescence. It consists of a cluster of sessile or short-stalked flowers in the leaf axil forming a false whorl at the nodes. At each node there are two bracts bearing a cluster of flowers opposite to each other. Example- *Coleus*
- Cyathium:** It is a special type of cymose inflorescence. In this type, there is a cup-shaped involucre with stamens and stalked gynoecium, each stamen and the gynoecium represents a separate flower. Example- *Euphorbia*



Special types of inflorescence (A), (B) Verticillaster (C) Cyathium (D) L.S. of Cyathium

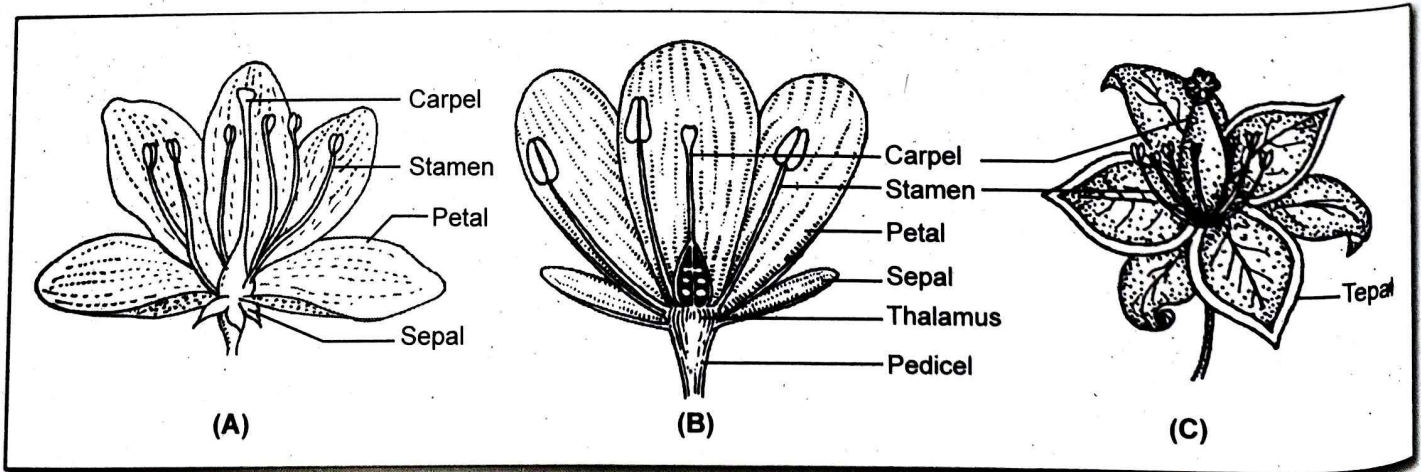
3. **Hypanthodium:** It is a specialized form of racemose inflorescence. Here, the peduncle forms a cup-shaped receptacle with an apical opening guarded by scales. Flowers are present on the inner wall the cup-shaped cavity. The male flowers are present near the opening with downwardly pointed scales. Below them are situated the female flowers and in the lowermost portion are present sterile flowers (gall flowers) and some female flowers also. Example- *Ficus*



(A) Hypanthodium (B) L.S. of hypanthodium

### Flower

The flower is a modified dwarf shoot of angiospermic plant that serves as a basic unit of sexual reproduction. It develops either in the axil of leafy bracts or at the tip of the axis. The short or long stalk of the flower is known as pedicel. Upon the pedicel there may be one to many small scaly structures called bracts. The terminal part of the pedicel gets swollen and is called the thalamus or receptacle. There are four types of floral leaves or organs such as sepals, petals, stamens and carpels develop from the nodes of the thalamus. All the flowers are found differ in size, shape, colour and pattern of arrangement of the floral parts yet most of them have similar structural plan.



(A) Complete flower of dicotyledon (B) L.S. of flower (C) Monocotyledon flower

A typical flower of angiosperm consists of four floral parts namely calyx, corolla, androecium and gynoecium.

1. **Calyx:** Calyx constitutes the outermost whorl and consists of sepals. Sepals may be green or coloured. It is protective in the bud condition.
2. **Corolla:** Corolla is the second whorl of the flower which is composed of petals. Usually, it is brightly coloured, scented with nectaries or honey glands to attract the insect for cross-pollination.
3. **Androecium:** Androecium represents the male reproductive whorl of the flower. It comprises stamens. Each stamen has usually a filament, anther and connective. Each anther consists of two lobes. Each lobe further consists of two chambers, which are called the pollen sacs. Thus, there are four pollen sacs in each anther. Each pollen sac produces a large number of pollen grains. The pollen grains develop the male gametes.
4. **Gynoecium:** Gynoecium is the innermost whorl of the flower and comprises the female organs called carpels. Each gynoecium or pistil consists of three parts: ovary, style and stigma. The swollen basal part of the pistil is called ovary. The ovary may have one or more locules. Each locule is provided with one or more ovules on placentae. On maturity after fertilization ovary develops into fruits and ovules develop into seeds. Above the ovary the carpel is protuded into a long or short style. The style ends with a round, sticky stigma. During pollination, the pollen grains are deposited on the stigma.

Sepals and petals of flower are called accessory whorls of the flower because these are not directly involved in the reproduction while the androecium and gynoecium are the essential or reproductive whorls of the flower as these are directly involved in reproduction. In some plants, the calyx and corolla of the flower are not differentiated from one another. In such case, these two are represented by another structure, called perianth. The unit structure of the perianth is called tepal.

In most of the flowers, the male and the female reproductive parts are present in a same flower. Such flowers are called bisexual flowers, example- pea, mustard, etc. In other flowers, any one of the reproductive parts either stamens or pistils are present in a flower. Such flowers are called unisexual flowers. Example- pumpkin, bitter guard, mulberry, etc.

## Some Descriptive Terms of the Flower

### Pedicel

Pedicel is a stalk of a flower.

1. **Pedicellate:** A flower with a stalk or pedicel. Example- sunflower
2. **Sessile:** A flower without a stalk or pedicel. Example- rice
3. **Sub sessile:** A flower with a very short pedicel is known as sub-sessile. Example- *Solanum nigrum*

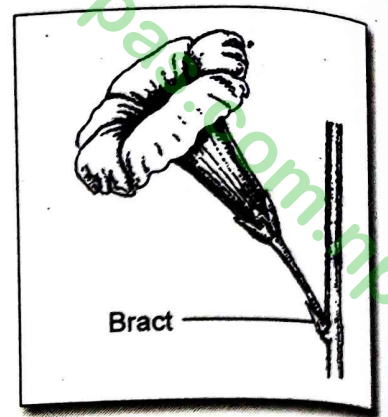
### Complete and Incomplete Flowers

1. **Complete:** A flower in which all the four whorls, i.e., calyx, corolla, androecium and gynoecium are present, is called complete flower. Example- pea
2. **Incomplete:** The flower in which any one of the four whorls are absent, the flower is called incomplete flower. Example- maize
3. **Naked:** A flower in which perianth or sepals and petals are absent, the flower is called naked. Example- *Euphorbia*

## Bracts

A modified, small leaf-like structure present at the base of a flower is called bract.

1. **Bracteate:** A flower with a bract is called bracteate. Example- pea
2. **Ebracteate:** Flower having no bract is called ebracteate. Example- mustard
3. **Involucre:** A whorl of bracts. Example- sunflower
4. **Glume:** Sterile scaly bracts present at the base of spikelet that encloses flowers. Example- wheat



A flower with bract

## Bracteole

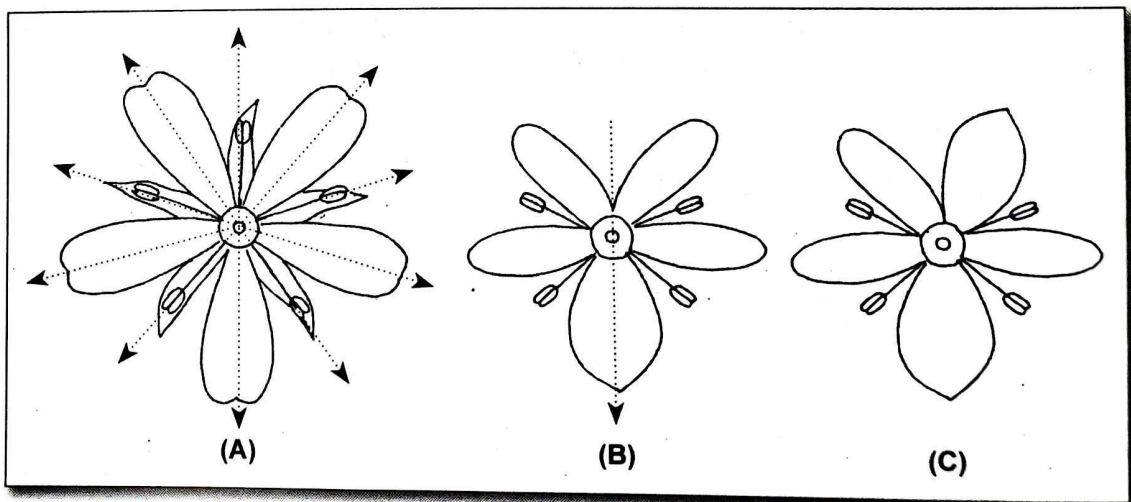
In some cases, a secondary bract arises at the base of individual flower, is called bracteole. The flower with bracteole is called bracteolate. Example- wheat

## Unisexual, Bisexual, Neuter and Achlamydous Flowers

1. **Unisexual:** A flower having either stamens or carpels. If only stamens are present it is said to be **staminate** (e.g., maize) and if only carpels (pistils) are present it is said to be **pistillate**. (e.g., ray florets of marigold)
2. **Bisexual:** A flower having both stamens and carpels is called bisexual flower. Example- pea
3. **Neuter:** Both the reproductive organs of a flower are absent. Example- some ray florets of sunflower
4. **Achlamydous:** Both calyx and corolla or perianth are absent. Example- *Euphorbia*

## Symmetry of Flower

The symmetry of a flower is defined as the divisibility of the flower vertically into two halves. The symmetry of the flower may be actinomorphic, zygomorphic and asymmetrical.

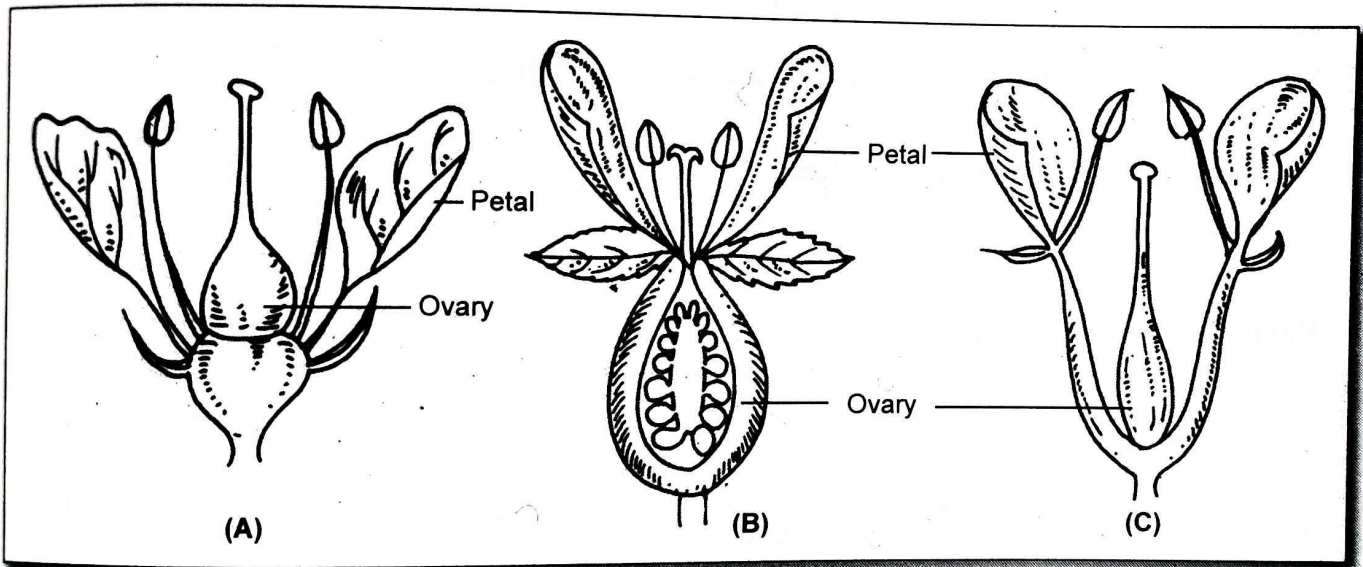


Symmetry of flower – (A) Actinomorphic (B) Zygomorphic (C) Asymmetrical

1. **Actinomorphic:** A flower, which can be divided by any vertical plane into two equal and similar halves, is known as actinomorphic or regular flower. Example- mustard
2. **Zygomorphic:** When a flower can be divided into two equal halves by only one vertical plane, it is called zygomorphic flower. Example- pea
3. **Asymmetrical:** A flower, which cannot be divided into two equal halves by any plane, is called asymmetrical flower. Example- *Canna*

## Types of Flower

1. **Hypogynous flower:** A flower in which the ovary is borne on a small thalamus while the other floral parts are inserted below the ovary. The ovary is said to be superior because its position is above the other three whorls. The other whorls are inferior because their positions are below the ovary. Example- mustard
2. **Perigynous flower:** The thalamus grows into a cup-shaped structure. The ovary lies at the base of the cup without touching the wall of the thalamus. The position of sepals, petals and stamens is neither below nor the top of ovary. Hence the position of ovary is half inferior. Example-rose
3. **Epigynous flower:** The thalamus grows upwards completely enclosing the ovary. The ovary wall gets fused with the thalamus. The sepals, petals and stamens arise from the top of ovary showing the superior position. The ovary is inferior because it is completely below the other floral whorls. Example- sunflower



Types of flowers— (A) Hypogynous (B) Perigynous (C) Epigynous

## Form of Flower

1. **Trimerous:** A flower in which the number of parts in each whorl is 3 or its multiple. Example- in most monocots
2. **Tetramerous:** A flower in which the number of parts in each whorl is 4 or its multiple. Example- mustard
3. **Pentamerous:** A flower in which the number of parts in each whorl is 5 or its multiple. Example- pea
4. **Heteromerous:** A flower is called heteromerous only when the member in all the whorl is neither the same nor any multiple

## Calyx

It is first and outermost whorl of the floral leaves and is composed of number of green or coloured sepals.

1. **Sepal:** A leaf- like division of calyx
2. **Polysepalous:** If the sepals are **free from each** other. Example- mustard
3. **Gamosepalous:** If **all the sepals are fused** wholly or partly with one another forming a small bell structure. Example- pea

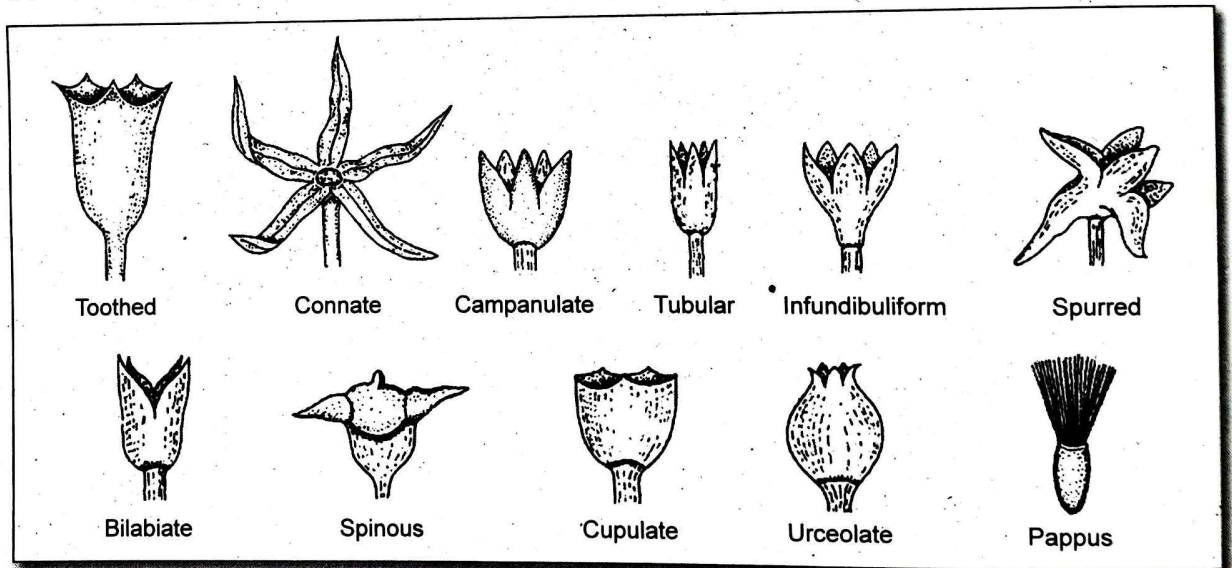
## Colour of Sepals

1. **Sepaloid:** Sepals are green in colour. Example- pea
2. **Petaloid:** Sepals are like petals; coloured. Example- *Cassia*

## Forms of Calyx

According to the fusion of sepals of calyx, calyx is of following types:

1. **Toothed:** Division between two sepals is very small. Example-black night shade
2. **Connate:** Sepals fused at the base Example- tomato
3. **Campanulate:** Bell shaped calyx. Example- pea
4. **Tubular:** Tube like calyx. Example- *Verbena*
5. **Infundibuliform:** Funnel like calyx. Example- *Atropa*
6. **Spurred:** One or two sepals drawn out in the form of a long beak or spur. Example- larkspur
7. **Bilabiate:** Two-lipped calyx. Example- *Salvia*
8. **Spinous:** One or two spines are developed on the side of calyx by the modification of sepals. Example- *Trapa*
9. **Globose:** Calyx swells like a globe. Example- *Physalis*
10. **Cupulate:** Club-shaped calyx. Example- *Gossypium*
11. **Urceolate:** Urn -shaped calyx. Example- *Silene*
12. **Pappus:** The calyx is modified into hairy structures. Example-calyx of marigold

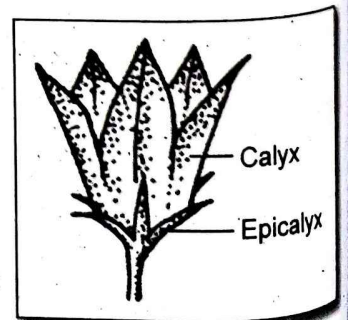


Forms of calyx

## Age of Calyx

According to duration, sepals are of following types:

1. **Caducous:** Calyx falls down immediately after opening of flowers. Example- *Argemone*
2. **Deciduous:** Falling at maturity. Example- mustard
3. **Persistent:** Remaining attached till maturation. Example- *Solanum nigrum*
4. **Epicalyx:** It is the extra whorl of green sepal like floral leaf present outside the calyx. Example- *Hibiscus*



Epicalyx of china rose

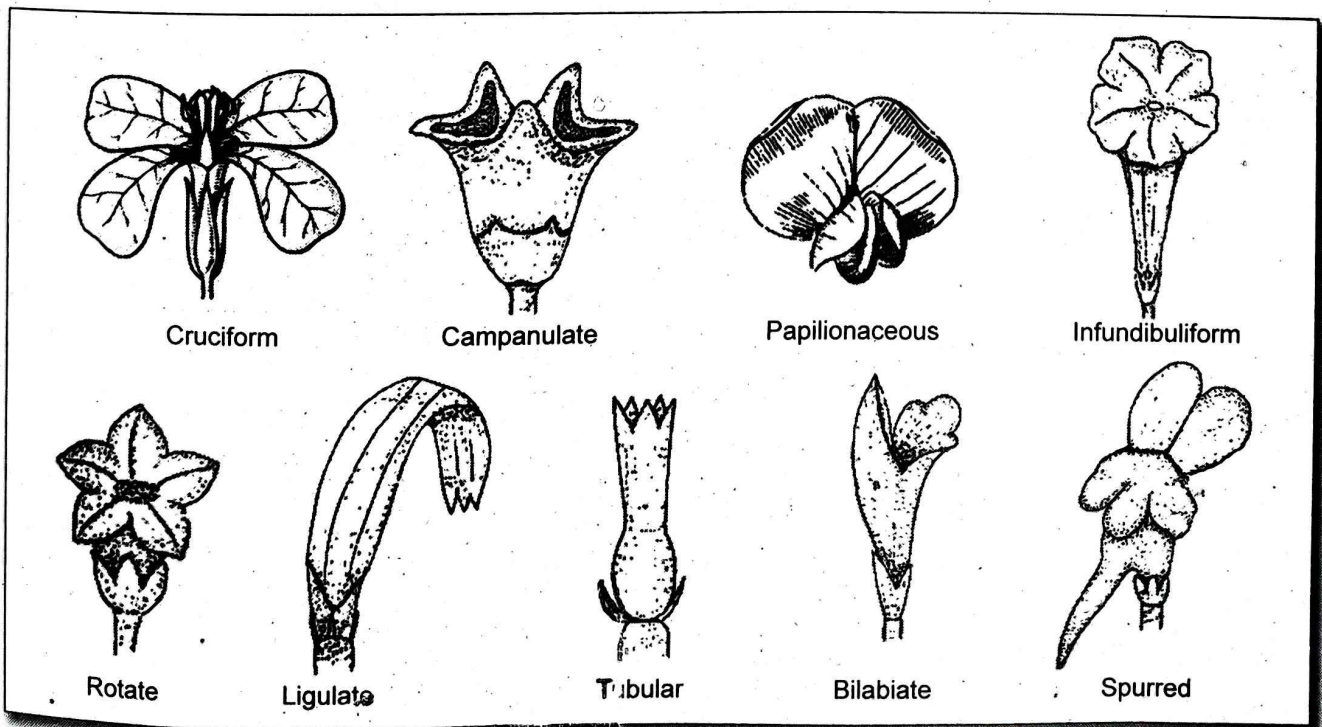
## Corolla

It is the second whorl of flower and is made up of petals

1. **Petal:** One of the floral leaves of corolla.
2. **Polypetalous:** Petals free from each other. Example- mustard
3. **Gamopetalous:** Petals fused to each other. Example- ray florets of marigold

## Forms of Corolla

1. **Cruciform:** The corolla consists of four free petals arranged in the form of cross. Each petal is differentiated into a claw and a limb. Example- mustard
2. **Campanulate:** Bell-shaped corolla; the petals are fused to each other. Example- tobacco
3. **Papilionaceous:** Butterfly like. It is composed of five petals of which one posterior is largest and is known as standard or vexillum, the two lateral ones, partially covered by standard are known as wings or alae, and the two innermost anterior are smaller and united to form a boat-shaped structure keel or carina. Example- pea
4. **Infundibuliform:** Funnel-shaped corolla. Example- *Datura*
5. **Rotate:** Wheel shaped gamopetalous corolla. Corolla tube is narrow and short while the limbs are flat and circular and at right angles to the tube. Example- brinjal
6. **Ligulate:** Strap-shaped. Zygomorphic corolla forming a short, narrow tube below and ligule like flat structure above. Example- sunflower
7. **Tubular:** Corolla is tubular or cylindrical. Example- disc florets of sunflower
8. **Bilabiate:** The gamopetalous corolla is divided into two lips, the upper lip and lower lip. Example- *Ocimum*
9. **Spurred:** A sac like or tubular projection of a petal. Example- *Viola*
10. **Nectary:** A nectar-secreting gland in petals. Example- *Salvia*

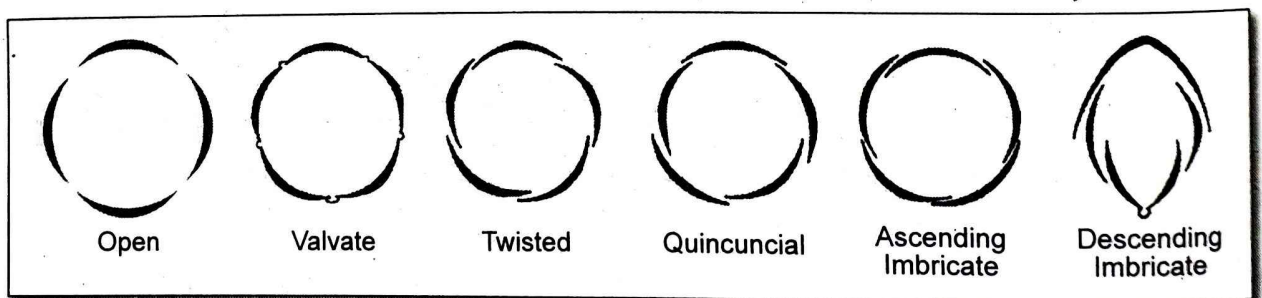


Forms of corolla

## Aestivation of Calyx and Corolla

The mode of arrangement of sepals or petals i.e., floral leaves in a flower bud in relation to one another is known as aestivation. It is a diagnostic character in the classification of angiosperms. It may be of following types.

1. **Open:** The margins of adjacent sepals or petals are apart from one another. Example- corolla of mustard
2. **Valvate:** Margins of adjacent floral leaves i.e. sepals and petals simply touch to each other but not overlapping. Example- disc florets of sunflower
3. **Twisted:** In this case, one margin of a petal of a whorl covers the margin of the adjacent petal and the other margin is covered over by the margin of adjacent petal. This order may be clockwise or anti-clockwise as well as regular. Example- china rose.
4. **Imbricate:** In this case, the sepals or petals overlap in irregularly. It is of following sub types.
  - a. **Quincuncial:** It is a special type of imbricate aestivation. Aestivation with five floral leaves, two floral leaves are external, two internal and the fifth with one margin external and other margin internal. Example-calyx of *Cucurbita maxima*
  - b. **Ascending imbricate aestivation:** Out of the five floral leaves i.e., sepals or petals, posterior sepal or petal being overlapped by the two lateral ones while they are being overlapped by anterior sepals or petals. Example- calyx of pea
  - c. **Descending imbricate or vexillary:** Out of five floral leaves i.e., sepals or petals the posterior floral leaf is large and completely external and overlapping the two lateral floral leaves, the later overlapping the two anterior floral leaves. Example- corolla of pea
  - d. **Imbricate proper:** In this aestivation, one sepal or petal lie completely external and overlapping both the margins of the adjoining members and one lies completely internal with both margins overlapped by the margins of the adjoining sepals or petals. The remaining members are intermediate with one margin internal and other margin external. Example- *Cassia*



Aestivation of corolla

## Perianth

In some plants, calyx and corolla are not differentiated and a single whorl is present instead of them. This outermost, non-essential or accessory floral leaves are called perianth. The unit structure of perianth is called tepals. In grasses, the perianth lobes are minute and membranous and called lodicules. Example- *Asphodelus*

**Tepal:** The individual floral leaves of perianth.

**Polytepalous or polyphyllous:** Tepals free from each other.

**Gamotepalous or gamophyllous:** The tepals are fused together at the ends.

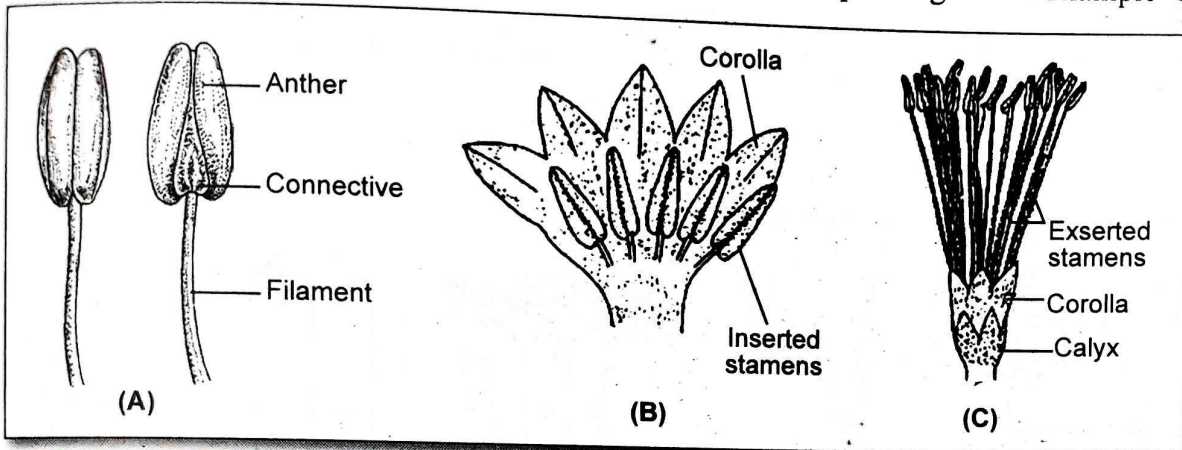
**Aestivation:** The arrangement of the tepals in bud. [Same as in calyx and corolla]

## Androecium

It is the male reproductive organ and lies inner to the corolla of the flower. It is made up of one or more stamens or microsporophylls. In other words androecium is the collective term for all the stamens and staminodes.

**Stamen:** A modified leaf in flowering plants bearing pollen sacs. It consists of filaments and anthers.

**Staminodes:** Rudimentary stamens which do not produce fertile pollen grains. . Example- *Stellaria*



(A) Stamens – Dorsal (face), Ventral (back) views (B) Inserted stamens (B) Exserted stamens

**Inserted:** Stamens are shorter than the corolla tube. Example - *Dianthus*

**Exserted:** Stamens are projecting beyond the petals. Example- *Acacia*

**Introrse:** Anthers facing inwards from the centre of the flowers. Example- *Hibiscus*

**Extrorse:** Facing outward from the centre of the flower referred for anthers. Example- *Argemone*

## Orientation of Face

**Definite:** Less than ten stamens. Example- *Brassica campestris*

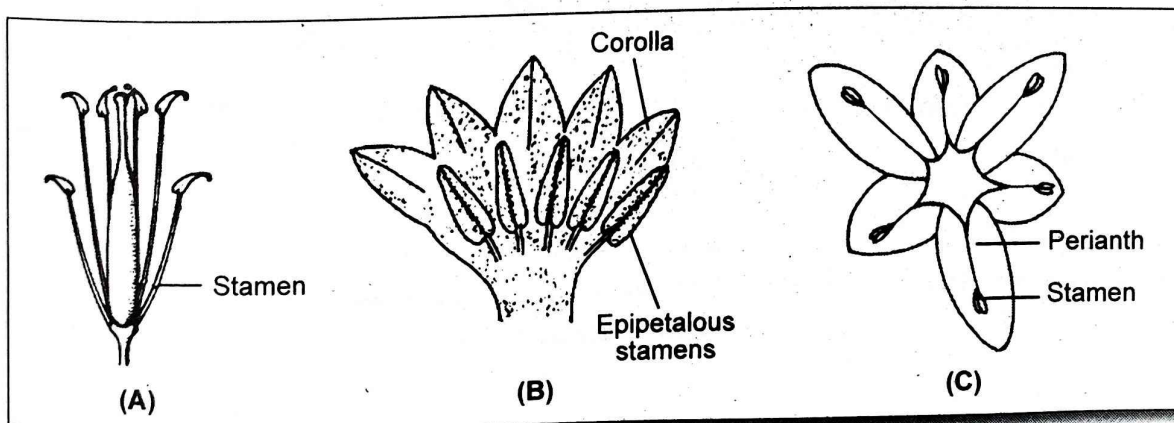
**Indefinite:** More than ten stamens. Example- *Hibiscus*

## Adhesion of Stamens

**Polyandrous:** Androecium consisting of free stamens. Example- mustard

**Epipetalous:** Stamens fused on the petals or corolla tube. Example- *Solanum*

**Epiphyllous:** If the stamens are attached to tepals, this condition is called epiphyllous.



Adhesion of stamens– (A) Polyandrous (B) Epipetalous (C) Epiphyllous

**Epitetalous:** Stamens borne on the tepals. Example – *Asphodelus*

**Gynandrous:** Stamens fused with the carpels. Example- *Calotropis*

### Cohesion of Stamens

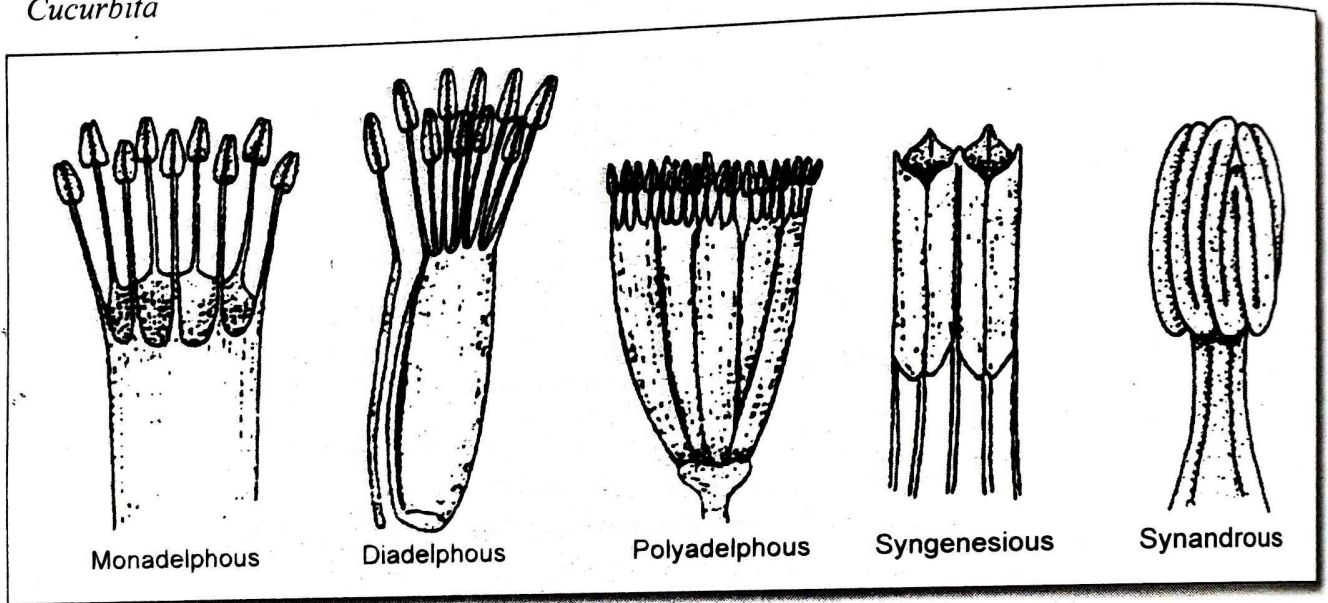
**Monadelphous:** The filaments of all stamens are fused together into bundle and the anthers are free.  
Example- china rose

**Diadelphous:** The filaments of stamens are fused together to form two bundles and anthers are free.  
Example- pea

**Polyadelphous:** Stamens united in many bundles. Example- lemon

**Syngenesious:** The anthers are united together but the filaments remain free. Example- sunflower

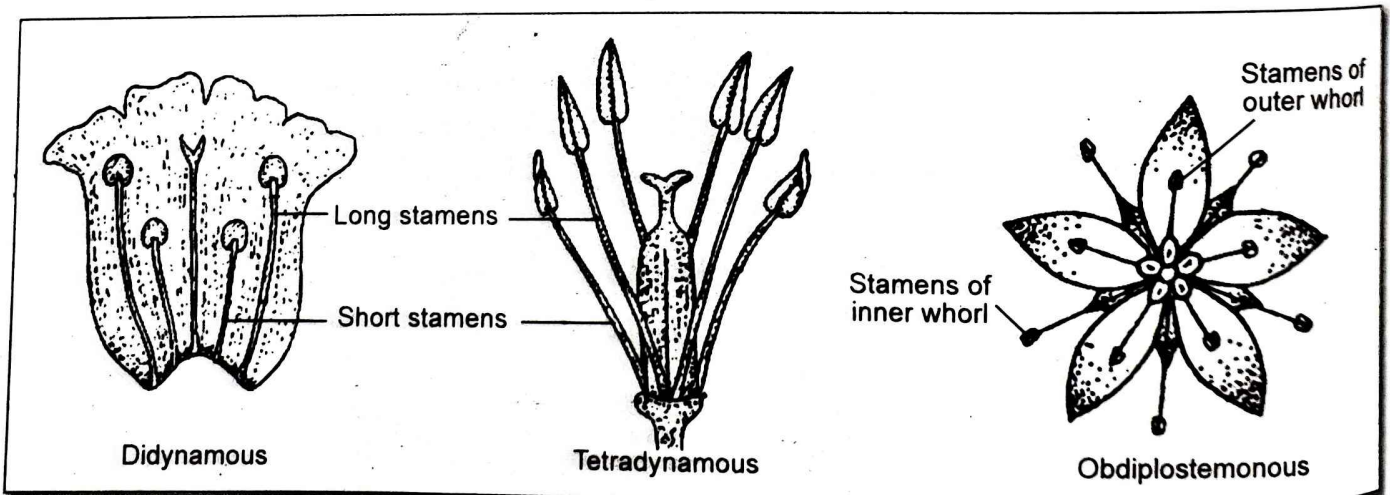
**Synandrous:** Both anthers and filaments of stamens fused throughout the whole length. Example- *Cucurbita*



Forms of cohesion of stamens

### Length of Stamens

**Didynamous:** Out of four stamens, two stamens are long and two short. Example- *Ocimum*



Length of stamens

**Tetradyamous:** Out of six stamens, two stamens of outer whorl are short and four stamens of inner whorl are long, the stamens are called tetradyamous. Example- mustard

**Obdiplostemonous:** Stamens found in two alternating whorls and that of the outer whorl opposite the petals. Example- *Geranium*

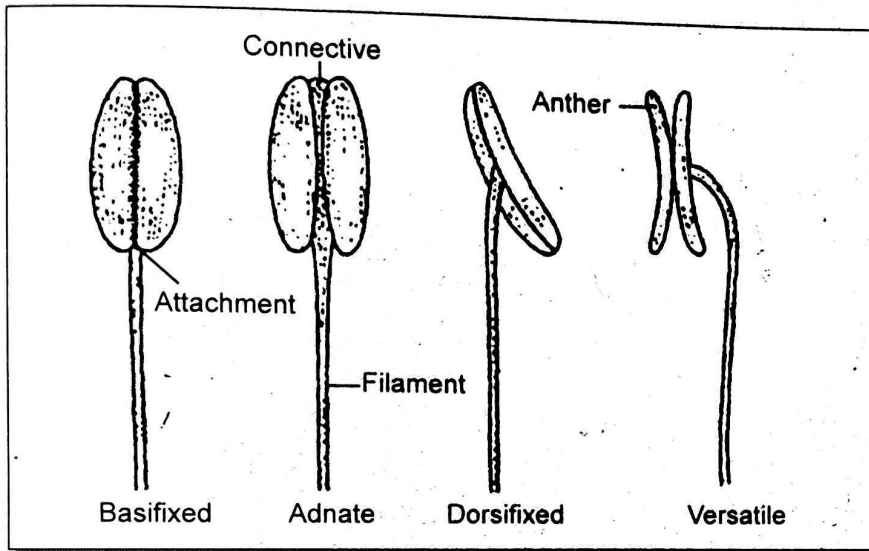
## Attachment of Filament to Anther

**Basifixed:** The filament is attached to the base of the anther. Example- mustard

**Adnate:** The filament runs throughout the length of the anther and becomes continuous with the connective. Example- *Ranunculus*

**Dorsifixed:** The filament is attached to the dorsal side (back) of the anther. Example- *Prunus sativus*

**Versatile:** The filament is attached to the dorsal side (back) of the anther at one point only in a way that the anthers can swing freely on the filament. Example- grasses



Attachment of filament to anther

## Anther Cross Section

**Monothealous:** Single-celled anther. Two loculi are seen in a transverse section of the anther. Example- *Hibiscus*

**Diethalous:** Two-celled anther. Four loculi are seen in a transverse section of the anther. Example - *Papaver*

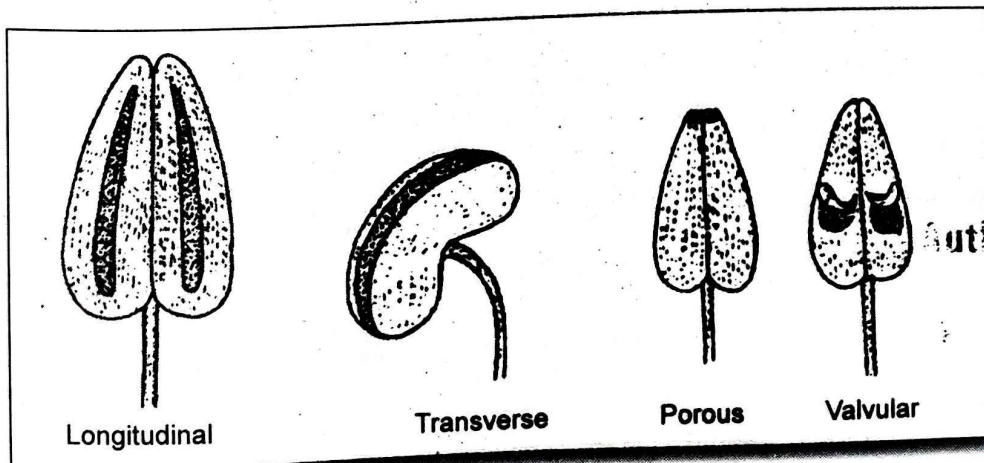
## Dehiscence of Anther

**Longitudinal:** When the anthers dehisce by longitudinal slits. Example- *Datura*

**Porous:** When pollen is liberated through apical or basal pores. Example- *Solanum*

**Transverse:** Dehiscing at right angles to long axis of theca. Example- *Hibiscus*

**Valvular:** The anther dehisces by the anther wall in the form of valves is called valvular. Example- *Berberis*



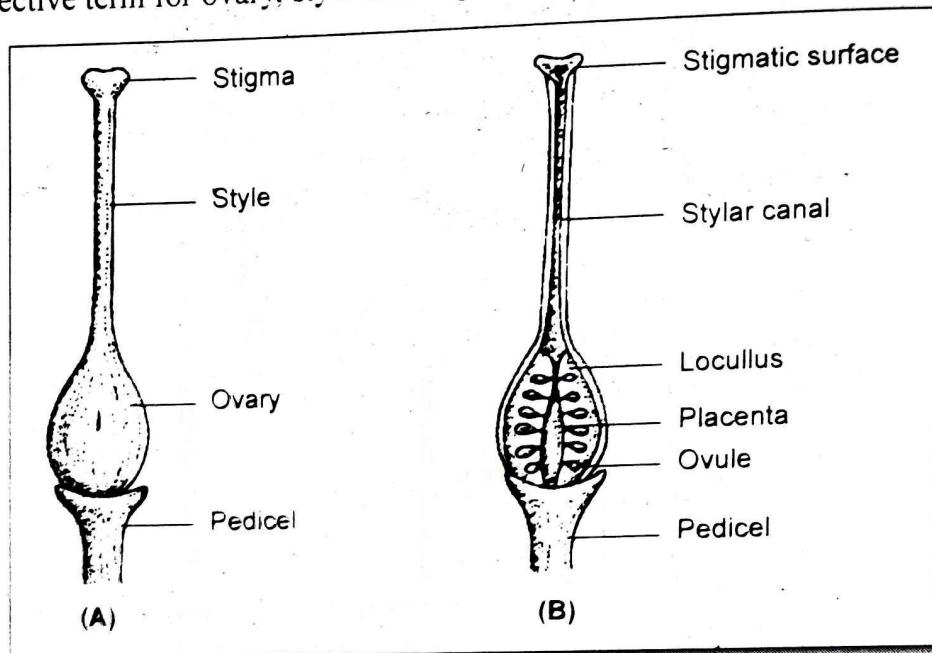
Types of anther dehiscence

## Gynoecium

Gynoecium or pistil is the innermost whorl of flower that constitutes the female reproductive organ. It is made up of one or more carpels.

**Carpel:** A modified leaves which bear the ovules, a simple pistil or one of the segments of a compound pistil.

**Pistil:** A collective term for ovary, style and stigma.



Parts of pistil- (A) External view of pistil (B) L.S. of pistil

### Number of Carpels

**Monocarpellary:** The pistil is composed of only one carpel. Example - pea

**Bicarpellary:** A condition when the pistil is composed of two carpels. Example- mustard

**Tricarpellary:** A condition when the pistil is composed of three carpels.

**Polycarpellary:** A condition when the pistil is composed of many carpels. Example- rose

### Position of Ovary

**Superior:** An ovary is said to be superior only when its base lie above the insertion of other floral parts. Example- mustard

**Inferior:** In epigynous flower, the ovary is borne below attachment of all other floral parts and adnate to them. Example- *Coriandrum*

**Semi-inferior:** Intermediate condition between superior and inferior. Example- pea

### Apocarpous and Syncarpous

**Apocarpous:** A polycarpellary condition when the carpels are free. Example- rose

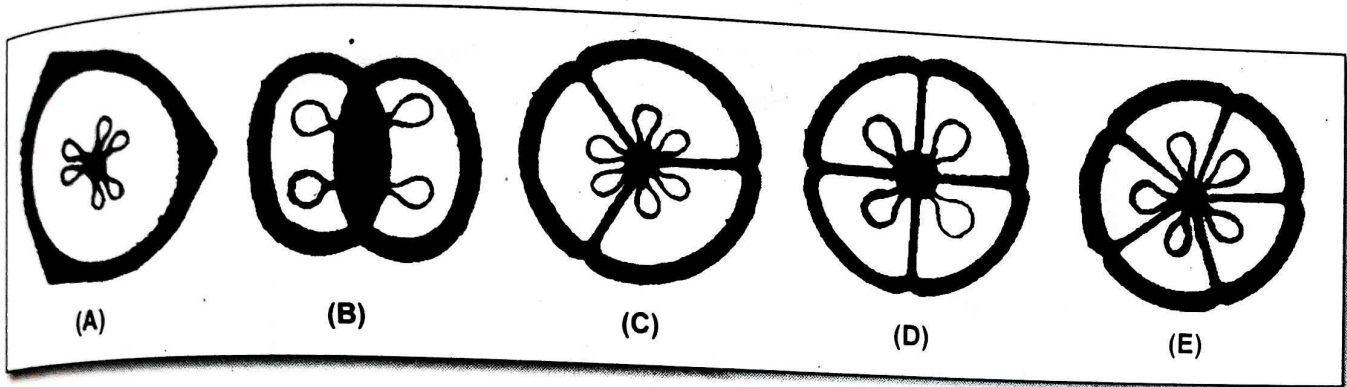
**Syncarpous:** A polycarpellary condition when the carpels are wholly partially united. Example- mustard

### Locules or Chambers of Ovary

**Unilocular:** Ovary with one chamber. Example- pea

**Bilocular:** Two ovarian chambers. Example- *Petunia*

- Trilocular:** Three ovarian chambers. Example- *Asphodelus*  
**Tetralocular:** Four ovarian chambers. Example- *Ocimum*  
**Pentalocular:** Five ovarian chambers. Example- shoe flower  
**Multilocular:** Many ovarian loculi. Exmample- *Althaea*

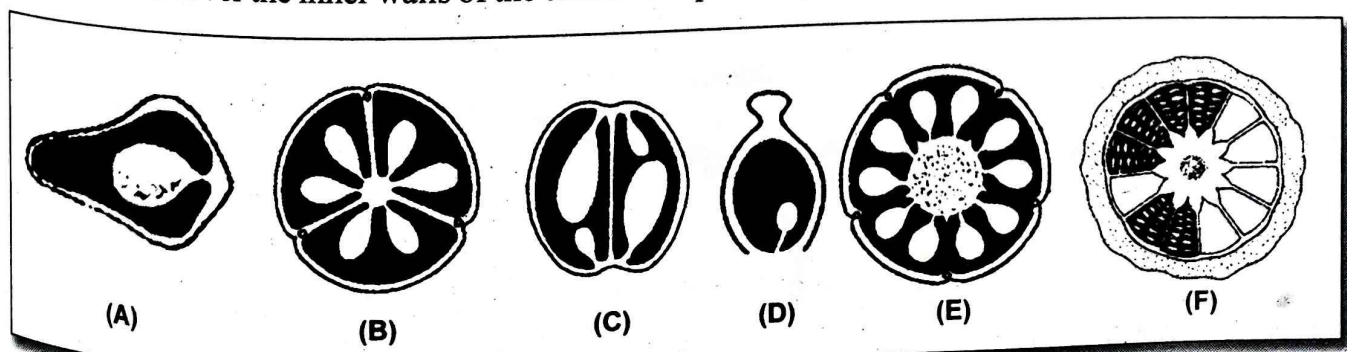


T.S. of Pistil showing loculi- (A) Unilocular (B) Bilocular (C) Trilocular (D) Tetralocular (E) Pentalocular

### Placentation

The arrangement of ovules and placentae on the ovary wall is called placentation.

- Marginal:** The placenta bearing the ovules along the junction where two margins of a carpel fuse. It exists in an ovary that is one chambered. It is a common type of placentation in simple or monocarpellary ovary. Example- Pea
- Axile:** The placenta bearing the ovules develops from the central axis corresponding to the margin of the syncarpous pistil. The ovary contains two to many chambers. Example- tomato
- Parietal:** The placenta bearing the ovules develop on the inner wall of the ovary at the junction of the fused margins of adjacent carpels. Ovary is one chambered but sometimes may divide by a false septum called replum. Example- mustard
- Basal:** The placenta bearing the ovule develops from the base of the unilocular ovary and bears only one ovule. Example- sunflower
- Free central:** The pistil is polycarpellary and syncarpous but the ovary is unilocular. The placenta is located on the central axis with many ovules attached to it. Example - *Stellaria*
- Superficial:** The gynoecium is multilocular, polycarpellary and syncarpous. Large number of ovules are borne all over the inner walls of the chambers spreading without specific order. Example- waterlily



Placentation- (A) Marginal (B) Axile (C) Parietal (D) Basal (E) Free central (F) Superficial

### Style

The slender stalk that supports the stigma is called style.

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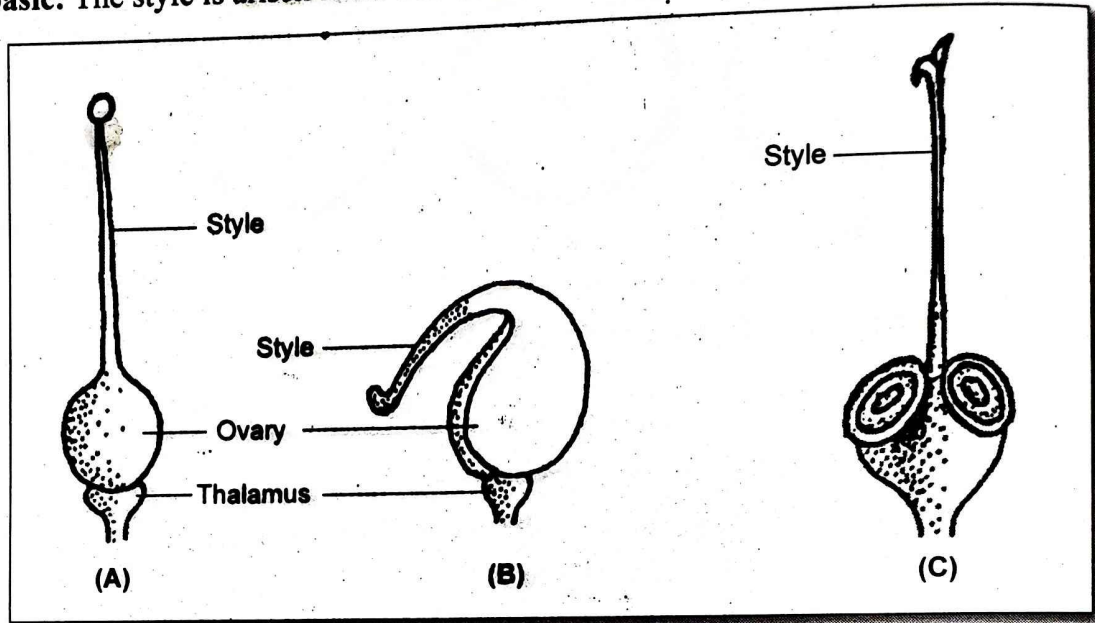
### Types of Style

Depending upon its origin, style is of three types.

**Terminal:** The style lying straight in the top of the ovary. Example- china rose

**Lateral:** The tip of the ovary is bent on one side and so the style arises from the side of the ovary. Example- mango

**Gynobasic:** The style is arisen from the mid basal part of ovary. Example- *Salvia*



Types of styles- (A) Terminal (B) Lateral (C) Gynobasic

### Stigma

It is the terminal part of style or the terminal receptive part of pistil.

### Types of Stigma

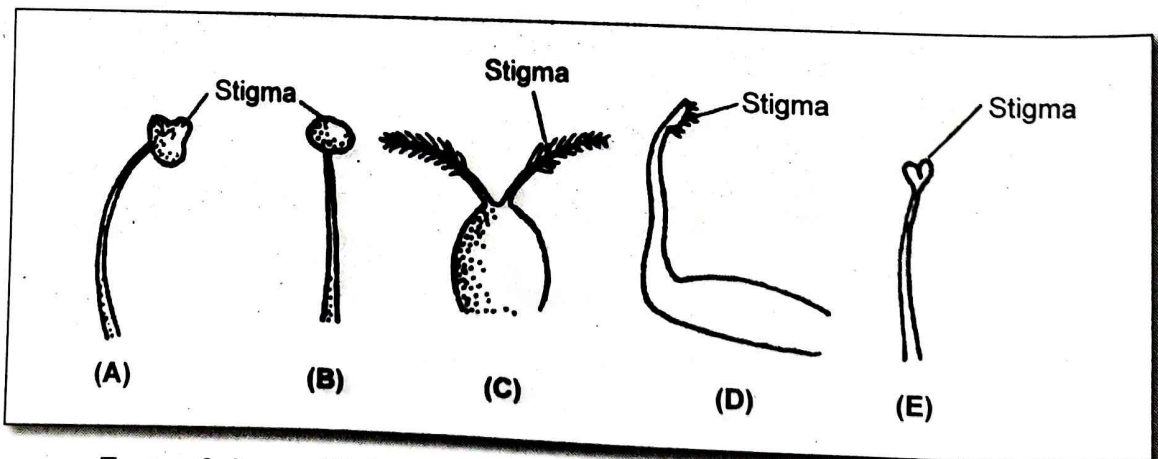
**Capitate:** Swollen or cap shaped stigma. Example- pea

**Discoid:** The stigma is disc shaped. Example- china rose

**Plumose or Feathery:** Stigma with feathers like structure. Example- rice

**Linear:** Width equal to style. Example- *Althaea*

**Bifid:** Stigma with two lobes. Example- sunflower

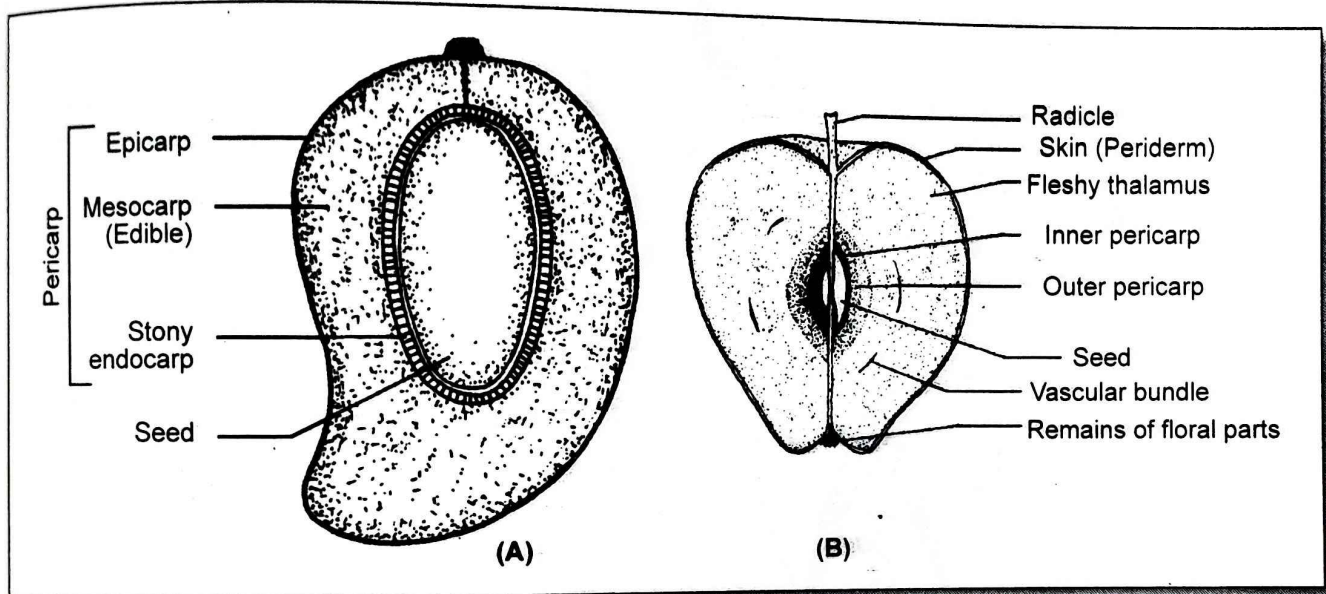


Types of stigma- (A) Capitate (B) Discoid (C) Plumose (D) Linear (E) Bifid

## Fruit

Fruit is one of the characteristics of the flowering plant. It usually develops after fertilization. Thus, **the fruit may be defined as the matured ripened ovary containing seeds.** In other word, it is defined as a modified form of fertilized ovary. It consists of two parts: pericarp and seeds. Pericarp is the fruit wall which is usually differentiated into three layers, outer epicarp, a middle one as mesocarp and the innermost as the endocarp.

But in some cases fruit develops without fertilization. The fruit develops without fertilization is called **parthenocarpic fruit.** Example - banana. Fruits are of two types. They are: **true fruit** and **false fruit.** A true fruit or eucarp is one which develops only from the ovary of a flower. A fruit that develops by the fusion of floral parts (e.g. thalamus, base of sepals, petals, etc.) with the pericarp is called false fruit or pseudocarp or accessory fruit (e.g., apple, mulberry, etc.)



Fruits– (A) True fruit (Mango) (B) False fruit (Apple)

On the basis of pericarp and the condition of gynoecium, fruits are of three types:

1. Simple fruits.
2. Aggregate fruits
3. Composite or multiple fruits.

## Simple Fruit

A simple fruit develops from the monocarpellary ovary or multicarpellary, syncarpous ovary of a flower, with or without other parts. It may be of two types:

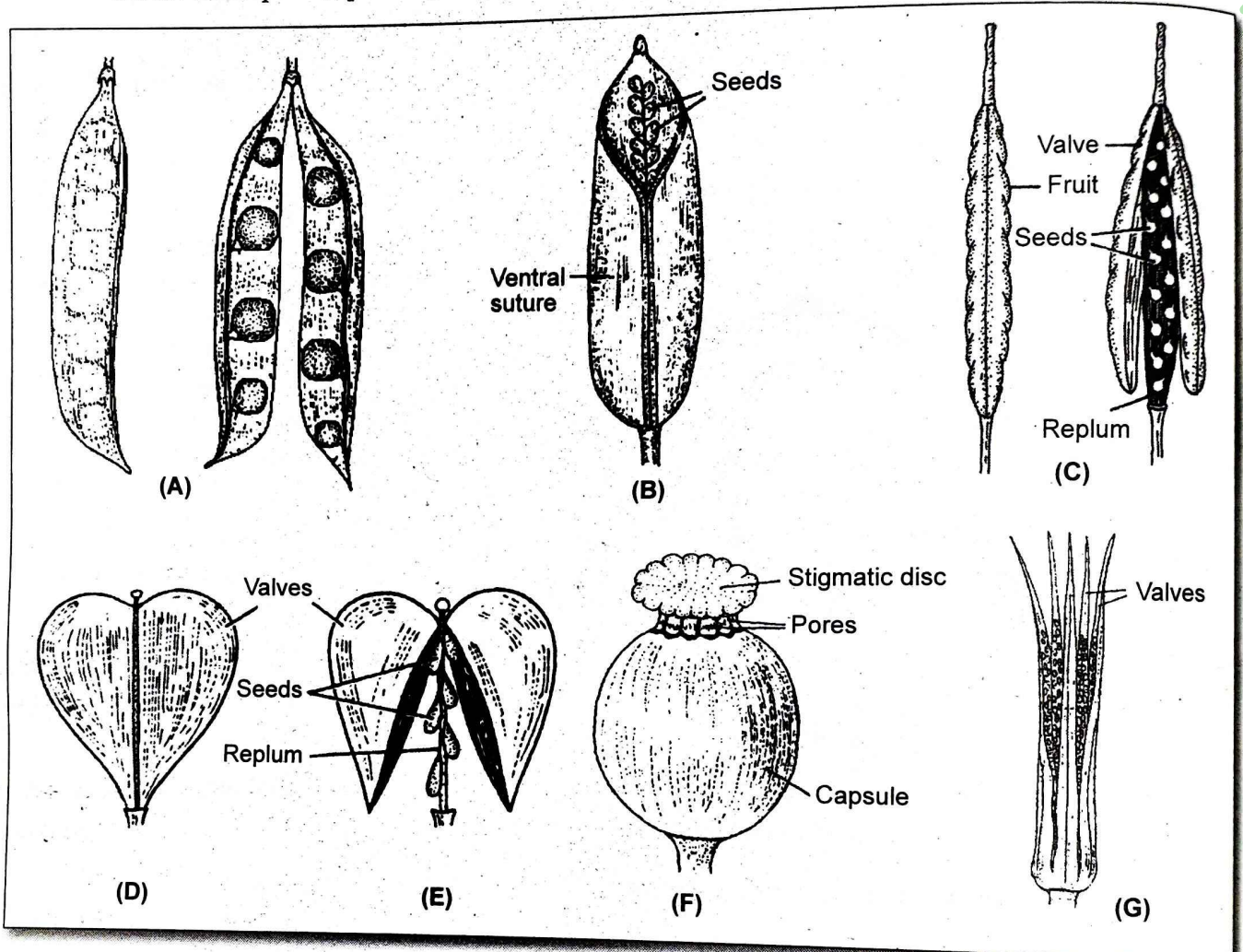
- (A) Dry fruits      (B) Succulent or fleshy fruits

### A. Dry fruits

Dry fruits are divided into three types. They are dehiscent, indehiscent and schizocarpic fruits.

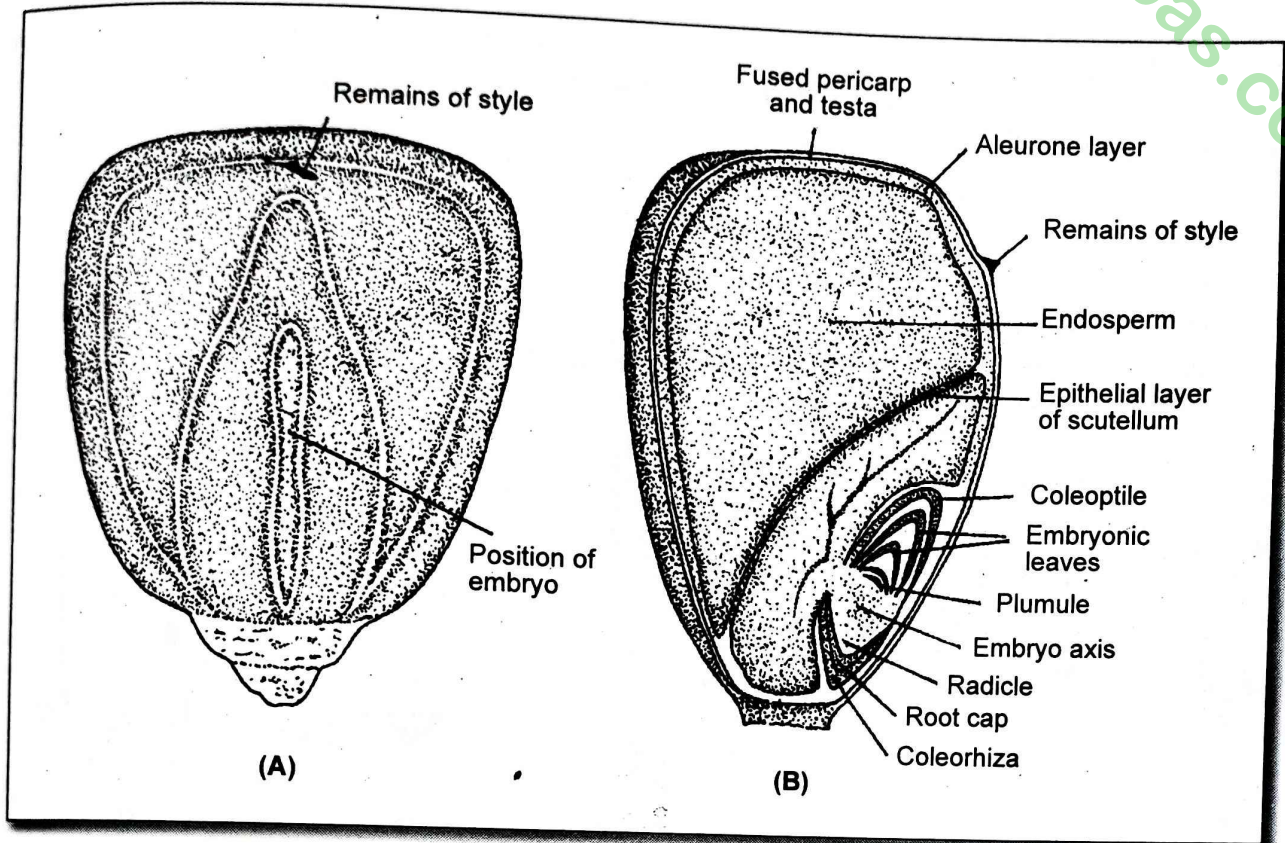
- a. **Dehiscent fruits or capsular fruits:** In dehiscent fruits, pericarp is burst automatically after ripening and seeds are dispersed due to internal pressure. It is of following types:
  - i. **Legume or Pod:** It is a one chambered fruit that develops from a monocarpellary syncarpous, unilocular, superior ovary with many ovules in each locule on marginal placentation. The mature fruit burst along with both ventral and dorsal sutures. Example- pea
  - ii. **Follicle:** In structure, it resembles legume, but it dehisces by ventral suture only. Example- *Calotropis*

- iii. **Silique:** It develops from bicarpellary, syncarpous ovary having parietal placentation. In the beginning ovary is unilocular but later it is bilocular due to the development of false septum called replum. The fruit is elongated and cylindrical. It dehisces by two valves starting from base upward to expose the replum bearing seeds. Example - *Brassica*, *Raphanus*, etc.
- iv. **Silicula:** It resembles the silique but it is much shorter and flattened that contains only a few seeds. Example- *Capsella* (*Shepherd's purse*)



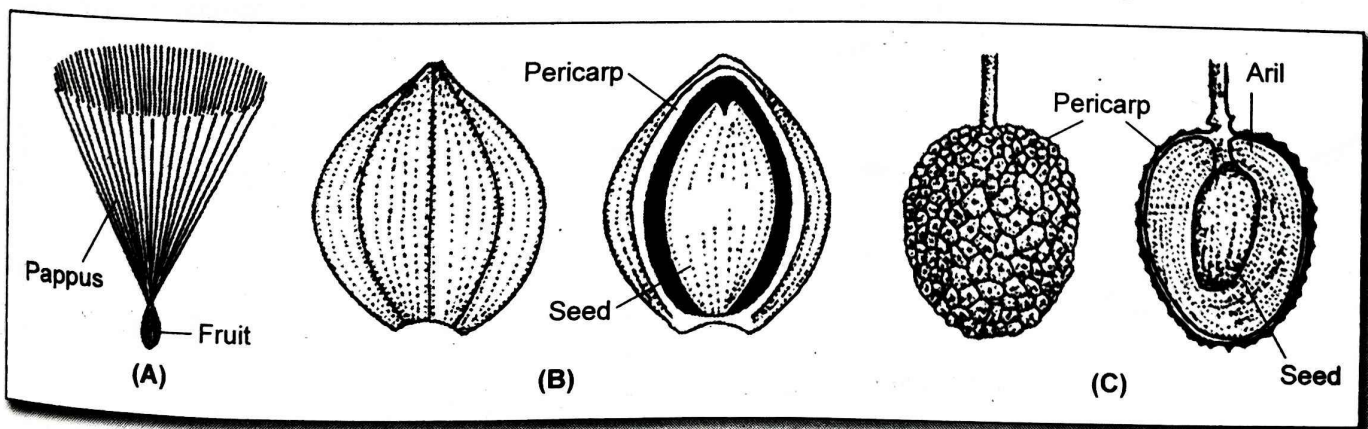
Dry and dehiscent fruits (A) Legume (B) Follicle (C) Silique (D), (E) Silicula (F) Porocidal Capsule (G) Loculicidal Capsule

- v. **Capsule:** It is many seeded, unilocular or multilocular fruit that develops from superior or inferior, bicarpellary or polycarpellary ovary. It dehisces by pores in poppy, transversely, in cock's comb, loculicidal in cotton, lady's finger and *Hibiscus*
  - vi. **Porous:** It develops from polycarpellary, syncarpous, superior ovary and sometimes from inferior ovary. The fruit is multilocular and of many seeds. It dehisces by various methods. Example- poppy
- b. **Indehiscent fruits:** Indehiscent fruits are those fruits which do not rupture after ripening and seeds remain inside the pericarp. Seeds of this fruit are liberated by the decay of pericarp. They are of two types: dry and fleshy.
- i. **Caryopsis:** These fruits develop from a monocarpellary pistil with superior, unilocular and single ovuled ovary. These fruits are one seeded and thin dry pericarp is completely fused with the seed coat or testa. Example- maize, wheat, rice, etc.



Caryopsis of Maize (A) External view (B) V.S. of grain

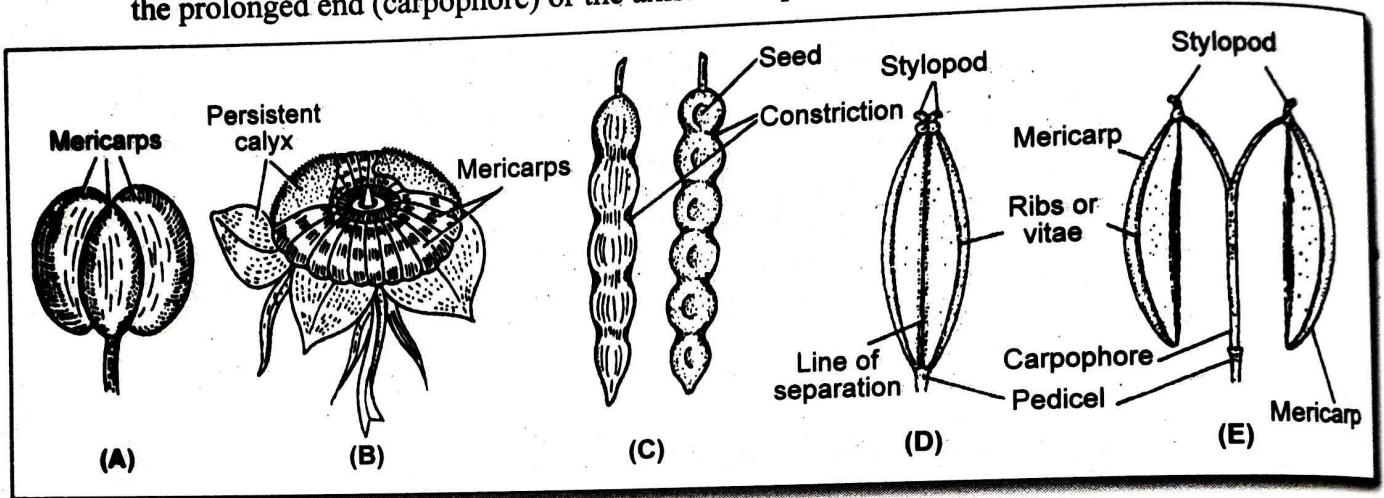
- ii. **Cypsela:** It is dry, one-chambered and one seeded fruit that develops from bicarpellary, syncarpous, unilocular, inferior ovary. In this fruit pericarp and the seed coats are free from each other. Example- sunflower
- iii. **Achene:** A small, dry, one-chambered and one-seeded fruit with the pericarp is free from the seed coat developing from a superior, monocarpellary ovary. A single flower produces an aggregate of achenes because the fruit has developed from the apocarpous pistil. Example- *Clematis*
- iv. **Nut:** It is dry, one chambered and one-seeded fruit which develops from bicarpellary or polycarpellary syncarpous, superior ovary. In these fruits the pericarp is hard and stony. Example-litchi



Dry or indehiscent fruits- (A) Cypsela (B) Achene (C) Nut

- c. **Shizocarpic fruits:** These fruits develop from polycarpellary syncarpous, superior ovary with numerous ovules on marginal or basal placenta. These fruits after ripening split up into many single seeded indehiscent parts, known as mericarps but these mericarps do not rupture further. These are of following types:

- i. **Carcerulus:** This type of fruit is developed from a superior bilocular to multilocular ovary. At maturity it breaks up into single-seeded mericarps. Example- garden nasturtium
- ii. **Lomentum:** These are the fruits develop from monocarpellary superior ovary. Actually, these fruits have constrictions between the seeds and usually, breaks into mericarps, is containing one seed. Example- Tamarind (Imali), radish, etc.
- iii. **Crelocarp:** A dry, indehiscent, two-chambered fruit developing from an inferior, bicarpellary ovary; when ripe splits into two, indehiscent, one-seeded mericarps which remain attached to the prolonged end (carpophore) or the axis. Example - coriander, carrot



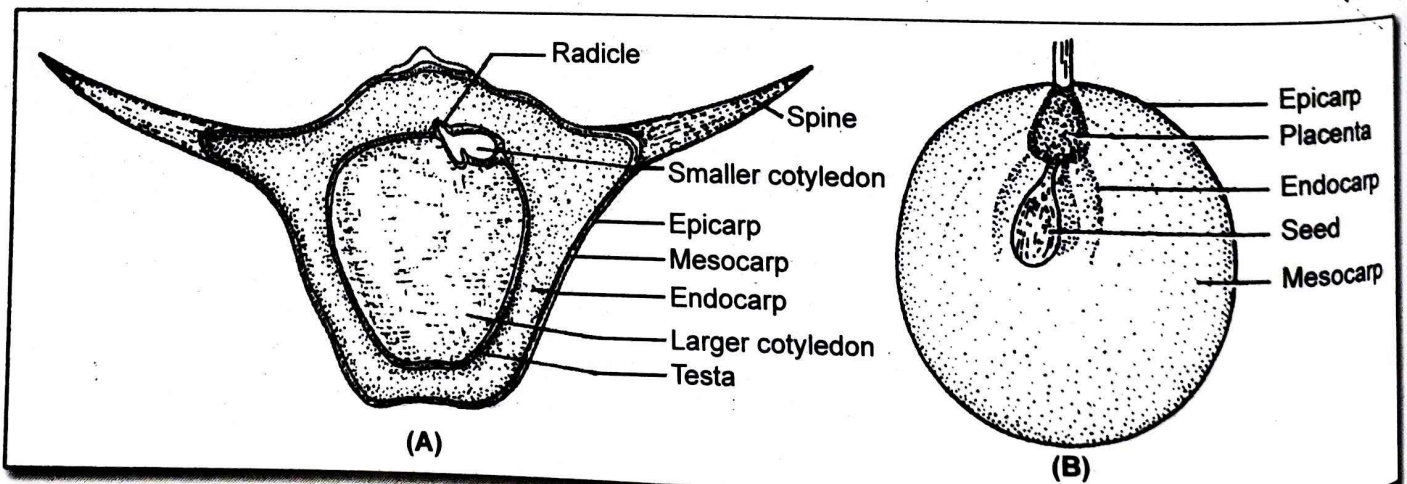
Shizocarpic fruits- (A) (B) Carcerulus (A) Garden nasturtium (B) Althaea (C) Lomentum (D) (E) Cremocarp

### B. Succulent or Fleshy Fruits

These fruits are fleshy and juicy as pericarp is thick and distinguishable into epicarp, mesocarp and endocarp. These are following types:

**Drupe:** These fruit are fleshy and juicy as their pericarp is thick at maturity. The epicarp forms the skin of the fruit, the mesocarp which is often fleshy or fibrous and the endocarp is hard and stony. Normally, within the endocarp there is a seed. Example- mango, cherry, peach, almond, coconut, etc.

**Berry:** A superior (rarely inferior) indehiscent, usually many-seeded, fleshy or pulpy fruit developing from a single carpel or more commonly from a syncarpous pistil, with axile or parietal placentation. Example- tomato, grapes, brinjal, guava, etc.

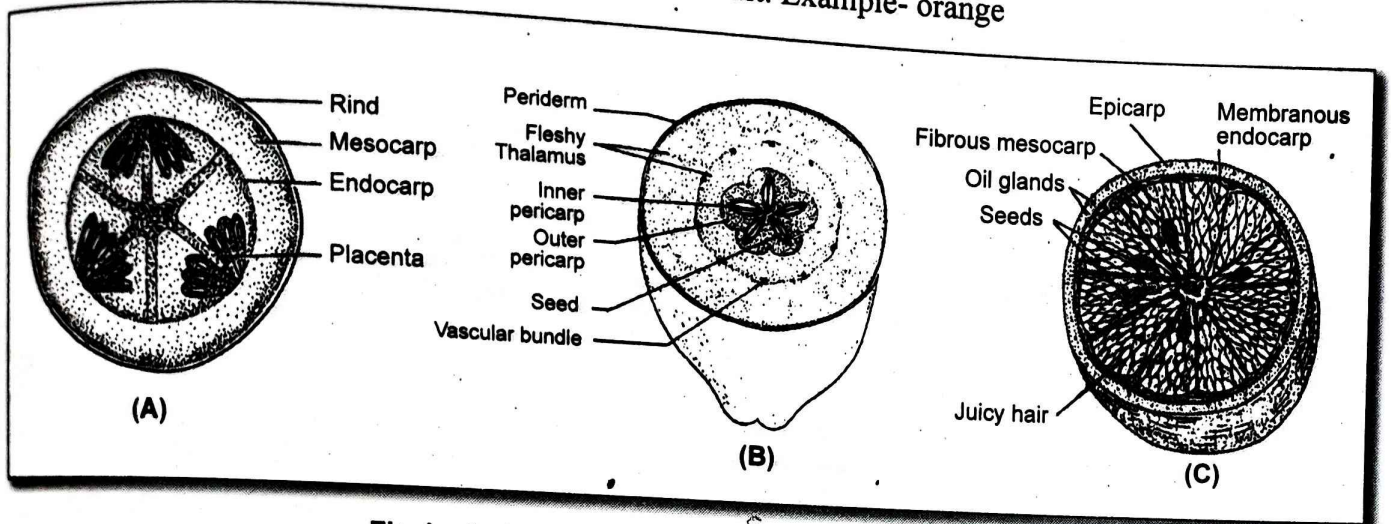


Fleshy fruits- (A) Drupe of Trapa (Sanghaara) (B) Berry of grape

**Pepo:** A fleshy, many-seeded fruit developing from an inferior, one-celled or three-celled syncarpous pistil with parietal placentation. Example- members of Cucurbitaceae

**Pome:** It is developed from an inferior, two or more chambered, syncarpous ovary surrounded by fleshy thalamus. It is many seeded and its fleshy part is developed from thalamus. Thus, it is also called false fruits. Example- apple

**Hesperidium:** A superior, many-seeded, fleshy fruit develops from a syncarpous pistil with axile placentation; the endocarp projecting inwards forming distinct chambers and the epicarp and mesocarp fused together forming the separable rind of the fruit. Example- orange

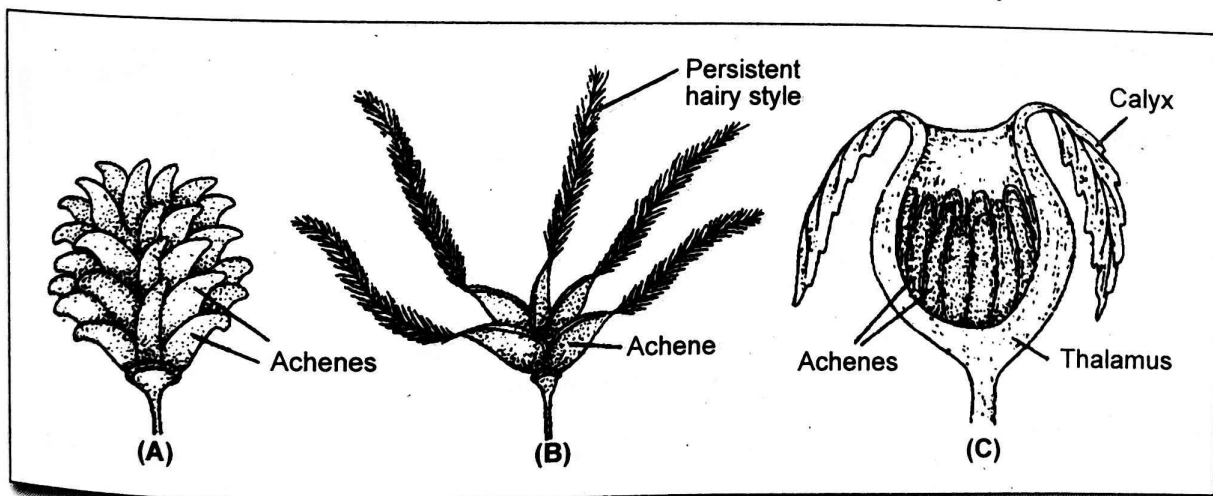


Fleshy fruits– (A) Pepo (B) Pome (C) Hesperidium

## 2. Aggregate Fruits

It develops from a single flower with an apocarpous pistil. As the carpels are free, each of them develops into a simple fruitlet. So aggregate fruit consists of a collection of simple fruitlets as many as the number of free carpels borne by a single flower. An aggregate of fruitlets borne by a single flower is known as etaerio. It is of following types:

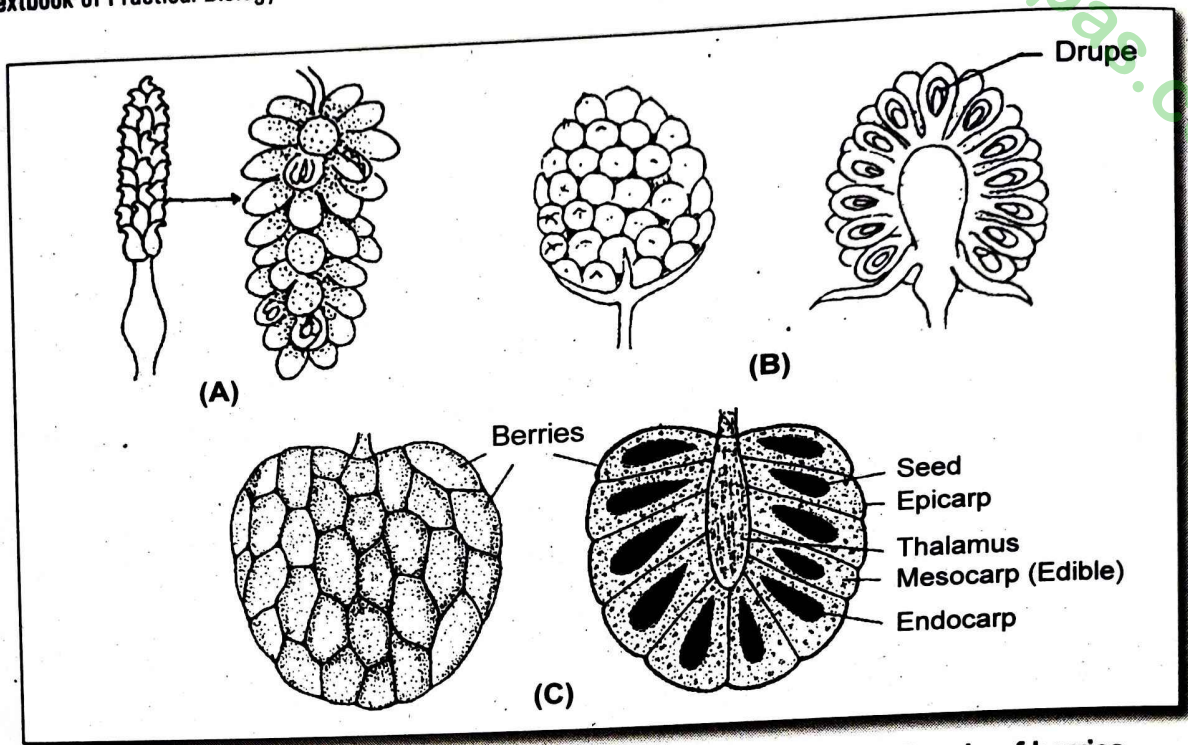
**Etaerio of achenes:** A single carpel of an apocarpous pistil develops into a achene that are aggregated on a single axis to form an etaerio of achenes. Example- *Clematis*, strawberry, etc.



Aggregate fruits– Etaerio of Achenes (A) *Ranunculus* (Buttercup) (B) *Clematis* (C) Hip of Rose

**Etaerio of follicles:** The individual fruitlet is similar with that of normal follicle and all the follicles are attached or aggregated to the same axis. Example- *Calotropis*, *Michelia*, etc.

**Etaerio of drupes:** A number of small drupes develops from different carpels of a flower and are aggregated together on the fleshy thalamus. Example- raspberry (*Rubus idaeus*)

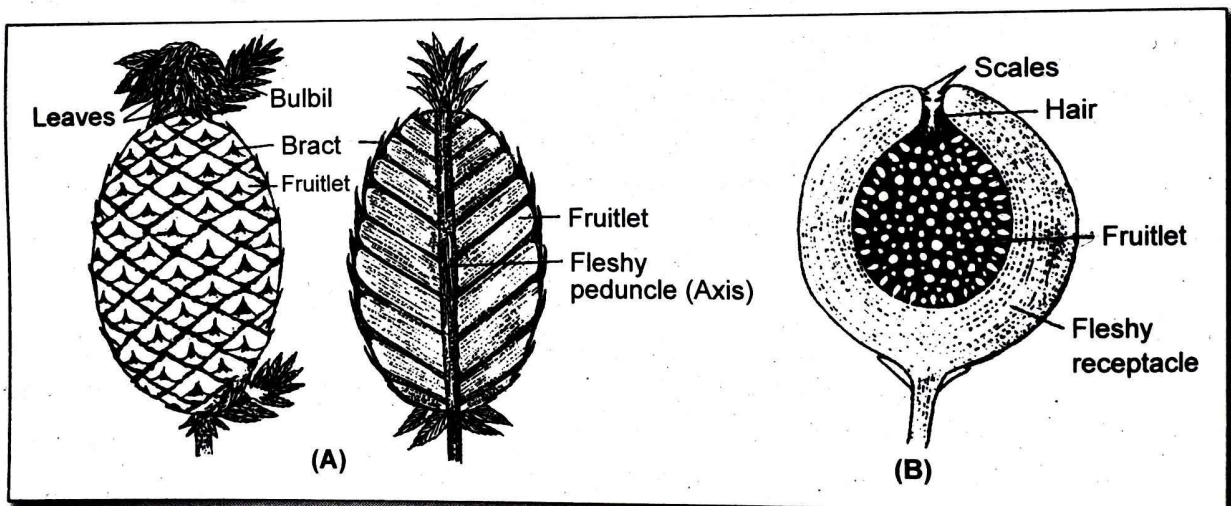


Aggregate fruits- (A) Etaerio of follicles (B) Etaerio of drupes (C) Etaerio of berries

**Etaerio of berries:** They are developing from different carpels lying on all sides of the fleshy thalamus. The apical parts of berries fuse each other and make a common ring. Example- custard apple (Sarifa)

### 3. Multiple or Composite Fruit

These fruits are developed from the complete inflorescence. It means the multiple fruit is a group of fruitlets that develop from the different flowers of an inflorescence. It is of two types:

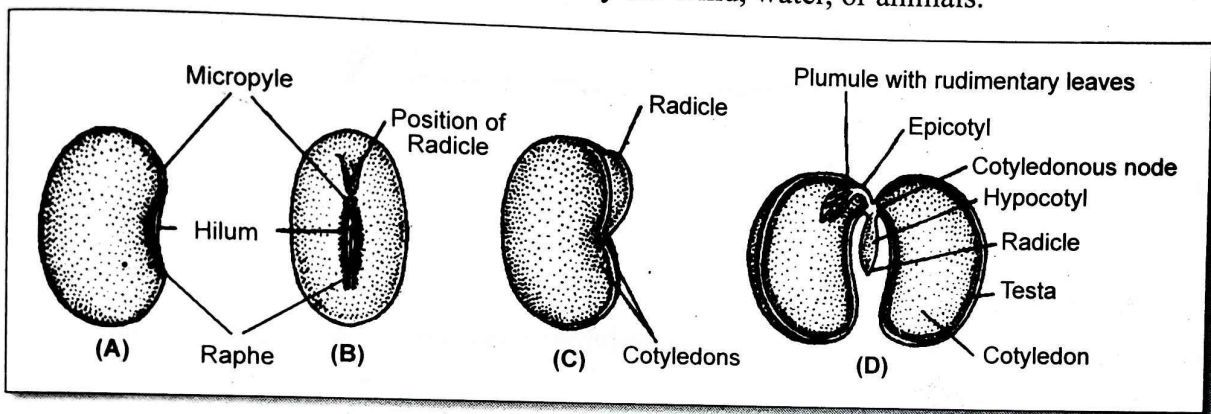


Composite fruit- (A) Sorosis (B) Syconus

**Sorosis:** These fruits develop from a spike or spadix female catkin inflorescence. The whole inflorescence becomes a compact mass due to fusion of succulent perianth of the flowers. The flower after fertilization and ripening becomes fleshy and juicy along with the inflorescence axis. Example- *Ananas sativus* (pineapple), (jackfruit), *Morus sp.* (mulberry), etc.

**Syconus:** It develops from the hypanthodium inflorescence. It develops from a hollow, pear shaped, fleshy receptacle which encloses a number of minute male and female flowers. The receptacle becomes fleshy. The enclosed female flowers produce small achene like fruitlets. Syconus has a small pore protected by scale leaves. Example- banyan, peepal, etc.

**Seed** : Seed is mature fertilized ovule of angiosperms and gymnosperms that contains an embryo and the food it will need to grow into a new plant. Seeds provide a great reproductive advantage in being able to survive for extended periods until conditions are favorable for germination and growth. The seeds of angiosperms are enclosed in an ovary that develops into a fruit, such as a pome or nut. The structure of seeds varies somewhat. All seeds are enclosed in a protective seed coat. In certain angiosperms the embryo is enclosed in or attached to an **endosperm**, a tissue that it uses as a food source either before or during germination. The seed with endosperm is called endospermic and the seed without endosperm are called non-endospermic. All angiospermic embryos also have one or two **cotyledons**, they are called monocotyledons and dicotyledons respectively. Many angiosperms have evolved specific fruits for dispersal of seeds by the wind, water, or animals.



Structure of bean seed– (A), (B) external structure (C) Seed coat removed (D) seed cut open to show various parts

### Viva Questions

Students must remember

1. What do you understand by venation of leaf?

**Ans:** The arrangement of veins and vein lets in the leaf.

2. What is inflorescence?

**Ans:** The arrangement of flowers on the floral axis is called inflorescence.

3. What do you mean by aestivation?

**Ans:** The arrangement of floral leaves in the bud condition is called aestivation.

4. What do you mean by androecium?

**Ans:** Androecium is the male reproductive organ of the flower. It consists of filament and anther.

5. What do you mean by gynoecium?

**Ans:** Gynoecium is the female sex organ of the flower. It is composed of one or more carpels.

6. What do you mean by carpel?

**Ans:** Carpel is an ovule-bearing structure evolved from non-green leaf like appendage, the megasporophyll.

7. What do you mean by placentation?

**Ans:** Arrangement of placentatae and ovules on the ovary wall is called placentation.

8. What do you mean by fruit?

**Ans:** The fruit is a ripened ovary enclosing seeds. It develops after fertilization.

9. Define true fruit.

**Ans:** When only the ovary of the flower develops into the fruit, it is called the true fruit.

## DESCRIPTION OF A FAMILY

The following characteristics are used to describe and identify a flowering plants:

### Habitat

The natural abode or locality of the plant i.e., whether grown in naturally or cultivated as food crop, an ornamental plant or wild.

### Habit (Nature)

- i. Herb, undershrub, shrub or tree.
- ii. Annual, biennial or perennial.
- iii. Any special characters such as parasite, epiphyte mesophyte, xerophyte or hydrophyte.

### Root

- i. Tap or fibrous
- ii. Branched or unbranched.
- iii. Any special modification. i.e., nodulated, napiform, fusiform, conical, stilt, prop, aerial, climbing, tuberous, etc.

### Stem

- i. Nature of stem i.e. erect, prostrate, climbing or twining; if climbing, write mode of climbing i.e. climb by leaf tendrils, leaflet tendrils, stipular tendril or stem tendrils.
- ii. Special modification such as rhizome, bulb, tuber, runner, sucker, phylloclade, etc.
- iii. Branched or unbranched
- iv. Texture i.e., herbaceous or woody
- v. Solid or fistular
- vi. Cylindrical, angular, flattened or reduced
- vii. Hairy, glabrous, waxy or spiny
- viii. Colour-green, grey, etc.

### Leaf

- i. Insertion - radical, cauline and ramal
- ii. Phyllotaxy - alternate, opposite or whorled. If opposite, whether superposed or decussate
- iii. Sessile, sub sessile or petiolate
- iv. Stipulate or exstipulate. Stipule may be leafy (foliaceous), spiny, tendrilar, etc.
- v. Leaf base - sheathing connate or ligulate or amplexical
- vi. Kind - simple or compound
- vii. If simple, write about the form of lamina - acicular, linear, lanceolate, ovate, oblong, lyrate, etc.

- viii. Incision of lamina - pinnatifid or palmatifid; pinnatisect or palmatisect, etc.
- ix. Margin of lamina - entire, dentate, serrate, hairy, spiny, etc.
- x. Apex - acute, obtuse, acuminate, mucronate, etc.
- xi. Surface - hairy, glabrous, glaucous or spiny
- xii. Venation - reticulate or parallel, unicostate or multicostate
- xiii. Texture - foliaceous, fleshy, succulent, etc.
- xiv. Colour - Green or pigmented
- xv. In a compound leaf, the leaflet should be described in the way as simple leaf.

### **Inflorescence**

The inflorescence is a cluster of flowers present on the peduncle or floral axis. If the flower is not solitary, the inflorescence has got the following features.

- i. Simple, mixed, compound and special
- ii. If simple, racemose or cymose
- iii. If racemose - raceme, spike, catkin, spadix, corymb, umbel, head or capitulum, etc.
- iv. If cymose - uniparous, biparous, multiparous cyme, helicoid or scorpioid, or solitary axillary
- v. If compound and mixed - compound spike, compound umbel, compound corymb, spike of spikelets, panicle, panicle of spikelets, etc.
- vi. If special type - hypanthodium, cyathium, verticillaster, etc.

### **Flower**

- i. Sessile or pedicellate
- ii. Bracteate or ebracteate, (describe nature of bracts - if present)
- iii. Bracteolate or ebracteolate
- iv. Actinomorphic or zygomorphic
- v. Complete or incomplete
- vi. Unisexual or bisexual
- vii. Hypogynous, perigynous or epigynous
- viii. Bimerous, trimerous, tetramerous, pentamerous, etc.
- ix. Colour of flower
- x. Any other special feature

### **Calyx**

- i. Number of sepals.
- ii. Polysepalous or gamosepalous
- iii. Nature and form of sepals- deciduous, caducous, persistent, etc.
- iv. Special forms - tubular, campanulate, bilabiate, lance shaped, infundibuliform, etc.
- v. Green or petaloid
- vi. Superior or inferior
- vii. aestivation - valvate, twisted, imbricate or vexillary
- viii. Shape and size

**Corolla**

- i. Number of petals
- ii. Polypetalous or gamopetalous
- iii. If polypetalous, write the form and nature of petals. i.e., rosaceous, papilionaceous, cruciform, etc.
- iv. If gamopetalous, write special form, e.g. campanulate, tubular, bilabiate, ligulate, etc.
- v. Sepaloid or petaloid
- vi. Shape and size
- vii. Aestivation of corolla - valvate, twisted, imbricate or vexillary
- viii. Any special features

**Perianth**

If calyx and corolla are not clearly distinguished and appear more or less similar in shape, then collectively they are called perianth of the flower. If perianth is present, describe it in the manner as one describes calyx or corolla.

- i. Number of tepals
- ii. Polytepalous or polyphyllous, gamotepalous or, gamophyllous
- iii. Sepaloid or petaloid
- iv. Aestivation - valvate, twisted, imbricate or vexillary
- v. Colour of tepals

**Androecium**

- i. Number of stamens; definite or indefinite
- ii. Free or fused; if fused nature of cohesion - monadelphous, diadelphous, polyadelphous or syngenesious. If free, any special forms, i.e., didynamous, tetradynamous, etc.
- iii. Nature of the adhesion-epipetalous, free from petals or gynandrous
- iv. Length of stamens - general length, inserted or exerted
- v. Attachment of anthers - Adnate, basifixed, dorsifixed or versatile
- vi. Anthers - Monothealous or dithealous
- vii. Colour of the anthers

**Gynoecium**

- i. Number of carpels- monocarpellary, bicarpellary or polycarpellary
- ii. Apocarpous (free) or syncarpous (united)
- iii. Ovary superior or inferior
- iv. Number of loculi in ovary - unilocular, bilocular, trilocular, etc.
- v. Number of ovules in each locule of ovary.
- vi. Type of placentation - marginal, axile, free central, parietal, basal or superficial.
- vii. Nature of style - long or short, slender, terminal, lateral or gynobasic.
- viii. Nature of stigma - simple, lobed or branched; feathery, bearded, hairy, capitate, curved, etc.
- ix. Any special features.

**Fruit**

It may be simple, aggregate, multiple; pod or legume, follicle, lomentum, capsule, siliqua, silicula, achene, cypsela, caryopsis, nut, pome, drupe, berry, berries, etc.

**Seed**

- i. Albuminous or exalbuminous
- ii. Single or two cotyledons
- iii. Position, shape and size of the embryo

**Floral formula**

**A floral formula is a simple and a concise way to describe the salient characteristics of a flower.** It represents the number, cohesion and the relative position of different whorls of a flower. So, after describing a plant, a floral formula is required. The different whorls of a flower are represented by an English letter: K for calyx, C for corolla, P for Perianth, A for androecium and G for gynoecium. The number of different floral parts is shown by figures written in sub script after the symbol for a whorl. One figure is written for each whorl. If any one of the floral parts is missing, the part is simply represented as 0 in sub script after the symbol for a whorl. If the number of any floral parts is greater than 10 or indefinite the figure of that part is represented by infinity ( $\infty$ ). If members are present in different whorls, the different whorls are written separately with a + sign between them. Thus,  $A_{2+4}$  means androecium of 6 stamens are arranged in two whorls of 2 outer and 4 inner. In case of united (cohesion) of floral parts, the figure is placed within first brackets. Adhesion of floral parts is expressed by an arc joining the two whorls. For example, adhesion between fused petals or corolla and androecium is the epipetalous condition. This condition is expressed by using a small arc between the corolla and gynoecium. The superior or inferior position of ovary of gynoecium is denoted by a line below or above the figure. A symmetry of flower is represented by symbol  $\oplus$  for actinomorphic and  $\%$  for zygomorphic flowers. A male flower is indicated by the symbol  $\sigma$ , female by  $\rho$  and bisexual flower by  $\sigma\rho$ . The different symbols used in floral formula are as follows.

Br.	-	Bracteate
Ebr.	-	Ebracteate
Brl.	-	Bracteolate
Ebrl.	-	Ebracteolate
$\oplus$	-	Actinomorphic flower
$\%$	-	Zygomorphic flower
$\sigma\rho$	-	Bisexual flower
$\sigma$	-	Male flower
$\rho$	-	Female flower
$K_n$	-	Sepals n, free
$K_{(n)}$	-	Sepals n, fused
$C_n$	-	Petals n, free
$C_{(n)}$	-	Petals n, fused
$P_n$	-	Tepals n, free
$P_{(n)}$	-	Tepals n, fused

- $A_n$  - Stamens n, free
- $A_{(n)}$  - Stamens n, monoadelphous
- $A_{n+n}$  - Stamens free, into whorls of n each.
- $C_{(n)} A_n$  - Epipetalous stamens
- $G_n$  - Carpels n, apocarpous
- $G_{(n)}$  - Carpels n, syncarpous
- $G_{(n)}$  - Carpels n, syncarpous; inferior ovary
- $G_{(\underline{n})}$  - Carpels n, syncarpous; superior ovary
- $G_n$  - Carpels n, apocarpous; inferior ovary
- $G_n$  - Carpels n, apocarpous; superior ovary
- $A \underline{G}$  - Androecium and gynoecium united

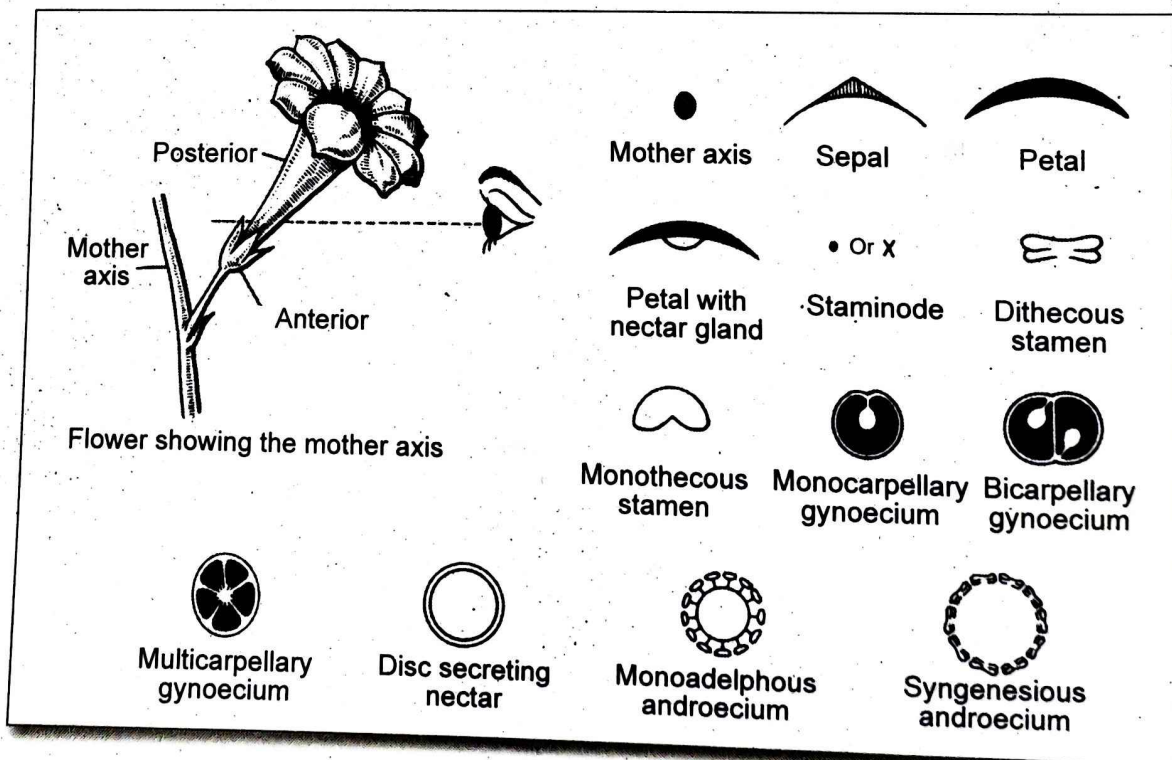
The floral formula should be written in the following order: presence or absence of bracts, presence or absence of bracteoles, symmetry, sex, calyx, corolla, androecium, gynoecium.

### Floral Diagram

A floral diagram is an imaginary section through the bud of a flower, representing its horizontal plane. It consists of series of concentric circles, each of which represents one whorl of floral parts.

At the top of floral diagram a dot is written, which is called mother axis. Mother axis represents the original stem from which the flower stalk or pedicel arises. At the bottom of the diagram, there is a bract, the leaf in the axil of which the flower develops. If bracteoles are present, they are shown on the lateral sides. In floral diagram, the calyx and corolla show the number and aestivation where as the androecium shows anthers and gynoecium is expressed by ovary showing placentation.

The following of symbols are used while drawing the floral diagram.



Various symbols used in a floral diagram

## Diagnostic characters

The distinguishing features of the genus should be assembled.

## Systematic position

After completion of the description, the systematic position of genus should be given with the help of key. Generally, Bentham and Hooker's system of classification has been followed for its simplicity. The following hierarchy is to given for classification of any plant.

Group –

Sub group –

Division –

Series –

Order –

Family –

Genus –

Species –

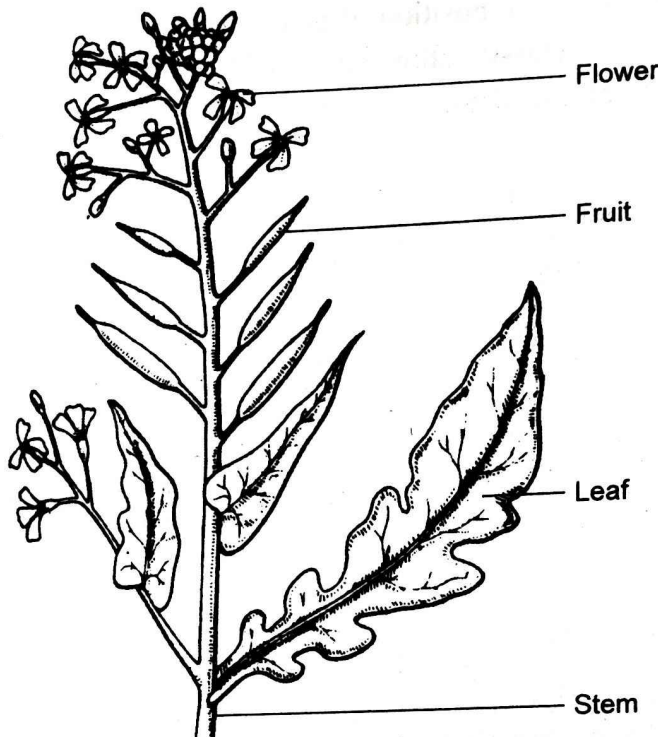
## Key for describing an angiospermic plant

The following procedure is applied to describe the plant in the laboratory:

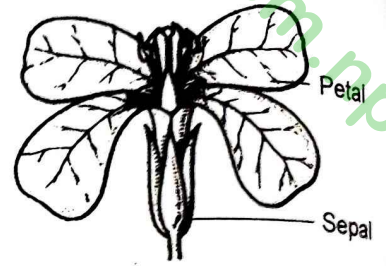
1. Describe the given plant material with the help of key given in page.
2. Sketch a well-labelled diagram of given plant showing the arrangement of leaves and the inflorescence.
3. Draw a diagram of complete flower. Cut the L.S. of flower with the help of blade. Identify the flower- either zygomorphic or actinomorphic. In case of zygomorphic flower cut along the plane of symmetry. Sketch the well-labelled diagram of L.S. of flower. If necessary, simple microscope can be used.
4. Separate the floral whorls one by one and study. Draw calyx, corolla, androecium and gynoecium separately. Observe the stamens by the use of microscope and describe. Cut T.S. of ovary and observe it under dissecting microscope. Sketch the diagram of T.S. of ovary and describe gynoecium and ovary.
5. Describe the type of fruit, if available sketch the fruit.
6. Write floral formula according to the description of the plant.
7. Draw floral diagram according to the description of the plant.
8. Identify the plant upto family.
9. Write the botanical name and common name of the given plant by the help of your teacher.
10. Write the classification and distinguishing characters of plant.

Date

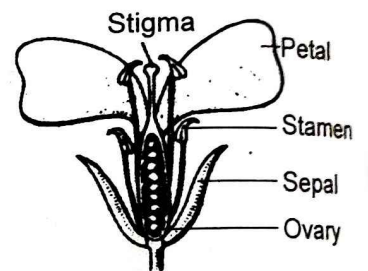
**DESCRIBE THE BRASSICA CAMPESTRIS IN SEMI-TECHNICAL TERMS**



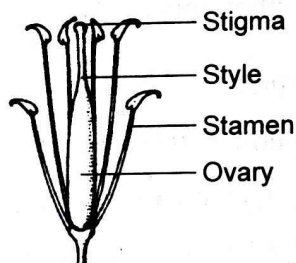
A twig of *Brassica campestris*



A flower



L.S. Flower



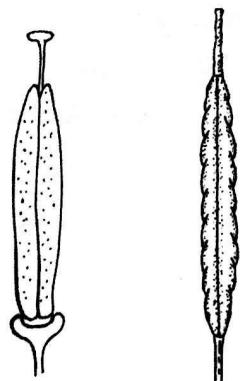
Androecium and Gynoecium



Corolla

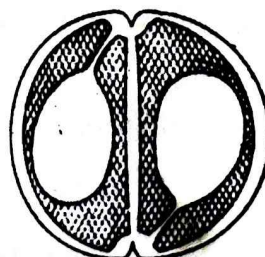


Calyx

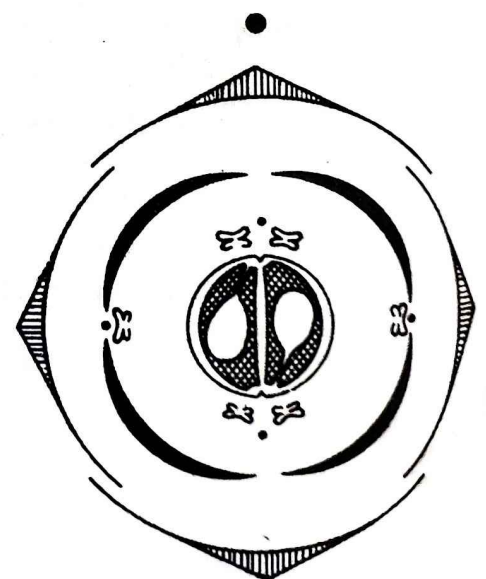


Gynoecium

Fruit



T.S. of Ovary



Floral Diagram

**OBJECTIVE****DESCRIBE THE *BRASSICA CAMPESTRIS* IN SEMI-TECHNICAL TERMS**

**Botanical description of the plant :** *Brassica campestris* Linn. ( Mustard)

**Habitat :** Terrestrial, mesophyte, cultivated for vegetable and oil.

**Habit :** An annual herb

**Vegetative characters**

**Root :** Tap root, branched.

**Stem :** Herbaceous, erect, branched, terete, slightly hairy, solid, green.

**Leaves :** Cauline and ramal, simple, exstipulate, alternate, lower old leaves sub-sessile and lyrate while the upper young leaves are sessile and entire, hairy, acute apex, unicostate reticulate venation.

**Floral characters**

**Inflorescence :** Racemose, typical raceme.

**Flower :** Ebracteate, pedicellate, actinomorphic, regular, bisexual, complete, tetramerous, hypogynous, yellow.

**Calyx :** Sepals 4, polysepalous, arranged in two alternate whorls of two sepals each, imbricate aestivation, sepaloid, deciduous, inferior.

**Corolla :** Petals 4, polypetalous, cruciform, clawed, arranged in one whorl, each alternating with sepals, valvate aestivation, inferior.

**Androecium :** Stamens 6, polyandrous, arranged in two whorls, two outer stamens smaller and four inner stamens longer, tetradynamous; anthers dithecal, basifixed and introrse.

**Gynoecium :** Bicarpellary, syncarpous, ovary superior, unilocular but appears as bilocular due to the development of a false septum called replum; one or more ovules in a locule; parietal placentation; style short and simple; stigma bifid.

**Fruit :** Siliqua.

**Seeds :** Small, round, non-endospermic.

**Floral formula :** Ebr.  $\oplus \begin{matrix} \text{♂} \\ \text{♀} \end{matrix} K_{2+2} C_4 A_{2+4} \underline{G_{(2)}}$

**Salient features**

1. An annual herb.
2. Tap root
3. Leaves exstipulate, unicostate reticulate venation, simple.
4. Inflorescence raceme.
5. Flowers ebracteate, hypogynous, tetramerous.
6. Polysepalous, arranged in two alternate whorls of two sepals each.

7. Polypetalous, cruciform corolla.
8. Polyandrous, tetradynamous stamens, anthers ditheous and basifixed.
9. Bicarpellary, syncarpous, ovary superior, parietal placentation, unilocular but appears as bilocular due to the development of a false septum called replum.
10. Fruit siliqua.

### Classification [Bentham and Hooker]

Kingdom: Plantae

- Subkingdom: Phanerogamae

Division: Angiospermae

Class: Dicotyledonae

Sub class: Polypetalae

Series: Thalamiflorae

Order: Parietals

Family: Cruciferae (Brassicaceae)

Genus: *Brassica*

Species: *campestris*

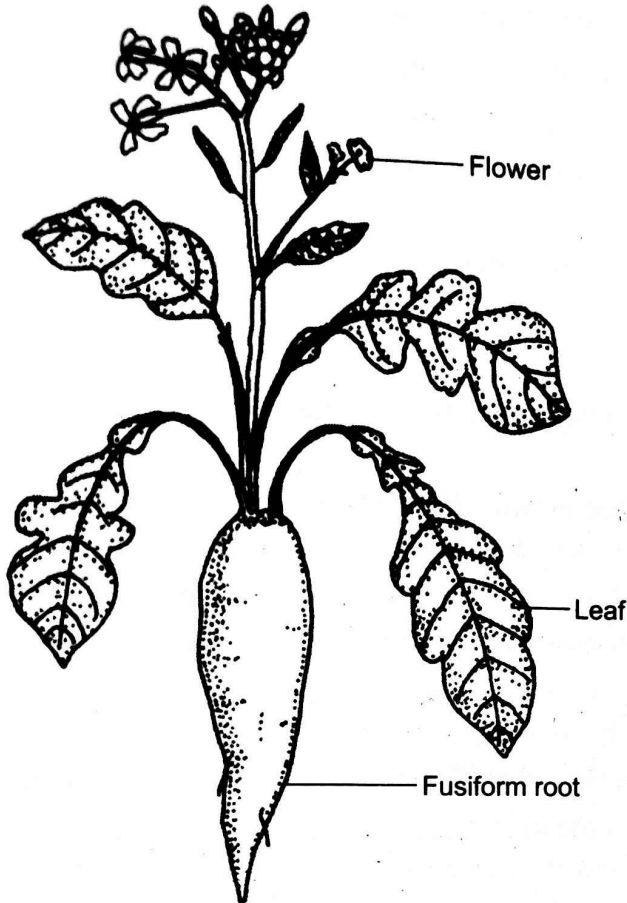
Common name: Mustard ( Local name: Tori)

Table : Name of some common plants of the family cruciferae

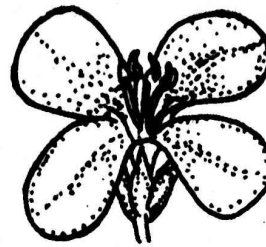
S.N.	Botanical name	English name	Nepali name	Uses
1.	<i>Brassica campestris</i>	Mustard	Tori	Oilseed
2.	<i>Raphanus sativus</i>	Radish	Moola	Vegetable
3.	<i>Brassica oleracea var. botrytis</i>	Cauliflower	Kauli	Vegetable
4.	<i>Brassica oleracea var. capitata</i>	Cabbage	Banda	Vegetable
5.	<i>Brassica rapa</i>	Turnip	Gantemoola	Vegetable
6.	<i>Iberis amara</i>	Candytuft	-	Ornamental
7.	<i>Brassica oleracea var. gongylodes</i>	Knol, Kohl	Gyanth-gobi	Vegetable
8.	<i>Lepidium sativum</i>	Garden cress	Chansoor	Vegetable
9.	<i>Brassica nigra</i>	Black mustard	Kali tori	Oilseed
10.	<i>Capsella bursa-pastoris</i>	Shepherd's purse	-	Weed

Date

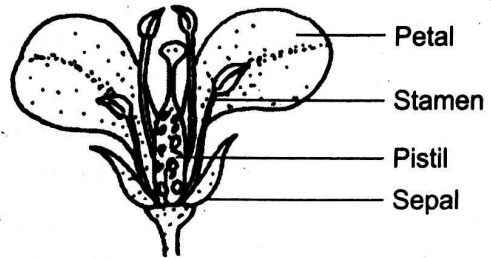
# DESCRIBE THE RAPHANUS SATIVUS IN SEMI-TECHNICAL TERMS



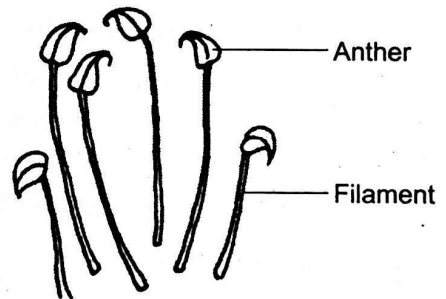
A flowering Radish Plant



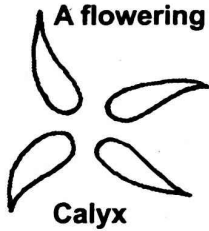
A Flower



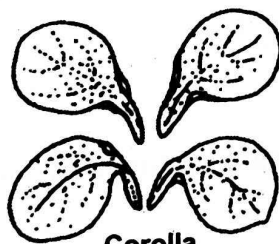
L.S. of Flower



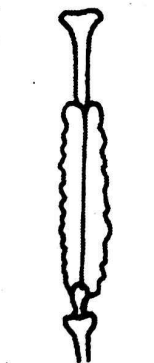
Stamens



Calyx



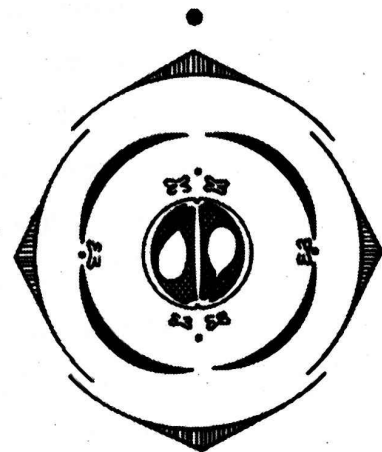
Corolla



Gynoecium



T.S. of Ovary



Floral Diagram

**OBJECTIVE****DESCRIBE THE *RAPHANUS SATIVUS* IN SEMI-TECHNICAL TERMS**

**Botanical description of the plant :** A flowering branch of *Raphanus sativus*

**Habit:** An annual or biennial herb, cultivated for vegetable.

**Root:** Tap root, hypocotyl swell up into fusiform structure due to the storage of food.

**Stem:** In initial stage stem is reduced. After completion of vegetative growth, the reduced stem elongates in the form of a floral shoot, floral shoot erect, cylindrical, herbaceous, solid, hairy, green and with pungent smelling juice.

**Leaf:** Radical as well as cauline and ramal, whorled or spiral, exstipulate, simple, sessile, lyrate, obtuse, surface hairy, unicostate reticulate venation, green.

**Inflorescence:** Racemose, corymbose raceme.

**Flower:** Ebracteate, ebracteolate, pedicellate, complete, bisexual, actinomorphic, regular, hypogynous, pentamerous, cruciform, white.

**Calyx:** Sepals four, polypetalous, arranged in two whorls of two each, inner whorls are longer, sepals are lanceolate, petaloid, imbricate aestivation, deciduous, inferior.

**Corolla:** Petals four, polypetalous, cruciform. each petal consists of a claw and limb, limb horizontally placed, alternate to sepals, white with purple veins, inferior, valvate aestivation.

**Androceium:** Stamens six, polyandrous, tetradynamous stamens, arranged in two whorls, two stamens of outer whorl are smaller than the four stamens of inner whorl, two nectaries are present, one each at the base of outer stamens and at the innerside, anthers ditheous, basifixed, introse, inferior.

**Gynoeium:** Carpels two, (bicarpellary), syncarpous, ovary superior, unilocular but becomes bilocular due to the presence of false septum across the placenta, ovules many, parietal placentation, ovary long, cylindrical and transversely placed, style short, stigma bilobed.

**Fruit:** An indehiscent lomentose siliqua.

**Floral formula:** Ebr.  $\oplus \overset{\text{♂}}{\text{♀}} K_{2+2} C_4 A_{2+4} G_{(2)}$

**Salient Features**

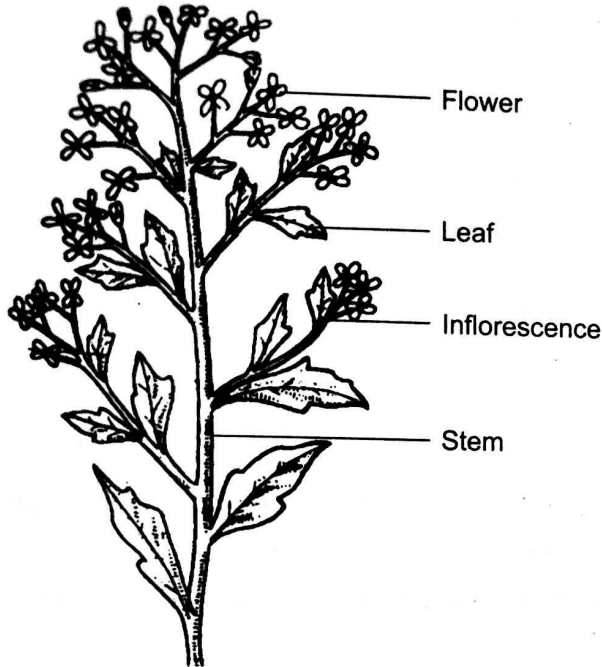
1. An annual or biennial herbs with pungent smelling juice.
2. Leaves exstipulate and lyrate.
3. Inflorescence corymbose raceme.
4. Flowers actinomorphic, bisexual, tetramerous, hypogynous.
5. Calyx polysepalous, arranged in two whorls of two each, imbricate aestivation.
6. Corolla polypetalous, cruciform.
7. Stamens tetradynamous
8. Carpels two, syncarpous, ovary bilocular due to the presence of false septum, parietal placentation.
9. Fruit lomentose siliqua.

**Classification [Bentham and Hooker]**

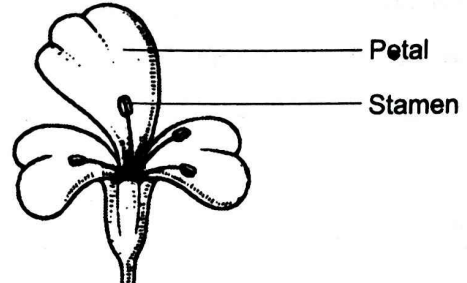
Same as in *Brassica campestris* (Mustard)

Date

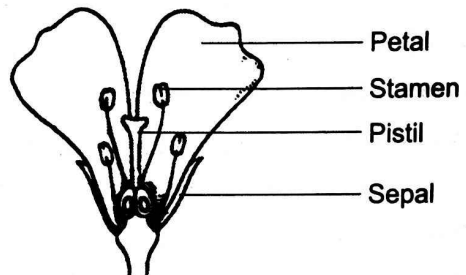
# DESCRIBE THE IBERIS AMARA IN SEMI TECHNICAL TERMS



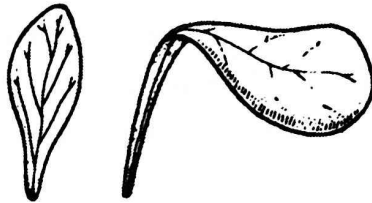
A Twig of *Iberis amara*



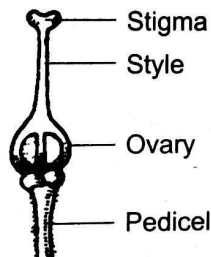
A Flower



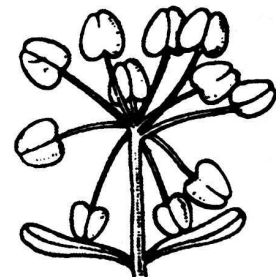
L.S. of Flower



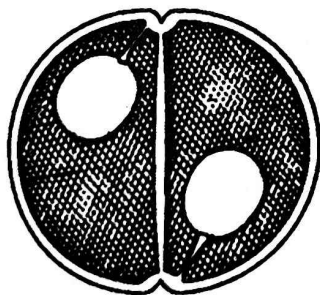
Unequal Petals



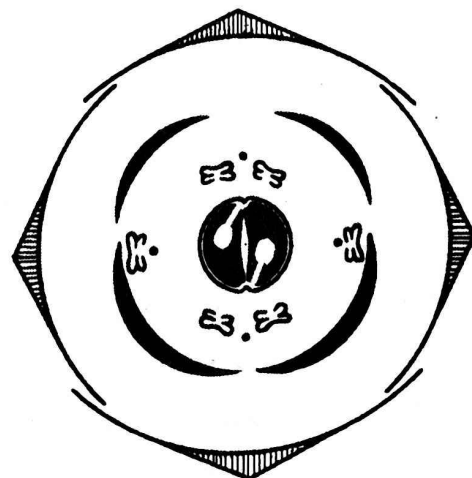
Pistil



Fruits



T.S. of Ovary



Floral Diagram

**OBJECTIVE****DESCRIBE THE *IBERIS AMARA* IN SEMI-TECHNICAL TERMS**

**Botanical description of the plant:** *Iberis amara* Linn.; English (Candytuft)

**Habitat:** Terrestrial, mesophyte, cultivated for ornamental purpose.

**Habit:** An annual herb

**Vegetative characters**

**Root.** Tap root, branched.

**Stem:** Herbaceous, erect, aerial, branched, cylindrical, glabrous, solid, green.

**Leaves:** Cauline and ramal, simple, exstipulate, alternate, sometimes opposite, sessile, margin somewhat dissected, glabrous, acute apex, unicostate reticulate venation.

**Floral characters**

**Inflorescence:** Racemose, corymbose raceme.

**Flower:** Ebracteate, pedicellate, actinomorphic, irregular, zygomorphic, bisexual, complete, tetramerous, hypogynous, white, cyclic.

**Calyx:** Sepals 4, polysepalous, arranged in two alternate whorls of two sepals each, imbricate aestivation, boat shaped, petaloid, deciduous, inferior.

**Corolla:** Petals 4, polypetalous, cruciform, two anterior petals large, two posterior petals small, (This differences in size brings about zygomorphy in flower) each petal consists of a claw and limb, arranged in one whorl, each alternating with sepals, valvate aestivation, inferior.

**Androecium:** Stamens 6, polyandrous, arranged in two whorls, two outer lateral stamens shorter and four inner antero-posterior stamens longer, tetradynamous; anthers ditheous, basifixed and introrse.

**Gynoecium:** Bicarpellary, syncarpous, ovary superior, unilocular when young but at maturity appears as bilocular due to the development of a false septum called replum; one or more ovules in a locule; parietal placentation; style short and simple; stigma bifid.

**Fruit:** Siliqua.

**Seeds:** Small, round, non-endospermic.

**Floral formula:** Ebr.  $\oplus \overset{\circlearrowleft}{\text{K}}_{2+2} \text{C}_4 \text{A}_{2+4} \text{G}_{(2)}$

**Salient features**

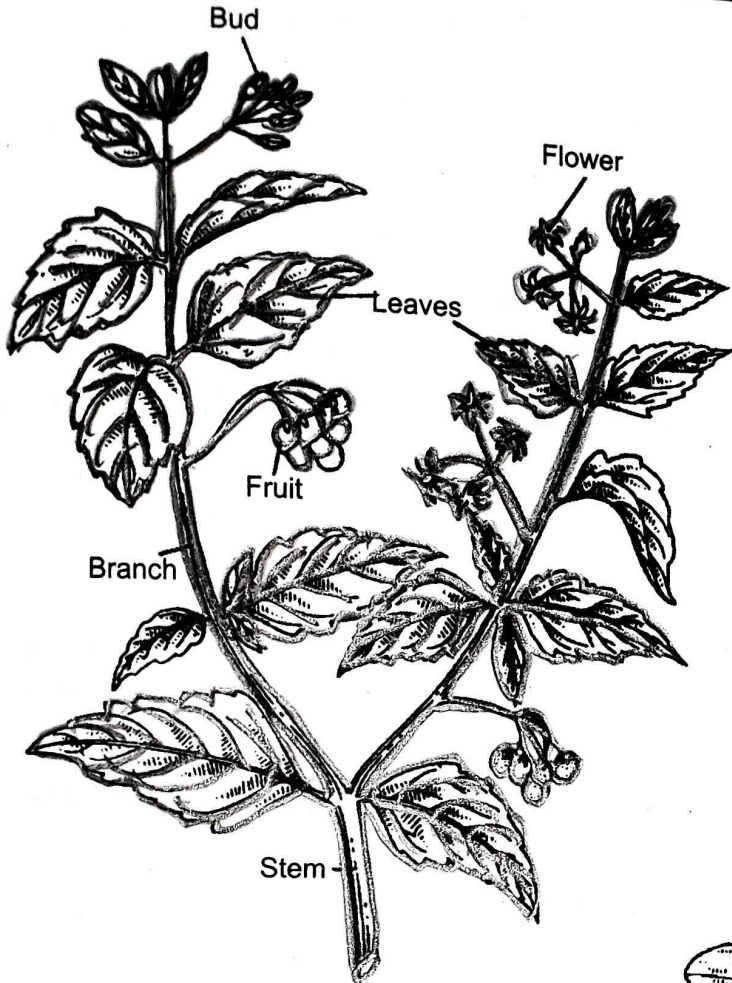
1. An annual herb with tap root
2. Leaves exstipulate, unicostate reticulate venation, simple.
3. Inflorescence corymbose raceme.
4. Flowers ebracteate, hypogynous, tetramerous.
5. Polysepalous, arranged in two alternate whorls of two sepals each.
6. Polypetalous, cruciform corolla.
7. Polyandrous, tetradynamous stamens, anthers ditheous and basifixed.
8. Bicarpellary, syncarpous, ovary superior, parietal placentation, unilocular but appears as bilocular due to the development of a false septum called replum. Fruit siliqua.

**Classification [Bentham and Hooker] :** Same as in *Brassica campestris* (Mustard)

puspas.com.mp

Date

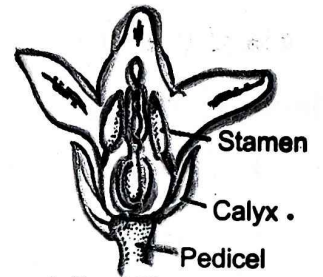
# DESCRIBE THE SOLANUM NIGRUM IN SEMI-TECHNICAL TERMS



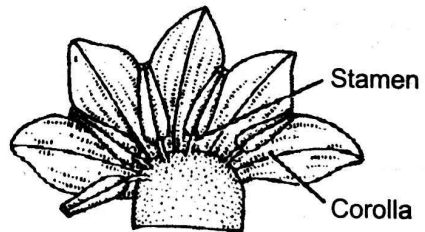
A twig of *Solanum nigrum*



A Flower



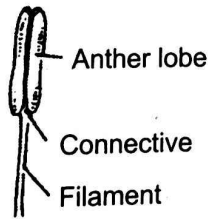
L.S. of Flower



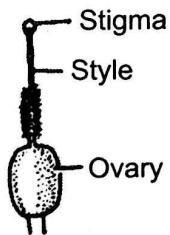
Corolla Open



Calyx



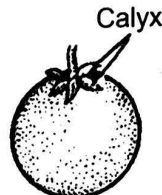
Stamen



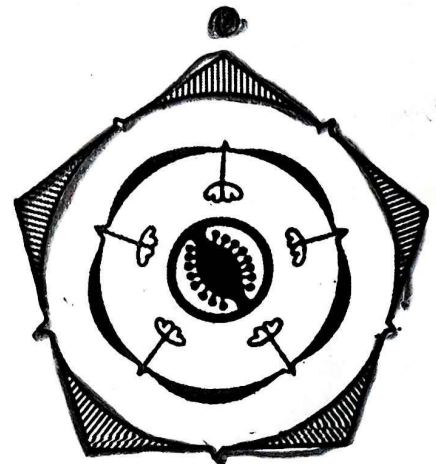
Pistil



T.S. Ovary



Fruit



Floral Diagram

**OBJECTIVE****DESCRIBE THE *SOLANUM NIGRUM* IN SEMI-TECHNICAL TERMS**

**Botanical description of the plant:** *Solanum nigrum* Linn. (Black night shade)

**Habitat:** Terrestrial, mesophyte, growing wild in shady places.

**Habit:** An annual small herb

**Vegetative characters**

**Root.** Tap root, branched.

**Stem:** Herbaceous, erect, branched, terete with distinct ribs, glabrous, solid, green.

**Leaves:** Cauline and ramal, simple, exstipulate, alternate, petiolate or sub sessile, ovate, margin dentate, slightly hairy, acute apex, unicostate reticulate venation.

**Floral characters**

**Inflorescence:** Cymose, extra-axillary sub umbellate (Helicoid) cyme.

**Flower:** Ebracteate, pedicellate, actinomorphic, regular, (Strictly speaking flowers are zygomorphic because of the oblique position of ovary with swollen placenta), bisexual, complete, pentamerous, hypogynous, small and white.

**Calyx:** Sepals 5, gamosepalous, campanulate or pentafid, valvate aestivation, sepaloid, persistent, hairy, inferior.

**Corolla:** Petals 5, petals fused at base, gamopetalous, rotate, lobes oblong, each alternating with sepals, valvate or twisted aestivation, white, inferior.

**Androecium:** Stamens 5, polyandrous, epipetalous, alternating to petals; filament short; anthers long, ditheous, basifixed, introrse and yellow.

**Gynoecium:** Bicarpellary, syncarpous; ovary obliquely placed, superior, bilocular; many ovules in each loculus; axile placentation with swollen placenta; style simple, hairy at the base; stigma bilobed.

**Fruit:** Berry, with saucer-shaped persistent calyx.

**Seeds:** Endospermic.

**Floral formula:** Ebr.  $\oplus \overset{\sigma}{\text{K}}_{(5)} \overset{\text{C}}{\text{C}}_{(5)} \overset{\text{A}}{\text{A}}_5 \overset{\text{G}}{\text{G}}_{(2)}$

**Salient features**

1. An annual herb.
2. Tap root
3. Leaves exstipulate, unicostate reticulate venation, simple.
4. Inflorescence cymose, helicoid cyme.
5. Flowers ebracteate, hypogynous, pentamerous.
6. Gamosepalous, persistent.
7. Gamopetalous, rotate.

8. Polyandrous, epipetalous, alternating to petals, anthers dithecal and basifixed.
9. Bicarpellary, syncarpous; ovary obliquely placed, axile placentation with swollen placenta, style hairy at the base.
10. Fruit berry.

### Classification [Bentham and Hooker]

**Kingdom:** Plantae

**Subkingdom:** Phanerogamae

**Division:** Angiospermae

**Class:** Dicotyledonae

**Sub class:** Gamopetalae

**Series:** Bicarpellatae

**Order:** Polemoniales

**Family:** Solanaceae

**Genus:** *Solanum*

**Species:** *nigrum*

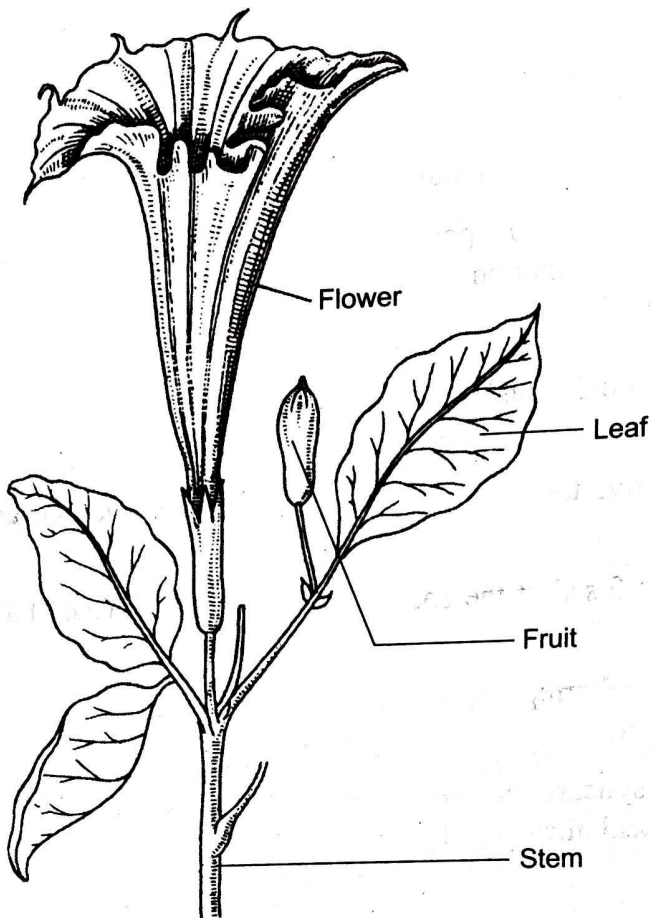
**Common name:** Black night shade (Local name: Makoi)

**Table : Name of some common plants of family solanaceae**

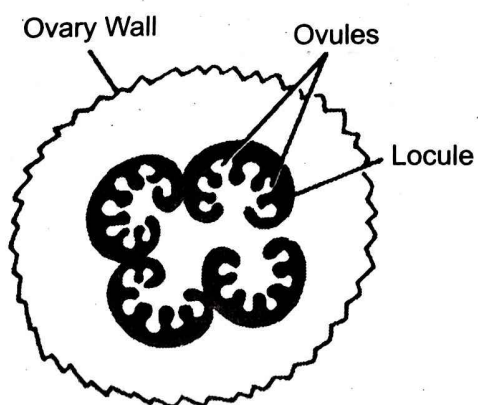
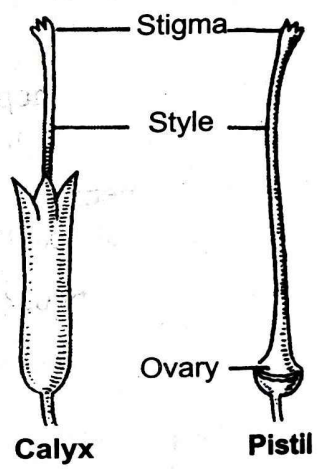
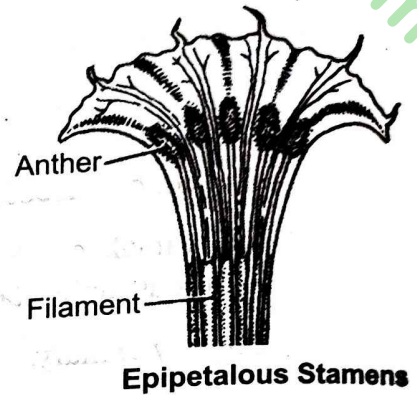
S.N.	Botanical name	English name	Nepali name	Uses
1	<i>Capsicum annuum</i>	Red pepper	Khursani	Culinary
2	<i>Lycopersicum esculentum</i>	Tomato	Golvenda	Vegetable
3	<i>Solanum melongena</i>	Brinjal	Bhanta	Vegetable
4	<i>Solanum tuberosum</i>	Potato	Alu	Vegetable
5	<i>Nicotiana tabacum</i>	Tobacco	Surti	Narcotic/ medicine
6	<i>Atropa belladonna</i>	Belladonna	Belladonna	Medicine
7	<i>Solanum nigrum</i>	Black nightshade	Jangali Makai	Atropin/ weed
8	<i>Brunfelsia hopeana</i>	'Yesterday-today and tomorrow' plant	-	Ornamental
9	<i>Datura stramonium</i>	Stramonium	-	Narcotic/ medicine
10	<i>Withania somnifera</i>	Aswagandh	Aswagandha	Medicine
11	<i>Cestrum nocturnum</i>	Night Jasmine	Rat Ki Rani	Ornamental
12	<i>Cestrum diurnum</i>	Day Jasmine	Din Ka Raja	Ornamental
13	<i>Datura metel</i>	Thorn apple	Dhaturo	Narcotic medicine

Date \_\_\_\_\_

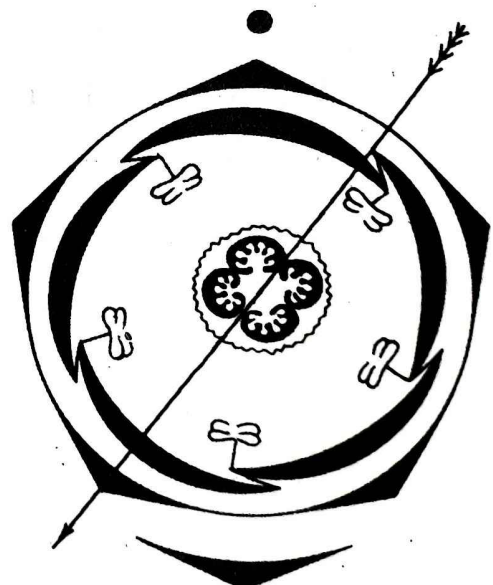
# DESCRIBE THE DATURA STRAMONIUM IN SEMI-TECHNICAL TERMS



A Flowering Twig of *Datura*



T.S. of Ovary



Floral Diagram

## OBJECTIVE

DESCRIBE THE *DATURA STRAMONIUM* IN SEMI-TECHNICAL TERMS

**Botanical description of the plant:** A flowering twig of *Datura stramonium*

**Habit:** An annual herb.

**Root:** Tap and branched.

**Stem:** Erect, branched, herbaceous, cylindrical, hairy fistular, green.

**Leaf:** Cauline and ramal, exstipulate, alternate to opposite, petioled, simple, ovate, toothed or dissected, acute, glabrous, unicostate reticulate venation, green.

**Inflorescence:** Solitary axillary.

**Flower:** Ebracteate, pedicellate, actinomorphic, bisexual, complete, regular, pentamerous except fourth whorl, hypogynous.

**Calyx:** Sepals five, gamosepalous, tubular, five-toothed, sepaloid, hairy, persistent, valvate aestivation, inferior.

**Corolla:** Petals five, gamopetalous, petals fused at the base, infundibuliform, surface hairy, white, twisted aestivation, inferior.

**Androecium:** Stamens five, polyandrous, alternipetalous, epipetalous, filament long and smooth, anthers ditheous, basifixed, introse, inferior.

**Gynoecium:** Carpels two, (bicarpellary), syncarpous, ovary posterior obliquely placed to the right and anterior to the left, superior, bilocular with many ovules on swollen placentae, axile placentation, style long, stigma small, bilobed, and capitate.

**Fruit:** A spinous capsule.

**Floral formula:** Ebr.  $\oplus \overset{\sigma}{\text{♀}} K_{(5)} \overline{C_{(5)}} A_5 \underline{G_{(2)}}$

## Salient Features

1. An annual erect herb with alternate to opposite leaves.
2. Inflorescence solitary axillary.
3. Flowers ebracteate, bisexual, pentamerous except pistil, hypogynous.
4. Calyx gamopetalous, sepaloid, persistent.
5. Corolla gamopetalous, infundibuliform.
6. Stamens polyandrous, epipetalous, alternate to petals.
7. Carpels bicarpellary, syncarpous, obliquely placed, bilocular, many ovules on swollen basal placentae, axile placentation.

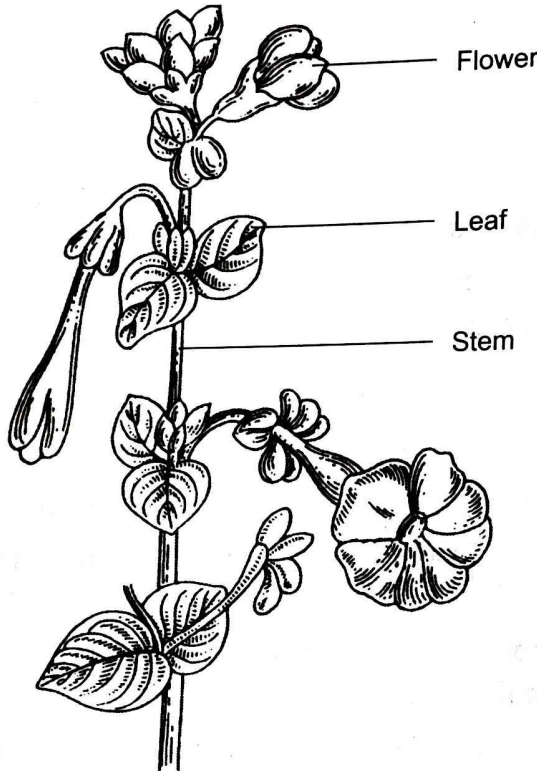
## Classification [Bentham and Hooker]

Same as in *Solanum nigrum* (Black night shade)

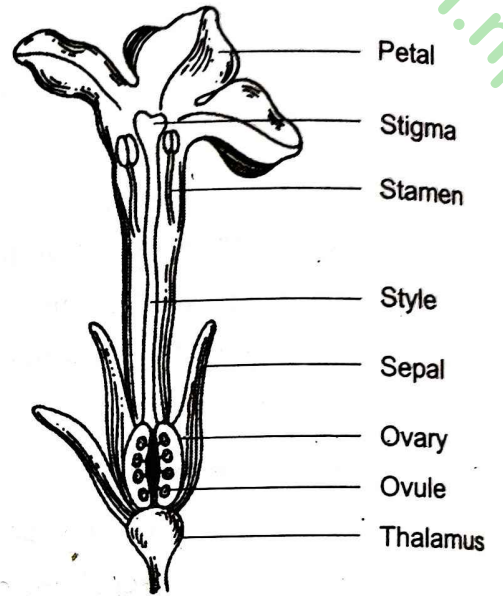
pustps.com.np

Date

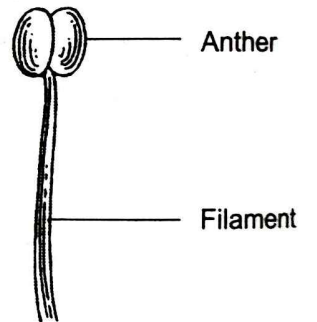
# DESCRIBE THE PETUNIA NYCTAGINIFOLIA IN SEMI-TECHNICAL TERMS



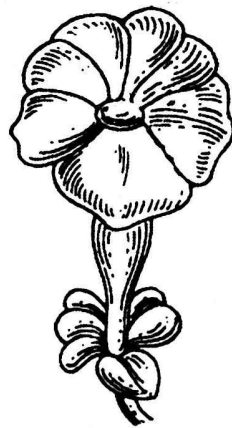
A Twig of Petunia



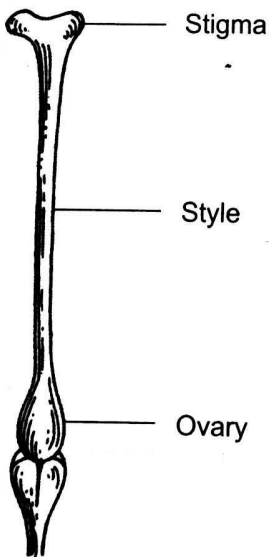
L.S. of Flower



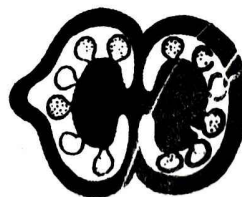
Stamen



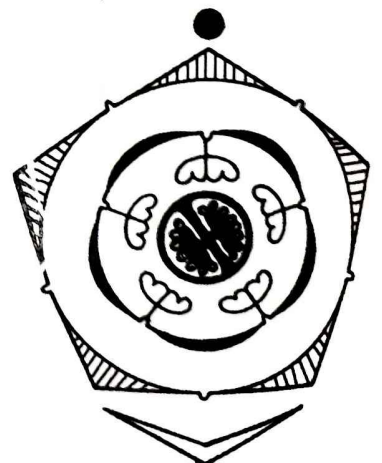
A flower



Pistil



T.S. of Ovary



Floral Diagram

**OBJECTIVE****DESCRIBE THE *PETUNIA NYCTAGINIFOLIA* IN SEMI-TECHNICAL TERMS**

**Botanical description of the plant:** *Petunia nyctaginifolia* Juss.

**Habitat:** Terrestrial, mesophyte, cultivated for ornamental purpose.

**Habit:** An annual herb.

**Vegetative characters**

**Root.** Tap root, branched.

**Stem:** Erect, herbaceous, aerial, branched, terete, hairy, solid, green.

**Leaves:** Cauline and ramal, simple, exstipulate, alternate in the basal part and opposite decussate in upper part, ovate, margin entire, hairy, acute apex, unicostate reticulate venation.

**Floral characters**

**Inflorescence:** Cymose, axillary dichasial cyme.

**Flower:** Bracteate, pedicellate, actinomorphic, regular, bisexual, complete, pentamerous, hypogynous.

**Calyx:** Sepals 5, gamosepalous, campanulate deeply lobed, valvate or quincuncial aestivation but in some cases imbricate. sepaloid, persistent, hairy, inferior.

**Corolla:** Petals 5, petals fused at base, gamopetalous, campanulate, each alternating with sepals, valvate or twisted aestivation, white or purple coloured, inferior.

**Androecium:** Stamens 5, polyandrous, epipetalous, alternating to petals; filament long of different lengths; anthers long, ditheous, basifixed, introrse and yellow.

**Gynoecium:** Bicarpellary, syncarpous; ovary obliquely placed, superior, bilocular; many ovules in each loculus; axile placentation with swollen placenta; style long and slightly twisted; stigma capitate.

**Fruit:** Capsule with persistent calyx.

**Seeds:** Endospermic.

**Floral formula:** Ebr.  $\oplus \overset{\text{♂}}{\text{♀}} K_{(5)} \overline{C_{(5)} A_5} G_{(2)}$

**Salient features**

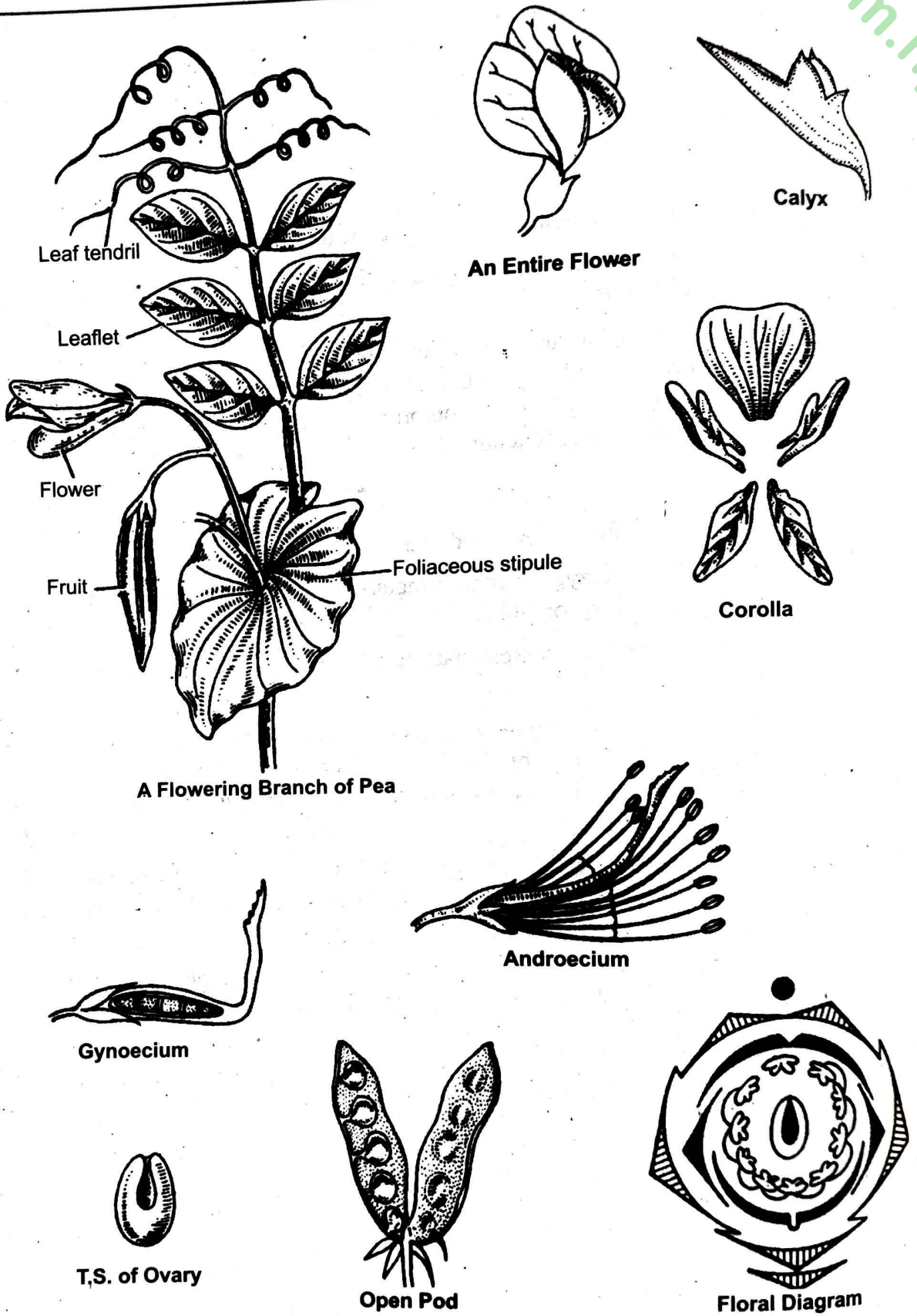
1. An annual herb. Tap root
3. Leaves exstipulate, unicostate reticulate venation, simple.
4. Inflorescence cymose, helicoid cyme.
5. Flowers ebracteate, hypogynous, pentamerous.
6. Gamosepalous, persistent.
7. Gamopetalous, rotate.
8. Polyandrous, epipetalous, alternating to petals, anthers ditheous and basifixed.
9. Bicarpellary, syncarpous; ovary obliquely placed, axile placentation with swollen placenta, style hairy at the base. Fruit berry.

**Classification [Bentham and Hooker]**

Same as in *Solanum nigrum* (Black night shade)

Date

# DESCRIBE THE PISUM SATIVUM IN SEMI-TECHNICAL TERMS



**OBJECTIVE****DESCRIBE THE *PISUM SATIVUM* IN SEMI-TECHNICAL TERMS**

**Botanical description of the plant:** *Pisum sativum* L. (Garden pea)

**Habitat:** Terrestrial, mesophyte, cultivated for vegetable and pulses.

**Habit:** An annual herb.

**Vegetative characters**

**Root.** Tap root, branches with nodules containing nitrogen fixing bacteria called *Rhizobium*.

**Stem:** Herbaceous, weak, climber, climbing with the help of leaf tendrils, cylindrical, fistular, branched, glabrous, glaucous.

**Leaves:** Cauline and ramal, alternate, stipulate, stipules large, ovate, semicordate, irregularly toothed at the base and foliaceous; leaf compound, imparipinnate, pinna or leaflets ovate, 4-6 in number, leaflets entire, smooth, net veined, oval to oblong, mucronate tips, green and glaucous; the rachis and upper leaflets ending into branched tendrils.

**Floral characters**

**Inflorescence:** Racemose, flowers arranged in axillary raceme or solitary.

**Flower:** Bracteate, pedicellate, zygomorphic, irregular, bisexual, papilionaceous, complete, pentamerous, hypogynous or perigynous, pink or white.

**Calyx:** Sepals 5, gamosepalous, campanulate calyx tube, ascending imbricate aestivation, seploid, persistent, inferior.

**Corolla:** Petals 5, polypetalous, papilionaceous i.e., the posterior petal is largest, called standard or vexillum, the two laterals are wings or alae and the inner two anterior are fused to form a boat-shaped structure called keel or carina; descending imbricate or vexillary aestivation, white or pink in colour, inferior.

**Androecium:** Stamens 10, diadelphous [1+(9)], 9 anteriorly placed stamens fused to form a staminal tube around the ovary while the 10th or 1 free is placed posteriorly; filaments long; anthers basifixed, ditheous, introrse, dehiscence by longitudinal splitting; yellow.

**Gynoecium:** Monocarpellary, ovary superior, unilocular, marginal placentation; ovary hairy, ovules many; style bent and long; stigma simple, terminal and hairy.

**Fruit:** Legume- pod with many seeds.

**Seeds:** Round, uniform, non-endospermic.

**Floral formula:** Br. %  $\frac{\text{♂}}{\text{♀}}$   $K_{(5)}$   $C_{1+2+(2)}$   $A_{1+(9)}$   $\underline{G}_1$

**Salient features**

1. An annual herb.
2. Tap root with nodules.
3. Leaves stipulate, imparipinnate compound leaves reticulate venation.
4. Inflorescence racemose.
5. Flowers bracteate, hypogynous, pentamerous, zygomorphic.

6. Gamosepalous, persistent, ascending imbricate aestivation.
7. Polypetalous, papilionaceous, descending imbricate aestivation.
8. Stamens 10, diadelphous [1 + (9)], anthers ditheous and basifixed.
9. Monocarpellary, unilocular, ovary superior, marginal placentation, style bent at the base, stigma hairy.
10. Fruit legume.

### Classification [Bentham and Hooker]

**Kingdom** : Plantae

**Subkingdom** : Phanerogamae

**Division** : Angiospermae

**Class** : Dicotyledonae

**Sub class** : Polypetalae

**Series** : Calyciflorae

**Order** : Rosales

**Family** : Leguminosae

**Sub family** : Papilionoideae

**Genus** : *Pisum*

**Species** : *sativum*

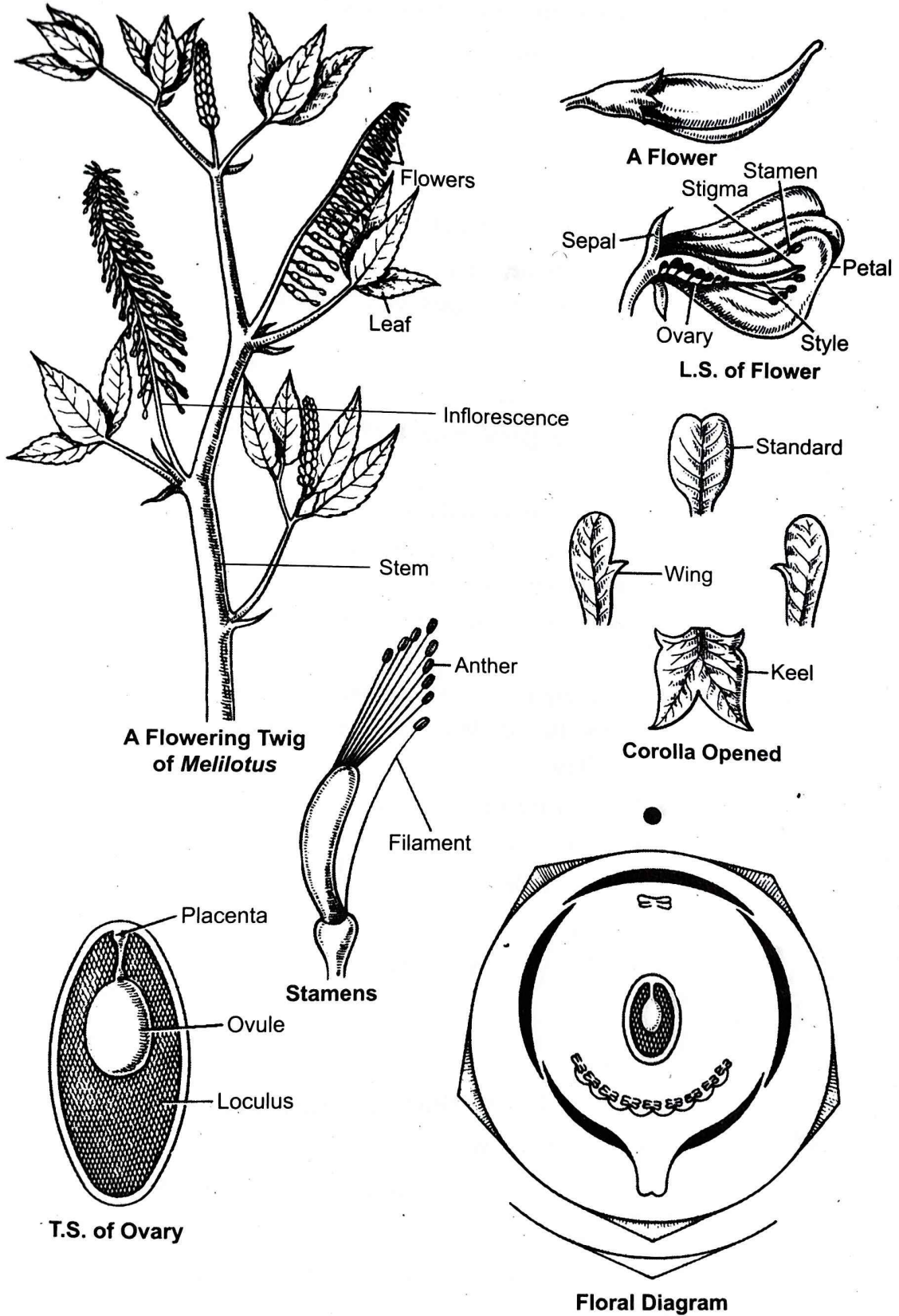
**Common name** : pea ( Local name: Kerau)

**Table** : Names of some common plants the sub-family of Papilionaceae

S.N.	Botanical name	English name	Nepali name	Uses
1.	<i>Arachis hypogea</i>	Ground nut	Badam	Oilseed
2.	<i>Dalbergia sissoo</i>	Rose wood	Sisau	Timber
3.	<i>Cicer arietinum</i>	Gram	Chana	Pulses
4.	<i>Pisum sativum</i>	Pea	Kerau	Pulses/vegetable
5.	<i>Phaseolus aureus</i>	Green gram	Moong	Pulses
6.	<i>Cajanus cajan</i>	Pigeon pea	Rahar	Pulses
7.	<i>Glycine max</i>	Soybean	Bhatmas	Oil/food
8.	<i>Phaseolus mungo</i>	Black gram	Kalo mas	Pulses
9.	<i>Lathyrus odoratus</i>	Sweet pea	Kerau phool	Ornamental
10.	<i>Vicia faba</i>	Broad bean	Bakula simi	Pulses/vegetable
11.	<i>Trifolium repens</i>	White clover	Pyauli	Forage
12.	<i>Pterocarpus marsupium</i>	Bijai saal	Bijai saal	
13.	<i>Lens esculenta</i>	Lentil	Musuro	Pulses
14.	<i>Sesbania aculeata</i>	Dhencha	Dhaincha	Green manure

Date

# DESCRIBE OF MELILOTUS INDICA IN SEMI-TECHNICAL TERMS



**OBJECTIVE****DESCRIBE THE *MILLOTUS INDICA* IN SEMI-TECHNICAL TERMS**

- Botanical description of the plant: *Milolotus indica* L.

**Habitat:** Terrestrial, mesophyte, wild.

**Habit:** An annual herb

**Vegetative characters**

**Root.** Tap root system.

**Stem:** Erect herbaceous, solid, branched, cylindrical, glabrous.

**Leaves:** Cauline and ramal, alternate, stipulate, stipule linear; petiolate, leaf compound, trifoliolate, leaflets ovate, margin serrate, mucornate apex, green; unicostate reticulate venation.

**Floral characters**

**Inflorescence:** Axillary typical raceme.

**Flower:** Bracteate, pedicellate, zygomorphic, bisexual, complete, pentamerous, hypogynous, may appear as perigynous, green.

**Calyx:** Sepals 5, gamosepalous, campanulate calyx tube, lanceolate, valvate aestivation, sepeloid.

**Corolla:** Petals 5, minute, polypetalous, papilionaceous i.e., the posterior petal is largest, called *standard* or *vexillum*, the two laterals are *wings* or *alae* and the inner two anterior are fused to form a boat-shaped structure called *keel* or *carina*; descending imbricate or vexillary aestivation, yellow in colour, inferior.

**Androecium:** Stamens 10, diadelphous [1+(9)], 9 anteriorly placed stamens fused to form a staminal tube around the ovary while the 10<sup>th</sup> or 1 free is placed posteriorly; filaments long; anthers dorsifixed, ditheous, introrse, anthers yellow.

**Gynoecium:** Monocarpellary, ovary superior, unilocular, marginal placentation, many ovules in a loculus; style long; stigma simple and hairy.

**Fruit:** Legume- pod with many seeds.

**Seeds:** Round, non-endospermic.

**Floral formula:** Br.  $\% \begin{matrix} \text{♂} \\ \text{♀} \end{matrix} K_{(5)} C_{1+2+(2)} A_{1+(9)} G_{(2)}$

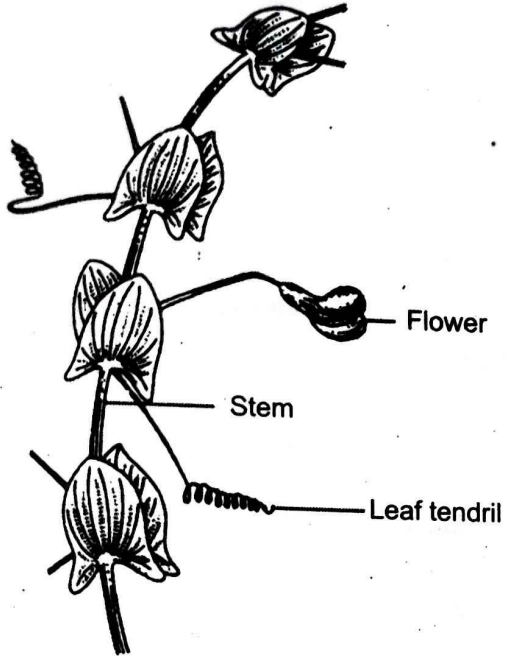
**Salient features**

1. An annual herb. Tap root system.
3. Leaves stipulate, compound leaves, trifoliolate, reticulate venation.
4. Inflorescence-axillary typical raceme.
5. Flowers bracteate, hypogynous, pentamerous, zygomorphic.
6. Gamosepalous, valvate aestivation.
7. Polypetalous, papilionaceous, descending imbricate aestivation.
8. Stamens 10, diadelphous [1 + (9)], anthers ditheous and dorsifixed.
9. Monocarpellary, unilocular, ovary superior, marginal placentation. Fruit legume.

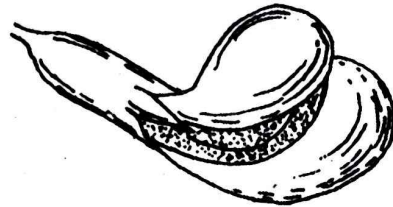
**Classification [Bentham and Hooker]:** Same as in *Pisum sativum* (Pea)

Date

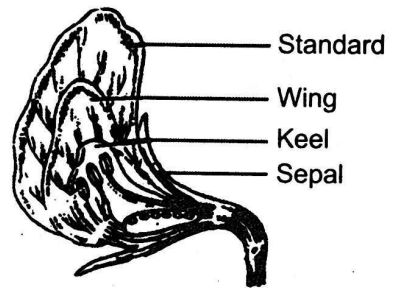
# DESCRIBE THE LATHYRUS APHACA IN SEMI-TECHNICAL TERMS



A Flowering Twig of *Lathyrus aphaca*



A Flower



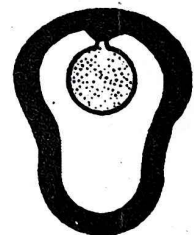
L.S. of Flower



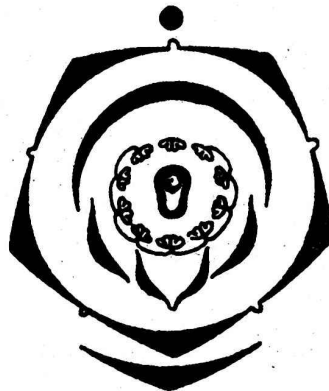
Stamen



(9) + 1, Androecium and Pistil



T.S. of Ovary



Floral Diagram

**OBJECTIVE****DESCRIBE THE *LATHYRUS APHACA* IN SEMI-TECHNICAL TERMS**

**Botanical description of the plant:** A flowering branch of *Lathyrus aphaca*.

**Habit:** An annual herb, wild.

**Root:** Tap, branched, nodules bear symbiotic nitrogen fixing bacteria (*Rhizobium radicola*)

**Stem:** Weak, herbaceous, aerial, climbing up with the help of leaf tendrils, branched, cylindrical, glabrous, glaucous, green.

**Leaf:** Cauline and ramal, alternate, stipulate, a pair of foliaceous stipules, hastate-shaped, entire margin, acute apex, leaf is modified into a tendril.

**Inflorescence:** Solitary axillary

**Flower:** Pedicellate, bracteate, zygomorphic, bisexual, complete, irregular, pentamerous in the outer three whorls, hypogynous, papilionaceous, cyclic, flower coloured.

**Calyx:** Sepals five, gamosepalous, sepaloid, inferior, valvate aestivation.

**Corolla:** Petals five, unequal, polypetalous, papilionaceous consisting a large posterior standard, two lateral petals called wings and anterior petals fused together to form boat-shaped keel. Keel enclose the stamens and pistil, petaloid, inferior, descending imbricate aestivation,

**Androecium:** Stamens 10, arranged in two bundles, i.e., diadelphous of (9)+1, nine stamens fuse at the base and form a tube around ovary, tenth lies posteriorly and free; anthers bicelled, basifixed, introrse.

**Gynoecium:** Carpel one, (monocarpellary), ovary superior, unilocular, many ovules, marginal placentation, style long and bent, stigma simple, hairy.

**Fruit:** Legume

**Floral Formula:** Br. %  $\overset{\circlearrowleft}{\text{♀}}$   $K_{(5)}$   $C_{1+2+(2)}$   $A_{1+(9)}$   $\underline{G_1}$

**Salient Features**

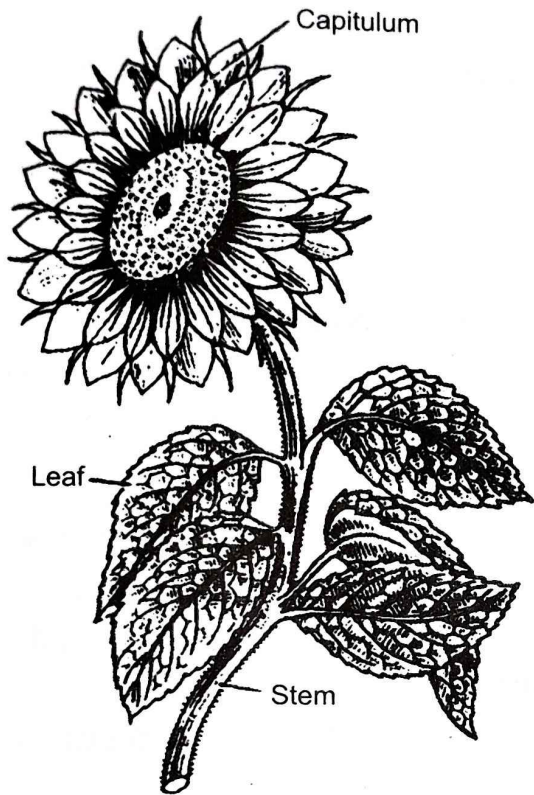
1. Root consisting many nodules which has nitrogen fixing bacteria.
2. Leaf is modified into tendrils and stipulate.
3. Solitary and axillary inflorescence.
4. Flower zygomorphic with papilionaceous corolla.
5. Stamens ten, arranged in two bundles i.e., diadelphous of (9) + 1
6. Monocarpellary ovary with marginal placentation.

**Classification [Bentham and Hooker]**

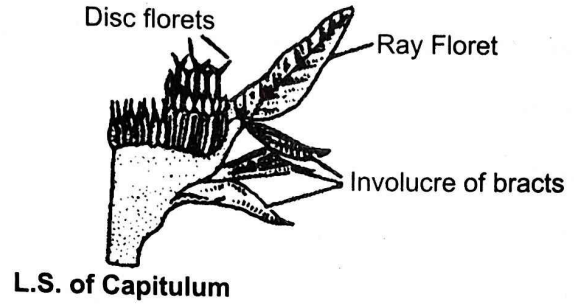
Same as in *Pisum sativum* (Pea)

Date

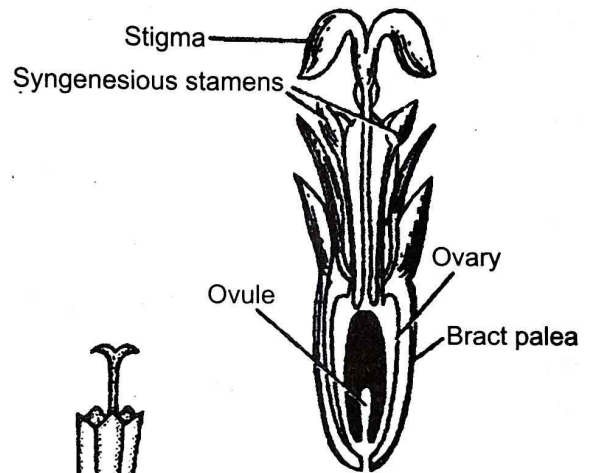
# DESCRIBE THE HELIANTHUS ANNUUS IN SEMI-TECHNICAL TERMS



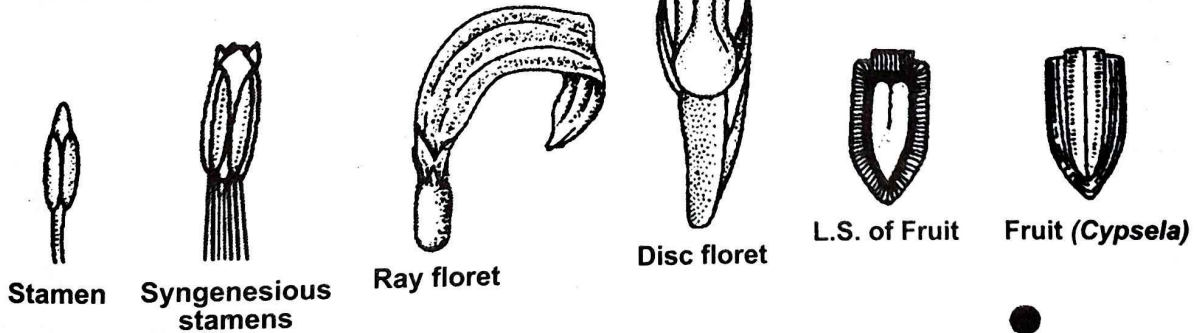
A Flowering Twig of Sunflower



L.S. of Capitulum



L.S. Flower



Stamen

Syngenesious stamens

Ray floret

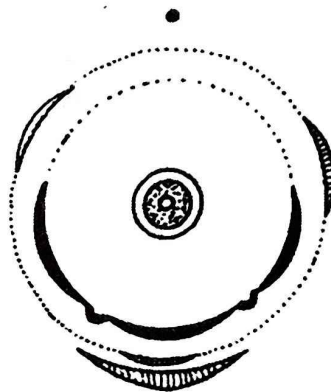
Disc floret

L.S. of Fruit

Fruit (Cypsela)



Pistil



Floral Diagram of Ray Floret



Floral Diagram of Disc Floret

**OBJECTIVE****DESCRIBE THE *HELIANTHUS ANNUUS* IN SEMI-TECHNICAL TERMS**

**Botanical description of the plant:** *Helianthus annuus* L. (Sunflower)

**Habitat:** Terrestrial, mesophyte, cultivated for ornamental purpose and for oil value.

**Habit:** An annual herb.

**Vegetative characters**

**Root:** Tap root, branched.

**Stem:** Herbaceous, erect, cylindrical, branched, pubescent, solid, green.

**Leaves:** Cauline and ramal, exstipulate, opposite, often the upper ones are alternate, petiolate, simple, ovate, acute apex, margin serrate, pubescent, unicostate reticulate venation, green.

**Floral characters**

**Inflorescence:** Racemose, head or capitulum with three series of involucre of leafy bracts.

**Flower:** Heterogamous i.e., capitulum consisting of two kinds of florets: flowers at periphery are called ray florets while those in the centre are known as disc florets; bracteate, regular, epigynous, sessile, bisexual or unisexual, actinomorphic or zygomorphic.

**Ray floret:** Bracteate, sessile, unisexual, pistillate or neuter, incomplete, ligulate, zygomorphic, epigynous, yellow.

**Calyx:** Represented by 2 or 3 modified sepals called pappus, superior.

**Corolla:** Petals 3 to 5 teeth that represent the number of petals, gamopetalous, ligulate with large flat strap-shaped limb and a basal tube, superior, valvate aestivation, yellow.

**Androecium:** Absent.

**Gynoecium:** Bicarpellary, syncarpous, ovary inferior with only one ovule, basal placentation,; style simple, long and slender; stigma bifid and curved.

**Floral formula:** Br. % ♀  $K_{(2 \text{ or } 3 \text{ Pappus})} C_{(3-5)} A_0 \overline{G}_{(2)}$

**Disc floret:** Arranged in the central part of the capitulum, bracteate, sessile, bisexual, complete, tubular, actinomorphic, epigynous, small, yellow.

**Calyx:** Sepals reduced and modified into 2-5 membranous white scales called pappus, superior.

**Corolla:** Petals 5, gamopetalous, tubular, superior, valvate aestivation, yellow.

**Androecium:** Stamens 5, epipetalous, alternating with the petals, superior; filaments short and free; anther large ditheous with prolonged connective, basifixed, syngenesious, introrse,

**Gynoecium:** Bicarpellary, syncarpous, ovary inferior with only one ovule, basal placentation,; style simple, long and slender; stigma bifid and curved.

**Floral formula:** Br. % ♂  $K_{(2-5 \text{ Pappus})} \overline{C}_{(5)} \overline{A}_5 \overline{G}_{(2)}$

**Fruit:** Cypsela.

**Seeds:** Non-endospermic.

**Salient features**

1. An annual herb.
2. Tap root system.
3. Leaves exstipulate, simple, reticulate venation.
4. Inflorescence head or capitulum.
5. Flowers bracteate, epigynous, zygomorphic.
6. Ray florets are ligulate while disc florets are tubular.
7. Calyx is represented by 2-5 modified scales called pappus.
8. Corolla 3-5, gamopetalous, valvate aestivation.
9. Stamens epipetalous, syngenesious anther.
10. Bicarpellary, syncarpous, unilocular with single basal ovule, ovary inferior, basal placentation.
11. Fruit cypsela.

**Classification [Bentham and Hooker]**

**Kingdom :** Plantae

**Subkingdom :** Phanerogamae

**Division :** Angiospermæ

**Class :** Dicotyledonae

**Sub class :** Gamopetalae

**Series :** Inferae

**Order :** Asterales

**Family :** Compositae [Asteraceae]

**Genus :** *Helianthus*

**Species :** *annuus*

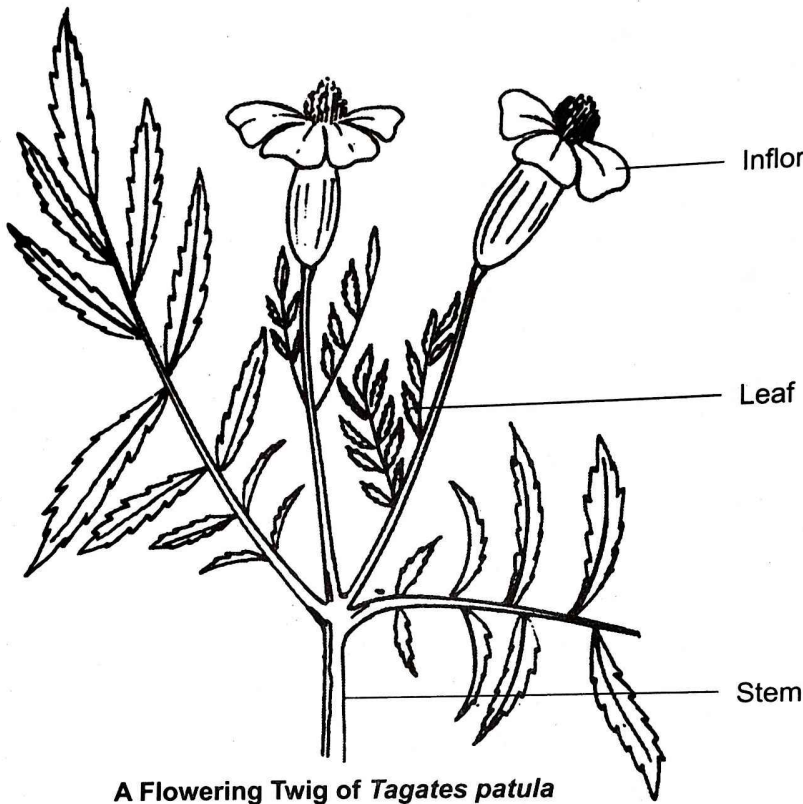
**Common name :** Sunflower (Local name: suryamookhi)

**Table : Names of Some Common Plants of family compositae**

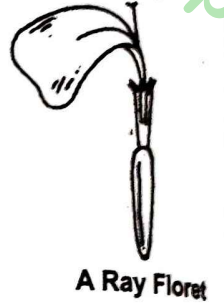
S. N.	Botanical name	English name	Nepali Name	Uses
1.	<i>Helianthus annuus</i>	Sunflower	Suryamukhi	Oilseed/ Ornamental
2.	<i>Tagetes patula, Tagetes erecta</i>	Marigold	Sayapatri	Ornamental
3.	<i>Lactuca sativa</i>	Garden lettuce		Salad/vegetable
4.	<i>Artemisia vulgaris</i>	Tite pati	Pati	Medicinal
5.	<i>Chrysanthemum coronarium</i>	Chrysanthemum	Godavari	Ornamental
6.	<i>Carthamus tinctorius</i>	Kusum	Kusum	Medicinal
7.	<i>Zinnia elegans</i>	Zinnia	Zinia	Ornamental
8.	<i>Guizotia abyssinica</i>	-	Jhuse til	Oil
9.	<i>Dahlia variabilis</i>	Dahlia	Lahure phool	Ornamental
10.	<i>Galinsoga parviflora</i>	-	Ghande jhar	Weed
11.	<i>Calendula officinalis</i>	Calendula	Asarphi	Ornamental

Date

# DESCRIBE THE TAGATES PATULA IN SEMI-TECHNICAL TERMS



A Flowering Twig of *Tagetes patula*



A Ray Floret



A Head or Capitulum



A Disc Floret



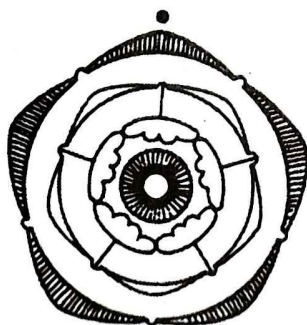
L.S. of Disc Floret



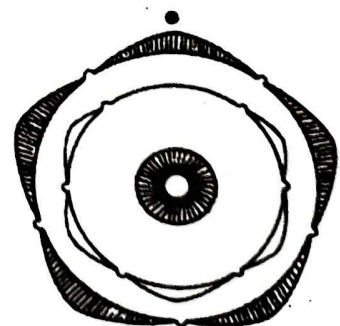
Syngenesious Stamens



T.S. of Ovary



Floral Diagram of Disc Floret



Floral Diagram of Ray Floret

**OBJECTIVE****DESCRIBE THE *TAGATES PATULA* IN SEMI-TECHNICAL TERMS**

**Botanical description of the plant:** *Tagates patula* L. ( Marigold)

**Habitat:** Terrestrial, mesophyte, cultivated for ornamental purpose.

**Habit:** An annual herb.

**Vegetative characters**

**Root.** Tap root, branched.

**Stem:** Herbaceous, erect, cylindrical, branched, nerved, solid, reddish in colour.

**Leaves:** Cauline and ramal, exstipulate, alternate to opposite, petiolate, simple deeply incised, lobes with serrate margin, acute apex, lamina glabrous, unicostate reticulate venation, green.

**Floral characters**

**Inflorescence:** Racemose, head or capitulum with involucre of green bracts.

**Flower:** Heterogamous i.e., capitulum consisting of two kinds of florets: flowers at periphery are called ray florets while those in the centre are known as disc florets; bracteate, regular, epigynous, sessile, bisexual or unisexual, actinomorphic or zygomorphic.

**Ray floret:** Bracteate, sessile, unisexual, pistillate, incomplete, ligulate, irregular, zygomorphic, epigynous, yellow.

**Calyx:** Represented by colourless bristles like 5 sepals called pappus, valvate, superior.

**Corolla:** Petals 3 to 5 teeth that represent the number of petals, gamopetalous, ligulate with large flat strap-shaped limb and a basal tube, superior, valvate aestivation, yellow.

**Androecium:** Absent.

**Gynoecium:** Bicarpellary, syncarpous, ovary inferior with only one ovule, basal placentation,; style simple, long and slender; stigma simple, bifid.

**Floral formula:** Br. % ♀  $K_{(2 \text{ or } 3 \text{ Pappus})} C_{(3-5)} A_0 \overline{G}_{(2)}$

**Disc floret:** Arranged in the central part of the capitulum, bracteate, sessile, bisexual, complete, tubular, actinomorphic, epigynous, small, yellow.

**Calyx:** Represented by colourless bristles like 2-5 sepals called pappus, valvate, superior.

**Corolla:** Petals 5, gamopetalous, tubular, superior, valvate aestivation, yellow.

**Androecium:** Stamens 5, epipetalous, alternating with the petals, superior; filaments short and free; anther large ditheous with prolonged connective, basifixed, syngenesious, introrse,

**Gynoecium:** Bicarpellary, syncarpous, ovary inferior with only one ovule, basal placentation; style simple, long and slender; stigma bifid and curved.

Floral formula:  $\text{Br. } \oplus \text{ } \overset{\circlearrowleft}{\text{K}}_{(2-5 \text{ Pappus})} \overset{\circlearrowright}{\text{C}}_{(5)} \text{A}_5 \overline{\text{G}}_{(2)}$

Fruit: Cypsela.

Seeds: Non-endospermic.

### Salient features

1. An annual herb.
2. Tap root system.
3. Leaves exstipulate, simple, reticulate venation.
4. Inflorescence head or capitulum.
5. Flowers bracteate, epigynous, zygomorphic.
6. Ray florets are ligulate while disc florets are tubular.
7. Calyx is represented by 2 or 3 modified scales called pappus.
8. Corolla 3-5, gamopetalous, valvate aestivation.
9. Stamens epipetalous, syngenesious anther.
10. Bicarpellary, syncarpous, unilocular with single basal ovule, ovary inferior, basal placentation.
11. Fruit cypsela.

### Classification [Bentham and Hooker]

Kingdom : Plantae

Subkingdom : Phanerogamae

Division : Angiospermae

Class : Dicotyledonae

Sub class : Gamopetalae

Series : Inferae

Order : Asterales

Family : Compositae [Asteraceae]

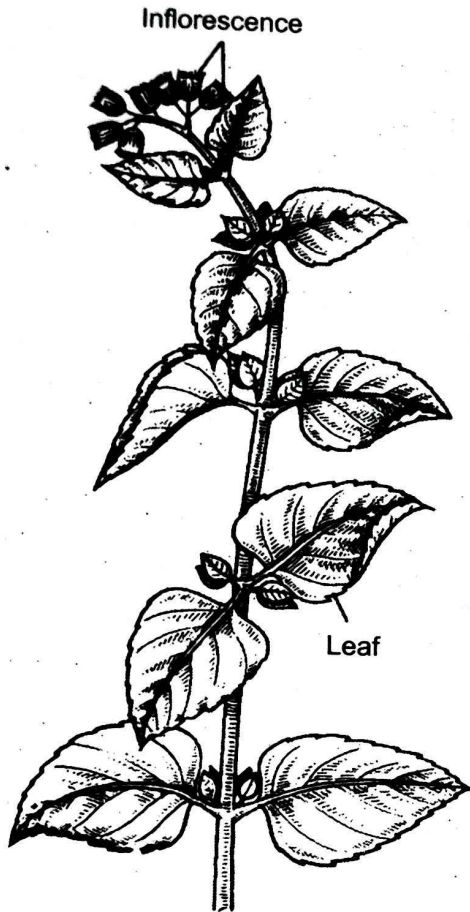
Genus : *Tagetes*

Species : *patula*

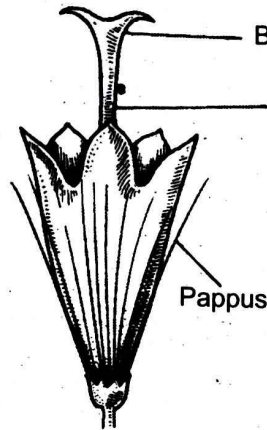
Common name : Marigold ( Local name: Sayapatri phool)

Date

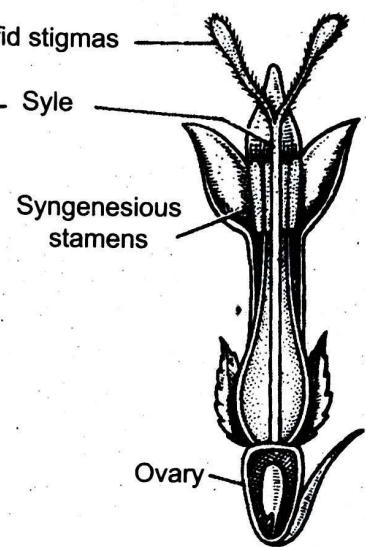
# DESCRIBE THE AGERATUM CONYZOIDES IN SEMI-TECHNICAL TERMS



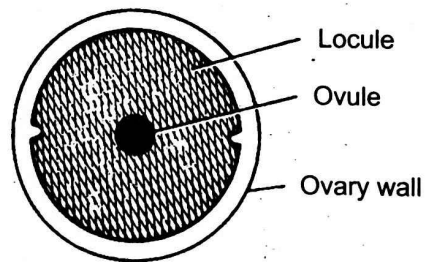
**A Flowering Twig of *Ageratum conyzoides***



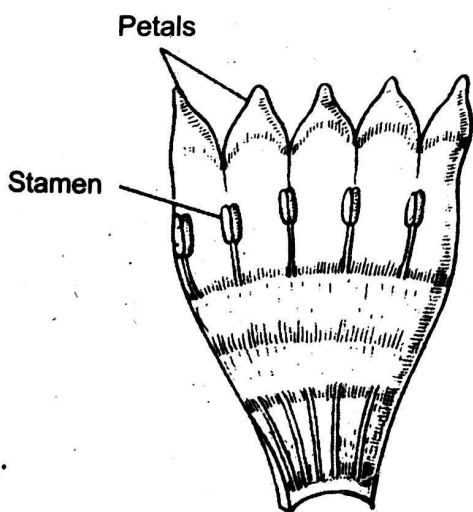
**A Flower**



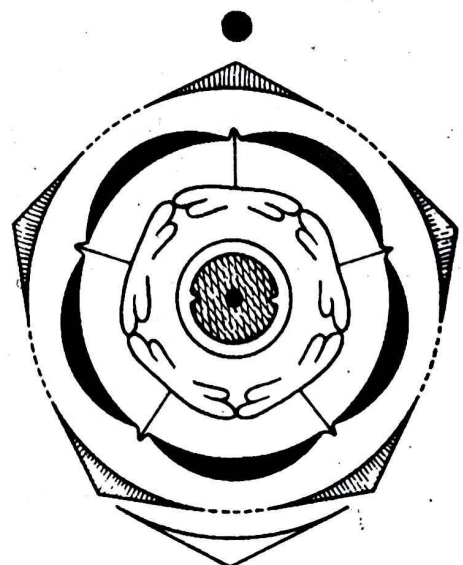
**L.S. of Flower**



**T.S. of Ovary**



**Epipetalous Stamens**



**Floral Diagram**

**OBJECTIVE****DESCRIBE THE *AGERATUM CONYZOIDES* IN SEMI-TECHNICAL TERMS**

**Botanical description of the plant:** Flowering twig of *Ageratum conyzoides*

**Habit:** An annual herb, wild.

**Root:** Tap, branched.

**Stem:** Erect, branched, herbaceous, solid, terete, hairy, purple - green in colour.

**Leaf:** Cauline and ramal, exstipulate, lower leaves opposite, upper leaves alternate, petiolate, simple, ovate, serrate margin, acute apex, hairy, unicostate reticulate venation, green.

**Inflorescence:** Racemose, a number of heads or capitula arranged in terminal corymbs, all flowers of a capitulum are tubular (homozygous), capitula are surrounded by two to three seriate involucre act as bracts.

**Flower:** Bracteate, bracts present in the form of involucre, sessile, tubular, actinomorphic, bisexual, complete, regular, epigynous, cyclic, bluish white in colour.

**Calyx:** Sepals represented by five scales or pappus, polysepalous, valvate aestivation, superior.

**Corolla:** Petals five, gamopetalous, tubular, valvate aestivation, superior, violet in colour.

**Androecium:** Stamens five, syngenesious, alternate to petals, epipetalous, filaments short and free, anthers ditheous, basifixed, introrse, superior.

**Gynoecium:** Carpels two, (bicarpellary), syncarpous, ovary inferior, unilocular, single basal ovule in a locule, basal placentation, style single, long and simple, stigma bifid.

**Fruit:** Cypsela

**Floral formula:** Br.  $\% \frac{\text{♂}}{\text{♀}}$   $K_{(5 \text{ Pappus})}$   $\overline{C_{(5)} A_5}$   $\overline{G_{(2)}}$

**Salient Features**

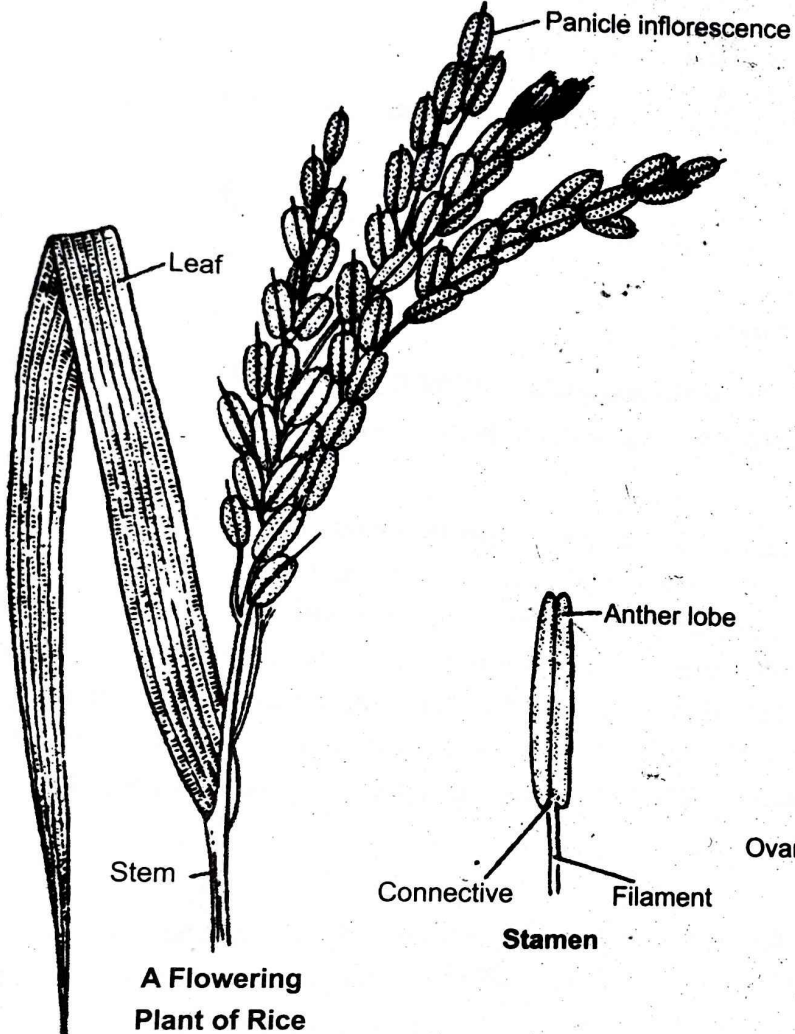
1. Leaves simple, alternate to opposite, petiolate, exstipulate.
2. Inflorescence head or capitulum, capitula consisting tubular flowers (homozygous).
3. Bracts present in the form of involucre.
4. Sepals are represented by scales or pappus.
5. Stamens syngenesious, epipetalous and alternate to petals.
6. Ovary inferior, bicarpellary, syncarpous, single basal ovule, basal placentation.

**Classification [Bentham and Hooker]**

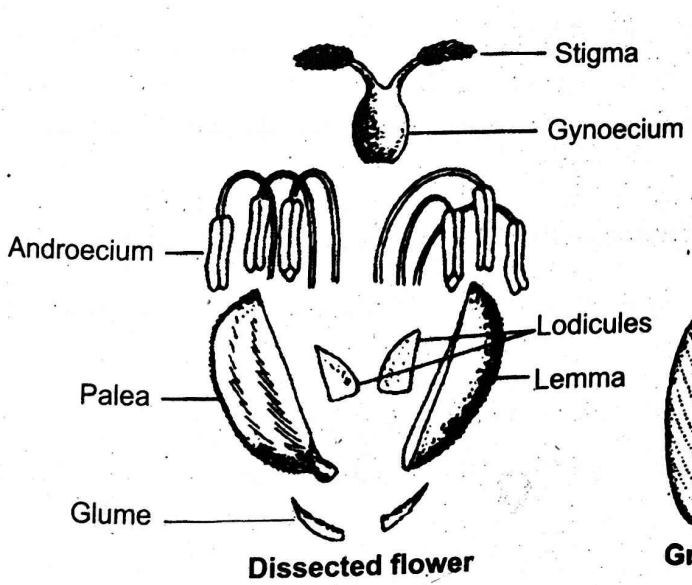
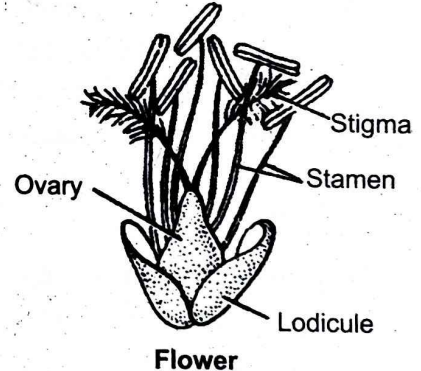
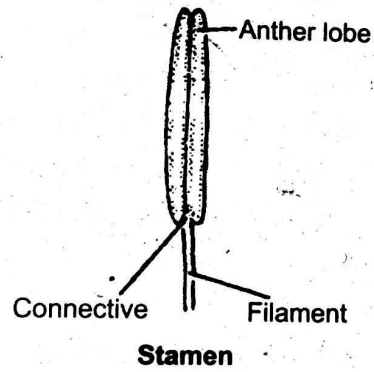
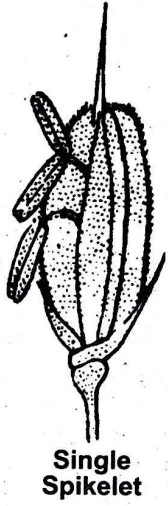
Same as in *Helianthus annuus* (Sunflower)

Date

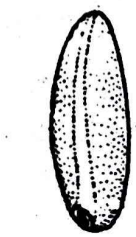
# DESCRIBE THE ORYZA SATIVA IN SEMI-TECHNICAL TERMS



A Flowering Plant of Rice



Dissected flower



**OBJECTIVE****DESCRIBE THE *ORYZA SATIVA* IN SEMI-TECHNICAL TERMS**

**Botanical description of the plant:** *Oryza sativa* L. (Rice)

**Habitat:** Semi aquatic or terrestrial free tillering plant, cultivated for food value.

**Habit:** An annual herb.

**Vegetative characters**

**Root:** Adventitious, fibrous root.

**Stem:** Erect, herbaceous, cylindrical, unbranched, tillering, differentiated into internodes and nodes, nodes swollen and solid; internodes long, fistular, glabrous, green and covered partly by the sheathing leaf base.

**Leaves:** Cauline, simple, alternate, distichous with two-rowed phyllotaxy, sessile, exstipulate, the foliage leaf consisting two parts, the leaf sheath and leaf blade. Leaf base forming tubular sheath, sheath open, surrounding internode incompletely, sheath usually thicker than the blade, margin of sheath is thin and transparent, inner surface glabrous while the upper surface is grooved and hairy. Ligule is present at the junction of the lamina and leaf sheath, two claw-like appendages present at the base of leaf blade and above the ligule are auricles, auricles hairy and pale green; leaf blade usually linear to lanceolate, stiff hairs present on the margin, acute apex, parallel venation.

**Floral characters**

**Inflorescence:** Terminal panicle of spikelets. The branch of the panicle terminates in one spikelet or a cluster of 2-7 spikelets. Each spikelet is short stalked and single flowered. The flower is enclosed by two small pointed and coriaceous bracts called non flowering glumes.

**Flower:** Bracteate, sessile, incomplete, bisexual, zygomorphic, hypogynous. Each flower has two bracts at its base; lemma and palea. Lemma is larger, five nerved, hairy, boat-shaped and frequently bears a long stiff hair called awn. Opposite to the lemma is a boat-shaped, three nerved and smaller bracteole known as palea.

**Perianth:** Represented by two thick, fleshy and broad structures called lodicules.

**Androecium:** Stamens 6, polyandrous, arranged in two whorls; filaments long and slender, anthers ditheous and versatile.

**Gynoecium:** Monocarpellary; [ theoretically the pistil is tricarpellary but only one carpel is functional], unilocular with single ovule, basal placentation, ovary superior; style two, long; stigma feathery.

**Fruits:** Caryopsis.

**Seed:** Endospermic and containing a single cotyledon.

**Floral formula:** Br. %  $\frac{\text{♂}}{\text{♀}}$  P<sub>2 lodicules</sub> A<sub>3+3</sub> G<sub>1</sub>

### Salient features

1. An annual semi-aquatic herbs.
2. Roots are fibrous type.
3. Stem terete and consisting long internodes and short conspicuous nodes.
4. Leaves simple, sessile, exstipulate, alternate with sheathing leaf base, parallel venation. The leaf sheath usually covers the internodes; ligule usually present.
5. Inflorescence spike of spikelets.
6. Flowers are minute, incomplete, trimerous, bisexual, zygomorphic, hypogynous, bracteate.
7. Perianth represented by 2 lodicules.
8. Stamens six, polyandrous, anthers ditheous and versatile,.
9. Gynoecium is monocarpellary with a single ovule, basal placentation, style two; stigma feathery.
10. Fruit caryopsis.

### Classification [Bentham and Hooker]

Kingdom : Plantae

Subkingdom : Phanerogamae

Division : Angiospermae

Class : Monocotyledonae

Series : Glumaceae

Family : Gramineae [Poaceae]

Genus : *Oryza*

Species : *sativa*

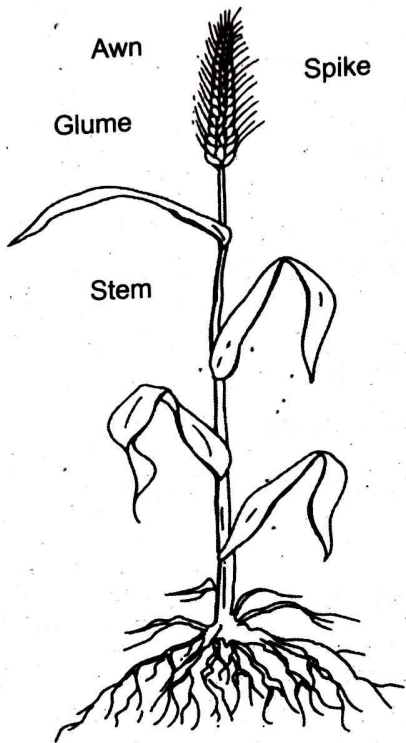
Common name : Rice ( Local name: Dhan)

Table: Names of some common plants from gramineae family

S. No.	Botanical name	English name	Nepali name	Uses
1	<i>Triticum aestivum</i>	Wheat	Gahun	Cereal/food
2	<i>Oryza sativa</i>	Rice	Dhaan	Cereal/food
3	<i>Zea mays</i>	Maize	Makai	Cereal/food
4	<i>Hordeum vulgare</i>	Barley	Jau	Cereal/food
5	<i>Eleusine coracana</i>	Millet	Kodo	Cereal/food
6	<i>Sorghum vulgare</i>	Sorghum	Junelo	Cereal/food
7	<i>Bambusa arundinacea</i>	Bamboo	Bans	Pulp/ furniture
8	<i>Saccharum officinarum</i>	Sugar cane	Ookhu	Sugar
9	<i>Cynodon dactylon</i>	Doob grass	Doobo	Fodder/weed
10	<i>Drepanostachyum falcatum</i>	Bamboo	Nigalo	Pulp/ furniture
11	<i>Phragmites karka</i>	-	Narkat	Utensil
12	<i>Cymbopogon winterianus</i>	Lemon grass	-	Aromatic oil

Date

# DESCRIBE THE TRITICUM AESTIVUM IN SEMI-TECHNICAL TERMS



A Whole Wheat Plant

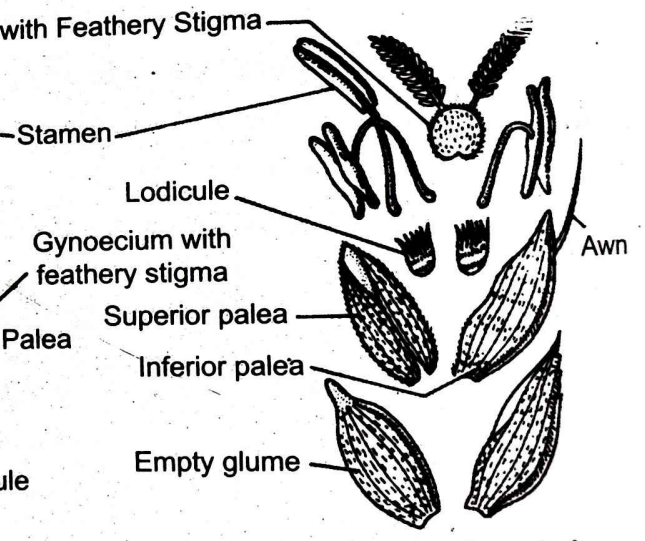
Leaves



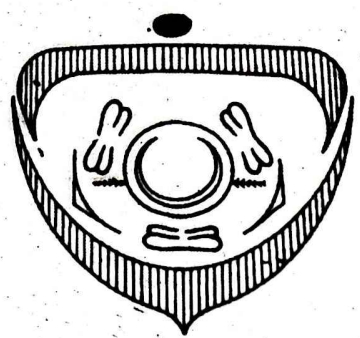
Roots



Open Flower



A Flower Dissected



Floral Diagram

**OBJECTIVE****DESCRIBE THE *TRITICUM AESTIVUM* IN SEMI-TECHNICAL TERMS**

**Botanical description of the plant:** *Triticum aestivum* L. (Wheat)

**Habitat:** Terrestrial, mesophyte, cultivated for food value.

**Habit:** An annual herb.

**Vegetative characters**

**Root:** Fibrous.

**Stem:** Erect, herbaceous, cylindrical, with long fistular internodes and short solid distinct nodes, unbranched, smooth, a number of trilliers.

**Leaves:** Cauline, simple, alternate, distichous with two-rowed phyllotaxy, sessile, exstipulate, the foliage leaf consisting two parts, the leaf sheath and leaf blade. Leaf base forming tubular sheath, sheath open, surrounding internode incompletely, sheath usually thicker than the blade, margin of sheath is thin and transparent, inner surface glabrous while the upper surface is grooved and hairy. Ligule is present at the junction of the lamina and leaf sheath, two claw-like appendages present at the base of leaf blade and above the ligule are auricles, auricles hairy and pale green; leaf blade usually linear to lanceolate, entire margin, acute apex, parallel venation.

**Floral characters**

**Inflorescence:** Spike of spikelets.

[Axis of inflorescence is called the rachis and that of spikelet is called rachilla. Two sterile scaly bracts called glumes are present at the base of rachilla. The glumes are placed one above the other on opposite side. Lower one is called first glume and the upper is called second glume. Both the glumes are boat shaped. Above the glumes a series of florets are present. Each flower has an inferior lemma and above it is a superior palea. The lemma frequently bears a long stiff hair called awn. The lemma and palea enclose a flower.]

**Flower:** Bracteate, sessile, incomplete, bisexual, zygomorphic, hypogynous. Each flower has two bracts at its base called lemma (outer) and palea (inner).

**Perianth:** Represented by two membranous scales called lodicules; situated above and opposite the palea.

**Androecium:** Stamens 3, polyandrous; filaments long and slender, anthers ditheous, dorsifixed when young and versatile when mature, dehiscence by longitudinal slits.

**Gynoecium:** Monocarpellary; [Theoretically the pistil is tricarpellary but only one carpel is functional], unilocular with single ovule, basal placentation, ovary superior; style absent; stigma bifid and feathery.

**Fruits:** Caryopsis The fruit is commonly called as seed.

**Seed:** Endospermic and containing a single cotyledon.

**Floral formula:** Br. %  $\frac{\text{♂}}{\text{♀}}$   $P_{2 \text{ lodicules}}$   $A_3$   $\underline{G_1}$

### Salient features

1. An annual herbs.
2. Roots are fibrous type.
3. Stem terete and consisting long internodes and short conspicuous nodes.
4. Leaves simple, sessile, exstipulate, alternate with sheathing leaf base, parallel venation. The leaf sheath usually covers the internodes; ligule usually present.
5. Inflorescence spike of spikelets.
6. Flowers are minute, incomplete, bisexual, zygomorphic, hypogynous, bracteate.
7. Perianth represented by 2 lodicules.
8. Stamens three, polyandrous, anthers ditheous and versatile,.
9. Gynoecium is monocarpellary with a single ovule, basal placentation, style absent; stigma bifid and feathery,
10. Fruit caryopsis.

### Classification [Bentam and Hooker]

**Kingdom :** Plantae

**Subkingdom :** Phanerogamae

**Division :** Angiospermae

**Class :** Monocotyledonae

**Series :** Glumaceae

**Family :** Gramineae [Poaceae]

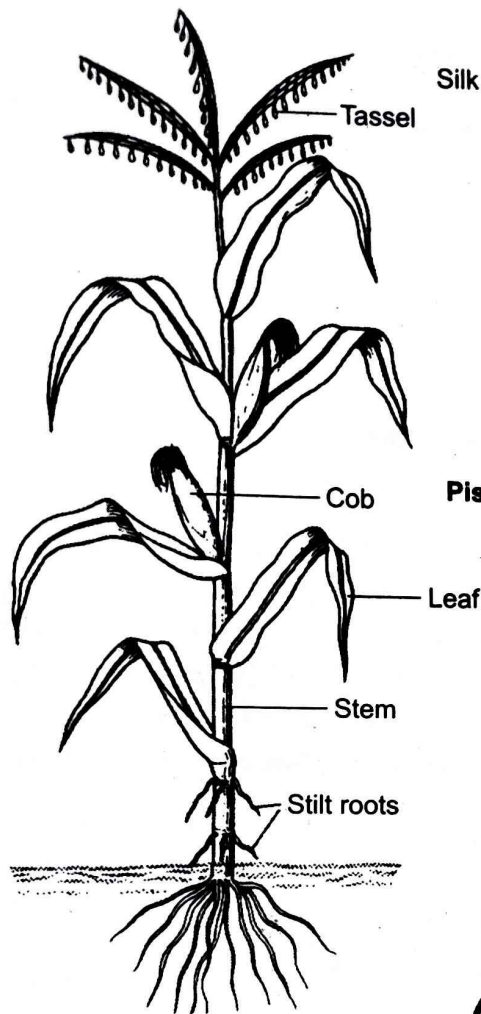
**Genus :** *Triticum*

**Species :** *aestivum*

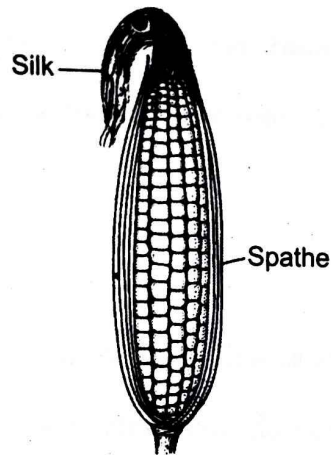
**Common name :** Wheat ( Local name: Gahun)

Date

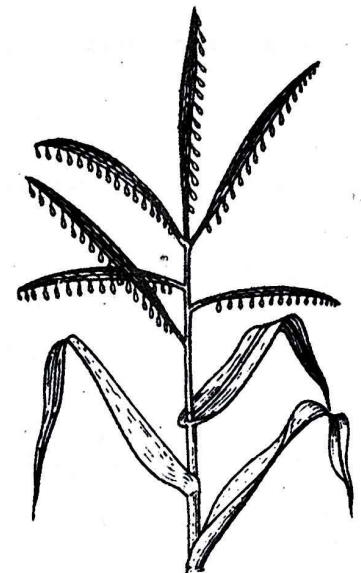
# DESCRIBE THE ZEA MAYS IN SEMI-TECHNICAL TERMS



A Whole Maize Plant



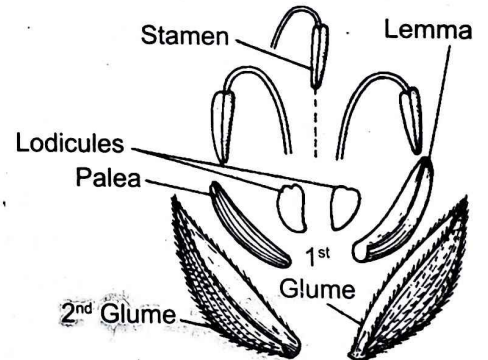
Pistillate Inflorescence



Staminate Inflorescence



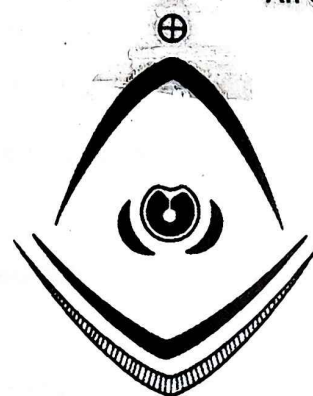
Paired Male



An Open Spikelet



Floral Diagram Male Flower



Floral Diagram Female flower

**OBJECTIVE****DESCRIBE THE *ZEA MAYS* IN SEMI-TECHNICAL TERMS**

**Botanical description of the plant:** *Zea mays* L. (Maize)

**Habitat:** Terrestrial, mesophyte, cultivated for food value.

**Habit:** An annual tall herb.

**Vegetative characters**

**Root:** Adventitious, fibrous root as well as stilt root.

**Stem:** Erect, herbaceous, cylindrical, solid, unbranched, glabrous, distinct long internodes and short nodes, nodes slightly swollen, internodes covered with sheathing leaf base, green.

**Leaves:** Cauline, simple, alternate, sessile, exstipulate, the foliage leaf consisting two parts, the leaf sheath and leaf blade. Leaf base forming tubular sheath, sheath open, surrounding internode incompletely, sheath usually thicker than the blade, margin of sheath is thin and transparent, inner surface glabrous while the upper surface is grooved and hairy. Ligule is present at the junction of the lamina and leaf sheath, two claw-like appendages present at the base of leaf blade and above the ligule are auricles, auricles hairy; leaf blade usually linear to lanceolate, wavy margin with stiff hairs, acute apex, parallel venation.

**Floral characters**

**Inflorescence:** Plant monoecious, diclinous, two kinds of flowers in different inflorescences, male in staminate and female in pistillate inflorescence respectively. Male spikelets arranged in terminal paniced racemes called tassel; single male spikelet has two flowers- one sessile and other pedicellate flowers enclosed by two empty glumes. Female spikelets arranged in compact row on a thick rachis covered by many layers of spathe like bracts. This axillary spike is called cob.

**Male flower:** Bracteate, one sessile and another pedicellate, each flower covered by two green bracts lemma and palea, zygomorphic, unisexual, staminate, incomplete.

**Perianth:** Represented by two minute membranous scales called lodicules; situated at the base of the flower.

**Androecium:** Stamens 3, polyandrous; filaments long and slender, anthers dithecous, versatile, pendulous, extrorse.

**Gynoecium:** Rudimentary or absent.

**Female flower:** Bracteate, bracts represented by two green outer lemma and inner palea, zygomorphic, unisexual, pistillate, incomplete, hypogynous.

**Perianth:** Represented by two minute membranous scales called lodicules.

**Androecium:** Absent.

**Gynoecium:** Monocarpellary; [ theoretically the pistil is tricarpellary but only one carpel is functional], unilocular, basal placentation, ovary superior; style filiform, silky and long; stigma hairy.

**Fruits:** Caryopsis.

**Seed:** Endospermic and containing a single cotyledon.

**Floral formula:**

Male flower: Br. % ♂  $P_{2 \text{ lodicules}} A_3 G_0$

Female flower: Br. % ♀  $P_{2 \text{ lodicules}} A_0 \underline{G_1}$

### Salient features

1. An annual tall monoecious crop plant.
2. Roots are fibrous as well as stilt type.
3. Stem terete and consisting long internodes and short conspicuous nodes.
4. Leaves simple, sessile, exstipulate, alternate with sheathing leaf base, parallel venation. The leaf sheath usually covers the internodes; ligule usually present.
5. Inflorescence spike of spikelets.
6. Flowers bracteate, unisexual, incomplete, trimerous, zygomorphic,
7. Perianth represented by 2 lodicules.
8. Male flower- terminal panicle of spikelets. Stamens three, polyandrous, anthers dithecous and versatile,
9. Female flower-axillary spike covered with lemma and palea. Gynoecium monocarpellary, basal placentation, style filiform and silky; stigma hairy.
10. Fruit caryopsis.

### Classification [Bentham and Hooker]

**Kingdom :** Plantae

**Subkingdom :** Phanerogamae

**Division :** Angiospermae

**Class :** Monocotyledonae

**Series :** Glumaceae

**Family :** Gramineae [Poaceae]

**Genus :** *Zea*

**Species :** *mays*

**Common name :** Maize ( Local name: Makai)

## Taxonomic Terms and Abbreviations in Latin

- adv.*; *Advena* Latin, alien, meaning introduced.
- aff.*; *Affinis*, related to;
- auct.*; *Auctorum*, meaning of authors.
- auct. non.*; *Auctorum non*, meaning not of authors.
- circa*, Meaning around, about.
- cv.*; *Cultivar*, meaning cultivar.
- comm.*; *Communicavit*, meaning he (she or it) communicated.
- corr.*; *Correctus*, meaning corrected (by).
- cult.*; *Cultivarietas*, meaning cultivated.
- cf.*; *Confer.*, meaning compare (with).
- cons.*; *Conservandum*, meaning to be conserved.
- descr.*; *Descriptione*, meaning description.
- e.*; *Ex.*, meaning from, according to.
- ex.*; Meaning from, according to.
- exs.*; *Exsiccatus*, meaning dried (herbarium) specimen.
- epitheta hybrida.*, Specific epithets made up of parts of words from two or more different languages.
- epitheta specifica rejicienda.* Rejected specific epithets.
- et*, Meaning and.
- et al.*; *Et alii*, meaning and others.
- e.p.*; *Ex parte*, meaning in part.
- excl.*; *Exclusus*, meaning excluded.
- exc.* *Except.*
- fig.*; *Figura*, meaning figure, illustration.
- fil.*; *Filius*, meaning son.
- forma* Meaning form.
- gen.*; *Genus*, meaning genus.
- gen. prop.* As a proper genus.
- hab.*; *Habitat*, place where a plant grows.
- herb.*; *Herbarium*, meaning, a herbarium.
- hb.*; *Herbarium*, meaning a herbarium.
- hort.*; *Hortulanorum*, meaning of gardeners.
- hortus siccus.* Herbarium.
- hom illeg.* Later homonym (illegitimate).
- ib.*; *Ibidem*, meaning in the same place.

ic.; Icon., figure.

ined.; *Ineditus*, not published.

in sched.; In *schedula*, meaning on a herbarium sheet or label.

in situ. In the original location.

in syn.; *In synonymis*, meaning in synonymy.

incl.; *Inclusus*, meaning included.

ined.; *Ineditus*, meaning unpublished.

inq.; *Inquilinus*, meaning naturalized.

bat.; *Latus*, meaning broad, wide.

leg.; *Lego*, collected, together to pick.

mss.; Manuscript name.

m.; *mihi*, Meaning to me, of me.

*Pro rrdnore parte*, meaning for the smaller part.

n.nov.; *Nomen novium*, meaning new name.

n.sp.; *Species nova*, meaning new species.

n.v.; *Non virus*, meaning not seen.

no.; *Numero*, meaning number.

nom.; *Nomen*, meaning name.

nom. alt.; *Nomen alternativum*, alternative name.

nom. conk; *Nonwn confusum*, confused name.

nom. confus.; *Nomen confusum*, confused name.

nom. cons.; *Nomen conservandum*, conserved name.

nom. conserv.; *Nomen conservandum*, conserved name.

nom. dub.; *Nomen dubiom*, dubious name.

nom. hybr.; *Nomen hybridum*, hybrid name.

nomina, Meaning names.

n.v.; *Non vide*, meaning not seen.

op. cit.; *Opera citato*, meaning in the publication cited.

p.c.; *Personal communication*.

p.p.; *Pro parte*, partly.

prov.; *Provisorius*, meaning provisional.

Q.e.; *Quod est.*, meaning which is.

n.n.; *Nomen neglectum*, meaning neglected name.

n.n.; *Nomen nudum*, meaning naked name.

nom. oblit.; *Nomen oblitum*, meaning forgotten name.

rejec.; *Nomen rejiciendum*, rejected name.

*recent.*; *Recentiorum*, meaning of recent authors.

*rite*, Meaning according to the rules, correctly.

*sec.*; *Secundum*, meaning according to.

*s.l.*; *Sensu lato*, meaning in the wider sense.

*sens. lat.*; *Sensu lato*, meaning in the wider sense.

*s.n.*; *Sine numbeo*, meaning without number, unnumbered:

*saltem*, Meaning at least.

*sp.*; Species (singular) spp.; Species (plural).

*sp. n.*; *Species nova*, meaning new species.

*sp. nov.*; *Species nova*, meaning new species.

*sect.* Section

*ser.* Series

*sin. descr. gen.*; *Sine descriptio genus*, without proper description of genus.

*ssp.* Subspecies.

*subg.* Subgenus.

*st. nov.*; *Status novum*, new state.

*sched.*; *Scheda*, meaning the label (of a specimen).

*ser.*; *Series*, meaning series.

*sine typo.* Meaning without type.

*sub. sp.*; *Subspecies*, subspecies.

*trans. nov.*; *Translatio nova*, meaning new transfer.

*typ. typos*, meaning type.

*sic.* Meaning in this manner, used in citations in parentheses after a printed word or number to confirm that an orthographic or other error is intended, or that it represents an exact quotation of an original. *sine typo.* Meaning without type. *sub.*

*t.c.*; *Tomus citatus*, meaning in the volume cited. *trans.*

*nov.*; *Translatio nova*, meaning new transfer. *typ. typos*, meaning type.

*typ. cons.*; *Types cnservandus*, meaning type to be conserved vicarius Meaning substitute.

*vicinus* : Meaning neighbour.

*v. et.*; *Vide etiam*, meaning see also.

*viz.*; *Videlicet*, meaning namely.

*var.*; *Varietas*, Variety.

*vid.*; *Vide*, meaning see.

## Glossary of Modern Taxonomic Terms

- accepted name:** A name adopted by an author as the correct name for a taxon.
- analogy:** Pertains to similarity of function, structure or behaviour due to convergent evolution rather than to common ancestry.
- authority:** The name of the author cited after a scientific name; author citation.
- autonym:** An automatically established name, applied to a nominate subordinate taxon.
- available:** Used of a work or name that must be considered for purposes of nomenclature.
- chemotaxonomy:** The application of biochemical techniques and the use of biochemical characters in taxonomy.
- composite species:** A species comprising two or more subspecies.
- correct name:** The name by which a taxon should properly be known.
- cultivar (cv):** A variety of plant produced and maintained by cultivation
- devalid name:** A name that is not valid because it was published before the starting date of the group concerned.
- effective publication:** Publication in accordance with the requirements of the Code.
- empirical taxonomy:** Classification of organisms based on observed phenotypic similarity.
- figure type:** An original figure or illustration of a specimen.
- homology:** Used of characters that share an evolutionary transformation from the same ancestral character state.
- holotype:** The single specimen designated or indicated as the type specimen of a nominal species by the original author at the time of publication or the single specimen when no type was specified but only one specimen was present.
- IAPT:** International Association of Plant Taxonomy. **ICBM:** International Code of Botanical Nomenclature. **ICNB:** International Committee on Nomenclature of Bacteria. **ICNV:** International Committee on Nomenclature of Viruses. **iconotype:** A drawing or photograph of the type specimen.
- lectotype:** The type specimen selected from the syntype series by subsequent author in the absence of a holotype.
- manuscript (autograph):** Typewritten or handwritten, not reproduced as multiple copies; typically that copy submitted for publication.
- manuscript name:** An unpublished scientific name.
- protoplastotype:** A cast of a primary type.
- protype:** An entire specimen that replaces a fragmentary holotype; neotype.
- publication:** The process of distributing graphic material in a manner that satisfies the criteria of effective publication of the appropriate Code; valid publication.
- reprint:** A printed copy of an article or work distributed subsequent to the publication of the work.
- revision:** A critical reappraisal of a taxon or group in the light of new material or new interpretation.
- rule:** A mandatory provision (Article) of a Code of Nomenclature.
- syntype:** Any of two or more type specimens listed in the original description of a taxon when a holotype was not designated.

## OBJECTIVE

## STUDY OF MORPHOLOGY OF MUSTARD PLANT

## Requirements

**Apparatus:** Dissecting microscope, blade, needle, forceps, lens

**Material:** A whole fresh mustard plant

## Procedure

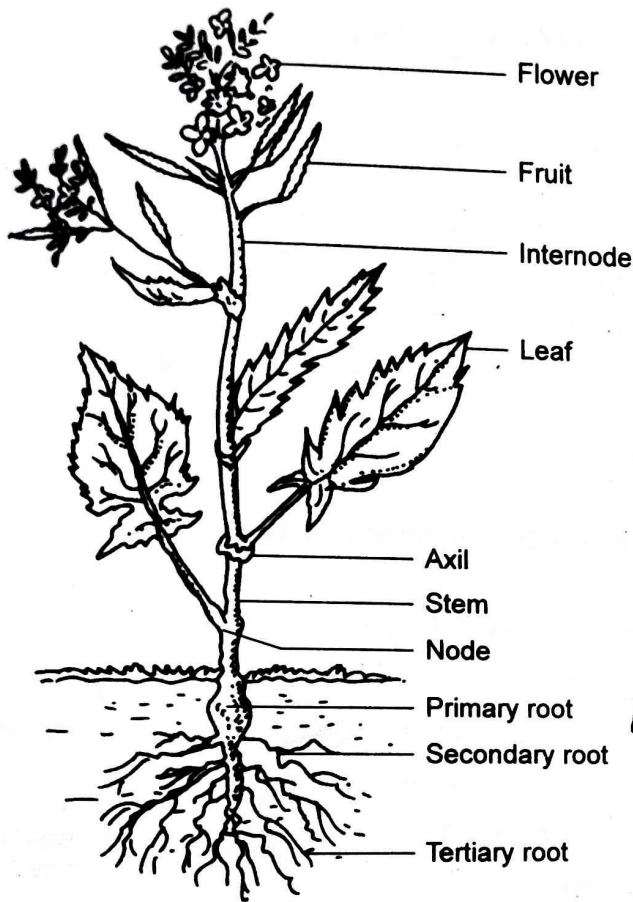
1. Take a whole fresh mustard plant and observe its habitat, vegetative and reproductive parts.
2. Separate out the floral parts using forceps and study them under the lens and the dissecting microscope.
3. Draw a well labeled diagram of whole mustard plant, a flower, L.S. of flower, floral parts and fruit.

## Comments

1. Mustard is a dicotyledonous plant that grows in the soil having sufficient water, minerals and air.
2. It is an annual herb cultivated for vegetable and oil.
3. It bears well developed tap root system.
4. Stem is green, herbaceous, erect, slender, branched and consists of nodes and internodes.
5. Stem tip ends at terminal bud and the branches arise from axillary buds.
6. The leaves are green, petiolate, extipulate, lyrate, alternately arranged on the stem. The leaf blade bears unicostate reticulate venation.
7. The inflorescence of the mustard is the typical raceme.
8. The flowers are small, ebracteate, yellow coloured and developed from the floral buds.
9. The mustard flower consists of a short stalk called pedicel and a set of all floral whorls such as calyx, corolla, androecium and gynoecium.
10. Calyx is the outermost whorl of the flower that consists of four free green leaves like sepals.
11. The corolla is the second whorl of the flower that consists of four free petals. Each petal has a narrow lower part the claw and broad upper part called limb.
12. The third whorl of the flower is called androecium that consists of six free stamens. Out of six stamens two outer stamens are short while the four inner are long. The stamens constitute the male reproductive part of a flower. Each stamen consists of long filament and dithecous anther at tip.
13. Gynoecium constitutes the female reproductive organ. Pistil consists of two carpels and is divided into three parts: basal swollen ovary, an erect style and bilobed stigma.
14. The fruit is siliqua type which appears cylindrical and elongated.

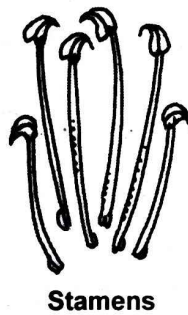
Date

# STUDY OF MORPHOLOGY OF MUSTARD PLANT

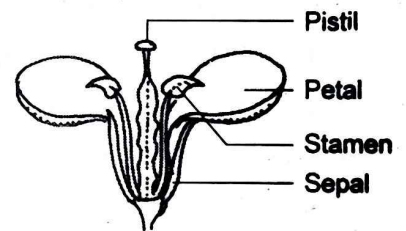


**A Whole Mustard Plant**

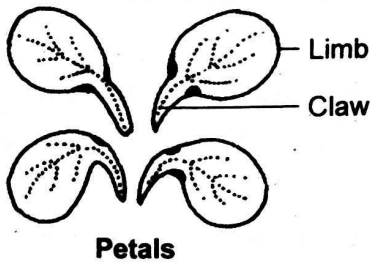
Classification (Five Kingdom)	
Kingdom	- Plantae
Division	- Tracheophyta
Sub-division	- Spermatophyta
Class	- Angiospermae
Sub-class	- Dicotyledonae
Genus	- <i>Brassica</i>
Species	- <i>campestris</i>
Common name	- Mustard



**Stamens**



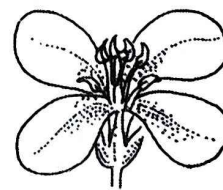
**L.S. of Flower**



**Petals**



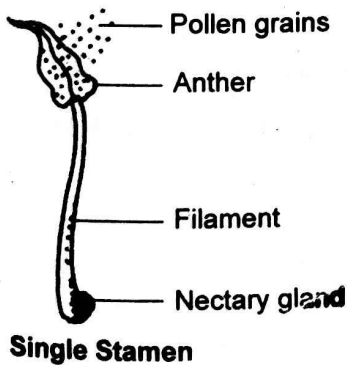
**Sepals**



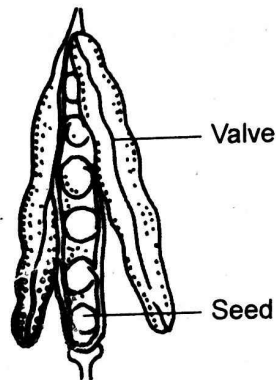
**An Entire Flower**



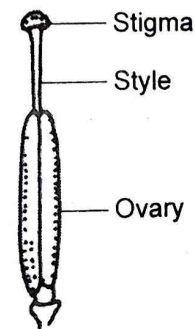
**Fruit**



**Single Stamen**



**Dehisced fruit**



**Pistil**



**Seed**

**OBJECTIVE****STUDY OF MORPHOLOGY OF SUNFLOWER PLANT****Requirements**

**Apparatus:** Dissecting microscope, blade, needle, forceps, lens

**Material:** A whole fresh sunflower plant

**Laboratory work**

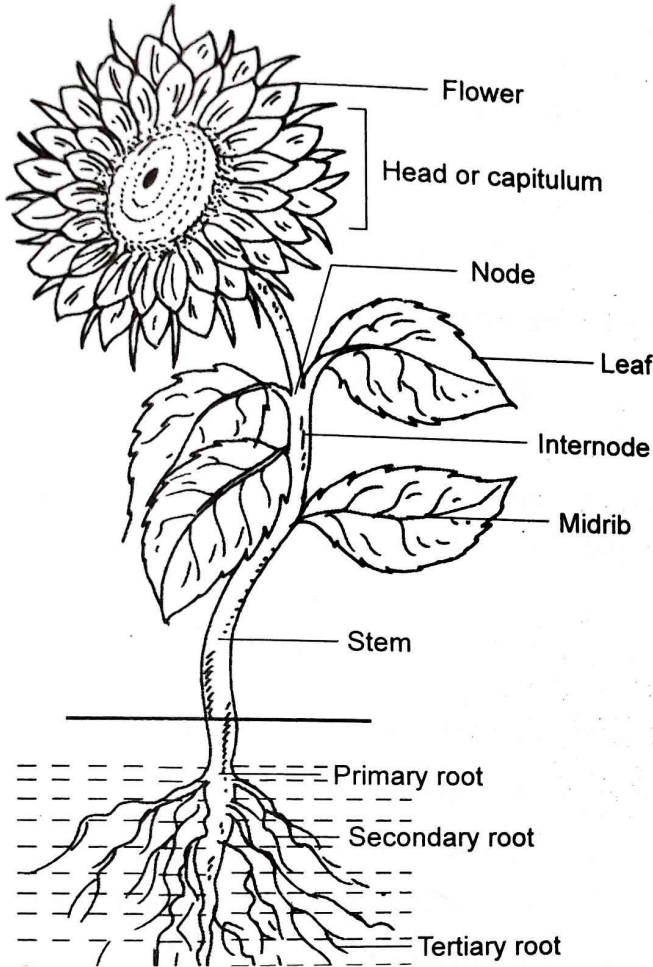
1. Take a whole fresh sunflower plant and observe its habitat, vegetative and reproductive parts.
2. Separate out the ray florets, disc florets and floral parts using needle, blade and forceps; and study them under the lens and the dissecting microscope.
3. Draw a well labelled diagram of whole mustard plant, a ray floret, a disc floret, L.S. of ray and disc florets, floral parts and fruit.

**Comments**

1. Sunflower is a dicotyledonous plant which grows in the soil having sufficient moisture, minerals and air.
2. It is a common tall annual herb cultivated for oil and ornamental purpose.
3. It bears long well developed tap root system.
4. Stem is green, hairy, tall, erect, slender, branched and consists of nodes and internodes.
5. Stem tip ends at terminal bud and the branches arise from axillary buds.
6. The leaves are simple, green, petiolate, extipulate, hairy, alternately arranged on the stem. The leaf blade bears unicostate reticulate venation.
7. The inflorescence of the sunflower is the head or capitulum consisting of pistillate ray florets at the periphery and bisexual disc florets at the centre. Capitulum makes the flower well adapted for entomophily pollination.
8. The capitulum is surrounded by a three series of small green and leafy bracts called involucre.
9. The ray florets are many large zygomorphic flowers and consist of a strap-shaped corolla which projects outward.
10. Most of the ray florets do not have male and female reproductive organs; hence the florets are called neuter.
11. Calyx is the outermost whorl of the flower that is represented by membranous scales called pappus in both ray and disc florets.
12. The disc florets are tubular, complete, actinomorphic and bisexual.
13. The third whorl of the flower is called androecium that consists of five stamens. They are syngenesious type with fused long anthers and free filaments.
14. Gynoecium or pistil is the innermost or fourth whorl of the flower that constitutes the female reproductive organ. Pistil consists of two carpels and is divided into three parts: basal swollen inferior ovary, an erect style and bilobed stigma. In cross section, ovary consists of single ovule in its one loculus.
14. The fruit is cypsela type with one- seeded fruit.

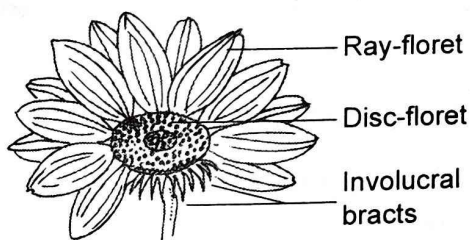
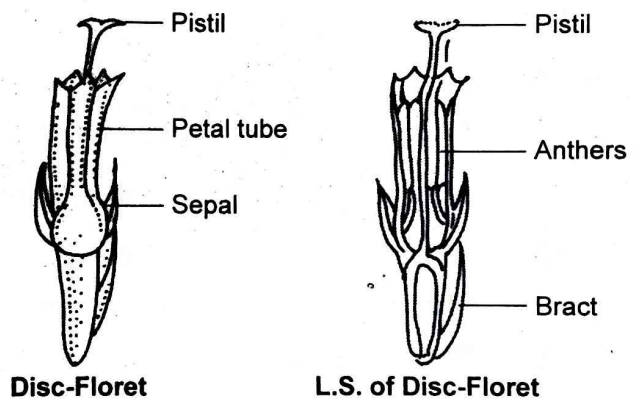
Date

# STUDY THE MORPHOLOGY OF SUNFLOWER PLANT

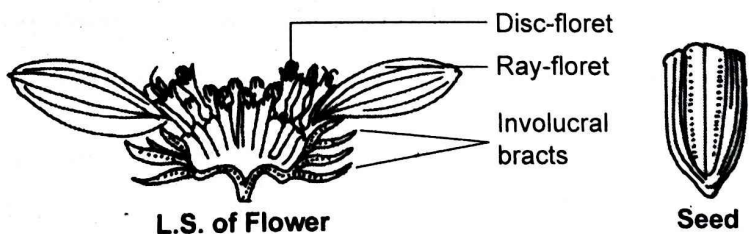


A Whole Sunflower Plant

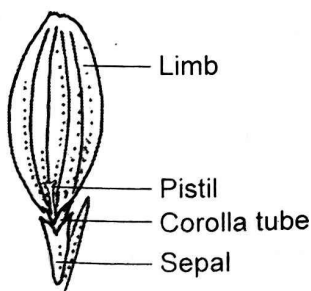
Classification [Five Kingdom]	
<b>Kingdom</b>	- Plantae
<b>Division</b>	- Tracheophyta
<b>Sub-division</b>	- Spermatophyta
<b>Class</b>	- Angiospermae
<b>Sub-class</b>	- Dicotyledonae
<b>Genus</b>	- <i>Helianthus</i>
<b>Species</b>	- <i>annuus</i>
<b>Common name</b>	- Sunflower



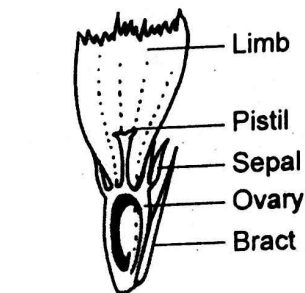
An Entire Flower



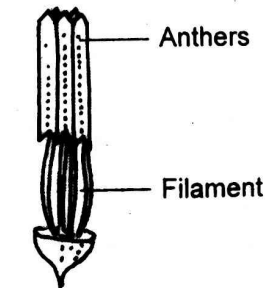
L.S. of Flower



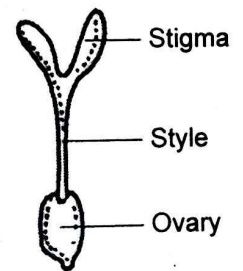
Ray-Floret



L.S. of Ray-Floret



Stamens



Pistil

**OBJECTIVE****STUDY OF MORPHOLOGY OF RICE PLANT****Requirements**

**Apparatus:** Dissecting microscope, blade, needle, forceps, lens

**Material:** A whole fresh rice plant

**Laboratory work**

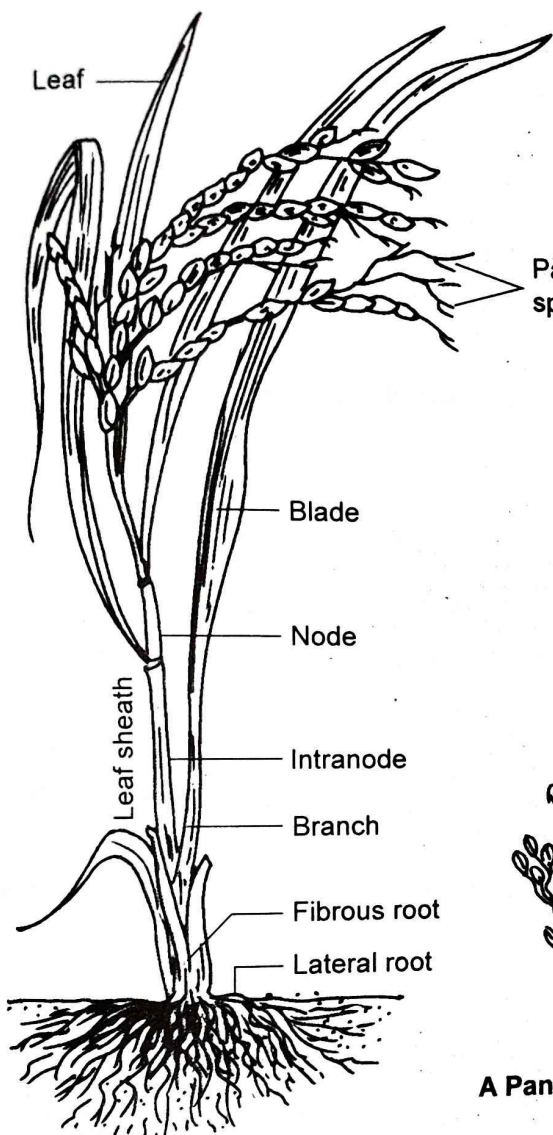
1. Take a whole fresh rice plant and observe its habitat, vegetative and reproductive parts.
2. Separate out the flower and floral parts using needle, blade and forceps; and study them under the lens and the dissecting microscope.
3. Draw a well labelled diagram of whole rice plant, a panicle of spikelets, single spikelet an entire flower, dissected flower, floral parts and rice grain. Note the important characters of the maize plant morphological.

**Comments**

1. The rice plant is semi-aquatic free tillering annual tall grass cultivated for food value.
2. It bears well developed shallow adventitious root system.
3. Stem is greenish yellow, erect, herbaceous, cylindrical, hollow and distinguished into nodes and internodes. The internodes are short at the base and become longer towards the apex.
4. The leaves are green, sessile, exstipulate, isobilateral, alternately arranged on the stem at each node. The leaf blade is divided into lower sheath, upper blade and ligule and auricles at the junction of sheath and blade. The sheath encircles the major part of the internodes. The leaf blade is long, narrow, lanceolate, acuminate apex, wavy margin with parallel venation.
5. The inflorescence of the rice is the terminal panicle with spikelets.
6. Each spikelet is laterally compressed and one flowered, borne on a short pedicel subtended by two small boat-shaped empty glumes with stiff hairs.
7. The flower is surrounded by a upper outer larger bract is called flowering glume or the lemma and the inner smaller lower bract is called palea. These make the husk or hull.
8. Within the bracts, perianth is represented by two membranous lodicules; six stamens in two alternating whorls and a pistil with two laterally exerted feathery stigmas on two elongated styles are present.
9. Calyx is the outermost whorl of the flower that consists of four free green leaves like sepals.
10. The fruit is a caryopsis type i.e., one seeded fruit enclosed in a brownish husk.
11. Rice grain with husk is called paddy or rough rice and without husk is called brown or cleaned rice.

Date

# STUDY OF MORPHOLOGY OF RICE PLANT

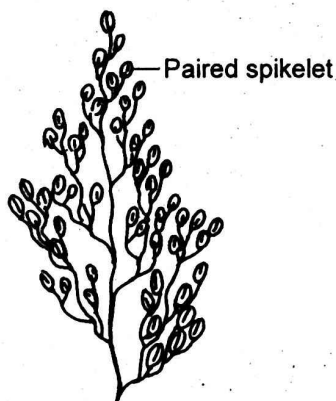


A Whole Rice Plant

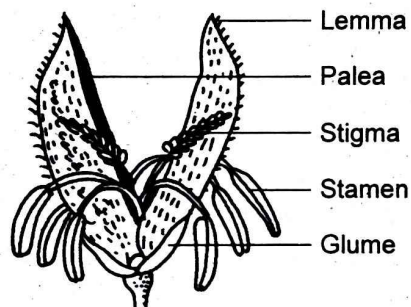
## Classification [Five Kingdom]

Kingdom	- Plantae
Division	- Tracheophyta
Sub-division	- Spermatophyta
Class	- Angiospermae
Sub-class	- Monocotyledonae
Genus	- <i>Oryza</i>
Species	- <i>sativa</i>
Common name	- Rice (Dhan)

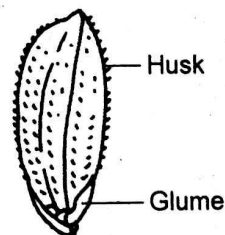
Panicle of spikelets



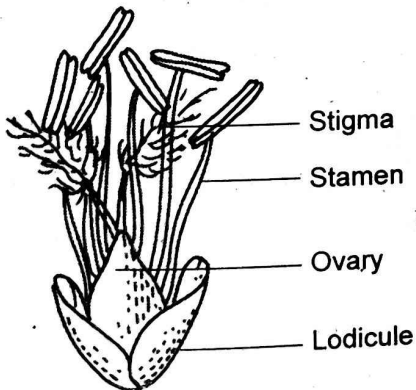
A Panicle of Spikelets



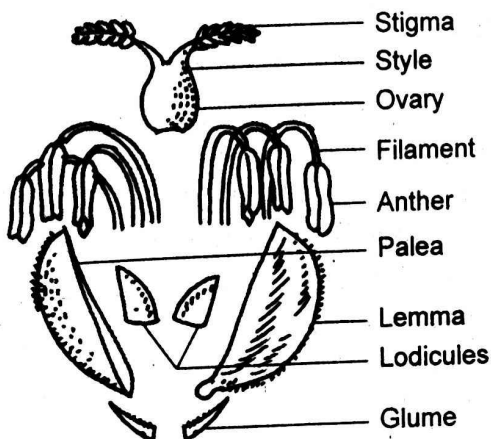
Single Spikelet



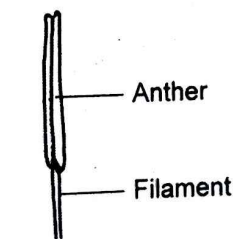
A Paddy Grain



An Entire Flower



Dissected Flower



Stamen

**OBJECTIVE****STUDY OF MORPHOLOGY OF MAIZE PLANT****Requirements**

**Apparatus:** Dissecting microscope, blade, needle, forceps, lens

**Material:** A whole fresh maize plant.

**Laboratory work**

1. Take a whole fresh maize plant and observe its habitat, vegetative and reproductive parts.
2. Separate out the male spikelet, cob and floral parts using needle, blade and forceps; and study them under the lens and the dissecting microscope.
3. Draw a well labelled diagram of whole maize plant, a pair of male spikelet, dissected male spikelet, ripened cob, floral parts and seed.

**Comments**

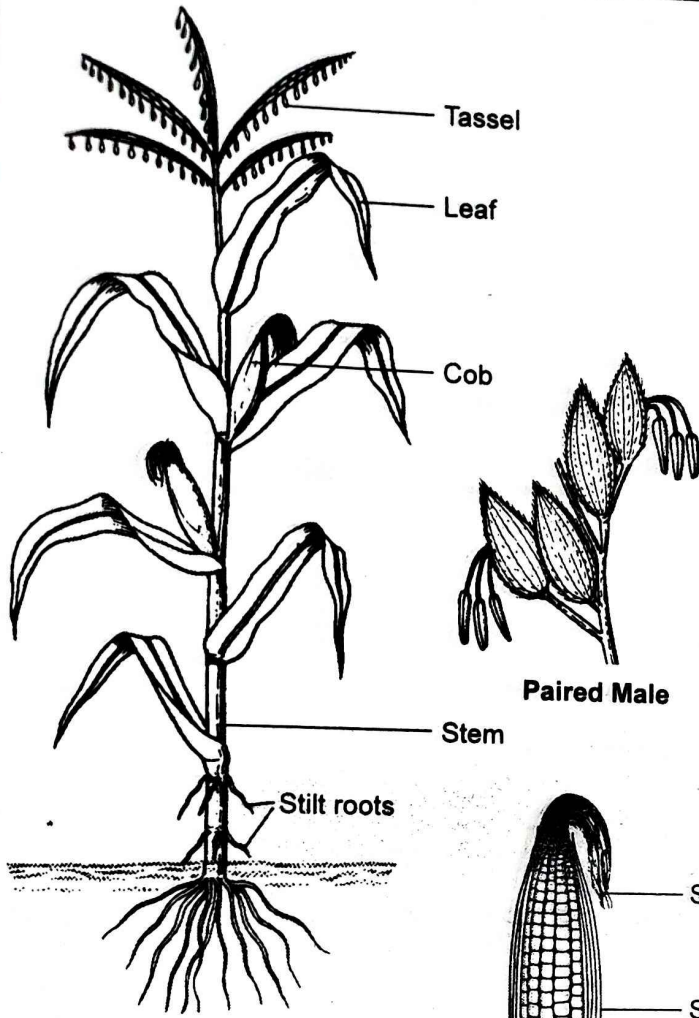
1. Maize is a monocotyledonous plant which grows in the soil having sufficient water and minerals.
2. It is an annual tall herbaceous grass plant cultivated for grains.
3. It bears adventitious root system that arises from underground nodes as a crown. The nodes just above the ground also give out whorl of thick, short and stout whorls of roots that grow obliquely downwards to fix into the soil. Such roots are called stilt roots.
4. Stem is tall, stout, erect, unbranched, solid, smooth and consists of distinct nodes and internodes. The main stem tapers and finally ends in a male inflorescence.
5. The leaves arise from nodes alternately as a long, sessile, exstipulate, simple, strap shaped organs. Each leaf is differentiated into lower broad sheath and upper long narrow blade and membranous ligule at the junction between sheath and blade.
6. The leaf sheath covers around the major portion of the internode. The blade is thin, isobilateral, linear, lanceolate, acuminate with wavy margin and parallel venation.
7. The inflorescence of the mustard is the typical raceme.
8. The maize is a monoecious plant as it bears male and female flowers in the same plant.
9. The male inflorescence is called as tassel and the female inflorescence cob or ear.
10. The male on staminate flower is borne terminally as a compact panicle of spikelets.
11. Each spikelet bears a pair of glumes with two floral parts; each enclosed by a lemma and palea and has perianth or two lodicules, three stamens.
12. The Pistillate flower represents an ear developed from the axil of leaf. Each ear consists of a central axis called cob. The cob has many female spikelets which later develop into ovaries or grains arranged in many vertical rows. Many layers of green spathe like bracts surround the cob.
13. Each female spikelet contains only one pistil consisting of a large single ovary, long filiform style called silk and long brownish silky hair-like stigma. At maturity, the styles and stigmas hang down in a tuft from the top of the spadix.
14. The fruit of maize is caryopsis type in which seed coat is fused with pericarp.
15. The grain or corn kernel has got four parts: the tip cap, the pericarp and seed coat together called as hull, the endosperm and the embryo or germ.

Date

# STUDY OF MORPHOLOGY OF MAIZE PLANT

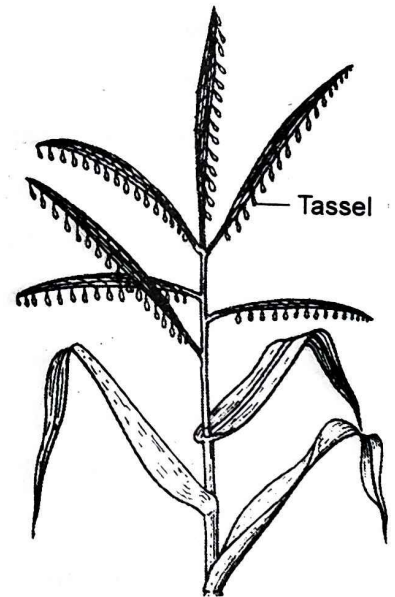
## Classification [Five Kingdom]

Kingdom	- Plantae
Division	- Tracheophyta
Sub-division	- Spermatophyta
Class	- Angiospermae
Sub-class	- Monocotyledonae
Genus	- <i>Zea</i>
Species	- <i>mays</i>
Common name	- Maize (Makai)

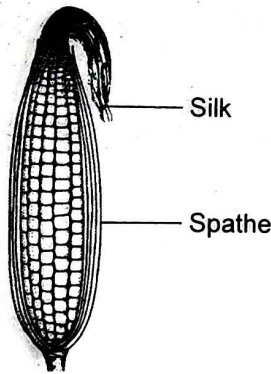


A Maize Plant

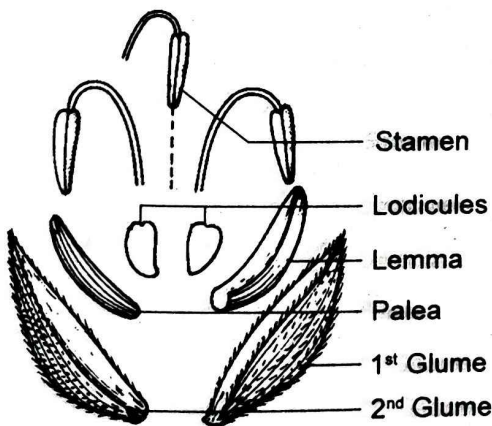
Paired Male



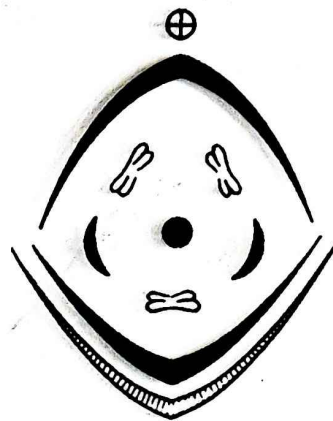
Staminate Inflorescence



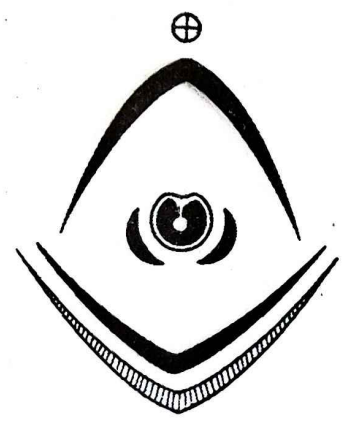
Pistillate Inflorescence



An Open Spikelet



Floral Diagram of Male Flower



Floral Diagram of Female flower

1. What is plant-morphology?

**Ans:** The study of form and structure of plants is called plant morphology.

2. What type of inflorescence is found in maize?

**Ans:** Spikelet.

3. Is, rice a monocotyledon plant?

**Ans:** Yes, it is.

4. Name the type of inflorescence of rice.

**Ans:** Terminal panicle with spikelets.

5. How many number of stamens are found in a flower of rice plant?

**Ans:** There are six stamens in flower of rice plant.

6. Name the type of seed in rice.

**Ans:** Albuminous.

7. What type of pistil is found in mustard?

**Ans:** Bicarpellary, syncarpous.

8. Name the types of root found rice and mustard plants.

**Ans:** Rice - Fibrous ; Mustard- Tap

9. Define dicot plants.

**Ans:** Those plants which have two cotyledons in their seeds are called dicot plants.

10. Define monocot plants.

**Ans:** Those plants which have only one cotyledon in their seeds are called monocot plants.

11. Write the scientific name of mustard and sunflower and rice plants.

**Ans:** Mustard: *Brassica campestris*

Sunflower: *Helianthus annuus*

Rice: *Oryza sativa*

12. Name four floral parts of a flower.

**Ans:** Calyx, corolla, androecium and gynoecium.

13. What is seed?

**Ans:** A seed is developed from a fertilized ovule and consists of an embryo, an endosperm and testa.

14. Name any two monocot plants.

**Ans:** *Zea mays* and *Triticum aestivum*

15. Name any two plants which have reticulate venation.

**Ans:** Mustard and Mango

## EXPERIMENTS OF ECOLOGY

### Theory

Pond ecosystem can be defined as the interaction between aquatic plants and animals with their aquatic environment. The freshwater pond as a whole represents a complete self-maintaining and self-regulating ecosystem. A pond consists of different regions on the basis of water depth and types of vegetation and animals:

- A. **Littoral:** It is uppermost shallow water region, which is usually occupied by rooted plants or floating green plants.
- B. **Limnetic:** It is the middle zone which ranges from the shallow to depth of effective light penetration. Examples are phytoplaktons such as blue green algae and diatoms.
- C. **Profundal:** It is the deep-water zone where there is no effective light penetration. Producers are absent in this zone. It includes snails, crab, annelids and decomposers.

### Procedure

Students are advised to visit a pond nearby your place. Observe biotic and abiotic components of pond and show their relationships.

### Observation

Students must observe the organisms in a pond and make a separate record of producers, consumers, decomposers and abiotic substances.

Components	Name of the organisms
Producers	
Primary consumers	
Secondary consumers	
Tertiary consumers	
Abiotic components	

### Conclusions

The solar energy from sunlight are transferred through a series of organigms starting from plants to various groups of organisms present in the ecosystem.

**OBJECTIVE****STUDY OF BIOTIC COMPONENTS OF POND ECOSYSTEM**

Pond ecosystem can be defined as the interaction between aquatic plants and animals with their aquatic environment. The freshwater pond as a whole represents a complete self-maintaining and self-regulating ecosystem. The pond consists of two basic components. These components are:

- A. Biotic components
- B. Abiotic components

**A. Biotic components** - These are the living organisms of an ecosystem. On the basis of the nutrition, biotic components are grouped into three categories

- a. Producers
- b. Consumers
- c. Decomposers

a. **Producers:** These are the living organisms that can synthesize their food photosynthetically. They are known as autotrophs. Examples of producers of pond ecosystem are the aquatic green plants, such as *Hydrilla*, *Spirogyra*, *Vallisneria*, *phytoplanktons*, *Pistia*, etc. These may be sub-merged or floating plants. These green plants trap the solar energy and convert the radiant (solar) energy into chemical energy which is stored in the body of organisms.

b. **Consumers:** These include the living organisms that can't prepare their food. They are dependent on plant or animals for the food. They are also known as heterotrophs. Consumers are of three types:

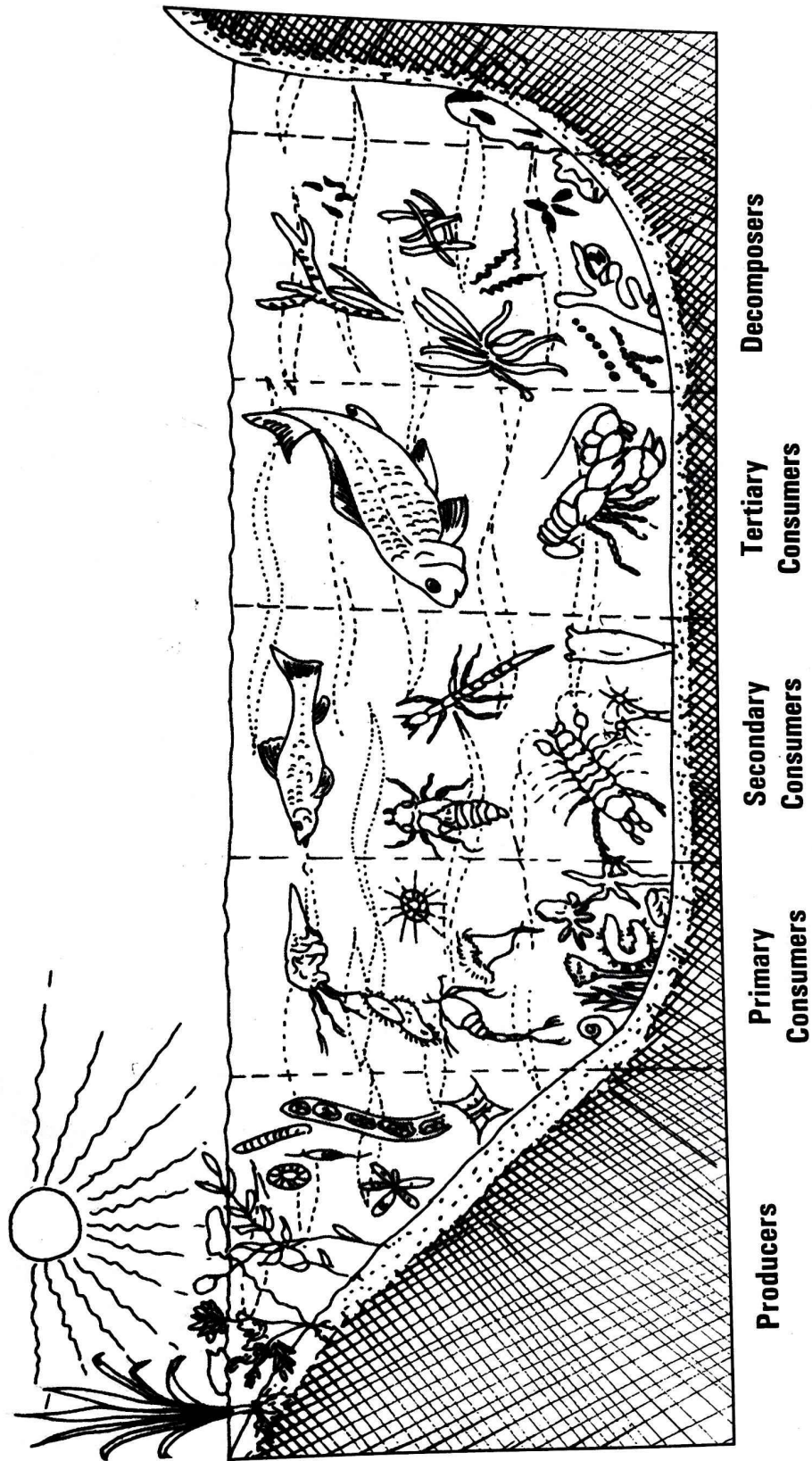
- i. **Primary consumers:** These include the living organisms that are completely dependent on the green plants or producers. They are known as herbivores. Examples are zooplanktons, tadpole larva, aquatic insects (*Cyclops*, *Daphnia*), mollusca, etc.
- ii. **Secondary consumers:** These include the living organisms that are dependent on primary consumers for food. They are also called primary carnivores. The omnivores are also included in secondary consumers. In pond ecosystem, the secondary consumers are frog, small fishes, crab, water snakes, etc.
- iii. **Tertiary consumers:** These include the living organisms that are dependent on both primary and secondary consumers. They are also called secondary carnivores. Examples are big fishes, turtles, water birds, etc.

c. **Decomposers** - These include the living organisms which are dependent on the dead or decaying plants or animals. After the death of plants or animals, decomposers transform the complex organic molecules into simpler inorganic molecules. These are also known as saprophytes or transformers. Examples are bacteria, fungi, earthworm, etc.

**B. Abiotic components** - These are the non-living organisms of an ecosystem. The examples of abiotic components in pond ecosystem are water, light, temperature, soil, gases ( $O_2$ ,  $CO_2$ ), minerals, pH, etc. These abiotic factors directly or indirectly influence distribution, occurrence and survival of organisms of pond ecosystem.

Date

# STUDY OF BIOTIC COMPONENTS IN POND ECOSYSTEM



Diagrammatic representation of a pond ecosystem

**OBJECTIVE****STUDY OF AN AQUARIUM AS AN POND ECOSYSTEM****Theory**

Aquarium is an artificial pond or tank made of glass where aquatic plants and animals are kept for the aesthetic value. It is generally kept in the homes or laboratories. It is an example of fresh water pond ecosystem. It also represents the interaction or interrelationship between biotic and abiotic organisms found in an aquarium.

**Procedure**

Students are advised to observe biotic and abiotic components of an aquarium of your laboratory and show their relationships.

**Observation**

Students must observe the organisms in the aquarium and mention the records of producers, consumers, decomposers and abiotic substances.

**Conclusion**

Like the pond ecosystem, aquarium also consists of two basic components. The main components are:

- A. Biotic components
- B. Abiotic components

**A. Biotic components** - These are the living organisms of an ecosystem. On the basis of the nutrition, these are grouped into three categories -

- a. Producers
- b. Consumers
- c. Decomposers

a. **Producers** - These are the living organisms that can synthesize their food by their own. They are also known as autotrophs. Examples of producers in aquarium are the aquatic green plants, such as *Hydrilla*, *Vallisneria*, phytoplanktons, etc.

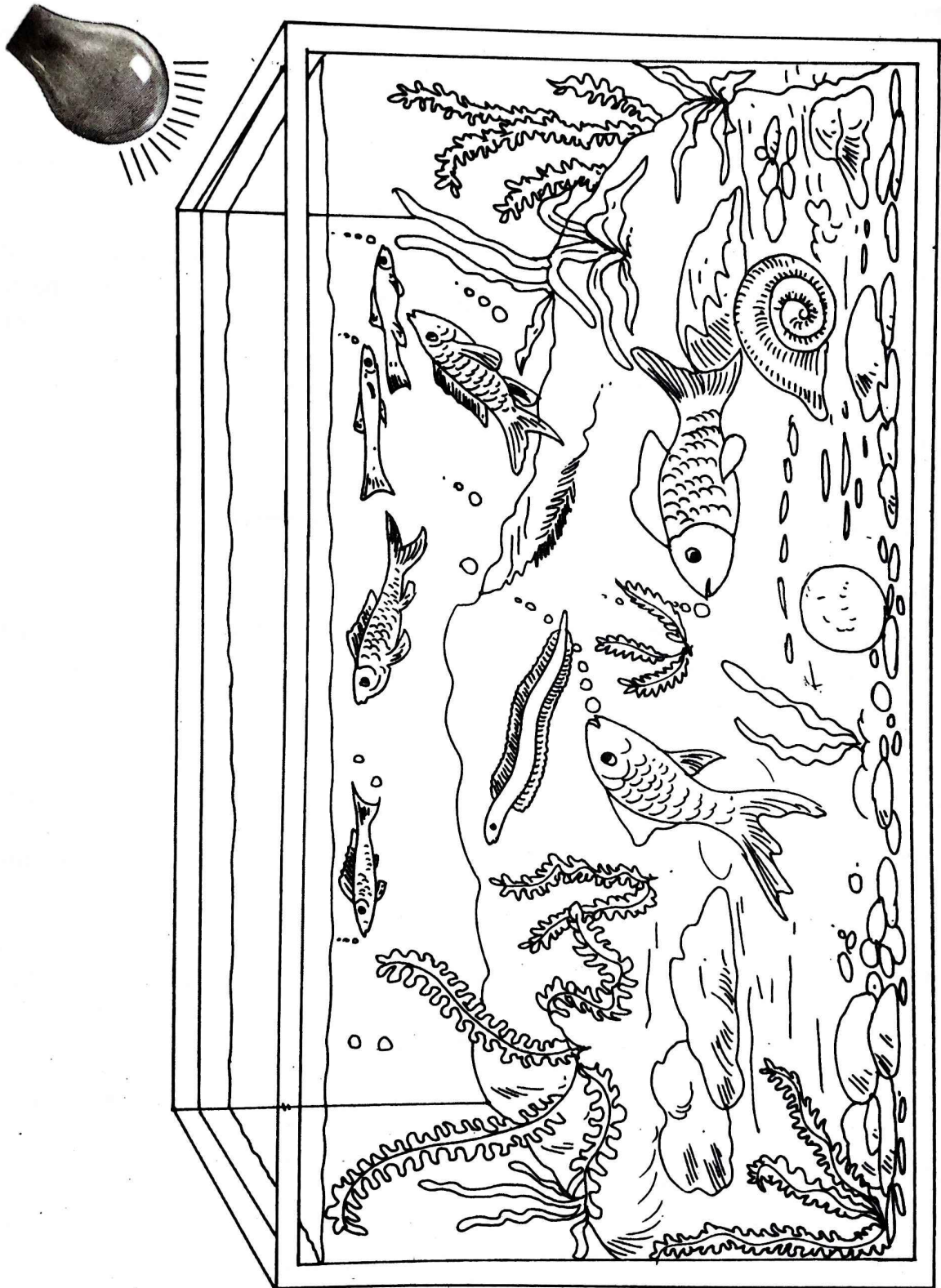
b. **Consumers** - These include the living organisms that can't prepare their food. They are dependent on producers directly or indirectly. The consumers in an aquarium are mainly small beautiful fishes and some snails. Secondary and tertiary consumers are absent. Fishes are provided with artificial food.

c. **Decomposers** - These include the living organisms which are dependent on the dead or decaying plants or animals. After the death of plants or animals, decomposers transform the complex organic molecules into simpler inorganic molecules. These are also known as saprophytes or transformers like bacteria.

**B. Abiotic components** - The abiotic components in aquarium are water, light, temperature, gases ( $O_2$ ,  $CO_2$ ), minerals, pH, etc. These abiotic factors directly or indirectly influence distribution, occurrence and survival of organisms. Aquarium has the water constantly aerated. Intensity of light and the temperature are also adjusted artificially. Artificial foodstuff are also provided time to time.

Date

# STUDY OF AN AQUARIUM AS AN POND ECOSYSTEM



Diagrammatic representation of an aquarium

**OBJECTIVE****STUDY OF A DIAGRAM SHOWING FOOD CHAIN USING AN AQUARIUM****Theory**

In an ecosystem, green plants or producers utilize the solar energy from sun light and synthesize the food materials. The solar energy is stored in the producers in the form of complex organic materials, such as carbohydrates, proteins, etc. This energy is transferred to other consumers in an ecosystem by eating.

Therefore, food chain can be defined as “the transfer of energy in form of food from one organism to other group of organisms through repeating eating and lastly being eaten”.

In the ecosystem, producers are eaten up by primary consumers. The primary consumers are eaten up by the secondary consumers which is further consumed by tertiary consumers. After the death of the plants and animals, decomposers convert the organic into inorganic materials, which are utilised by the producers. In this a chain of energy is formed in an ecosystem.

**Procedure**

Students are advised to observe the biotic and abiotic components of an aquarium of your laboratory and show their relationships. Make an energy flow chart on the basis of relationship,

**Observation**

Students must mention the records of the organisms observed in the aquarium or pond. They should make separate record of producers, consumers, decomposers and abiotic substances.

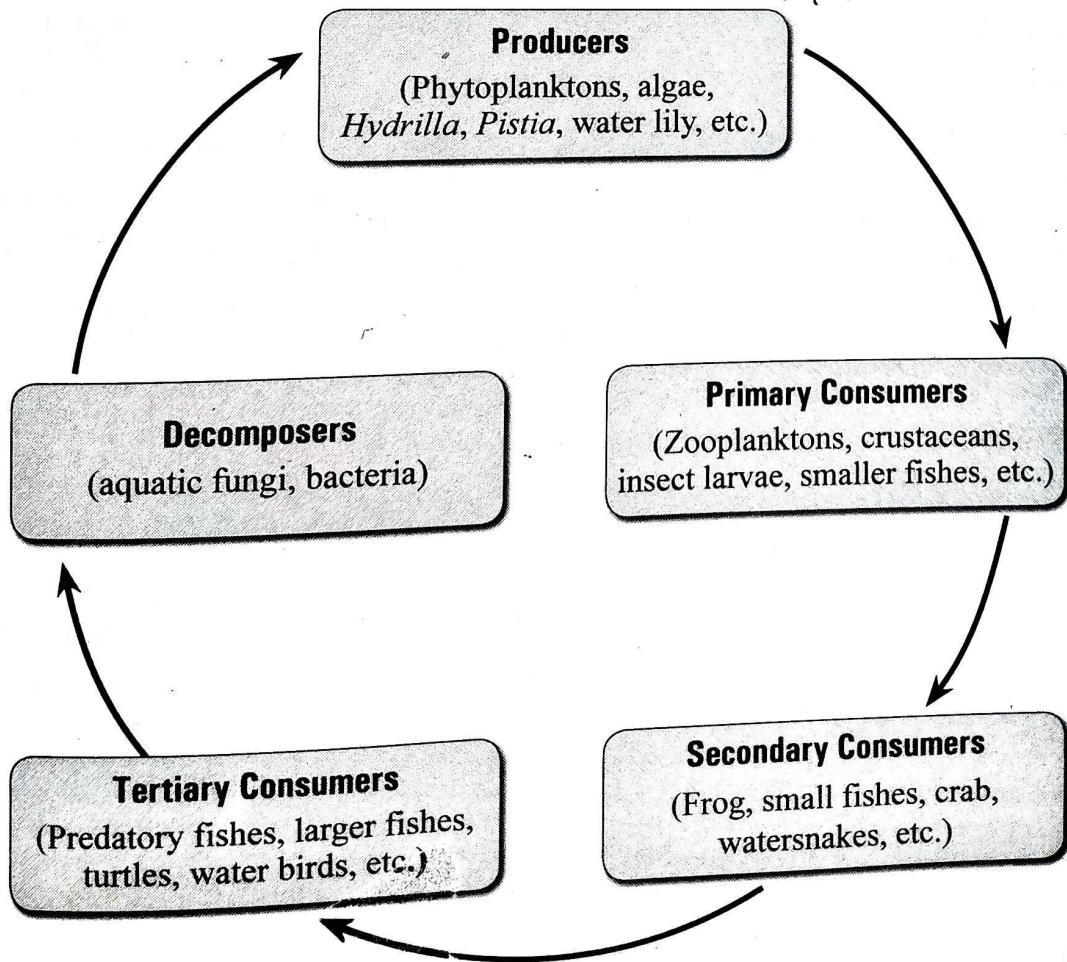
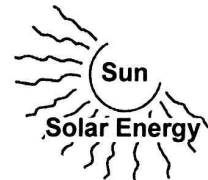
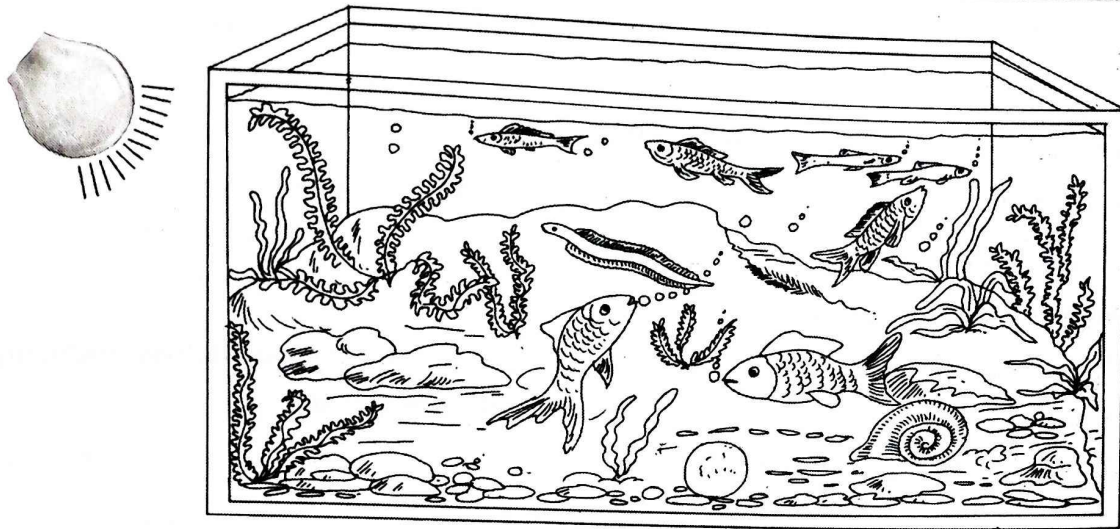
Components	Name of the organisms
Producers	Phytoplanktons, algae, <i>Hydrilla</i> , <i>Pistia</i> , water lily, etc.
Primary consumers	Zooplanktons, crustaceans, insect larvae, smaller fishes, etc.
Secondary consumers	Frog, small fishes, crab, watersnakes, etc.
Tertiary consumers	Predatory fishes, larger fishes, turtles, water birds, etc.
Decomposers	Aquatic fungi, bacteria
Abiotic components	Water, light, temperature, gases ( $O_2$ , $CO_2$ ), minerals, pH, etc.

**Conclusion**

1. Reception of radiant energy of sun.
2. Manufacture of organic materials from inorganic ones by producers (Photosynthesis).
3. Consumption of producers by consumers and further elaboration of consumed materials and
4. After the death of producers and consumers, complex organic compounds are degraded and finally converted by decomposers and converters into such forms as are suitable for reutilization by producers.

Date

# STUDY OF FOOD CHAIN USING AN AQUARIUM



Flow chart Showing Food chain

1. What is ecosystem?

**Ans:** The inter-relationship between biotic and abiotic substances is called ecosystem.

2. What are the components of ecosystem?

**Ans:** Ecosystem is composed of two components:

- a. Biotic
- b. Abiotic.

3. Define the term producer?

**Ans:** Producers are the living organisms that synthesize their food photosynthetically. They are also known as autotrophs. Examples of producers are the green plants.

4. What are consumers?

**Ans:** Consumers are the living organisms that can't prepare their food. They are dependent on plant or animals for food. Consumers are three types:

- a. Primary consumer,
- b. Secondary consumer,
- c. Tertiary consumer.

5. Define primary, secondary and tertiary consumers?

**Ans: Primary consumers** are the living organisms that are completely dependent on the green plants or producers. They are also known as herbivorous. In pond ecosystem, primary consumers are zooplanktons, tadpole larva, molluscs, aquatic insects (Cyclops, Daphnia), etc.

**Secondary consumers** are the living organisms that are dependent on primary consumers. In pond ecosystem, the secondary consumers are frog, small fishes, crab, water snakes, etc.

**Tertiary consumers** are the living organisms that are dependent on both primary and secondary consumers. There are carnivores. In pond ecosystem, the tertiary consumers are big fishes, turtles, water birds, etc.

6. What are decomposers?

**Ans:** Decomposers are the living organisms which are dependent on the dead or decaying plants or animals. After the death of plants or animals, decomposers transform the complex organic molecules into simpler inorganic molecules. These are also known as saprophytes or transformers. The examples are bacteria and fungi.

7. What do you mean by food chain?

**Ans:** Food chain can be defined as "the transfer of energy in form of food from one organism to other group of organisms through repeated eating and lastly being eaten".

8. What happens when any group of organism absent in ecosystem?

**Ans:** Ecosystem gets imbalanced.

## STUDY OF PLANT ADAPTATION

Plants grow well in optimum water conditions, temperature and soil components as well as grow under abnormal conditions. They show different morphological and anatomical modifications to adjust themselves in varied conditions of the environment. These modifications make the plants able to survive and reproduce within the limits of a particular environment. The modified features which help plant to exist in different conditions in which they grow is called plant adaptation. In other word, adaptation can be defined as the structural and physiological adjustments made by living organisms to survive successfully in particular habitats and to cope in their environment. Plants are divided into different groups on the basis of the ability of plants to grow in varied environmental conditions like water supply, water requirement, rate of transpiration, nature of soil components, etc. They are mesophytes, hydrophytes and xerophytes.

Those plants growing well in optimum conditions of water, temperature and soil are called mesophytes. However many plants have adapted themselves to grow under abnormal conditions. Those plants growing in or on the water are called hydrophytes whereas some other plants prefer to grow in the scarcity of water in the soil i.e., dry and sandy soil are called xerophytes.

### A. Hydrophytes

Those plants growing in or on the water are called hydrophytes. They are classified into three groups;

1. **Floating hydrophytes:** The plants growing in the water but their whole parts or leaves are floating in water are called floating hydrophytes or plants. Examples, *Trapa*, *Pistia*, *Lemna*, *Azolla*, etc.
2. **Submerged hydrophytes:** The plants which are growing completely inside the water are called submerged hydrophytes or plants. Examples, *Hydrilla*, *Potamogeton*, *Vallisneria*, etc.
3. **Amphibious hydrophytes:** They are those plants which are primarily submerged but when the water is dries up they grow as a land plant. Examples, *Sagittaria*, *Jussieuia*, *Alsima*, etc.

### B. Mesophytes

Mesophytes are the common land plants which grow well in land with suitable conditions like sufficient water, air as well as suitable soil temperature. These plants can not grow in saline or water logged soil. Their growth is normal and has no any special water conserving mechanism. They can remove excess of water from the plant parts during transpiration. Mesophytes include grasses, herbs, shrubs, trees, etc. Examples, *Rosa alba* (rose), *Mangifera indica* (mango), *Dalbergia sissoo* (Sisham), *Brassica campestris* (mustard), *Cyanodon dactylon* (daboo), etc.

### C. Xerophytes

The plants adapted to grow and survive in dry conditions are called xerophytes. These plants are well adapted in water scarcity condition. These plants have special morphological and anatomical features to conserve water and to reduce the transpiration rate. Examples, *Opuntia*, *Pinus*, *Aloe*, etc.

**OBJECTIVE****STUDY OF THE MORPHOLOGICAL ADAPATATIONS OF HYDROPHYTE (HYDRILLA)****Material required**

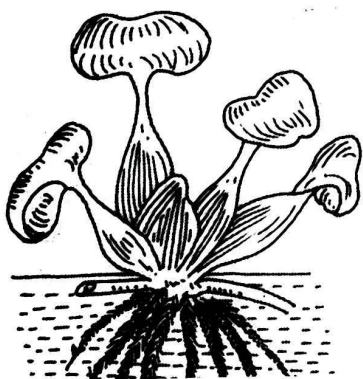
A fresh or preserved twig of Hydrilla plant.

**Laboratory activities**

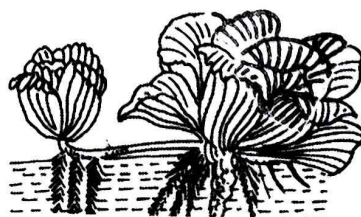
1. Take a twig of *Hydrilla* plant from your locality or specimen of *Hydrilla* and observe the different morphological and adaptational features.
2. Study and sketch a well labeled diagram of *Hydrilla* plant

**Comments**

1. Root system is poorly developed. Root hairs and root cap are absent.
2. Stem is delicate, flexible, spongy and green in colour.
3. Leaves are small, sessile, thin and ribbon shaped arranged spirally at nodes.
4. Leaves and stem are coated with waxy layer cuticle that protects the plant from chemical and physical injuries.
5. The small and narrow leaves of *Hydrilla* offer less resistance against water current.
6. The pollination takes place in it by water. This type of pollination is called hydrophily.
7. Seeds and fruits are lighter so they easily float on the water.
8. They usually reproduce by vegetative propagation.
9. The stem contains large air spaces between the cells which makes the stem spongy and soft.
10. Vascular tissues i. e., xylem and phloem are poorly developed.
11. Stomata and stem hairs are absent.



Eichhornia



Pistia

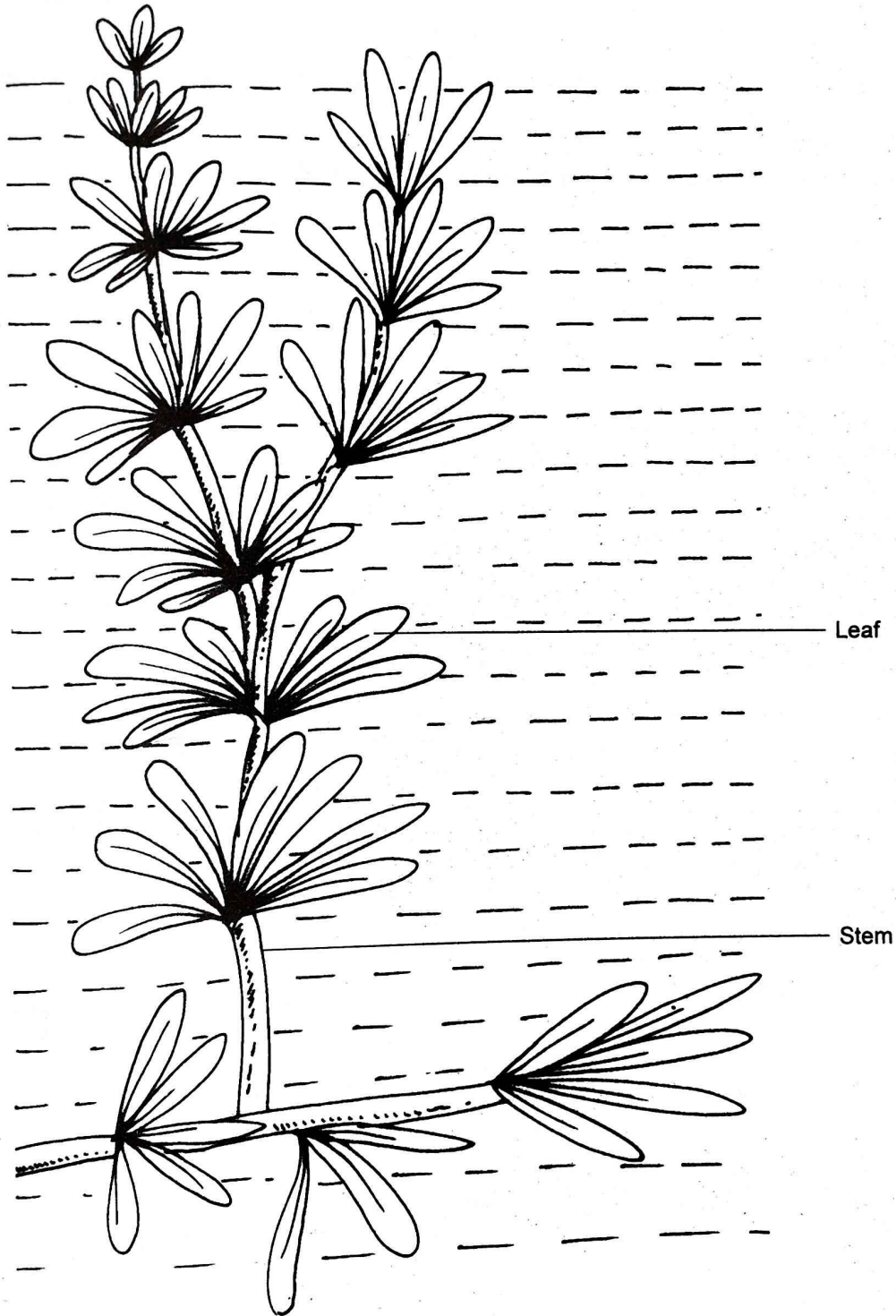


Lotus

Some Hydrophytic Plants

Date

# STUDY OF THE MORPHOLOGICAL ADAPATATIONS OF HYDROPHYTE ( HYDRILLA)



Hydrilla

**OBJECTIVE**

**TO STUDY THE MORPHOLOGICAL ADAPATATIONS OF XEROPHYTE (OPUNTIA)**

**Material required**

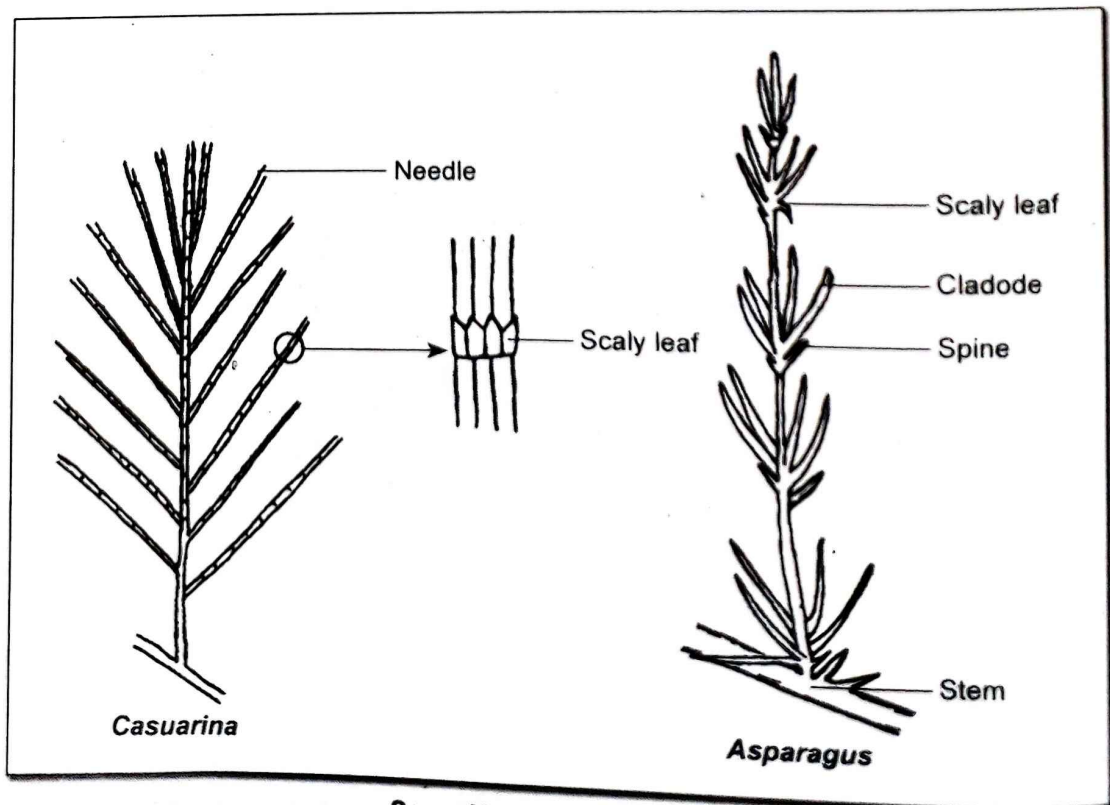
A twig of *Opuntia* plant.

**Laboratory activities**

1. Take a fresh twig of *Opuntia* plant from your locality and observe the different morphological and adaptational features.
2. Study and sketch a well labeled diagram of *opuntia* plant.

**Comments**

1. Roots are well developed and profuse branched and grow deep into the soil.
2. The plants are bushy, very much branched and covered with thick bark.
3. The stem is green, fleshy or succulent and modified into flattened structure called phylloclade.
4. The phylloclade contains nodes and internodes.
5. Phylloclade takes part in photosynthesis and store water and mucilage.
6. The leaves are modified into spines that reduce the transpiration rate.
7. They have deep seated or sunken stomata that avoid the loss of water.
8. The leaves and stem have thick waxy layer called cuticle on their surface to reduce transpiration rate.
9. The fruits are seeds are covered by thick and hard coating.
10. Conducting tissues are well developed.

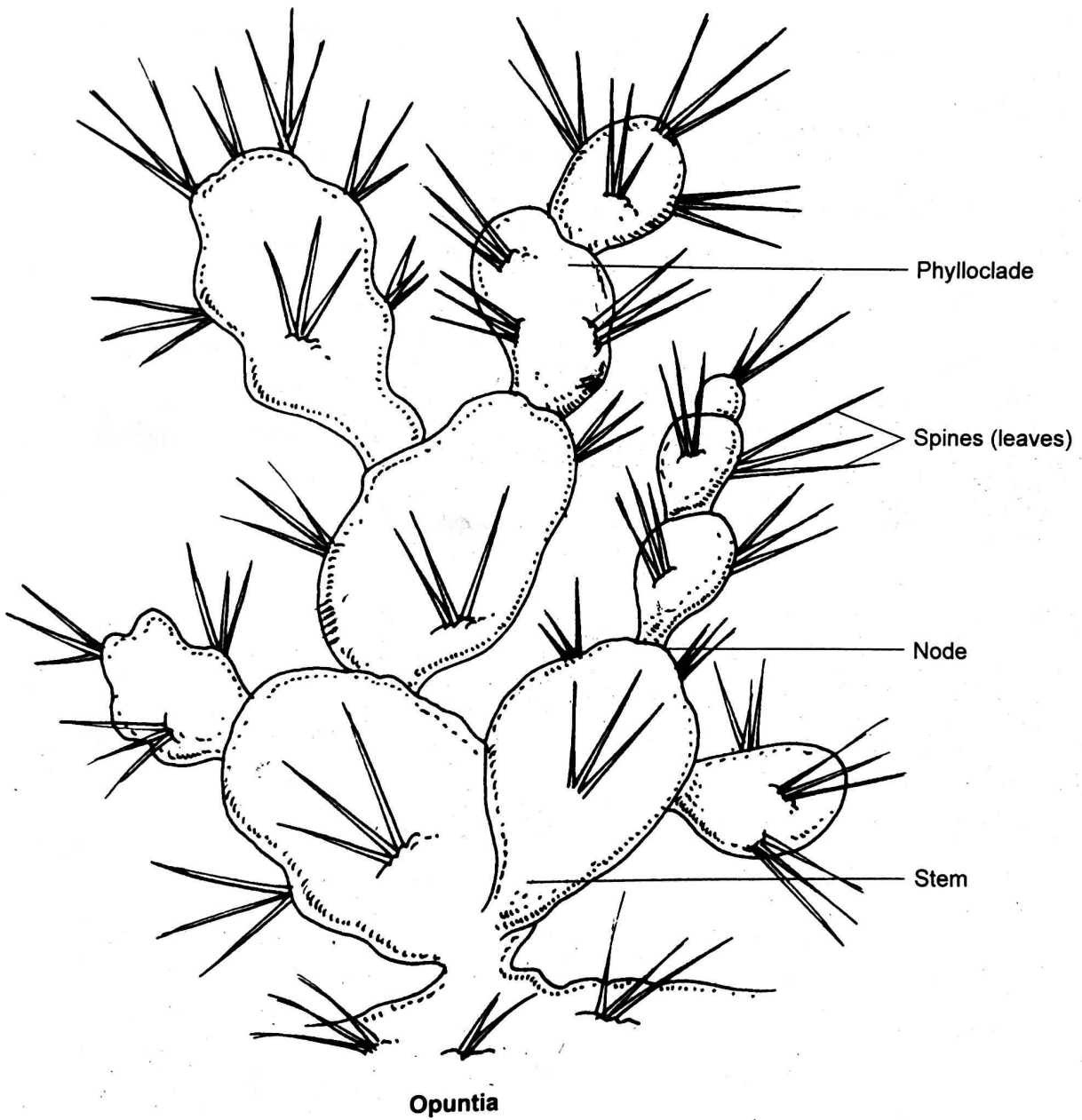


Some Xerophytic Plants

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Date

# STUDY OF THE MORPHOLOGICAL ADAPATATIONS OF XEROPHYTE (OPUNTIA)



**OBJECTIVE**

**TO STUDY THE MORPHOLOGICAL ADAPATATIONS OF MESOPHYTE (MANGO)**

**Material required**

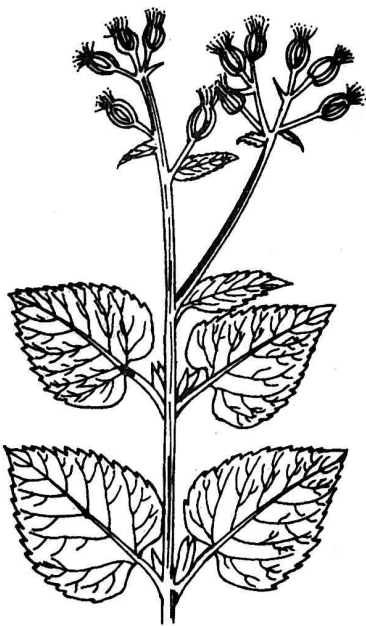
A twig of *Mangifera indica* (Mango) plant.

**Laboratory activities**

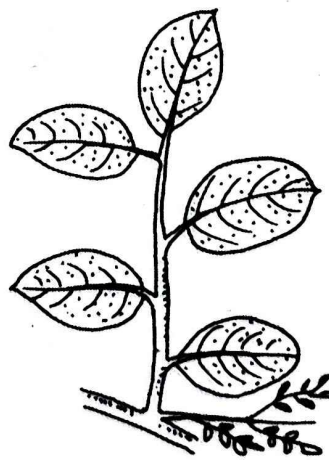
1. Take a fresh twig of *Mangifera indica* plant from your locality or herbarium and observe the different morphological adaptational features.
2. Study and sketch a well labeled diagram of *Mangifera indica* plant

**Comments**

1. Root and shoot systems are highly developed.
2. Root bears root cap and root hairs.
3. Leaves are usually large and broad that support in transpiration.
4. The mechanical and vascular tissues are highly developed.
5. They can remove excess amount of water in the form of vapour from their body during transpiration.
6. Stomata are usually found in young stem, and leaves for gases exchange and help in transpiration.
7. The growth in normal and have no any special water conserving mechanism.



*Ageratum*



*Dalbergia sisso*



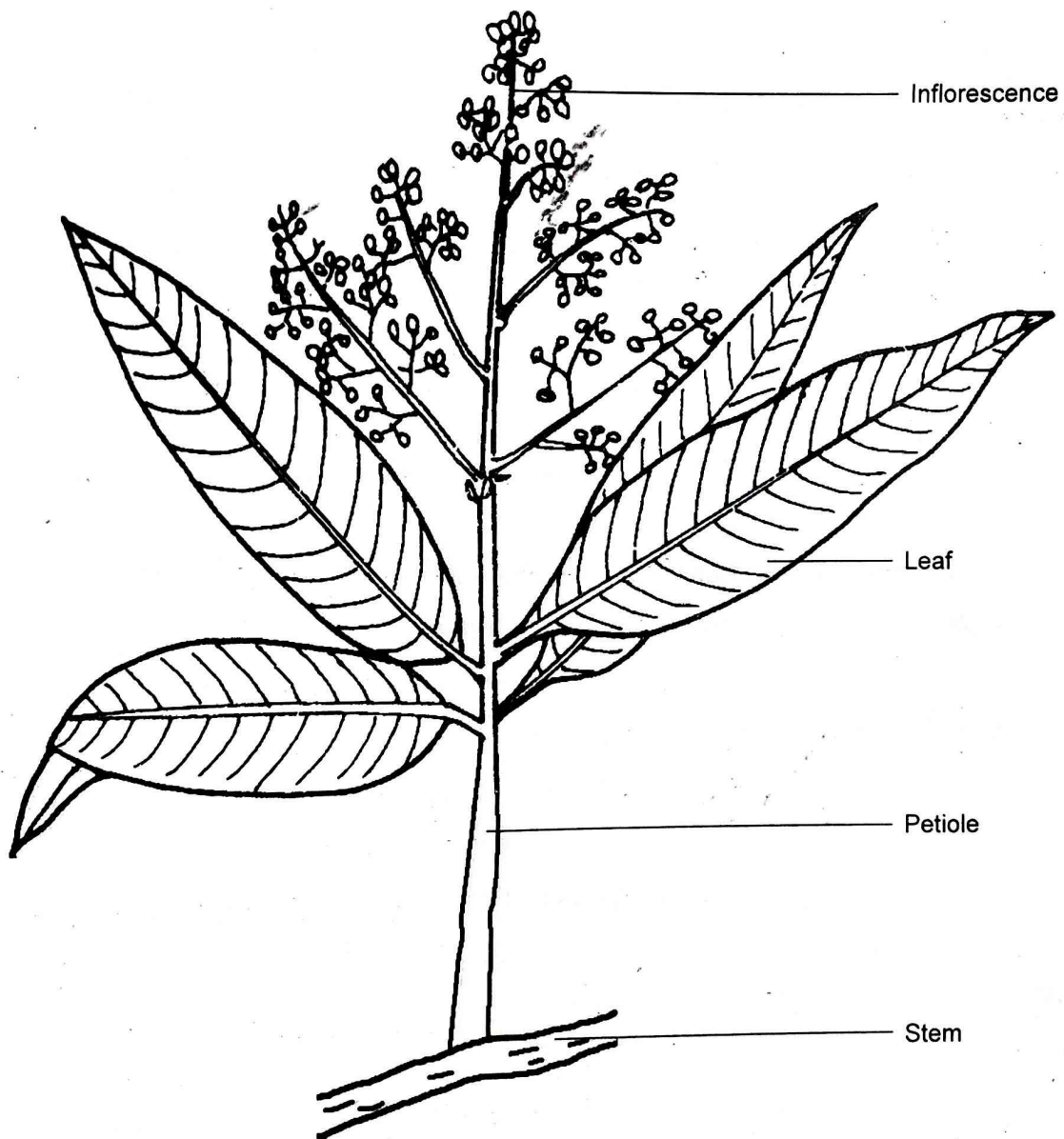
*Coriandrum*

**Some Mesophytic Plants**

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Date

# STUDY OF THE MORPHOLOGICAL ADAPATATIONS OF MESOPHYTE (MANGO)



A Twig of Mango

## Viva Questions

Students must remember

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1. What is adaptation?

**Ans:** Adaptation can be defined as the structural and physiological adjustments made by living organisms to survive successfully in particular habitats and to cope in their environment.

2. Classify the plants on the basis of habitat.

**Ans:** They are mesophytes, hydrophytes and xerophytes.

3. What are called hydrophytes?

**Ans:** Those plants growing in or on the water are called hydrophytes.

4. What are called mesophytes?

**Ans:** Those plants growing well in optimum conditions of water, temperature and soil are called mesophytes.

5. What are called xerophytes?

**Ans:** The plants adapted to grow and survive in dry conditions as desert are called xerophytes.

6. Write any two characteristics of hydrophytes.

**Ans:** The characteristics of hydrophytes are as follows:

- a. Stem is delicate, flexible, spongy and green in colour.
- b. Leaves are small, sessile, thin and ribbon shaped arranged spirally at nodes.

7. Write any two characteristics of mesophytes.

**Ans:** The characteristics of mesophytes are as follows:

- a. Root and shoot systems are highly developed.
- b. Leaves are usually large and broad that support in transpiration.

8. Write any two characteristics of xerophytes.

**Ans:** The characteristics of xerophytes are as follows:

- a. Roots are well developed and profuse branched and grow deep into the soil.
- b. The leaves are modified into spines that reduce the transpiration rate.

9. Name any three hydrophytes.

**Ans:** *Hydrilla*, *Potamogeton*, *Vallisneria*

10. Name any three mesophytes.

**Ans:** *Rosa alba* (rose), *Mangifera indica* (mango), *Dalbergia sissoo* (Sisham)

11. Name any three xerophytes.

**Ans:** *Opuntia*, *Pinus*, *Agave*, *Aloe*

12. What is a phylloclade?

**Ans:** Phylloclade is a modified stem which is green and fleshy.

13. What is a phyllode?

**Ans:** Phyllode is a modified leaf.

## FIELD STUDY

### Collection and Preservation of Plants

It is the very important for a biology student to know about the living organisms with their natural habitats. Students must observe flora and fauna while visiting the field site directly.

Field study makes a student easy to study and observe plants and animals and their relation with their natural habitats or environments.

### Planning for a Field Visit

Students must plan to organize the field visit in a group. They must select a site where you can observe plant and animal diversity. Students must get a map and collect local information of the visit site. Experts or biologists must guide students group.

### Equipment Required for Plant Collection

Students should plan and make proper arrangement before undertaking a trip for plant collection. They must carry the following equipment:

1. Plant Press.
2. A polyethene bag for keeping collected plants.
3. Gardener knife for cutting the branch.
4. Trowel for taking out the underground portion of herbaceous plants.
5. A bamboo sticks with a hook.
6. Hand lens to observe small plants.
7. Camera, if possible, to take snap of vegetation of that area. viii. Tags or labels.
8. Note copy, pencils/pen.

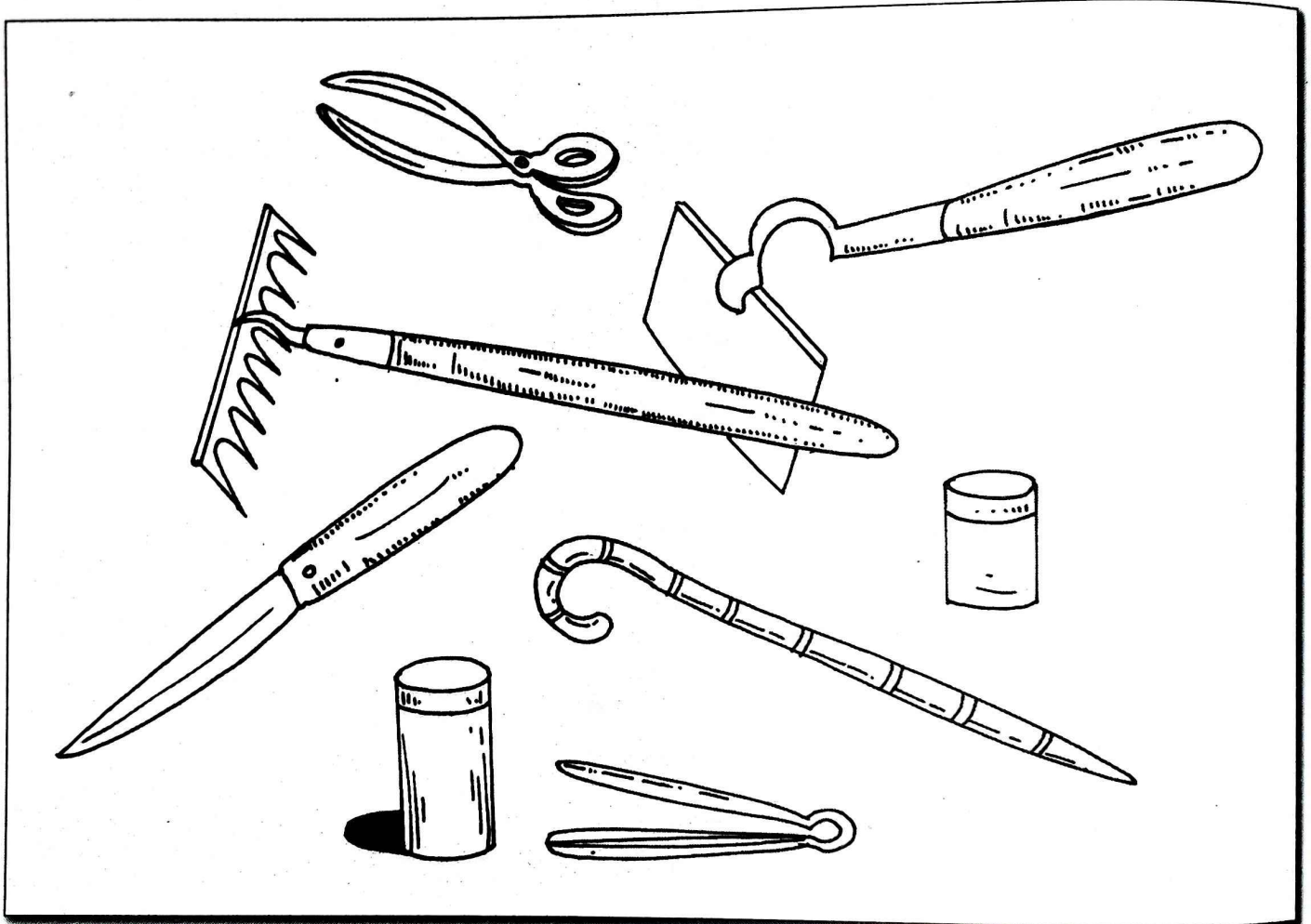
### Points to Remember While Collecting Plants for Herbarium

1. Plants which is to be collected should be healthv.
2. The herbaceous plants should be complete one, including all parts with roots.
3. It is must preferred to collect a plant at its flowering stage.
4. Note down the necessary information about the locality, altitude, habit of the plant, date of collection, etc.

## Drying of Plants for Herbarium

After collection of plants, press them as soon as possible on reaching home. It should use the folds of newspaper or blotting paper in the plant press. It should be taken care that the branches or leaves should not be overlapped or folded. It is usually done in diffuse sunlight. It takes 10-15 days for complete drying. Newspaper or blotting paper should be changed twice.

The main purpose of drying is to avoid decay and fungal growth on plants. Fungicides may be used to control fungi growth on plant.



Equipments for Plant Collection

## Mounting of Plants on Herbarium Sheet

After complete drying, plants are mounted on herbarium sheet. A herbarium sheet is usually 42 x 28 cm in size. It is made of rag paper of various thickness. For mounting the specimen is placed on a sheet and attached to adhesive tape or glue. Fruits seeds can be kept into small packets and attached to the herbarium sheets.


A herbarium sheet of a plant specimen provides a means of permanently preserving it for future study and reference. It is also used to compare a plant specimen with other related plant specimen,, useful for correct identification.

A herbarium sheet should be properly labelled at bottom right hand corner. Label should have following information:

Botanical name: \_\_\_\_\_  
Common name: \_\_\_\_\_  
Family: \_\_\_\_\_  
Locality: \_\_\_\_\_  
Habit: \_\_\_\_\_  
Date of collection: \_\_\_\_\_  
Name of collector: \_\_\_\_\_

### Identification of Plants and Listing of Herbarium Sheet

Students must take help from experts/teachers for identification of plants. Herbarium sheets are listed accordingly and can be used for further studies:



Name of plant : \_\_\_\_\_  
Common Name: \_\_\_\_\_  
Family: \_\_\_\_\_  
Locclity: \_\_\_\_\_  
Collected by: \_\_\_\_\_  
Date: \_\_\_\_\_

A Simple of Herbarium Sheet

## Maintenance of Herbarium Sheet

Herbarium specimen should be protected from serious damage caused by various organisms such as bacteria, fungi insect, etc. Spraying with bactericides, fungicides and insecticides respectively may prevent bacterial, fungal and insect damage. A 0.1% solution of mercuric chloride is very useful as preservative. Broad-spectrum pesticides include DDT (dichloro di-phenyl trichloroethane), PDB (paradichlorobenzene), carbon disulphide gas, etc. The entire herbarium may be fumigated with any common fumigant at regular interval of 1-2 years in order to kill all infective agents.

## Preservation of Other Plants

1. **Mosses:** These should be preserved into a small specimen bottle containing the given solution.

Water - 72 ml

Formaldehyde (40%) - 5 ml

Glycerine - 20 ml

Glacial acetic acid - 3 ml

2. **Algae:** These should be preserved in 5% formaldehyde solution. It retains chlorophyll.

3. **Fungi:** Fungi should be preserved in given solution.

Formaldehyde (40%) - 5 ml

Alcohol (50%) - 95 ml

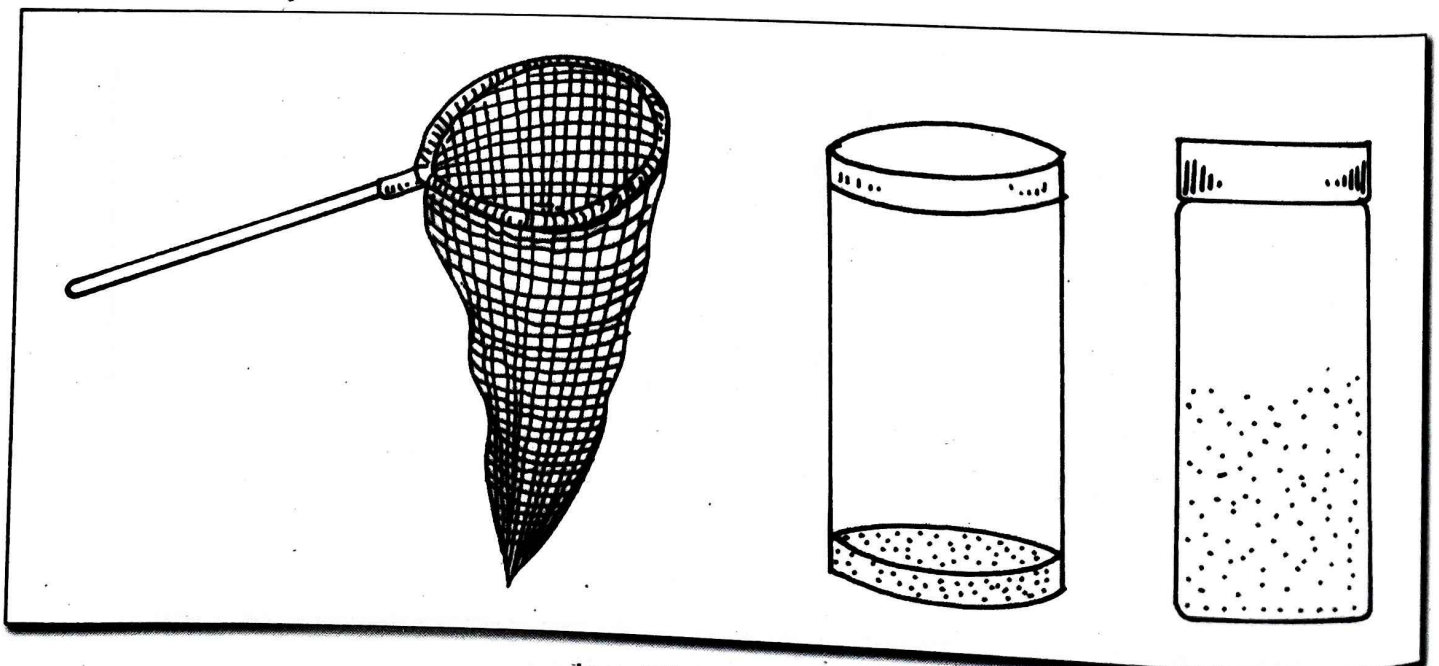
4. **Lichens:** They are not preserved in any solution. They are dried and stored in a box.

## Collection and Preservation of Animals

Students are suggested to collect the animals while visiting the field site.

### Equipment Required for Animal Collection

Students should plan and make proper arrangement before undertaking a trip for animal collection. They must carry the following equipment:



Insect Net and Bottles

1. Insect net
2. Fishing net
3. Traps
4. Bottles

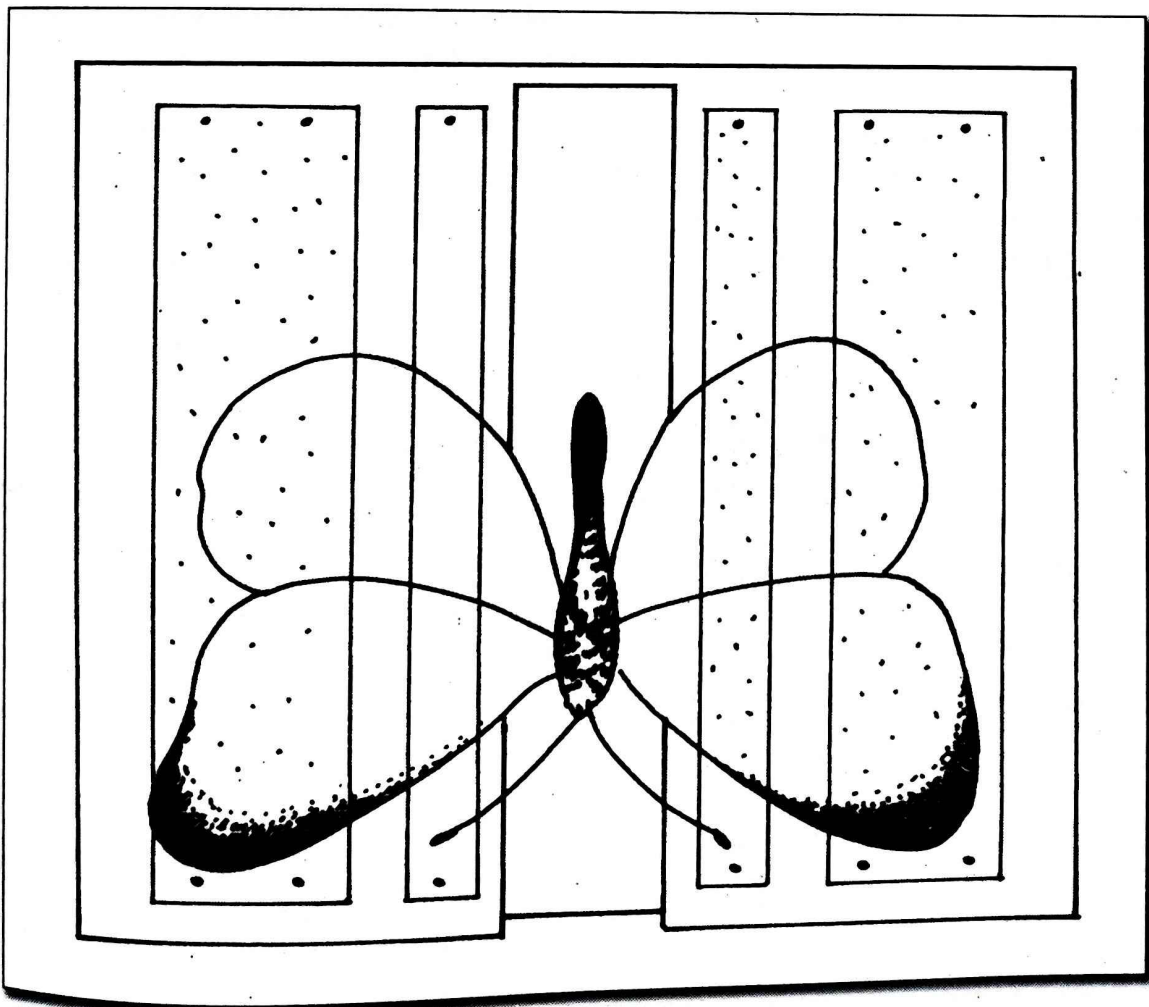
### Collection of Animals

Various methods and equipment are used to collect the animals. Collected animals are preserved for further studies. Equipment used for collection is listed above.

### Preservation of Animals

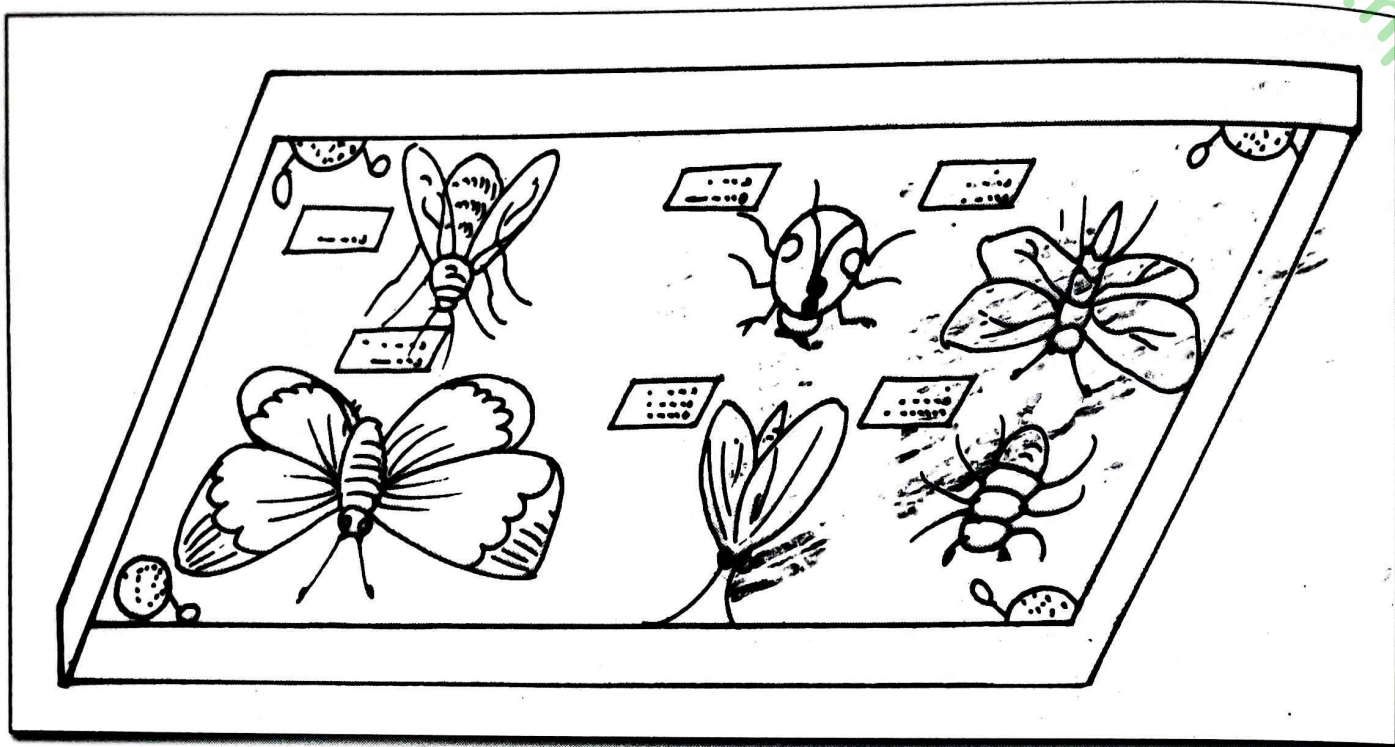
Preservation of plants and animals is essential to keep them for longer periods so that they can be studied further. Various methods are used to preserve animals:

1. **Insects:** Insects like butterflies, moths, grasshopper, cockroaches are collected by netting and killed by placing them into 70% alcohol solution or pin them in following way -
  - a. Take a thick mounting board.
  - b. Dry the sheets before pinning.
  - c. Pin the insect at the thorax.
  - d. Spread the wing and pin strips of paper across wings of either side.
  - e. Store in the collection box or insect cabinet.



Stretching and Drying of an Insect

2. **Small animals:** Small animals such as earthworms, molluscs, fishes, amphibians, reptiles are collected by netting or hand and preserved as a whole in a glass or transparent plastic jars of appropriate size containing 4% formaline or 70% alcohol. A small incision in the abdomen is made to allow the preservative to enter inside. This checks decay of animals.



**Preservation of Small Animals**

3. **Large animals:** Large animals such as birds and mammals are collected by trapping or hand, killed in a jar containing cotton soaked in chloroform to paralyze them. They are preserved as a whole in a glass or transparent plastic jars of appropriate size containing 4% formaline or 70% alcohol. A small incision in the abdomen is made to allow the preservative to enter inside. This checks decay of animals.

**Labelling**

Preserved animals should be labelled with following information:

Scientific name of animals: .....

Classification: .....

Locality: .....

Date of collection: .....

Name of collector: .....

## VIVA QUESTIONS

1. Give botanical name of any two plants belonging to family Solanaceae.

- Ans: i. Potato - *Solanum tuberosum*  
ii. Brinjal - *Solanum melongena*

2. Name the fruit of Solanaceae.

Ans: Berry or capsule.

3. What type of inflorescence is found in the sunflower?

Ans: Head or capitulum type of inflorescence..

4. Write the types of florets in Compositae family

Ans: Ray floret and disc floret.

6. Define zygomorphic flower?

Ans: Flower which can be divided into two equal halves when cut from only one vertical plane.

8. Why is *Solanum nigrum* is placed in the solanaceae family?

Ans: *Solanum nigrum* has obliquely placed ovary with swollen placenta, so it is belonging to solanaceae family.

9. What is hypogynous flower?

Ans: The flower in which all the floral whorls like calyx, corolla and androecium lies below the level of the ovary, is called hypogynous flower.

11. Define monadelphous stamens.

Ans: All the stamens are fused together to form single bundle in a flower is called monadelphous stamens.

12. What is epipetalous?

Ans: When the stamens adhere to the corolla wholly or partially by the filaments and anthers remain free.

13. What is complete flower?

Ans: A flower is said to be complete flower, if it has all the floral parts like sepals, petals, stamens and pistil.

14. How many stamens are found in *Pisum sativum*?

Ans: Ten, nine are fused and one is free.

15. Define bisexual flower.

Ans: A bisexual flower is that flower which contains both stamens and carpels.

16. Define species.

Ans: Species is the group of individuals which have close resemblance in their structure and function.

17. What is adaptation?

**Ans:** It is the process of adjustment of organisms to live successfully a particular environment.

18. Classify the plants on the basis of habitat.

**Ans:** Xerophytes, Mesophytes and hydrophytes.

19. What are called hydrophytes?

**Ans:** Those plants which are grown in or on the water are called hydrophytes.

20. Give any three examples of hydrophytes.

**Ans:** *Vallisneria*, *Hydrilla* and *Pistia*.

21. What are mesophytes?

**Ans:** The plants that grow in the soil having sufficient water, air and suitable temperature are called mesophytes.

22. Give any three common examples of mesophytes.

**Ans:** *Mangifera indica*, *Dalbergia sissoo* and *Brassica campestris*.

23. Give any one characteristics of mesophytes.

**Ans:** Vascular tissues are well developed.

24. Give any five examples of xerophytes.

**Ans:** *Opunita*, *Cactus*, *Aloe*, *Yucca*, *Pinus*, etc.

25. Define classification.

**Ans:** The arrangement of the plants into different groups on the basis of morphological characters is called classification.

26. Who discovered the bacteria first?

**Ans:** A. V. Leeuwenhoeck.

27. What are the four different types of bacteria on the basis of shape?

**Ans:** *Vibrios*, cocci, spirilla and bacilli.

28. Name the components of cell wall of bacteria.

**Ans:** It is peptidoglycan-polysaccharides crossed linked with short amino acid chains.

29. What do you mean by the term amphitrichous?

**Ans:** A single flagellum is present at both the ends of the bacterial cells.

30. What are symbiotic bacteria?

**Ans:** The bacteria which are closely associated with the roots of legumes and from this relationship, both have got the benefits, are called symbiotic bacteria.

31. Name the bacteria which causes 'Cholera'?

**Ans:** *Vibrio cholerae*.

32. Why are bacteria included under Monera?

**Ans:** Bacteria have got incipient nucleus and lack membrane bound cell organelles, so they are kept in kingdom monera.

33. What is significance of mitosis?

**Ans:** It helps in growth and development of multicellular organisms.

34. What is significance of meiosis?  
**Ans:** Meiosis maintains number of chromosomes constant. Through crossing over, it produces variations of genetic characters of the progeny essential for evolution.
35. Write the shape of the onion cell?  
**Ans:** Rectangular-shaped.
36. Name the type of cells found in onion cells.  
**Ans:** Parenchymatous cell.
37. What are different structures found in a onion cell?  
**Ans:** Cell wall, vacuole, nucleus, cytoplasm.
38. Which part of the onion cell take yellow-stained with iodine solution?  
**Ans:** Nucleus.
39. What is cell wall?  
**Ans:** Cell wall is a rigid, outer covering of the cell. It is made up of cellulose.
40. What is the shape the cell you study in *Geranium* leaf?  
**Ans:** Irregular shaped.
41. What is the shape of the cell found in *Tradescantia* leaf?  
**Ans:** More or less hexagonal shape.
42. What are the components of ecosystem?  
**Ans:** Biotic components and abiotic components.
43. Define the term producer?  
**Ans:** Producers are the green plants that can synthesize their food photosynthetically.
44. What are the main characteristic features of family Brassicaceae?  
**Ans:** Family Brassicaceae is characterized by:  
 (a) Cruciform corolla.      (b) Tetradyamous stamens and      (c) Fruit siliqua.
45. What do you understand by ligulate head?  
**Ans:** All the flowers are ligulate and zygomorphic i.e., the capitulum is homogamous.
46. Define tetradynamous .  
**Ans:** The stamens arranged in two whorls, 2 outer short and four inner long is called tetradynamous.
47. Define placentation.  
**Ans:** Arrangement of placentae and ovules on the ovary wall.
48. Define syncarpous.  
**Ans:** Fused condition of carpels.
49. Define hypogynous.  
**Ans:** A flower with superior gynoecium.
50. Define cruciform.  
**Ans:** Four free petals arranged in the form of cross is called cruciform. Each petal is divided into a expanded limb and a narrow claw.
51. Define papilionaceous.  
**Ans:** The five unequal free petals, one large posterior standard, two lateral wings and two innermost smallest united keels is called papilionaceous.

52. Define diadelphous.

**Ans:** Filaments of stamen united in two separate bundles.

53. Define caryopsis.

**Ans:** A very small, simple, dry, indehiscent, one-seeded fruit developing from a monocarpellary superior ovary. The pericarp fused with the seed coat e.g., maize, wheat.

54. Define capsule.

**Ans:** A dry dehiscent fruit develops from superior bi carpellary or polycarpellary ovary.

55. Define berry.

**Ans:** A fleshy or pulpy indehiscent many seeded fruit is called berry.

56. Define legume.

**Ans:** A simple dry dehiscent fruit develops from superior, monocarpellary one chambered ovary. It dehisces by two longitudinal sutures.

57. Define cypsel.

**Ans:** A dry indehiscent one-seeded fruit developing from a bicarpellary, syncarpous, inferior ovary the pericarp is free from the seed coat.

58. What do you mean by cell cycle?

**Ans:** The total change from one mitosis cell division to another mitosis cell division is called cell cycle.

59. What is mitosis cell division?

**Ans:** Mitosis is the division of the cell in which a single cell divides to form two cells, each having the same number of chromosomes as present in parent cell. It is also called somatic or vegetative cell division.

60. Write the importance of mitosis division.

**Ans:** Mitosis cell division is essential for the growth of plant and animal body. It helps to produce genetically identical cells.

61. What is meiosis cell division?

**Ans:** In meiosis cell division, a diploid cell divides to form four haploid cells, each having half the number of chromosomes present in the parent cell. It occurs in reproductive cells at the time of gametes or spores formation.

62. Name the nuclear divisions are found in meiosis?

**Ans:** Meiosis comprises of two nuclear divisions: (i) Heterotypic or meiosis first or reductional division (ii) Homotypic or meiosis second or equational division.

63. Why is mitosis an equational division?

**Ans:** The mitosis is an equational division because the daughter cells have the same number of chromosomes and equal amount of cytoplasm.

64. Why is meiosis a reductional division?

**Ans:** In meiosis cell division the number of chromosomes become half, therefore it is a reductional division.

65. Define synapsis.

**Ans:** The pairing of homologous chromosomes during zygotene sub stage is called synapsis.

66. Define crossing over.

**Ans:** The exchange of small segment of chromosome between homologous chromosomes is called crossing over.

67. What do you understand by ecology?

**Ans:** Ecology may be defined as the study of plants and animals in reciprocal relationship with their environment or external world.

68. What do you understand by ecological factor?

**Ans:** Any external force, substance or condition which surrounds and affects the life of an organism in any way is called ecological factor.

69. What do understand by trophic level?

**Ans:** Producer- consumer arrangement is known as trophic structure. and the food level is called trophic level.

70. What do you understand by food chain?

**Ans:** In the ecosystem food from one trophic level reaches the other trophic level and a chain is established. This is known as the food chain.

71. Give one example of unicellular fungus.

**Ans:** *Saccharomyces cerevisiae*.

72. Why are fungi called natural scavengers?

**Ans:** Fungi decompose dead plants and animals and thus clean the environment, therefore, they are called natural scavengers.

73. Define coenocyte.

**Ans:** The multinucleate, aseptate hyphae is known as coenocyte, e.g.: *Mucor*, *Rhizopus*.

74. Define heterothallism.

**Ans:** Sexual reproduction in which two dissimilar thalli are involved is called heterothallism.

75. Define spore.

**Ans:** The spore is a reproductive structure. It is usually unicellular, thin or thick walled, motile or non-motile structure. It is produced by mitotic or meiotic division of the parent cell.

76. Name the following.

**Ans:** Black bread Mold: *Rhizopus*, *Mucor*

77. Give two examples of Cyanobacteria.

**Ans:** *Nostoc* and *Oscillatoria*.

78. In which cells of *Nostoc* does nitrogen fixation take place?

**Ans:** Heterocyst.

79. Name the different types of photosynthetic pigments present in Cyanobacterial cell.

**Ans:** Chlorophyll a, carotenes and phycobillins.

**Section B**

**ZOOLOGY**



# STUDY OF MUSEUM SPECIMENS

## Important Terminology

These are the terms generally used in zoology which the students must know and remember:

### 1. Cellularity

The organisms are made up of cells. These are called as basic units of organisms. These may be of two types –

- (a) **Unicellular** – The organism made up of only one cell is called as unicellular or acellular. e.g.,– Protozoans.
- (b) **Multicellular** – The organisms made up of many cells are called as multicellular. They are also called metazoans. e.g.,– All organisms except protozoans.

### 2. Body Layer

It is the cellular layers which form the body. On the basis of body layers, animals are of two types –

- (a) **Diploblastic** – This term is used for those animals which are derived from two germ layers – outer-ectoderm and inner-endoderm. e.g.,– Sponges and coelenterates.
- (b) **Triploblastic** – This term is used for those animals which are derived from three germ layers; outer-ectoderm, middle-mesoderm, and inner-endoderm. e.g.,– Most of the animals are triploblastic except protozoans, poriferans and coelenterates.

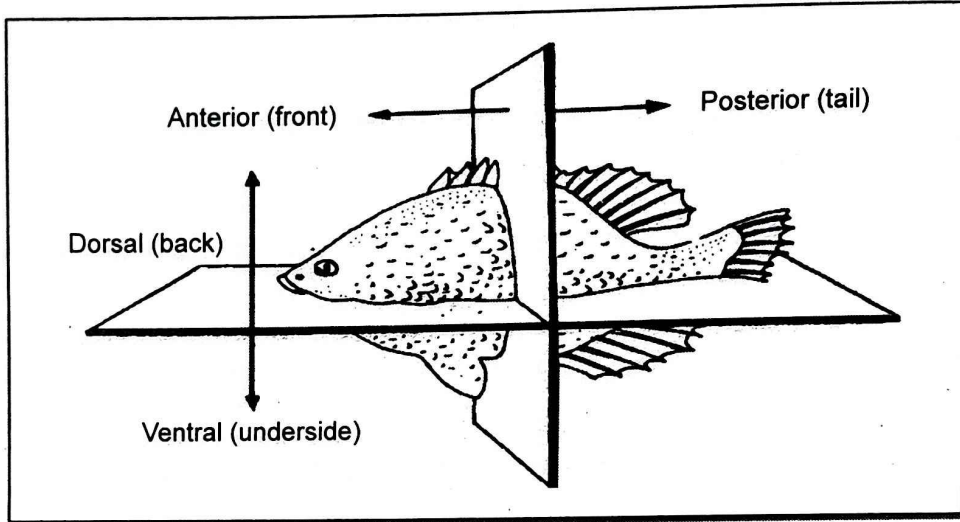
### 3. Body Organisation

- (a) **Cellular grade organisation** – An individual is made up of cells. Each cell performs all its vital activities independently. Tissue is absent. e.g.,– Porifers (*Sycon*, *Leucosolenia*).
- (b) **Tissue grade organisation** – The organism having tissues present but organ lacking. e.g, Hydra.
- (c) **Organ grade organisation** – The different tissues combine to form organs which perform specific function e.g.,– nose, trachea lungs-respiratory system; brain, spinal cord-nervous system, etc.
- (d) **System grade organization** – The different organs collectively perform a specific function to form a definite system. e.g.,– in all the chordates.

### 4. Body Surfaces

- (a) **Anterior end** – The part of the body which moves forward (and usually contains the mouth) is called anterior end.
- (b) **Posterior end** – The end of the body which lies opposite to anterior end.

- (c) **Dorsal surface** – The upper surface is dorsal surface which faces towards the sky in natural posture.
- (d) **Ventral surface** – The under surface which faces towards the ground in natural pose.
- (e) **Depressed body** – Dorsoventrally pressed or flattened.
- (f) **Laterally compressed** – Flattened laterally.



A fish having bilaterally symmetrical showing an anterior end, posterior end, dorsal and ventral surfaces

### 5. Symmetry

- (a) **Bilateral symmetry** – Body can be divided into two equal and similar halves when it is cut longitudinally and medially. Each half is the mirror image to one another. e.g.,– Platyhelminthes and upto Chordates.
- (b) **Radial or biradial symmetry** – Body can be divided into two equal and similar halves. when it is cut from any sides passing through the central axis, The radially symmetrical animals are mostly spherical or cylindrical. Example – coelenterates and echinoderms.
- (c) **Asymmetry** – Body plan is in such a way that when the animal cannot be cut into two equal halves e.g.,– *Amoeba*.

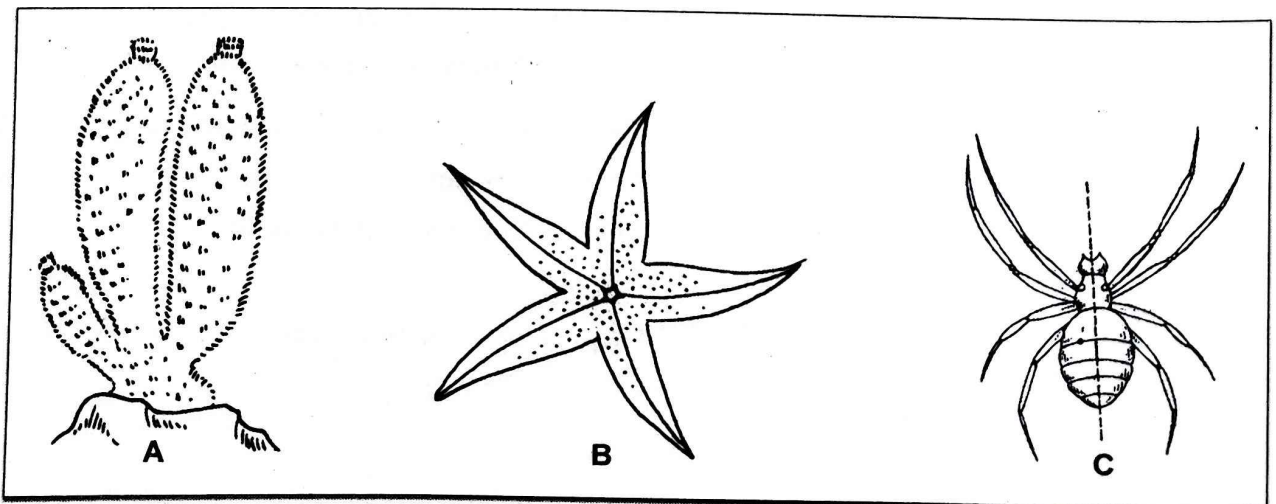


Diagram showing body symmetry.

A - Asymmetry; B - Radial symmetry; C - Bilateral symmetry.

## 6. Habitat

The place where organisms live successfully is called habitat. It may be following types –

- (a) **Aquatic** – Organisms which live only in water. It may of following types –
  - **Fresh water** is the water other than sea or ocean water such as ponds, rivers, lakes, slow running streams, drains, ditches, *etc.*
  - **Marine** word is used for sea or ocean water. The organisms which live in the seawater are called marine.
- (b) **Amphibious** – Those animals which can live both on land and in water, for example – frog.
- (c) **Terrestrial** – Those animals which live only on land e.g.,– man, lizards, *etc.*
  - **Aerial** – Those animals which can live in the air. e.g.,– birds and bats
  - **Arboreal** – Those animals which can live on trees and hold the branches of trees. e.g.,– monkeys.
  - **Burrowing** – Those animals which make burrows in the sand or soil and live inside. e.g.,– earthworm, snakes, some fishes, *etc.*

### Other terms related with habitat

- (a) **Solitary** – Animals which live alone or individually. e.g., – man, cat, dog, *etc.*
- (b) **Colonial** – Animals which form colonies to live together, e.g., – Bees, ants, some coelenterates (*Physalia, Obelia*), porifers (*Sycon*) *etc.*
- (c) **Sedentary** – Animals which attach fixed themselves to some substratum, such as rocks, logs of wood, sand, ships, *etc.* e.g.,– *Obelia, Sycon, etc.*
- (d) **Free swimming** – Those which can move freely here and there in the water, e.g.,– *Paramecium*, larva of frog, *etc.*
- (e) **Sessile** – Those which do not possess stalk. e.g.,– *Sycon*.
- (f) **Stalked** – Those which possess a stalk. e.g.,– *Vorticella*.
- (g) **Pelagic** – The animals occur on the surface of water of sea.
- (h) **Benthic** – Marine species which lead a sedentary life upon sea bottom.
- (i) **Abyssal** – Animals found in the deep mid water of sea where light penetration is low.
- (j) **Littoral** – Animals which live in intertidal zone of seacoast are called littorals.
- (k) **Lentic** – Organisms (fauna) inhabiting standing water bodies e.g.,– lakes, ponds, pools, swamps, *etc.* are called lentic.
- (l) **Lotic** – The animals found in the running water of river and stream like reptiles and fishes.

## 7. Body Temperature

- (a) **Cold blooded (Poikilothermic)** – Those animals whose body temperature is variable according to the environment. Body temperature is not constant. For example, frog or fish. They live in water. As the temperature of water goes down or raises up, the body temperature also goes down or raises up.

- (b) **Warm blooded (Homeothermic)** – Those animals whose body temperature is not variable according to the environment. Body temperature remains constant or fixed. e.g.,– Birds, mammals.

## 8. Coelom or body cavity

It is the cavity in between the body wall and the gut (alimentary canal) wall. It may be of –

- (a) **True coelom** – It is the cavity between the body wall and gut wall. It is formed by the splitting of mesoderm. True coelom is found in annelida and other higher animals.
- **Schizocoel** – It is the coelom formed by splitting of mesodermal layer. Examples are annelids, arthropods, mollusks, and higher chordates.
  - **Enterocoel** – It is the coelom formed by fusion of archenteron. Examples are echinoderms.
- (b) **Pseudocoelom** – It is the cavity which is filled with muscles. It is not formed by mesoderm but develops from blastocoel. e.g.,– Rotifera, Nematoda.
- (c) **Haemocoelom** – It is the cavity which is filled with blood. e.g.,– Arthropods.
- (d) **Acoelomate** – Coelom is not found in the body. e.g.,– Porifera and Coelenterate.

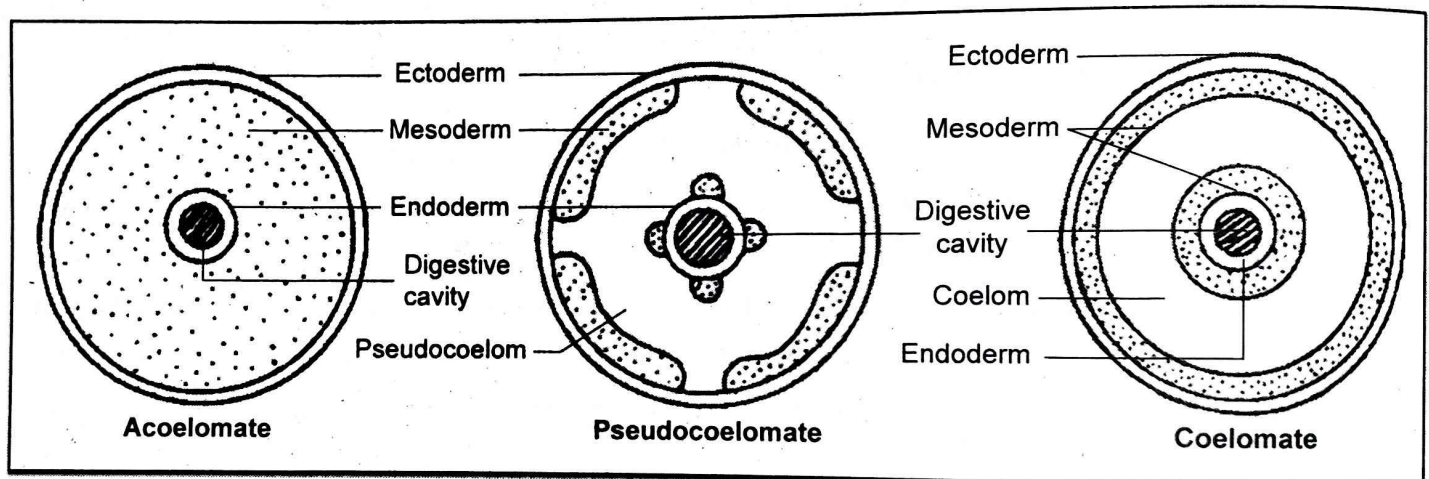


Fig 1.3 : Different types of coelom in animals

## 9. Locomotion

It is the process of movement of organisms from one place to the other. Organisms move with the help of locomotory organs. The locomotory organs in the organisms are –

- (a) **Pseudopodia** – These are the cytoplasmic processes found in the *Amoeba*, *Entamoeba*, etc.
- (b) **Flagella** – These are long, whip-like, cytoplasmic processes found in *Euglena*, *Trypanosoma*, etc. They are called as flagellates.
- (c) **Cilia** – These are small, cytoplasmic, minute hair-like processes, found in *Paramecium*, *Balantidium*, *Opalina*, etc.
- (d) **Setae** – These are the locomotory organs of earthworms. These are the chitinous structures found in earthworms.
- (e) **Parapodia** – These are the locomotory organs of *Neries*.
- (f) **Appendages** – These are the locomotory organs of arthropods.
- (g) **Muscular foot** – These are the locomotory organs of molluscs.

- (h) **Tube feet** – These are the locomotary organs of starfish.
- (i) **Fins** – These are the locomotary organs of fishes.
- (j) **Limbs** – Locomotary organs of vertebrates (Amphibia to Mammalia group).

## 10. Nutrition

It is the process of taking food. It is of following types-

- (a) **Holozoic nutrition** – An organism which takes food in solid form is called holozoic. It is also animal like, **heterotrophs** – depend on others for the food.
- (b) **Holophytic nutrition** – It is plant-like nutrition. It is also called **autotrophs** which can synthesize its own food by photosynthesis. Example – plants.
- (c) **Saprozoic nutrition** – The animals which feed on dead organic matter. e.g.,– Earthworm.
- (d) **Saprophytic nutrition** – The non-green plants which feed on dead organic matter. e.g.,– Fungi.
- (e) **Parasitic nutrition** – The organisms which live on other organisms and remain alive at the expense of host. e.g., – Liverfluke, Tapeworm, *etc.*
- (f) **Mixotrophic nutrition** – Those organisms which feed by more than one method. e.g.,– *Euglena*; which feed holophytically and saprozoically.
- (g) **Carnivorous** – Animals which feed on animal flesh. e.g.,– Tiger, Lion, *etc.*
- (h) **Herbivorous** – Those animals which feed on plants. e.g.,– Deer, Cattle, *etc.*

## 11. Digestion

It is the process of breaking down the complex foods into simpler foods chemically and mechanically.

Two types of digestion are –

- (a) **Intracellular digestion** – It is the type of digestion which takes place inside the cell. e.g.,– *Amoeba, Euglena, Paramecium, Sycon, Hydra, etc.*
- (b) **Extracellular digestion** – It is the digestion which takes place out side the cells. e.g.,– Earthworm and all other animals which possess alimentary canal.

## 12. Respiration

It is the process of taking oxygen to oxidise the simpler foods in order to release energy. It may be two types –

- (a) **Aerobic respiration** – It takes place in presence of oxygen.
- (b) **Anaerobic respiration** – It takes place in absence of oxygen. It takes place in internal parasites such as liver fluke, tape worm, round worm, *etc.*

**The respiratory organs in various organisms are –**

- (a) **General body surface** – respiratory organ of lower organisms such as *Paramecium, Sycon, Amoeba, Hydra, etc.*
- (b) **Gills** – respiratory organs found in aquatic animals such as fishes.
- (c) **Tracheae** – Minute tubes found in terrestrial animals such as insects.
- (d) **Book lungs** – Thin, lamellated structures found in scorpion for aerial respiration.

- (e) **Air sac** – A bag which is filled with air and is respiratory organ of gastropod molluscs e.g., – *Pila*.
- (f) **Lungs** – A bag like structure divided into many minute chambers called alveoli, found in terrestrial animals for aerial respiration. For example – frogs, lizards, snakes, birds, mammals.

### 13. Circulation

It is the process of flow of fluid (blood) within the body. There are two types –

- (a) **Open circulation** – It is the type of circulation in which blood circulates in the large open sinuses. Blood vessels are absent. Examples are arthropods.
- (b) **Close circulation** – It is the type of circulation in which blood flows through the closed blood vessels. Examples are annelids and vertebrates.

### 14. Excretion

It is the process of removal of waste substances from the body. The excretory organs in various organisms are –

- (a) **Contractile vacuole** – It is found in protozoans.
- (b) **Flame cell** – It is found in helminthes.
- (c) **Nephridia** – It is found in annelids.
- (d) **Malpighian tubule** – It is found in arthropods.
- (e) **Kidney** – It is found in vertebrates.

### 15. Reproduction

It is the process of giving young ones. It may be following types –

- (a) **Asexual reproduction** – It is a type of reproduction in which sexes are not involved. It takes place by one parent only. The asexual reproduction takes place by binary fission, multiple fission, budding, gemmule formation *etc.*
- **Binary fission** is a method of asexual reproduction in which a single parent divides to form two daughter individuals. The division may be transverse (*Paramecium*) or longitudinal (*Euglena*).
  - **Multiple fission** is also a method of asexual reproduction in which single parent divides several times to produce many daughter individuals. Example – *Plasmodium*.
  - **Regeneration** is a process in which an animal is cut into many parts and each part is able to grow and develop fully. e.g., – *Hydra*.
- (b) **Sexual reproduction** – It is a type of reproduction in which male and female sexes are involved. Male and female gametes are fused to form zygote.

#### Other terms related with reproduction

- (a) **Monoecious or Hermaphrodite or Bisexual** – An individual of a species having both the male and female reproductive organs e.g., – *Pheretima*, *Taenia*, *Fasciola*, *etc.*
- (b) **Unisexual or Dioecious** – When male and female reproductive organs are found in separate individual, the situation is called **dioecious**, for example – Man, *Pila*, *Prawn*, *etc.*

- (c) **Oviparous** – Animals which lay eggs. e.g.,– Fishes, amphibians, reptiles, birds.
- (d) **Viviparous** – Animals which give birth to young ones. e.g.,– Man.
- (e) **Ovo-viviparous** – Animals which give birth to the very immature birth. e.g.,– Kangaroo.
- (f) **Sexual Dimorphism** – When the male and female individuals are easily separated by looking externally only, the phenomenon is called sexual dimorphism. e.g.,– Human, *Ascaris*.
- (g) **Protandry** – It is a term used for the organism in which male reproductive organs (testis) mature earlier than the ovary. Example – Earthworm.
- (h) **Protogyny** – It is a term used for the organism in which female reproductive organs (ovary) mature earlier than the testis. Example – Human being.

## 16. Fertilization

It is a process of fusion of male and female gametes which result in the formation of zygote. It may two types.

- (a) **External fertilization** – The fertilization or fusion of male and female gametes takes place outside the body, for example – *Sycon*, frog, etc.
- (b) **Internal fertilization** – When the fertilization takes place inside the body, it is called internal fertilization – Birds, mammals.

## 17. Development

- (a) **Metamorphosis** – The larva undergoes certain changes to become adult, this process is called metamorphosis.
- (b) **Progressive Metamorphosis** – When the larva is simple and becomes complex in adult stage, for example – Tadpole of frog changes into adult.
- (c) **Retrogressive Metamorphosis** – When the larva is complex and more advanced than the adult, it is called retrogressive metamorphosis. It loses its certain characters. e.g., – Ascidiarians. Its larva has well developed notochord and nerve cord while these structures are absent and reduced in adult.
- (d) **Direct development** means when the egg changes into adult form without larval stage. (Egg → Adult)
- (e) **Indirect Development** means when the egg changes into larva and then into adult. (Egg → Larva → Pupa → Adult)

## COMMENTS ON PARAMECIUM

**Important character:** Paramecium is an unicellular and microscopic organism.

**Habit and Habitat:** It is a freshwater organism found in ponds, ditches, rivers, rice fields etc. It is abundant in stagnant water, where organic matter is plenty.

- Shape and Size:** Its anterior end is blunt and semicircular while the posterior end is pointed. Its shape is just like that of the sole of shoe, so it is named as "slipper animalcule." Its size is variable, ranging from 0.06 to 0.3 mm long.
- Pellicle:** It is a thin and elastic membrane which externally covers the body. **Function:** It gives and maintains the fixed shape of body.
- Cilia:** These are the small, numerous, hair like covering the entire body surface. These are longer in the posterior end called caudal tuft. Each cilium arises from the basal granule. **Function:** Cilia help in locomotion and food collection.
- Oral groove:** It is a large depression situated ventrally near the anterior end. It finally terminates into a food vacuole through vestibule and cytostome. **Function:** The oral groove, vestibule, cytostome and cytopharynx together form feeding apparatus.
- Cytopyge:** It is situated on the ventral surface of the oral groove. It is also called as permanent cell anal spot. **Function:** It is used to egest out the undigested food. It also acts as excretory organ.
- Trichocysts:** These are the rod shaped structure situated just below the pellicle. **Function:** The trichocyst helps in defence as well as in offence. According to modern views it also helps in sticking.
- Nuclear apparatus:** Paramecium is a binucleate (two nuclei), with nuclear dimorphism.
  - Mega-nucleus (Macro-nucleus)** – It is larger kidney shaped nucleus. **Function:** It controls the metabolic activities of the body.
  - Micro-nuclei** - It is smaller rounded nucleus situated in the depression of meganucleus. **Function:** It controls the reproduction.
- Contractile vacuoles:** There are two contractile vacuoles; one on each side of body. Each contractile vacuole is surrounded by 6 to 8 radial canals which collect water. **Function:** Contractile vacuoles function as osmoregulation.

### Viva Questions

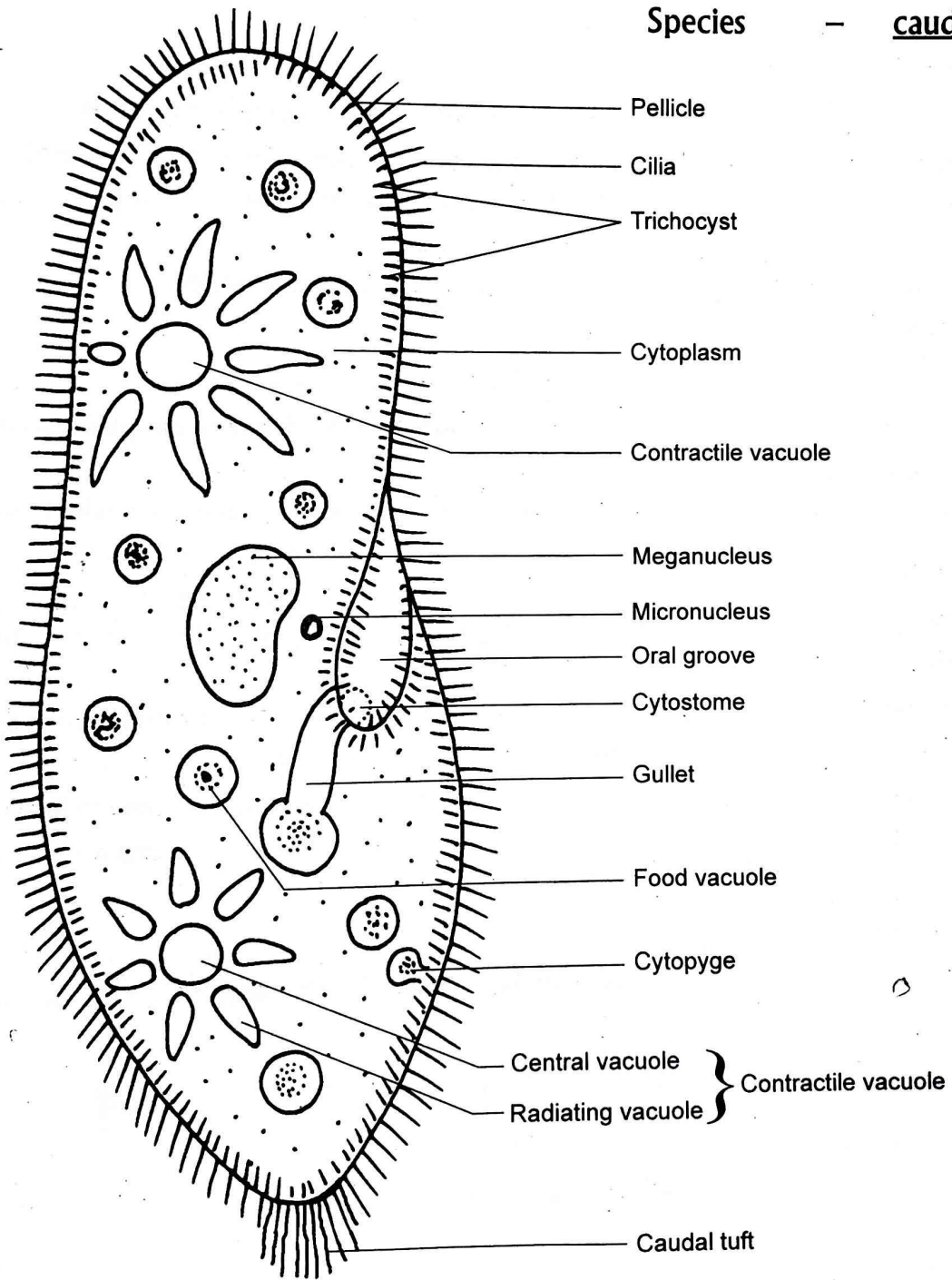
Students must remember

- Why is Paramecium kept in phylum protozoa?  
**Ans:** Because Paramecium is unicellular and microscopic.
- Why is Paramecium called slipper animalcule?  
**Ans:** As the shape of Paramecium is just like that of sole of shoe, so it is named as "slipper animalcule".
- What is the meaning of dimorphic nuclei?  
**Ans:** Paramecium consists of two nuclei of two different sizes – larger is bean shaped called meganucleus and smaller oval called micronucleus.

Date

# STUDY OF PERMANENT SLIDE

Kingdom - Protista  
 Phylum - Protozoa  
 Class - Ciliata  
 Genus - Paramecium  
 Species - caudatum



Paramecium

## COMMENTS ON PLASMODIUM

**Important character:** Plasmodium is an unicellular and microscopic organism.

**Habit and habitat:** Plasmodium is a sporozoan digenetic intracellular protozoan parasite. It is found in liver and RBC of human and in stomach and salivary glands of female Anopheles mosquito. It is common in terai parts of Nepal.

### Shape and Size

The infective stage of Plasmodium is sporozoite. It is small (10-15 mm long), sickle shaped, uninucleate and motile form of parasite.

### Life cycle

Life cycle of Plasmodium is digenetic. It completes its life cycle in two hosts -

- 1. Primary host:** It is female Anopheles mosquito, in which sexual cycle is completed. As the female Anopheles mosquito feeds on blood, only it serves as vector of malarial parasite. The parasite does not harm the mosquitoes.
- 2. Secondary host:** It is human, in which it completes its asexual cycle.

### Erythrocytic cycle

As the parasite enters the RBC of human, following stages are seen -

- 1. Trophozoite stage:** As the parasite enters the human RBC, it becomes spherical, this stage is called trophozoite stage.
- 2. Signet Ring Stage:** Inside the trophozoite, a large vacuole is developed which pushes the nucleus towards one side. It gives signet ring like appearance. This stage is known as signet ring stage.
- 3. Amoeboid stage:** Trophozoite enlarges and soon the vacuole disappears. The trophozoite becomes amoeba shaped, this is called amoeboid stage. The pseudopodia of this stage help in ingesting the cytoplasm of the corpuscles.
- 4. Schizont stage:** It is a rounded structure. Trophozoite undergoes mitotic divisions to form multinucleate stage called erythrocytic schizont which gives rise to merozoites.
- 5. Rosette stage:** It is the stage looks like rose flower in which merozoites come to lie near the membrane.
- 6. Merozoites and their release:** The merozoites are released into the plasma and further enter the fresh RBCs and repeat the erythrocytic schizogony.

### Economic Importance

Plasmodium causes a disease called malaria, characterized by alternate fever, sweating sensation and chilling sensation.

### Viva Questions

Students must remember

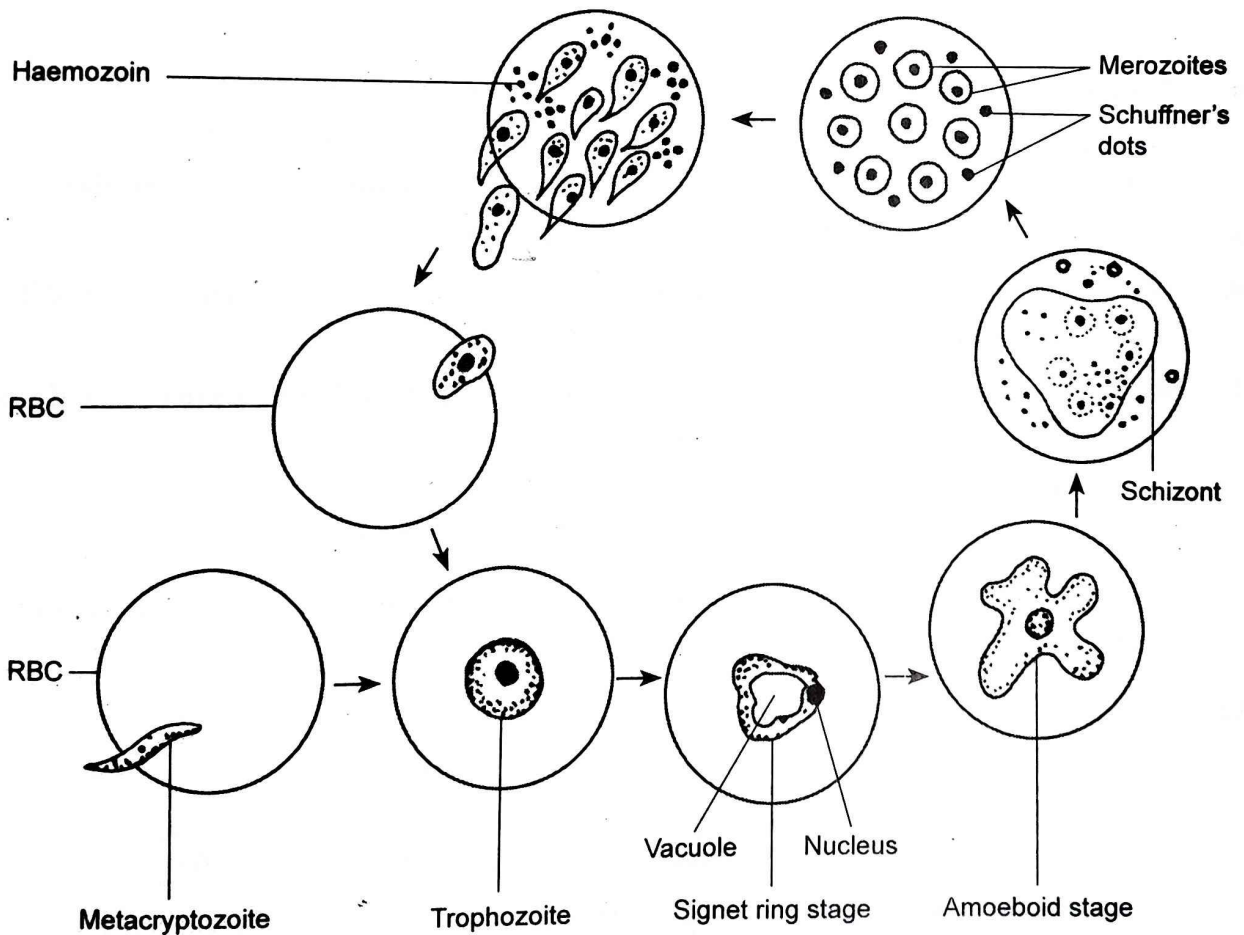
- 1. Why is Plasmodium kept in phylum protozoa?**  
**Ans:** Because Plasmodium is unicellular and microscopic.
- 2. Why is it called digenetic parasite?**  
**Ans:** Digenetic means two hosts – Primary host is mosquito and secondary host is human.
- 3. Name the disease caused due to Plasmodium.**  
**Ans:** Malaria, characterized by alternate fever. It is common in Nepal.

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Date

# STUDY OF PERMANENT SLIDE

Kingdom - Protista  
 Phylum - Protozoa  
 Class - Sporozoa  
 Genus - Plasmodium  
 Species - vivax



Erythrocytic Cycle of Plasmodium in Human

## COMMENTS ON SYCON

**Important character:** Body possesses numerous minute pores called **ostia**.

**Habitat:** Aquatic found in marine water. It is **sessile** (attached to the substratum), solitary or colonial.

- 1. Organisation:** It is multicellular organism with cellular grade of organisation. Tissues are absent.
- 2. Symmetry:** It is asymmetrical. It is vase shaped.
- 3. Body layer:** Body wall is **diploblastic** (two cellular layers) -
  - (i)** Outer layer (pinacoderm) - consisting of pinacocyte cells.
  - (ii)** Inner layer (choanoderm) - consisting of choanocyte cells.
- 4. Coelom:** They are acoelomate animals.
- 5. Water canal system:** It is system in which water enters in the body through incurrent canals and circulates in the body and expel out through spongocoel. It helps the sponge in nutrition, respiration, excretion, etc.
- 6. Nutrition:** It is **holozoic** type.
- 7. Digestion:** It is intracellular. Mouth and alimentary canal absent. The choanocyte or flagellate cells lining the inner layer ingest the food and digest it inside, hence called **intracellular**.
- 8.** Respiratory and excretory organs are absent. Osculum serves as an anus.
- 9. Skeleton:** Body is supported by **spicules** or **skeletons** which are made up of  $\text{CaCO}_3$  or silica or spongin fibres. These may be monoaxon, triaxon and tetraaxon.
- 10. Reproduction:** Reproduction is asexual by **budding** or **gemmule formation**. Sexual reproduction by gamete (ova and sperms) formation. It is hermaphrodite.
- 11.** Cross-fertilization is very common.
- 12. Regeneration:** It has the great power of regeneration.
- 13. Development:** Development is indirect having a free-swimming ciliated larva, the **amphiblastula** or **parenchymula**.

### Economic Importance

Sycon is used as cleaning material and used to make cushions.

### Viva Questions

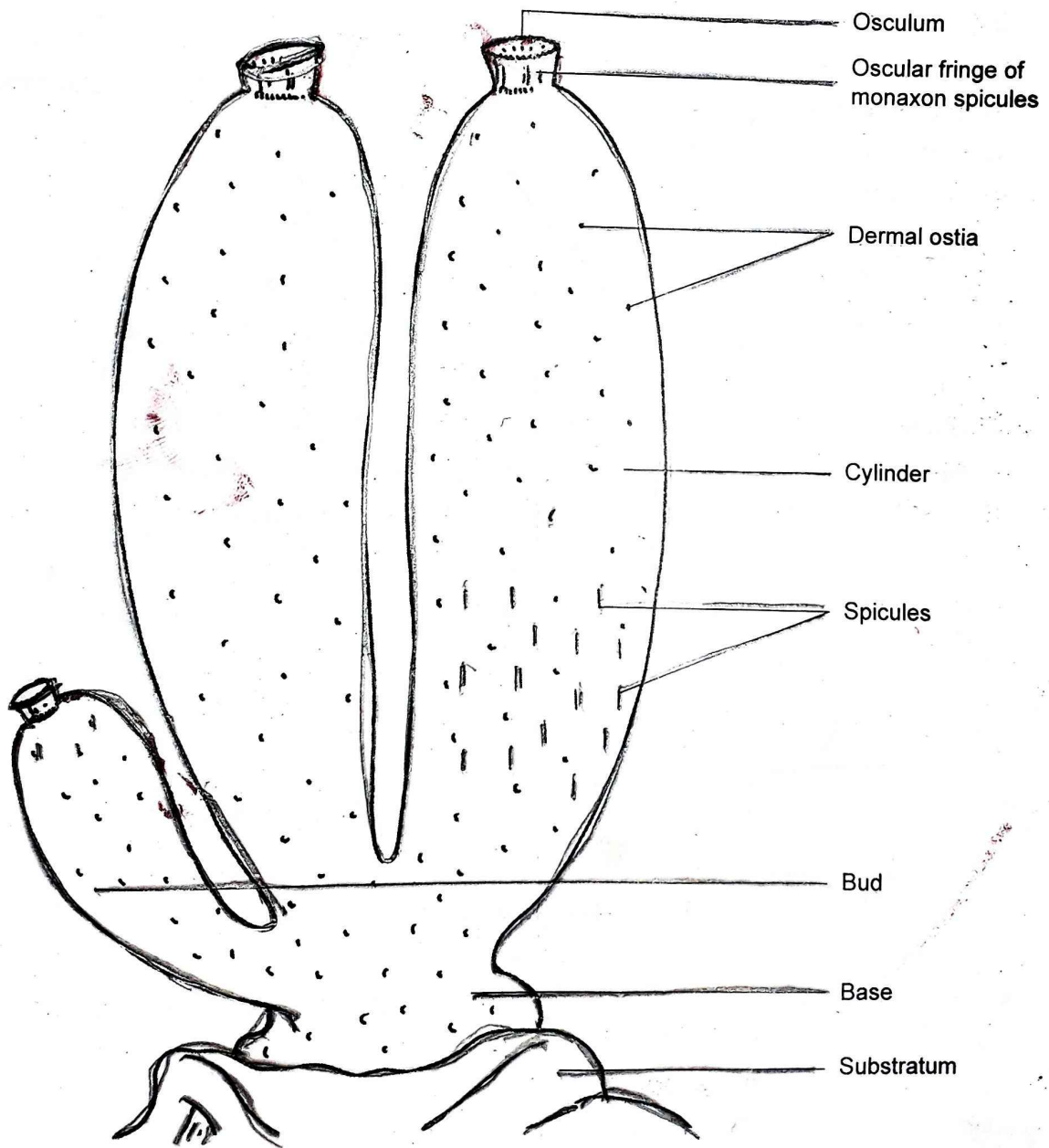
Students must remember

- Why is Sycon kept in phylum porifera?  
**Ans:** Because sycon possesses numerous minute pores called ostia.
- Why is sycon called sessile animal?  
**Ans:** Sessile means that the sycon is attached to the substratum.
- What is water canal system?  
**Ans:** It is system in which water enters in the body through incurrent canals and expel out through osculum. It helps the sponge in nutrition, respiration, excretion, etc.

Date

# STUDY OF MUSEUM SPECIMEN

Kingdom - **Animalia**  
Phylum - **Porifera**  
Class - **Calcarea**  
Genus - **Sycon**



Sycon Sp.

## COMMENTS ON HYDRA

**Important character:** Body possesses an internal hollow cavity or gastro-vascular cavity known as coelenteron and animals are called as coelenterates.

**Habitat:** It is aquatic found in freshwater. It remains attached to the substratum.

- Symmetry:** It is usually radially symmetrical. It is elongated, cylindrical body.
- Germ layers:** It is diploblastic (two cellular layers) -
  - Outer layer – ectoderm
  - Inner layer - endoderm
  - In between both layers, there is a gelatinous non-cellular layer - mesogloea.
- Its proximal end is known as pedal disc. It is provided with gland cells, which secrete adhesive substance to attach with substratum.
- Tentacles:** Mouth is encircled by 6-8 tentacles which bear nematocysts. Tentacles help to capture the prey present in water. Tentacles bear a stinging or nematocysts cells that secrete a hypnotizing chemical to paralyze the prey.
- Digestion:** Digestion in intracellular as well as extracellular.
- Coelom, respiratory, circulatory and excretory organs are absent.
- Respiration and excretion take place through general body surface.
- Reproductive system:** It reproduces both by asexually and sexually.
  - Asexually reproduction takes place by budding or fission or regeneration,
  - Sexually reproduction by formation of gametes (ova and sperms).
- Polymorphism:** It exhibits polymorphism or two forms of individuals -
  - Asexual form - **polyp**
  - Sexual form - **medusa**
- Alternation of generation:** Hydra illustrates an alternation of generation or metagenesis. Asexual generation (Polyp form) alternates with the sexual generation (medusa form) and vice-versa.

### Economic Importance

It is used in regeneration and grafting experiments.

### Viva Questions

Students must remember

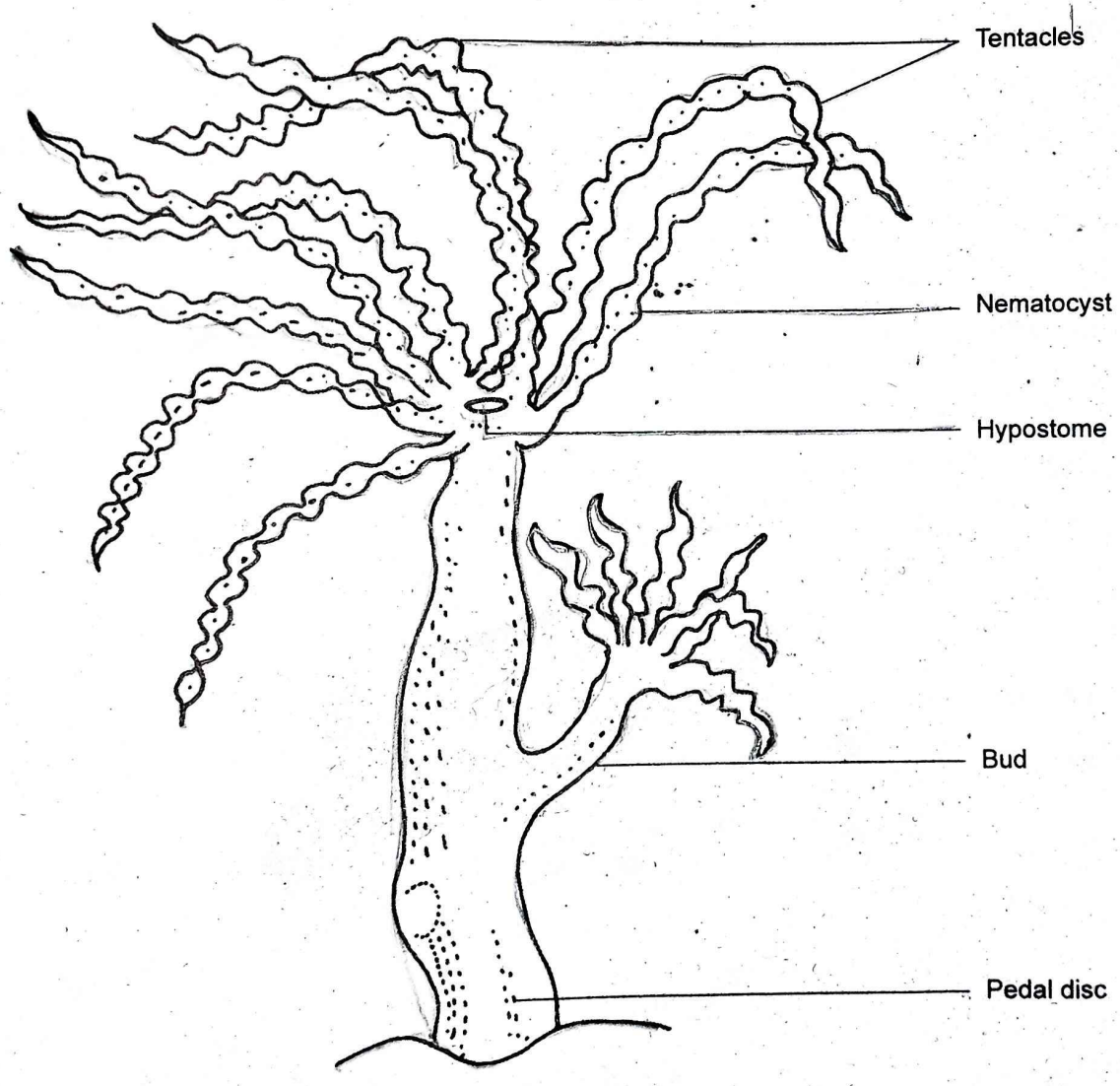
- Why is Hydra kept in phylum coelenterata?  
**Ans:** Because hydra possesses internal hollow cavity called gastro-vascular cavity or coelenteron.
- What is meaning of radial symmetry?  
**Ans:** Radial symmetry means that the body can be divided in two equal halves when the body is cut from any radial sides passing through the central axis.
- What is the function of tentacles?  
**Ans:** Tentacles help in locomotion and food capture as it bears stinging (nematocyst) cells.
- What is alternation of generation?  
**Ans:** Alternation of generation is defined as the hydra alternates its asexual generation (Polyp form) with the sexual generation (medusa form) and vice-versa.

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Date

# STUDY OF PERMANENT SLIDE

- Kingdom - Animalia
- Phylum - Coelenterata
- Class - Hydrozoa
- Genus - Hydra



Hydra Sp.

## COMMENTS ON LIVER FLUKE

**Important character:** Body is dorso-ventrally flattened or leaf like, hence called as flat worm.

**Habitat:** It is an endoparasite, found in the liver and bile ducts of sheep and cattle. It causes liver rot.

- Structure:** It is dorso-ventrally flattened or leaf like.
- Symmetry:** It is triploblastic and bilaterally symmetrical.
- Coelom:** It is acoelomate animal. The space between body wall and the internal organs is filled up with parenchyma.
- Suckers:** Liver fluke possesses two suckers - oral sucker and ventral sucker. These are the hold fast organs which enable the parasite to remain inside the bile ducts of liver.
- Nutrition** is parasitic type.
- Digestive system:** The alimentary canal is bifurcated and branched. Anus is absent.
- Respiratory system:** Respiratory organ is absent. It is anaerobic type.
- Flame cell:** It is an excretory organ also called protonephridia. Excretory pore is situated at posterior end.
- Nervous system:** It is primitive and a ladder like. It consists of a pair of anterior ganglia and a nerve cord connected by transverse nerves.
- Reproductive system:** It is well developed and complex. They are hermaphrodite or monoecious (male and female reproductive organs present in single body).
- Fertilization:** It is internal; may be cross or self. However, parthenogenesis or polyembryo commonly occur in larval forms.
- Life cycle:** Its life cycle is complex which requires two hosts. It is called digenetic.
  - Primary host – Sheep or cattle
  - Secondary host – Snail (aquatic)

### Economic Importance

It causes disease called liver rot in herbivorous animals.

### Viva Questions

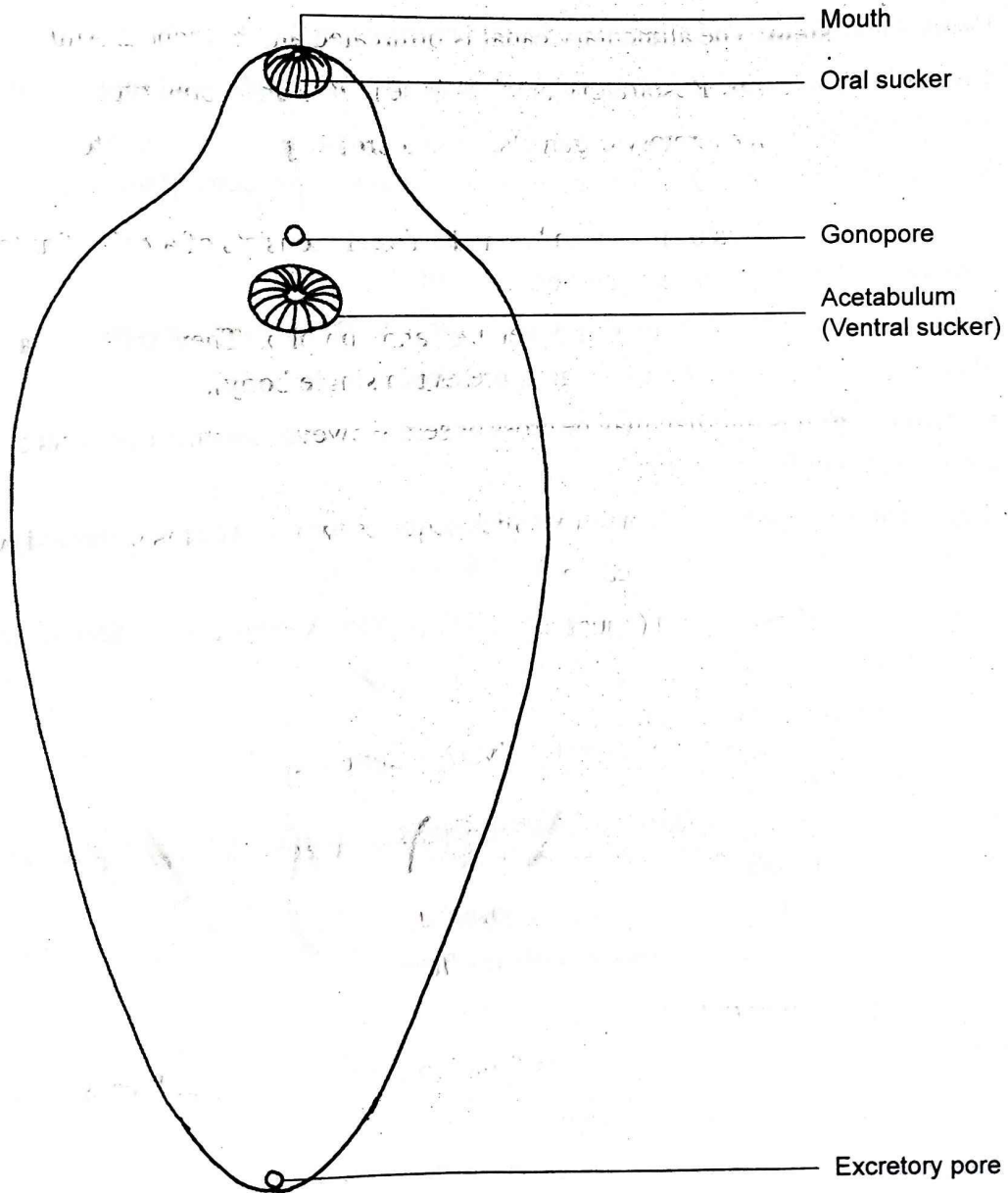
### Students must remember

- Why is Liver fluke kept in phylum Platyhelminthes?  
**Ans:** Because liver fluke is dorso-ventrally flattened.
- Why is it called liver fluke?  
**Ans:** Because, it is the worm which is found in the liver of sheep. It causes a disease – liver rot.
- What is the meaning of hermaphrodite?  
**Ans:** It is the bisexual, in which male and female reproductive organs present in single body.
- What is flame cell?  
**Ans:** It is the excretory organ of liver fluke and other flat worms.

Date

# STUDY OF MUSEUM SPECIMEN

Kingdom - Animalia  
Phylum - Platyhelminthes  
Class - Trematoda  
Genus - Fasciola  
Species - hepatica



*Fasciola hepatica*

## COMMENTS ON TAPE WORM

**Important character:** Body is dorso-ventrally flattened or ribbon like, hence called as tape worm.  
**Habitat:** It is an endoparasite, found in the intestine of human and other vertebrates. It is commonly known as **pork tape worm**, because it is caused by eating of pork meat. It causes a disease Taeniasis.

1. **Shape and size:** It is long segmented tape like body. It measures upto 2-4 meters.
2. **Structure:** The body is divided into three parts – Head, neck and proglottids.
  - (a) **Head or rostellum:** Head bears four suckers and double rows of hooks. It remains embedded inside the mucosa of human intestine.
  - (b) **Neck:** It is short and has the power of regeneration of proglottids.
  - (c) **Proglottids:** These are the segments which are three types – **Immature, mature** and **gravid** proglottids. The both male and female reproductive organs are present in each proglottid.
4. **Symmetry:** It is triploblastic and bilaterally symmetrical.
5. **Coelom:** It is acoelomate animal. The space between body wall and the internal organs is filled up with parenchyma.
6. **Nutrition** is parasitic type. Tapeworm has no digestive system. It absorbs nutrients through the body surface.
7. **Digestive system:** Alimentary canal is absent.
8. **Respiratory system:** Respiratory organ is absent. It is anaerobic type.
9. **Flame cell:** It is an excretory organ also called protonephridia.
10. **Nervous system:** It is primitive and a ladder like. It consists of a pair of anterior ganglia and a nerve cord connected by transverse nerves.
11. **Reproductive system:** It is well developed and complex. They are **hermaphrodite** or monoecious (male and female reproductive organs present each segment).
12. **Life cycle:** Its life cycle is complex which requires two hosts. It is called **digenetic**.
  - Primary host – Human
  - Secondary host – Pig or cattle

### Economic importance

It is an endoparasite, causes a disease Taeniasis in human. Men gets infection by eating improperly cooked, infected pork meat.

### Viva Questions

### Students must remember

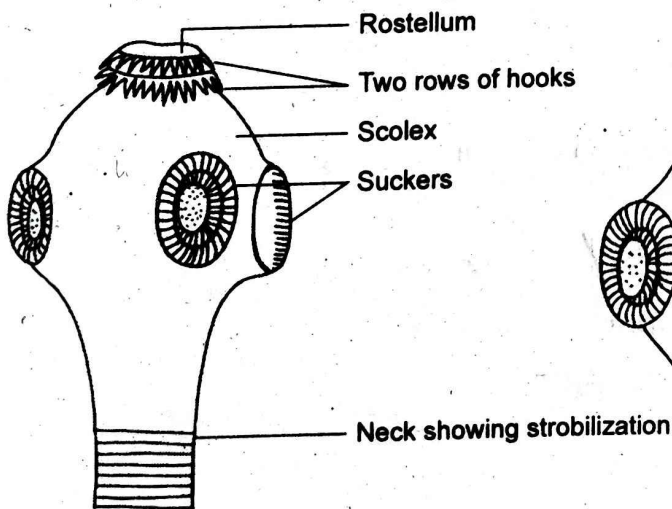
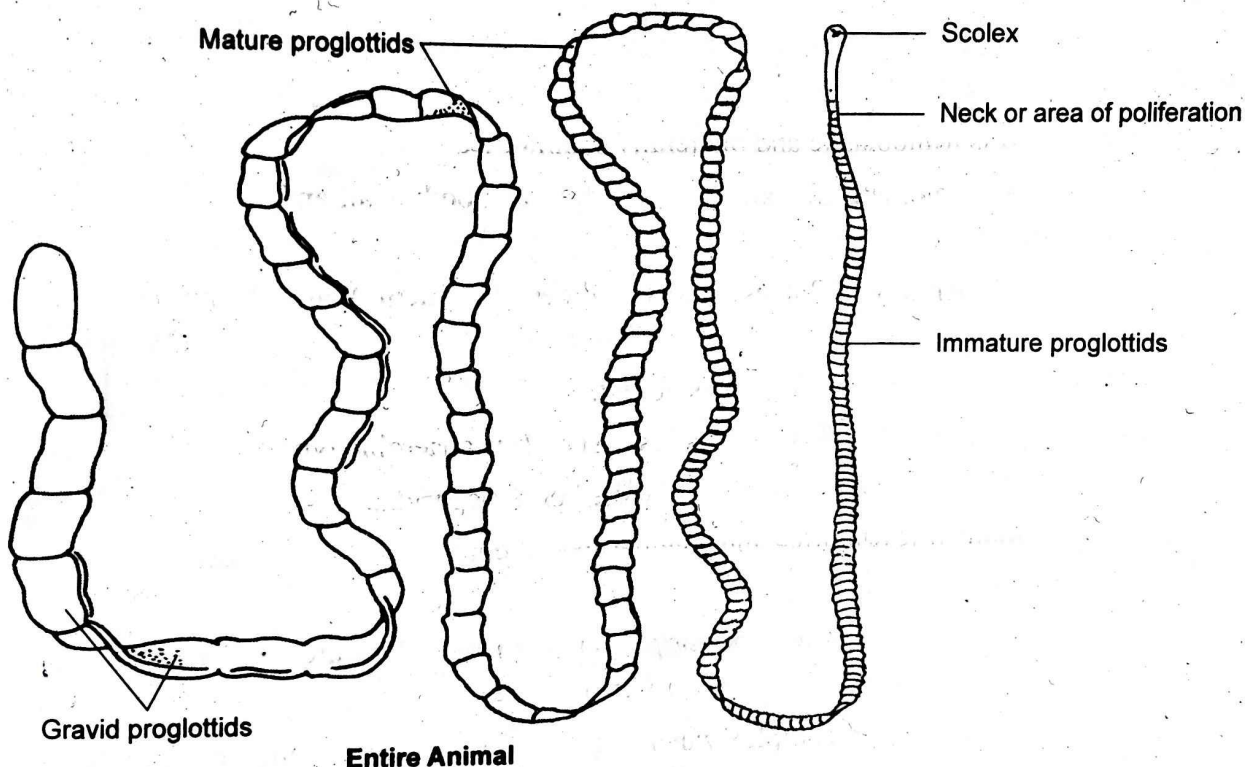
1. Why is tape worm kept in phylum Platyhelminthes?  
**Ans:** Because tape worm is dorso-ventrally flattened and tape like.
2. Why is it called pork tape worm?  
**Ans:** Because, it is the worm caused by ingesting the raw pig meat.
3. Where does the tape worm live?  
**Ans:** It is an endoparasite, lives in the intestine of human being.

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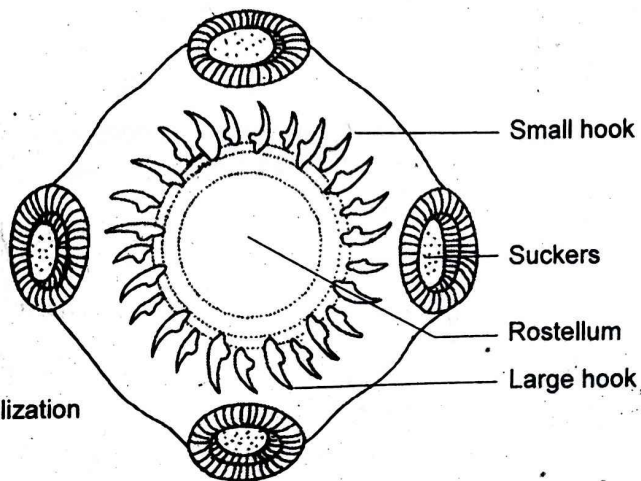
Date

# STUDY OF MUSEUM SPECIMEN

Kingdom - Animalia  
 Phylum - Platyhelminthes  
 Class - Cestoda  
 Genus - Taenia  
 Species - solium



**Scolex and neck in side view**



**Scolex in en-face view**

## COMMENTS ON ASCARIS

**Important character:** It is cylindrical, elongated, unsegmented and worm like.

**Habitat:** It is an endoparasite found in the small intestine of human. It causes a disease known as ascariasis.

- Structure:** It is cylindrical, elongated, unsegmented worm like.
- It is triploblastic and bilaterally symmetrical.
- Coelom:** Coelom is pseudocoelom type.
- Digestive system:** Alimentary canal is complete and straight. Mouth is terminal surrounded by lips.
- Respiratory system:** Respiration is anaerobic type.
- Excretory system:** Excretion takes place by lateral excretory ducts which collect the excretory substances and expel out through anus.
- Nervous system:** It consists of a nerve ring and a longitudinal nerve cord. Sense organs are poorly developed. Two types of sensory organs are -
  - Amphids** are the gustatory, sensory and chemoreceptors located at mouth.
  - Phasmids** are the chemoreceptors located in the tail region.
- Reproductive system:** It is unisexual or **dioecious** (male and female individuals are separate). Females are comparatively longer than males. No asexual reproduction.
- Life cycle:** Its life cycle is simple which requires single host, called monogenetic.
- A mature worm releases about 200,000 eggs. Development of egg is indirect with larval stages – rhabditid form and filariform larvae.

### Economic importance

It is an endoparasite, causes a disease Ascariasis in human. Person gets infection through contaminated hands, water and raw vegetables.

Male <i>Ascaris</i>	Female <i>Ascaris</i>
It is smaller than female.	It is longer than male.
Tail is curved.	Tail is straight.
Tail consists a pair of penial setae.	No penial setae.

### Viva Questions

Students must remember

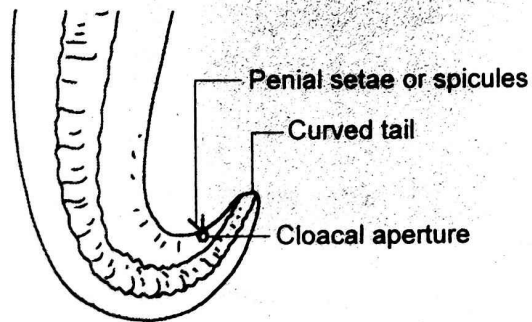
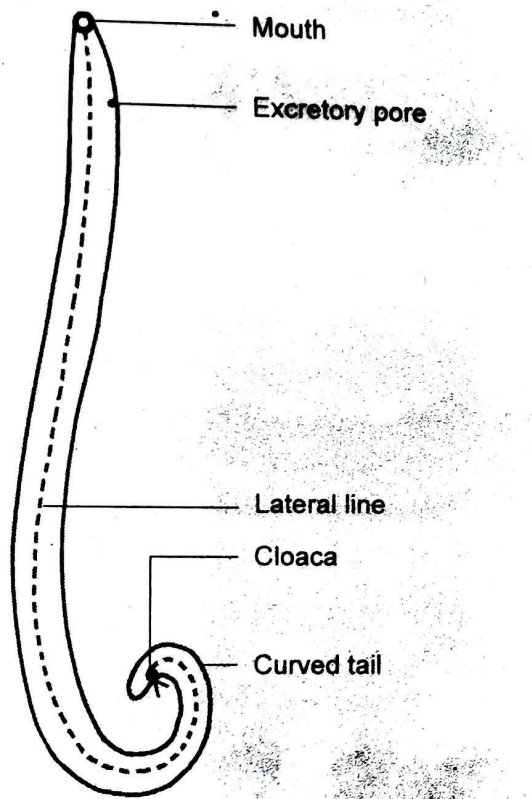
- Why is *Ascaris* kept in phylum Nematelminthes?  
**Ans:** Because *Ascaris* is cylindrical, elongated, unsegmented and worm like.
- Why is it called unisexual animal?  
**Ans:** Because, male and female worms are separated.
- Where does the round worm live?  
**Ans:** It is an endoparasite lives in the small intestine of human being and other vertebrates.
- What are the differences between male and female *Ascaris*?  
**Ans:** Male is smaller and has curved tail where as female is longer and has straight tail.

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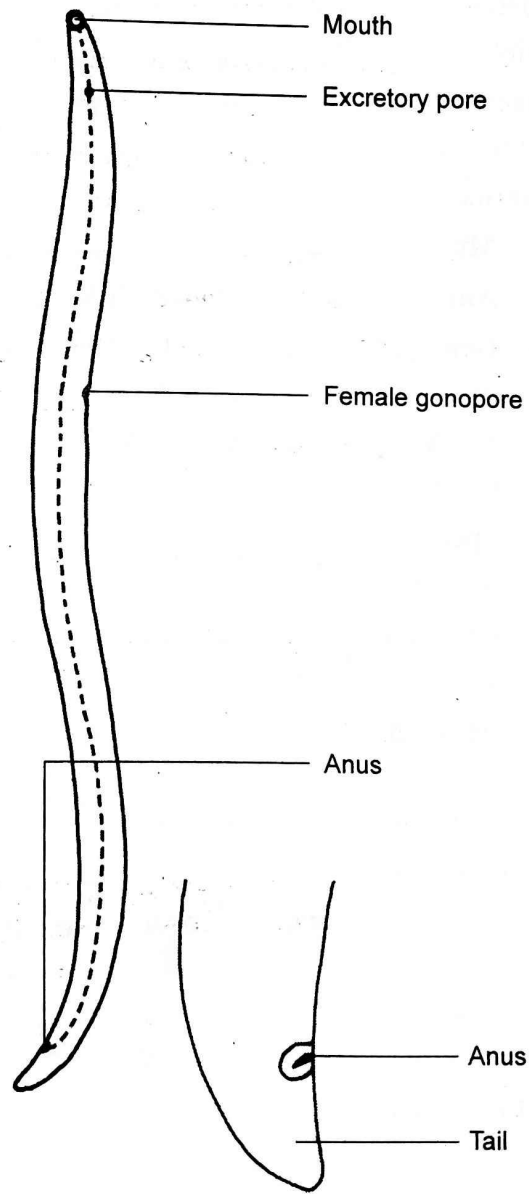
Date

# STUDY OF MUSEUM SPECIMEN

Kingdom - Animalia  
Phylum - Nematelminthes  
Class - Nematoda  
Genus - Ascaris  
Species - lumbricoides



Male



Female

Roundworm

## COMMENTS ON EARTHWORM

**Important character:** Earthworm is elongated and metamerically segmented.

**Habitat:** It is terrestrial, very common in the soil of gardens and irrigated farms. It generally inhabits an upper layer of earth to a depth of about 30 to 45 cms.

1. **Shape, size and colour:** The anterior end is tapering while the posterior end is more or less blunt. A mature worm measures about 15cm in length. The dorsal surface of body is darker than ventral surface due to presence of porphyrin pigment.
2. **Segmentation:** An earthworm is divided into 100-120 segments called metameres.
3. **Clitellum:** It is a thick collar or girdle like glandular thickening of body wall. It occurs in the segments 14, 15 and 16. During breeding season, clitellum forms **cocoons** in which ova are laid and fertilised.
4. **Prostomium:** There is no distinct head. The 1<sup>st</sup> segment is **peristomium**. It bears a mouth and a dorsal fleshy lobe like overhanging structure called **prostomium**.
5. **Setae:** These are the locomotory organs found in all segments except first, last and clitellum. Each segment has about 80 - 120 setae.
6. **External apertures**
  - (a) **Mouth:** It is large, crescentic and terminal aperture, situated in first segment.
  - (b) **Anus:** It is small and vertical slit like aperture at the end of last segment.
  - (c) **Genital openings:** Earthworm is hermaphrodite, so male and female generative apertures are found in the same individual.
    - **Male genital pores:** One pair located ventrolaterally in 18<sup>th</sup> segment.
    - **Female genital pore:** A single located mid-ventral in 14<sup>th</sup> segment.
  - (d) **Spermathecal pores:** There are four pairs of small ventro-lateral spermathecal apertures lying between segments of 5/6, 6/7, 7/8 and 8/9. They collect sperms.
  - (e) **Genital papillae:** These are copulatory papillae situated one pair each in 17<sup>th</sup> and 19<sup>th</sup> segments. These help in copulation.
  - (f) **Dorsal pores:** These are small openings situated after 12<sup>th</sup> segment to all segments except last segments.
  - (g) **Nephridiopores:** These are minute openings situated throughout the body except anterior first three segments. These excrete metabolic wastes.

### Viva Questions

Students must remember

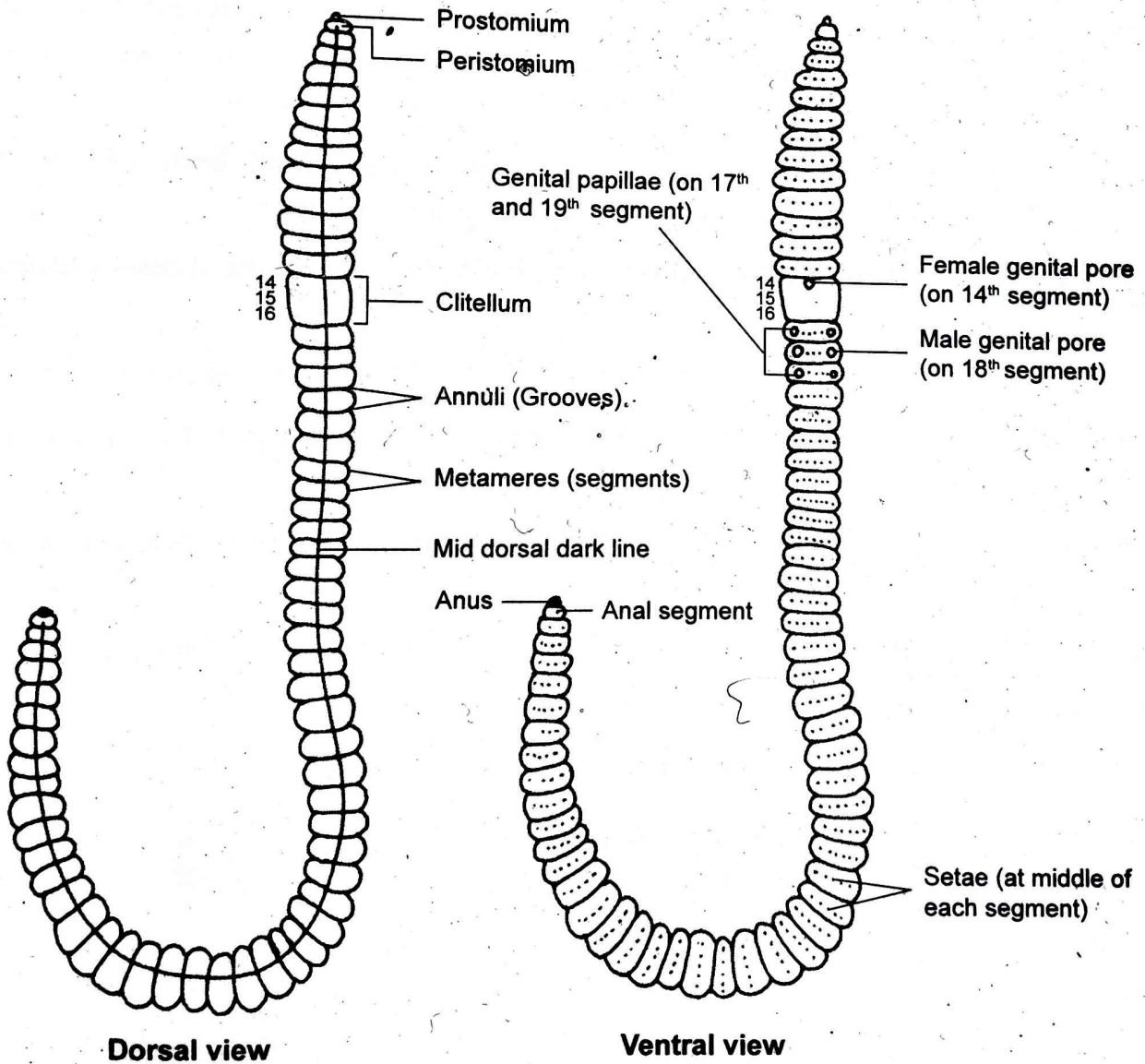
1. Why is earthworm kept in phylum Annelida?  
**Ans:** Because earthworm is cylindrical, elongated and metamerically segmented.
2. What is the meaning of metameric segmentation?  
**Ans:** Body is segmented externally as well as internally.
3. Which segment has male and female genital pores situated?  
**Ans:** Male genital pore is situated in 18<sup>th</sup> segment and female genital pore is in 14<sup>th</sup> segment..
4. What are the excretory organs and locomotory organs?  
**Ans:** The excretory organ is nephridia and locomotory organ is seta.

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Date

# STUDY OF MUSEUM SPECIMEN

Kingdom - Animalia  
 Phylum - Annelida  
 Class - Oligochaeta  
 Genus - Pheretima  
 Species - posthuma



*Pheretima posthuma*

## COMMENTS ON NEREIS

**Important character:** Nereis is elongated and metamerically segmented.

**Habitat:** It is found in U-shaped burrows in sand or mud of the seashore, commonly as clam worm or sand worm.

1. **Shape, size and colour:** It is elongated, bilaterally segmented. Its anterior end is broad and posterior end tapers. A mature worm measures about 40 cm. It is brownish in colour.
2. **Segmentation:** The body is divided into 80 to 200 segments depending on species.
3. **Clitellum:** Clitellum is absent.
4. **Body divisions:** The body is divided into three regions – **Head, trunk and pygidium.**
  - (a) **Head:** Nereis possesses a well developed head, consisting of peristomium and prostomium. It bears a pair of tentacles, two pairs of eyes, one pair of prostomial palps and two pairs of prostomial cirri. Tentacles, palps and cirri serve as sensory organs.
  - (b) **Trunk:** It is the entire body part except head and pygidium. Each trunk segment bears locomotory organ parapodia on lateral sides and nephridiopores.
  - (c) **Pygidium:** It is the last body segment, also known as anal segment. It bears a terminal anus, a pair of long appendages called anal cirri.
4. **Coelom:** It is true coelom type (coelomate animal), formed by the splitting embryonic mesoderm.
5. **Nephridia:** These are the excretory organs situated one pair in each segment except few anterior and few posterior segments.
6. **Blood vascular system:** It is closed type. Blood vessels are present. Blood is red due to presence of haemoglobin dissolved in plasma.
7. **Reproduction:** It is hermaphrodite. However, some species of Nereis are unisexual.

### Economic Importance

It is used as the food for higher animals.

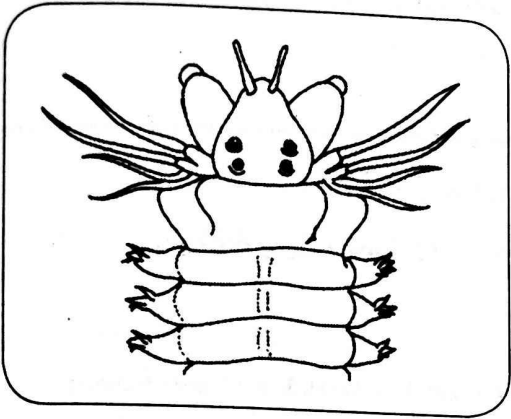
### Viva Questions

Students must remember

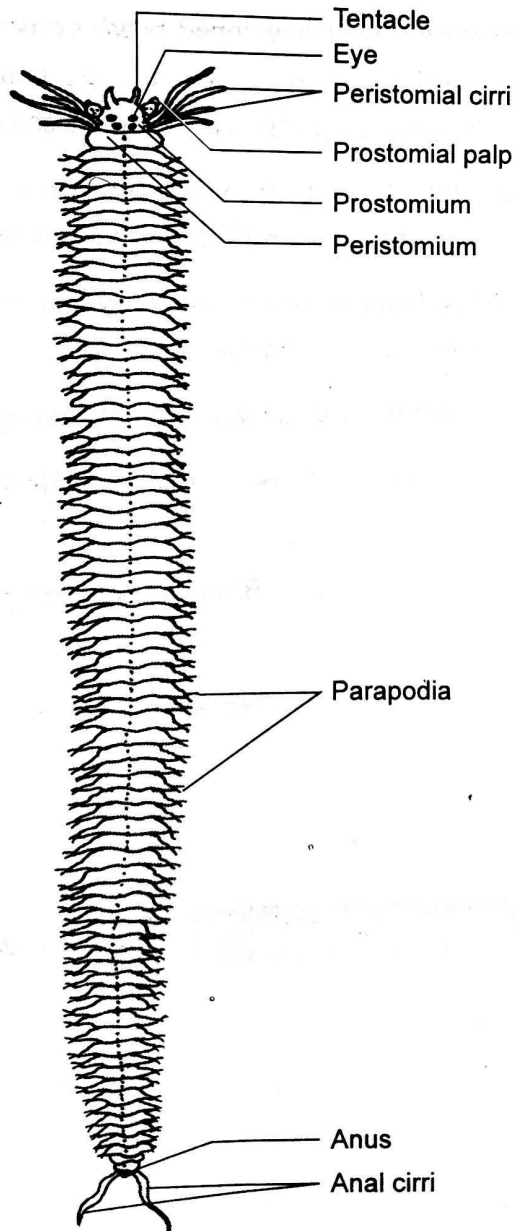
1. Why is Nereis kept in phylum Annelida?  
**Ans:** Because it is cylindrical, elongated and metamerically segmented.
2. What is the locomotory organ of Nereis?  
**Ans:** The locomotory organ of Nereis is parapodia.
3. What type of coelom is present in Nereis or earthworm?  
**Ans:** They have true coelom. It is formed by the splitting embryonic mesoderm.

Date

# STUDY OF MUSEUM SPECIMEN



Kingdom - Animalia  
Phylum - Annelida  
Class - Polychaeta  
Genus - Nereis



Nereis

## COMMENTS ON LEECH

**Important character:** Leech is elongated and metamerically segmented.

**Habitat:** It is found in freshwater ponds, lakes etc. It is an ectoparasite, sucking blood of fish, frogs, cattle and human. (called sanguivorous). During feeding, leech secretes hirudin, or anticoagulin in their saliva which prevents the clotting of blood.

1. **Shape, size and colouration:** It is soft, elongated and dorso-ventrally flattened. It measures upto 30 cm. Body of leech is brightly coloured. Its dorsal surface is olive green and ventral surface is orange – yellow or orange red.
2. **Segmentation:** Body of leech is metamerically divided into 33 segments or somites. Except the first two and last seven, each segment is further superficially subdivided into rings or annuli.
3. **Receptors:** There are five pairs of eyes located in the 1<sup>st</sup> five segments.
4. **Suckers:** There are two suckers – anterior sucker and posterior sucker. Anterior sucker is used to suck the blood (feeding) and posterior sucker is used for attachment and locomotion.
5. **Clitellum:** A permanent clitellum does not exist in leech. It develops temporarily during breeding season only. It occurs in the segments 9<sup>th</sup>, 10<sup>th</sup> and 11<sup>th</sup> segments.
6. **External apertures**
  - (a) **Mouth:** It is a narrow triradiate aperture, situated in the preoral chamber of anterior sucker.
  - (b) **Anus:** It is small aperture situated mid – dorsally on the 26<sup>th</sup> segment
  - (c) **Genital openings:** Leech is hermaphrodite, so male and female generative apertures are found in the same individual.
    - **Male genital pore:** One pair located ventrolaterally in 10<sup>th</sup> segment.
    - **Female genital pore:** A single located mid-ventral in 11<sup>th</sup> segment.
  - (d) **Nephridiopores:** These are minute openings situated one pair in each segment from 6 to 22 segments.

### Economic Importance

It sucks (feeds on) the blood of vertebrates. It is also used as medicines for piles.

### Viva Questions

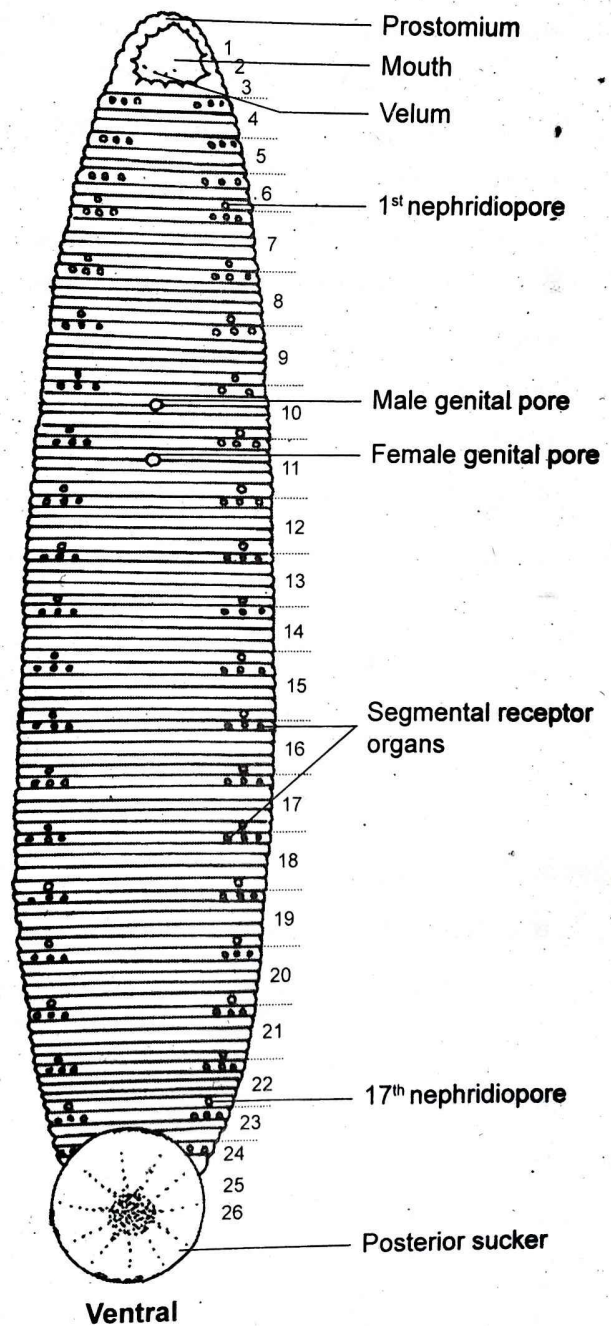
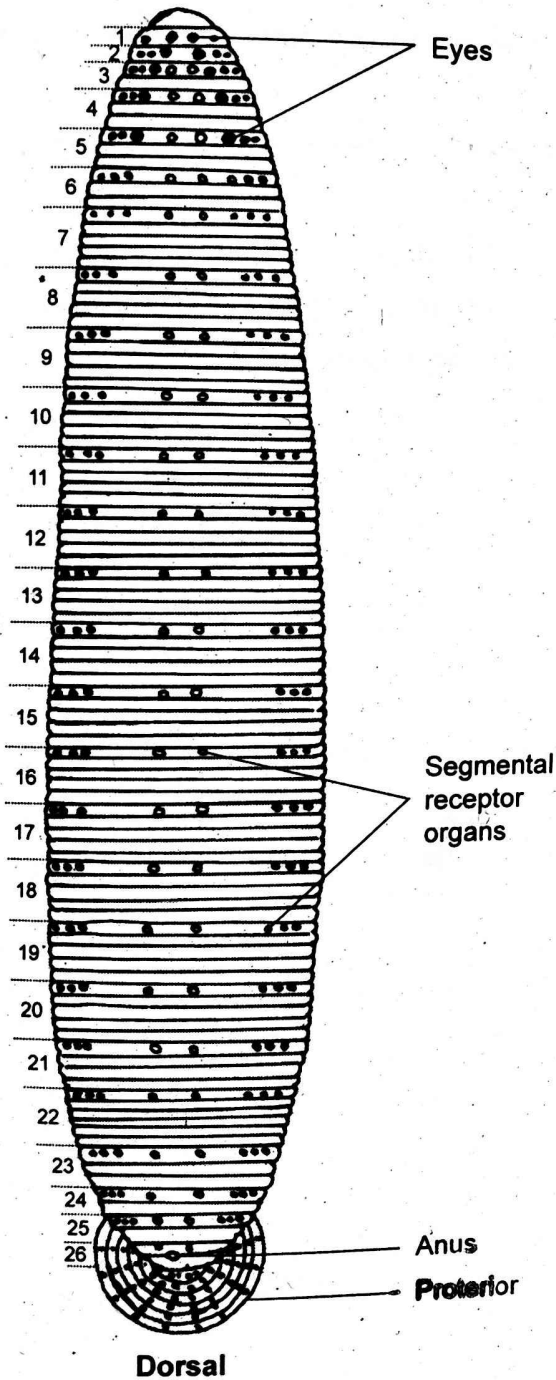
Students must remember

1. What is the difference between the clitellum of earthworm and clitellum of leech?  
**Ans:** Earthworm has permanent clitellum but leech has temporary clitellum.
2. Which segment has the clitellum present?  
**Ans:** Clitellum is present in 9<sup>th</sup>, 10<sup>th</sup> and 11<sup>th</sup> segments.
3. Why is leech called hirudinaria?  
**Ans:** Because leech secretes hirudin, or anticoagulin in their plasma which prevents the clotting of blood, during sucking blood (anti-coagulation).

Date

# STUDY OF MUSEUM SPECIMEN

Kingdom - **Animalia**  
 Phylum - **Annelida**  
 Class - **Hirudinea**  
 Genus - **Hirudinaria**  
 Species - **granulosa**



Leech

## COMMENTS ON PRAWN

**Important character:** Prawn consists of five pairs of jointed legs.

**Habitat:** It inhabits freshwater streams, rivers, ponds and lakes. It is omnivorous, feeding on small organisms like algae, mosses, small insects, etc.

- Shape and size:** It is elongated, more or less spindle shaped and bilaterally symmetrical. It measures 25 to 40 cm in length.
- Colouration:** Young prawns are pale greenish colour with orange red patches.
- Exoskeleton:** Body and appendages is covered externally by a hard chitinous exoskeleton.
- Body divisions:** The body of adult prawn is divided into two parts – anterior cephalothorax (fused head -thorax) and a posterior abdomen.
- Cephalothorax:** Head bears a pair of compound eyes, antenna and feeding apparatus. The thorax bears five pairs of walking legs.
- Abdomen:** It bears 6 pairs of abdominal appendages, one pair in each of its segments. The first five pairs are the swimming pleopods used as paddles, while the 6<sup>th</sup> pair is the uropods (as tail fin).
- Coelom:** It is haemo-coelom type (coelom is filled with blood).
- Digestive system:** Alimentary canal is straight and well developed. The mouth bears mouthparts as feeding apparatus.
- Respiration:** It takes place by gills or branchiae covered in a gill chamber.
- Circulatory system:** It is open type, consisting of perivisceral and pericardial sinuses. Blood vessels are absent.
- Excretory organ:** Excretion takes place by antennary or green glands.
- Sensory organs:** These include antennae, compound eye, statocysts, etc. Compound eye consists of many ommatidia to form several images.
- Reproduction:** They are unisexual i.e. male and female sexes are separate. Fertilization is internal.

### Economic Importance

It is used as food by man and other vertebrates.

### Viva Questions

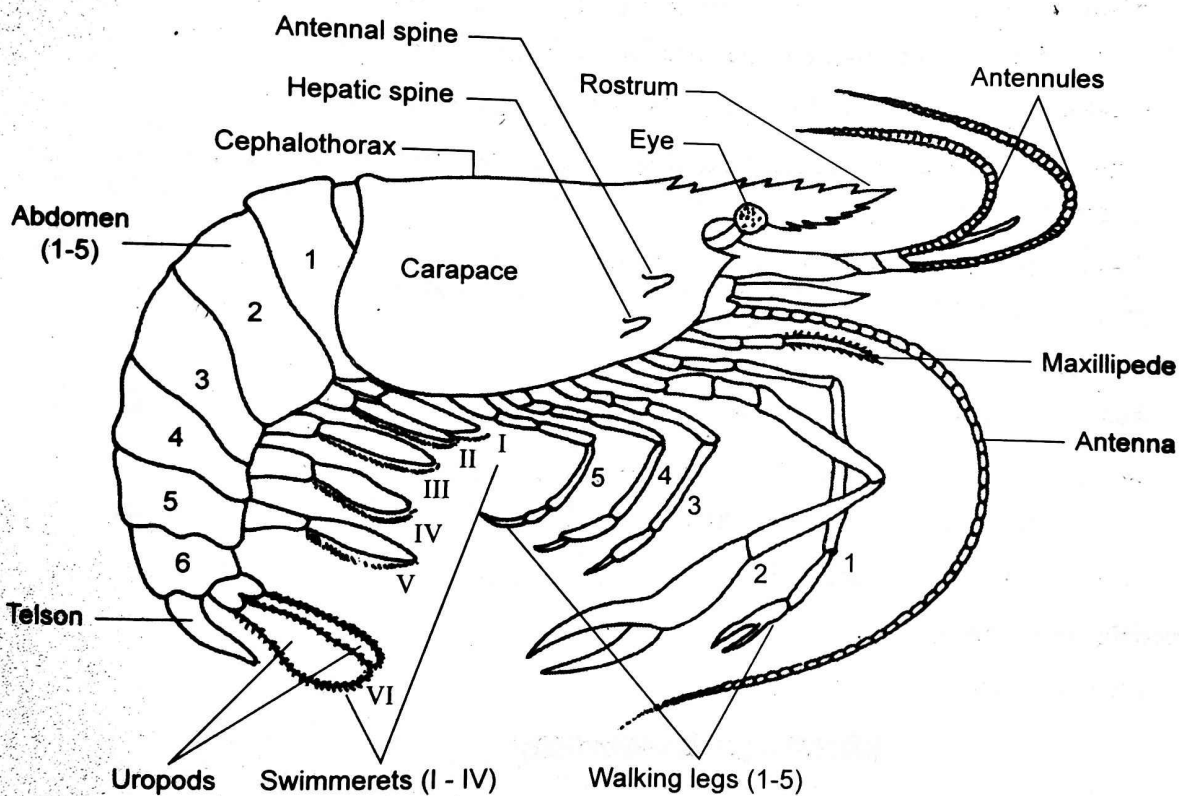
Students must remember

- Why is prawn kept in phylum Arthropoda?  
**Ans:** Because prawn bears jointed appendages
- Why is prawn kept in class crustacea?  
**Ans:** crusta means hard shell. Prawn is protected by a hard covering or exoskeleton.
- Where does the prawn found?  
**Ans:** It is found in freshwater streams, rivers, ponds and lakes.
- How many pairs of walking legs in prawn?  
**Ans:** It bears 5 pairs of walking legs.

Date

# STUDY OF MUSEUM SPECIMEN

Kingdom - Animalia  
 Phylum - Arthropoda  
 Subphylum - Mandibulata  
 Class - Crustacea  
 Genus - Palaemon



## COMMENTS ON CRAB (CANCER)

**Important character** – Crab consists of five pairs of jointed legs.

**Habitat** – It inhabits freshwater streams, rivers, ponds and lakes. It is called true crab.

- 1. Shape and colour** – It is flat and broad. It is dark brown in colour.
- 2. Exoskeleton** – Body and appendages is covered externally by a hard chitinous exoskeleton, also called carapace.
- 3. Body divisions** – The body of adult prawn is divided into two parts – anterior cephalothorax (fused head -thorax) and a posterior abdomen.
- 4. Cephalothorax** – It is broader than long. Antennules and antennae are small. Antennules and eye stalks are contained in sockets of carapace.
- 5. Abdomen** – It is segmented and reduced. It remains permanently bend under ceplahothorax. Uropods are absent.
- 6. Locomotion** – There are 5 pairs of well developed thoracic legs with claws. First legs are chelate, forming the large pinching claws. Remaining legs are non-chelate.
- 7. Coelom** – It is haemo-coelom type (coelom is filled with blood).
- 8. Respiration** – It takes place by gills or branchiae covered in a gill chamber.
- 9. Circulatory system** – It is open type consisting of perivisceral and pericardial sinuses. Blood vessels are absent.
- 10. Excretory organ** – Excretion takes place by antennary or green glands.
- 11. Nervous system** – It consists of a brain and double ventral nerve cord.
- 12. Sensory organs** – These include antennae, compound eye, statocysts, etc. Compound eye consists of many ommatidia to form several images.
- 13. Reproduction** – They are unisexual i.e. male and female sexes are separate. Fertilization is internal. They are either oviparous or ovoviviparous.

### Economic Importance

Used as food.

### Viva Questions

Students must remember

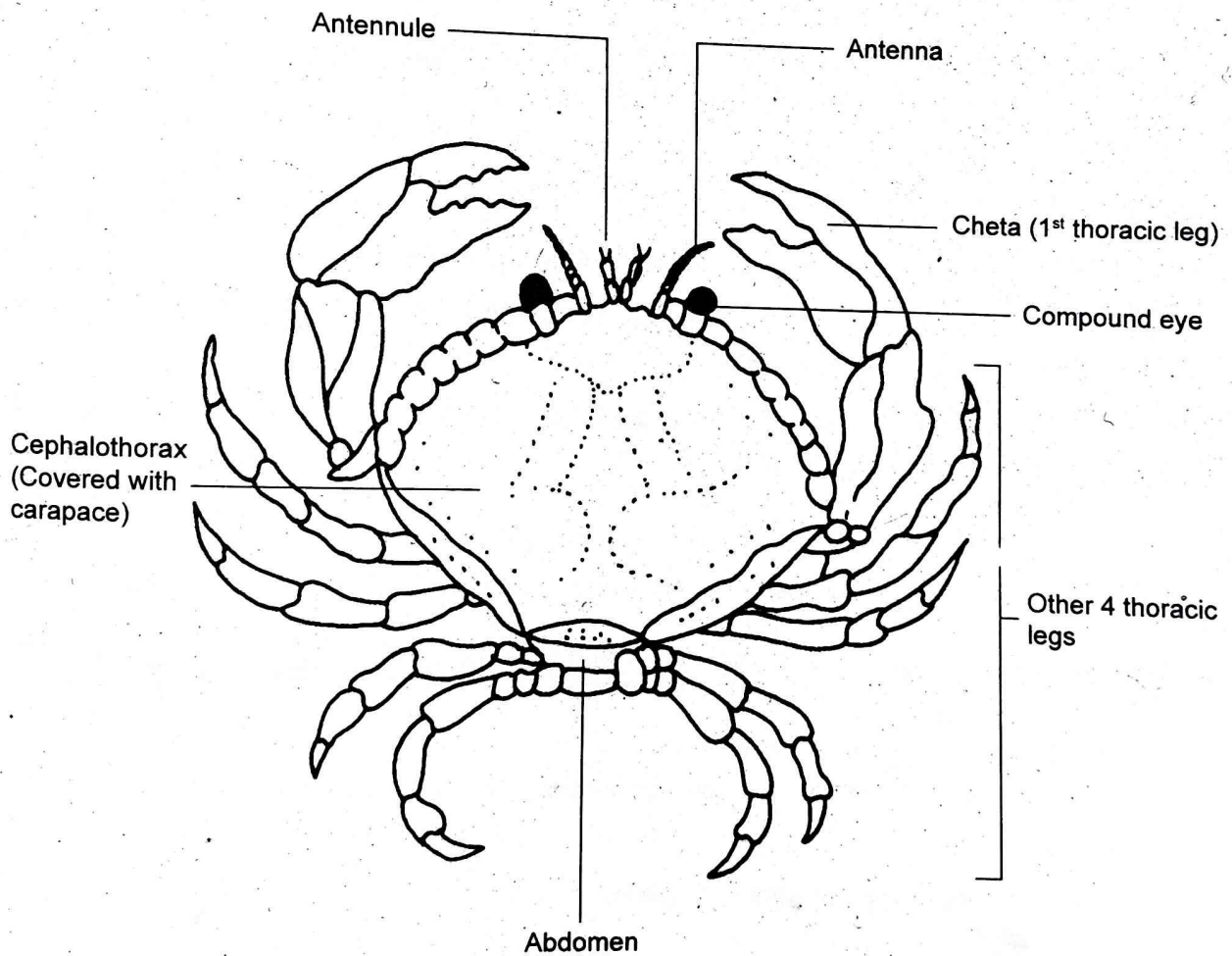
- Why is crab kept in phylum Arthropoda?  
**Ans:** Because crab bears jointed appendages
- Why is crab kept in class crustacea?  
**Ans:** crusta means hard shell. Crab is protected by a hard covering or exoskeleton.
- Where does the crab found?  
**Ans:** It is found in freshwater streams, rivers, ponds and lakes.
- How many pairs of walking legs in crab?  
**Ans:** It bears 5 pairs of walking legs.

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Date

# STUDY OF MUSEUM SPECIMEN

- Kingdom - Animalia
- Phylum - Arthropoda
- Subphylum - Mandibulata
- Class - Crustacea
- Genus - Cancer



Cancer (Crab)

# COMMENTS ON COCKROACH

**Important character:** Crab consists of three pairs of jointed legs (hexapoda).

**Habitat:** It is found in places where warmth, dampness and plenty of organic food. It is common pest of kitchens, hotels, godowns, storerooms, etc.

- Shape, size and colour:** The body is narrow elongated, bilaterally symmetrical, and dorsoventrally flattened. It measures 28-44 mm in length. The colour is shining reddish brown.
- Exoskeleton:** Body and appendages is covered externally by a hard chitinous exoskeleton.
- Body divisions:** The body of adult prawn is divided into three parts – head, thorax and abdomen.
- Head:** It is small and triangular. It bears a pair of large compound eyes, multi-segmented antenna mouth parts.
- Thorax:** It consists of three segments – prothorax, mesothorax and metathorax. Each thoracic segment bears a pair of walking legs. It also bears two pairs of wings.
- Abdomen:** It is 10 – segmented. The 10<sup>th</sup> abdominal segment bears a pair of anal cerci. Males have a pair of anal style at the 9<sup>th</sup> segment, which are absent in females.
- Coelom:** It is haemo-coelom type (coelom is filled with blood).
- Respiration:** It takes place by tracheal system (trachea, tracheoles and spiracles).
- Excretory organ:** Excretion takes place by malphigian tubules.
- Sensory organs:** These include antennae, compound eye, ocelli. Compound eye consists of many ommatidia to form several images.
- Reproduction:** They are unisexual i.e. male and female sexes are separate. Sexual dimorphism is distinct. Males have a pair of anal style at the 9<sup>th</sup> segment, which are absent in females.

## Economic Importance

It is a household pest, causes damage the food. It is also used as food for human.

### Viva Questions

Students must remember

- What is the meaning of haemocoelom?

**Ans:** Haemo-coelom is a type of coelom in which coelom is filled with blood.

- What is the excretory organ of cockroach?

**Ans:** Excretory organ is malphigian tubules.

- What do you mean by compound eye?

**Ans:** It is an eye consisting of many visual units called ommatidium. Each ommatidium is capable of producing a separate image of the object. This type of vision is called mosaic vision.

- What are the differences between anal style and anal cerci?

**Ans:** Anal styles are the male reproductive parts whereas the anal cerci are the sensory part used as auditory receptors.

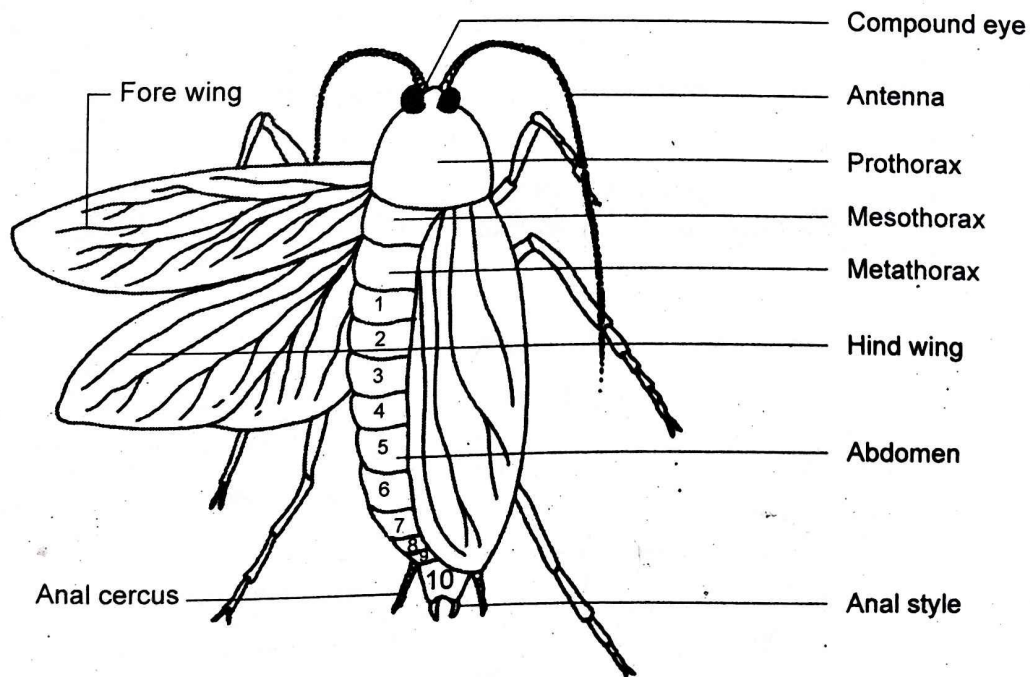
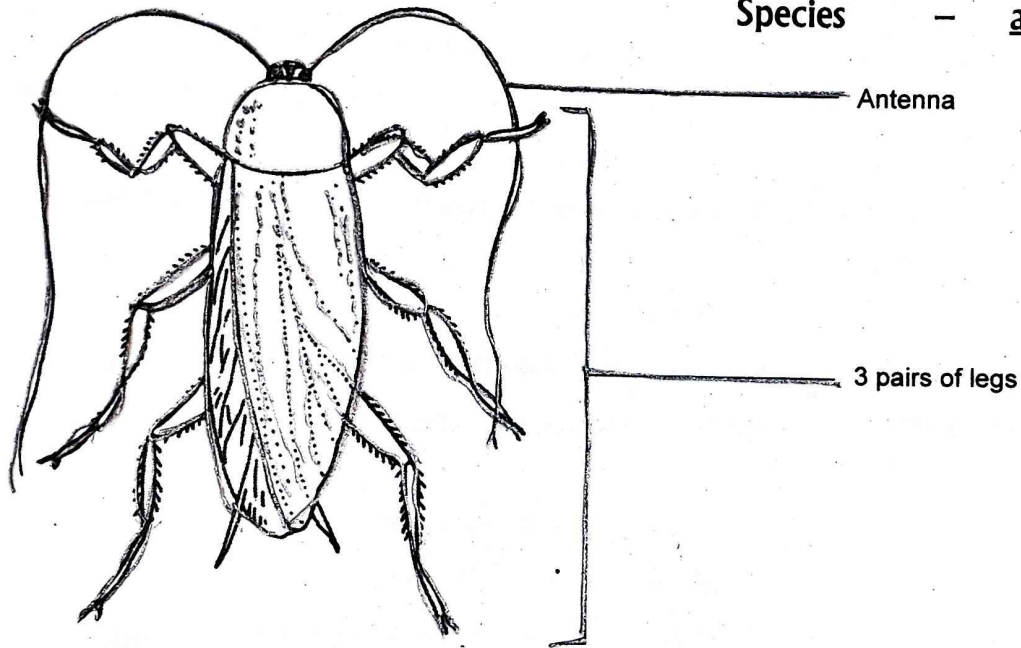
Male Cockroach	Female Cockroach
Anal style present in 9 <sup>th</sup> segment.	It is absent.

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Date

# STUDY OF MUSEUM SPECIMEN

Kingdom — Animalia  
Phylum — Arthropoda  
Class — Insecta  
Genus — Periplaneta  
Species — americana



Dorsal View (Male)

Cockroach

## COMMENTS ON BUTTERFLY

**Important character:** Butterfly possesses three pairs of jointed legs (hexapoda).

**Habitat:** *Pieris* is a common butterfly seen in the gardens during winter months. It is active during the day (diurnal). It feeds on the nectar of flower.

- Shape, size and colour:** It is large sized slender body, measures 28-44 mm in length. The body is covered by minute scales with many colour patterns.
- Body divisions:** The body is divided into three parts – head, thorax and abdomen.
- Head:** It is small, bears a pair of compound eyes. The antennae are long, filamentous and knobbed.
- Mouthparts consist of proboscis for sucking up the nectar of flower.
- Thorax:** It consists of three segments – prothorax, mesothorax and metathorax. Each thoracic segment bears a pair of legs.
- Wings:** Wings are two pairs, membranous and covered with overlapping scales. At rest, these wings are held vertically.
- Abdomen:** It is long and segmented.
- Respiration:** It takes place by tracheal system (trachea, tracheoles and spiracles).
- Circulatory system:** It is open type consisting of perivisceral and pericardial sinuses. Blood vessels are absent.
- Excretory organ:** Excretion takes place by malpighian tubules.
- Sensory organs:** These include antennae and compound eyes.
- Reproduction:** They are unisexual i.e. male and female sexes are separate. Fertilization is internal.

### Economic Importance

It helps in pollination of crop and other flowering plants; provide amusement by their brilliant colour; caterpillar is destructive to plant.

### Viva Questions

Students must remember

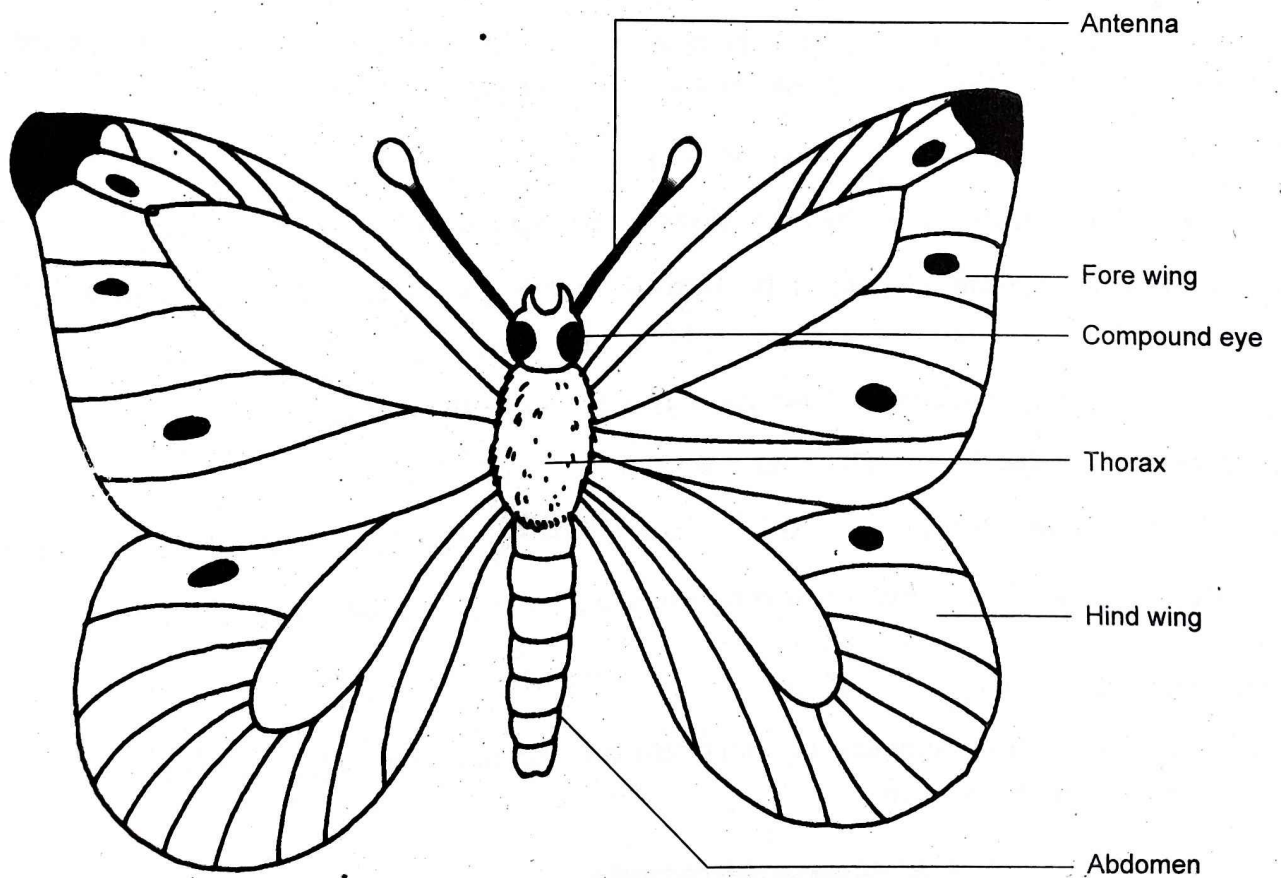
- Why is butterfly kept in phylum Arthropoda?  
**Ans:** Because it bears three pairs of jointed appendages
- What are the differences between butterfly and moth?

Butterfly	Moth
Active during day (diurnal)	Active during night (nocturnal)
Body is slender	Body is robust or stout
Antenna are long and filamentous	Antenna are short and feathery
At rest, wings are held vertically	At rest, wings are held horizontally
Usually colourful	Some are colourful

Date

# STUDY OF MUSEUM SPECIMEN

- Kingdom – Animalia
- Phylum – Arthropoda
- Class – Insecta
- Genus – Pieris



Butterfly

## COMMENTS ON MOTH

**Important character:** Moth possesses three pairs of jointed legs (hexapoda).

**Habitat:** It is terrestrial insect found in agricultural fields. It is active during the night (called nocturnal).

1. **Shape, size and colour:** It is small sized slender body, measures 15 mm long. It is creamy –white or yellow in colour with hairy body.
2. **Body divisions:** The body is divided into three parts – head, thorax and abdomen.
3. **Head:** It is small, bears a pair of compound eyes. The antennae are short and feathery.
4. **Mouthparts** consist of proboscis for sucking up the nectar of flower.
5. **Thorax:** It consists of three segments – prothorax, mesothorax and metathorax. Each thoracic segment bears a pair of legs.
6. **Wings:** Wings are two pairs, membranous and heavily covered with scales. Wings are marked by several faint or brown lines. At rest, these wings are held horizontally.
7. **Abdomen:** It is broad, segmented and hairy.
8. **Respiration:** It takes place by tracheal system (trachea, tracheoles and spiracles).
9. **Circulatory system:** It is open type consisting of perivisceral and pericardial sinuses. Blood vessels are absent.
10. **Excretory organ:** Excretion takes place by malphigian tubules.
11. **Sensory organs:** These include antennae and compound eyes.
12. **Reproduction:** They are unisexual i.e. male and female sexes are separate. Fertilization is internal.
13. **Development:** Metamorphosis is complete and the larva is called the caterpillar.

### Economic Importance

Pupa of it produces commercially important silk. Its caterpillar is harmful to plants, feeds on leaves of plants mainly mulberry plant.

### Viva Questions

Students must remember

1. Why is moth kept in phylum Arthropoda?

**Ans:** Because it bears three pairs of jointed appendages.

2. What is the difference between butterfly and moth?

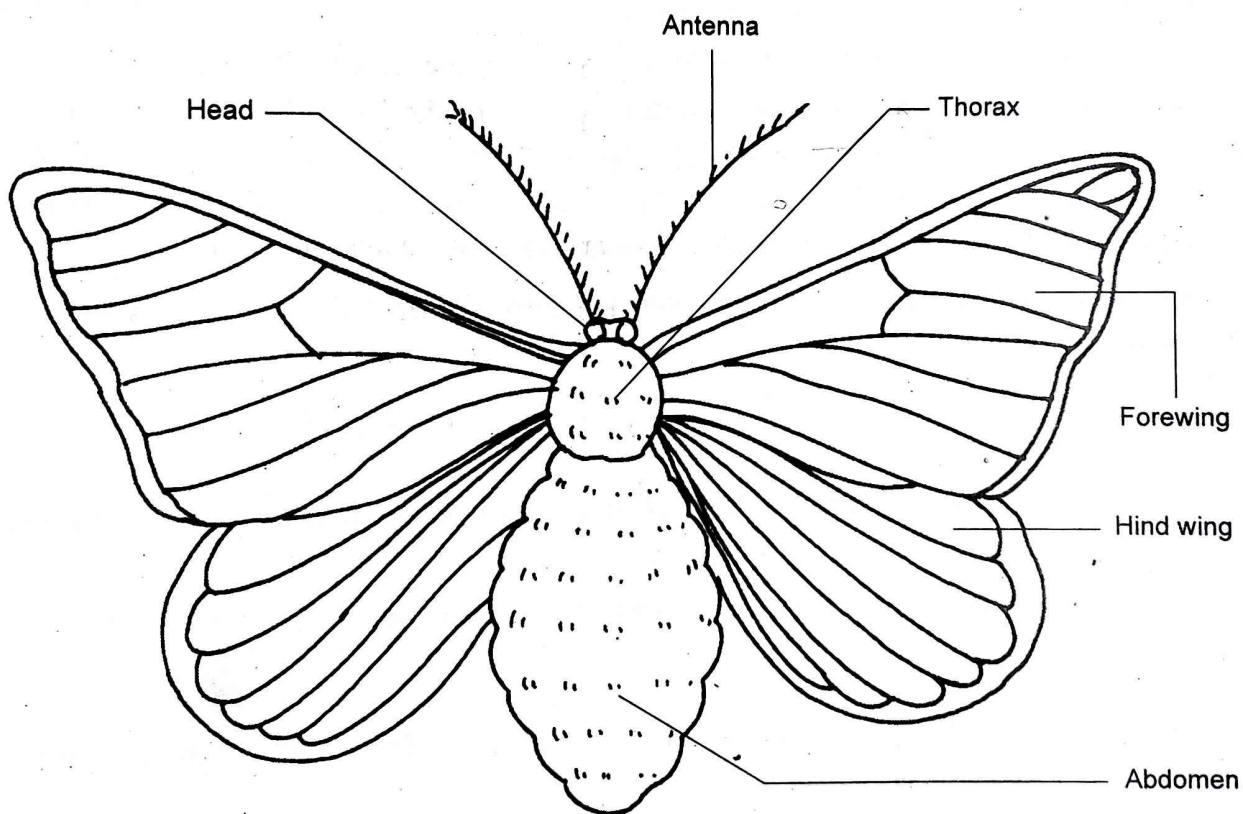
**Ans:** Butterfly has long and filamentous antenna, but moth has knobbed antenna. The wing of butterfly is held vertically at rest but in moth, wing held horizontally.

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Date

# STUDY OF MUSEUM SPECIMEN

Kingdom - Animalia  
Phylum - Arthropoda  
Class - Insecta  
Genus - Bombyx



Moth

## COMMENTS ON SCORPION

**Important character:** Moth possesses four pairs of jointed legs (called octopoda).

**Habitat:** It is a nocturnal animal found hidden under the stones, logs, crevices and underground in the burrows. They are nocturnal. They are carnivorous and predaceous, feeding chiefly upon spider, insects and other smaller animals.

- Shape, size and colour:** It is long, narrow, segmented and dorsoventrally flattened. Size measures from 10 cm in length. The dorsal surface is darker than the ventral.
- Exoskeleton:** Body and appendages is covered externally by a hard chitinous exoskeleton.
- Body divisions:** The body is made of 18 segments which is divided into two parts – anterior unsegmented prosoma or cephalothorax and posterior segmented opisthosoma.
- Prosoma or cephalothorax:** It is formed by fusion of head and thorax. It bears 1 pair of small chelate chelicerae, 1 pair of pedipalpi, 4 pairs of waling legs, 1 pair of median eyes and 3 pairs of lateral eyes.
- Chelicerae** are used for holding or tearing the prey. Pedipalpi are used as powerful and efficient clawed weapons characteristic of scorpion. It serves to seize the prey.
- Opisthosoma or abdomen:** It long and narrow. It is further divided into two parts – (i) Pre-abdomen (mesosoma) – 7 broad segments, and (ii) post-abdomen (metasoma) -5 narrow segments.
- The last segment bears the anus and a stinging apparatus or telson. It consists of poison gland and a sharp poison claw or sting. The sting is poisonous and painful.
- Respiration:** It takes place by 4 pairs of cuticular pulmonary sacs or book lungs, situated in mesosomal segments
- Excretory organ:** Excretion takes place by malphigian tubules and coxal glands.
- Sensory organs:** These include eyes, pectines and sensory hairs.
- Reproduction:** They are unisexual. Sexual dimorphism is not distinct. However, the male is usually smaller with longer pedipalpi.
- They are cannibals, often feeding upon other smaller scorpions. It sucks liquids from body of prey.

### Economic Importance

It can make painful bite from its sting which can prove fatal especially in children; feeds on harmful insects like cockroaches, beetles, etc.

### Viva Questions

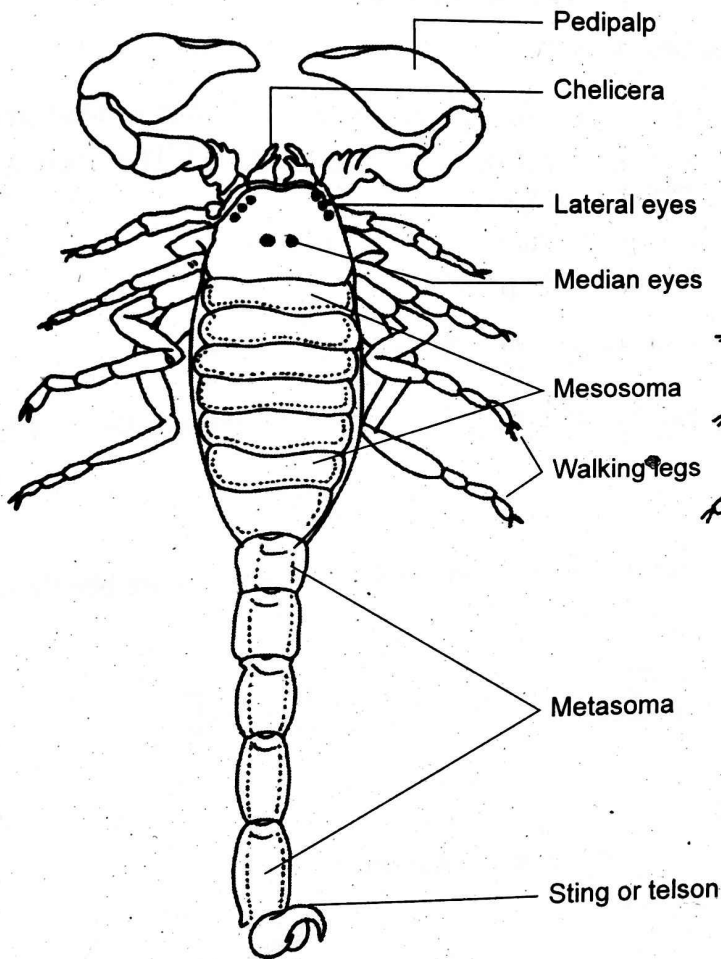
Students must remember

- Why is scorpion kept in class Arachnida?  
**Ans:** Scorpion is an arachnid animal because of presence of 4 pairs of legs.
- Why is scorpion called cannibal animal?  
**Ans:** As scorpion feeds upon the other smaller scorpions.
- Are scorpions poisonous?  
**Ans:** Yes, it has a sting used to kill or paralyse the prey. In case of human, its venom is not so dangerous but, may be painful.

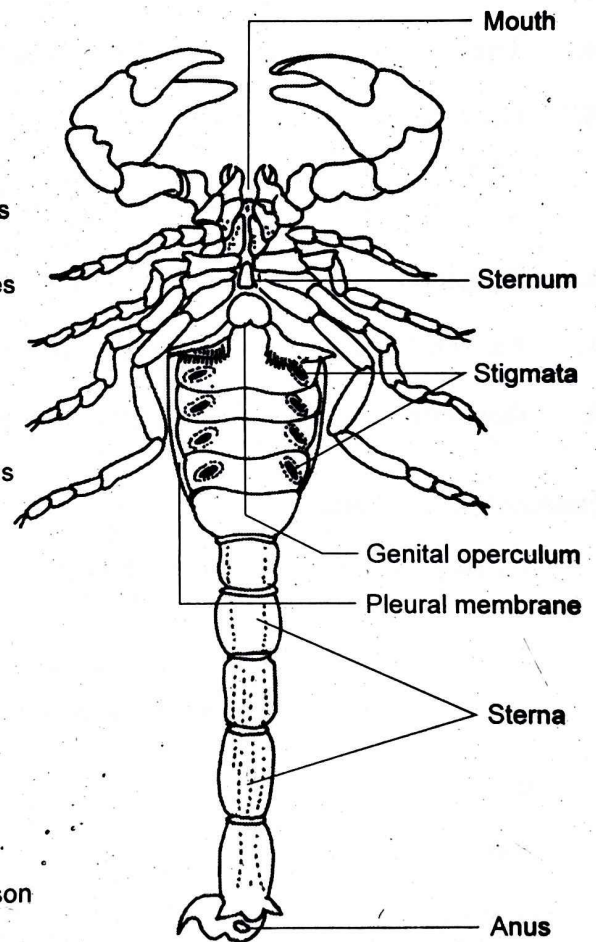
Date

# STUDY OF MUSEUM SPECIMEN

Kingdom - Animalia  
 Phylum - Arthropoda  
 Class - Arachnida  
 Genus - Palamnaeus



Dorsal View



Ventral View

## COMMENTS ON SPIDER

**Important character:** Spider possesses four pairs of jointed legs (also called octopoda).

**Habitat:** It is a common web-spider found on trees, gardens. All the spiders are predators. The soft tissues of prey are liquefied and sucked up aided by the pumping stomach.

1. **Shape, size and colour:** It is big and broad, brown in colour.
2. **Body divisions:** The body is divisible into two regions – anterior prosoma or cephalothorax and posterior opisthosoma (abdomen) connected together by narrow short waist.
3. **Prosoma:** It is covered by a thick carapace. It bears 1 pair of chelicerae, 1 pair of pedipalpi, 4 pair of simple eyes and 4 pairs of waling legs.
4. **The chelicerae** have poison glands and pedipalps.
5. **Opisthosoma or abdomen:** It is slightly oval and unsegmented. It is without appendages. It bears three pairs of spinnerets or spinning organs just anterior to the terminal anus. The openings of these spinning glands produce silken threads to spin the web.
6. **Respiration:** It takes place by means of book lungs or trachea or both
7. **Excretory organ:** Excretion takes place by malphigian tubules.
8. **Reproduction:** Sexes are separated. Female is larger than the male. Sexual dimorphism is not distinct.

### Economic Importance

It makes web to capture prey. It is also useful as it feets on harmful insects, so are beneficial.

### Viva Questions

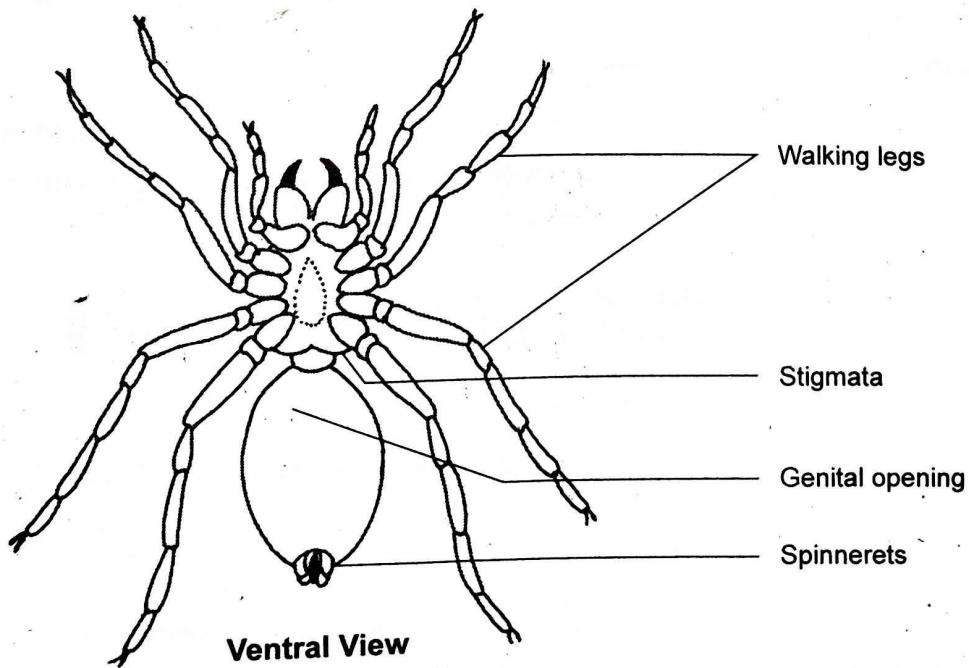
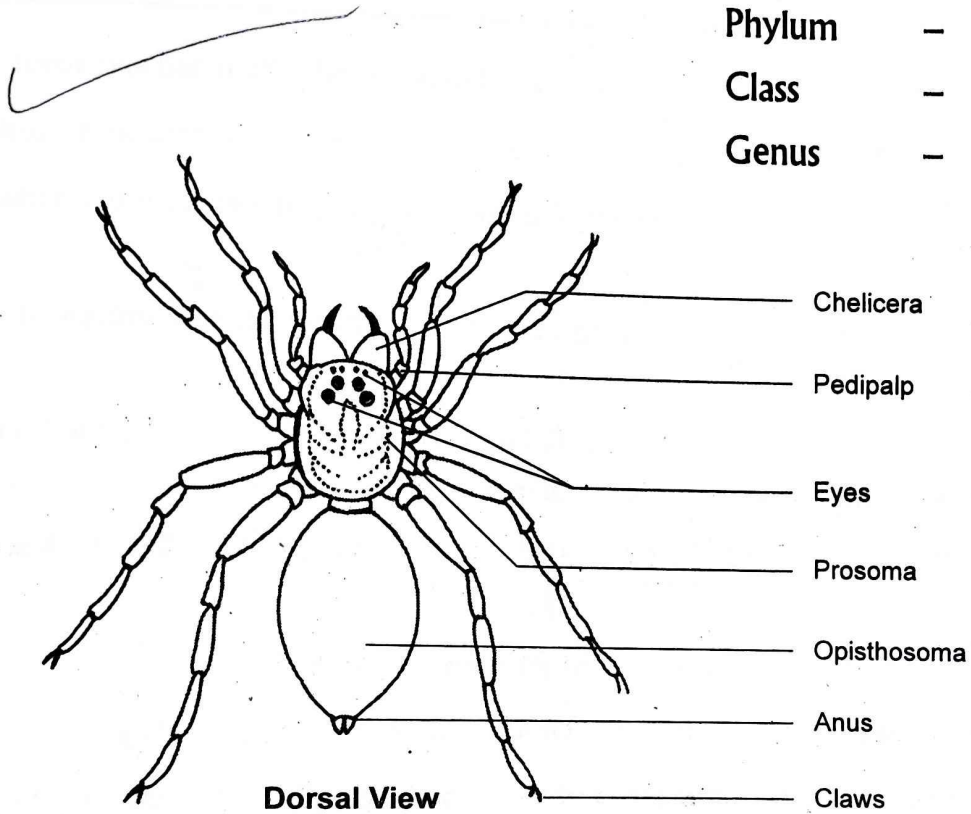
Students must remember

1. Why is spider kept in class Arachnida?  
**Ans:** Spider is an arachnid animal because of presence of 4 pairs of legs.
1. How does spider form web?  
**Ans:** Spider possesses 3 pairs of spinnerets at its tip, which produces silk threads for making webs.
2. What is the scientific name of spider?  
**Ans:** The scientific name of spider is Aranea.
3. Is spider poisonous?  
**Ans:** Some spiders are harmful to human.

Date

# STUDY OF MUSEUM SPECIMEN

Kingdom - Animalia  
Phylum - Arthropoda  
Class - Arachnida  
Genus - Aranea



Spider

## COMMENTS ON CENTIPEDE

**Important character:** It possesses many pairs of jointed legs. They are called as "hundred leggers".

**Habitat:** It is a terrestrial and nocturnal animal generally found in damp places like under bark, stones or rotten logs. It is carnivorous, feeding on insects and other smaller animals.

- Shape, size and colour:** Its body is elongated, dorso-ventrally flattened and about 20 cm long.
- Exoskeleton:** Body and appendages is covered externally by a hard chitinous exoskeleton.
- Body divisions:** The body is segmented and dorso-ventrally flattened. It is divided into two parts - head and trunk.
- Head:** It is small which bears two long many-jointed antennae, two groups of ocelli and mouth appendages.
- Trunk:** It is long and 21-segmented. Each trunk segment bears a pair of jointed walking legs. These legs are attached ventro-laterally to the segments.
- The first pair of legs** is modified into poisonous claws or maxillipedes which are connected with poison glands.
- The last pair of walking legs** is longer than the other legs.
- Respiration:** It takes place by tracheae. Spiracles are arranged segmentally.
- Excretory organ:** Excretion takes place by 1 or 2 pairs of malphigian tubules.
- Reproduction:** They are unisexual. Sexual dimorphism is not distinct. Single gonad is present.

### Economic importance

Centipedes are agile, fast-moving and carnivorous. They kill their prey with their poison claws. Centipede is carnivorous. It bites by poison claws. It causes a painful bite causing fever, dizziness and headache.

### Viva Questions

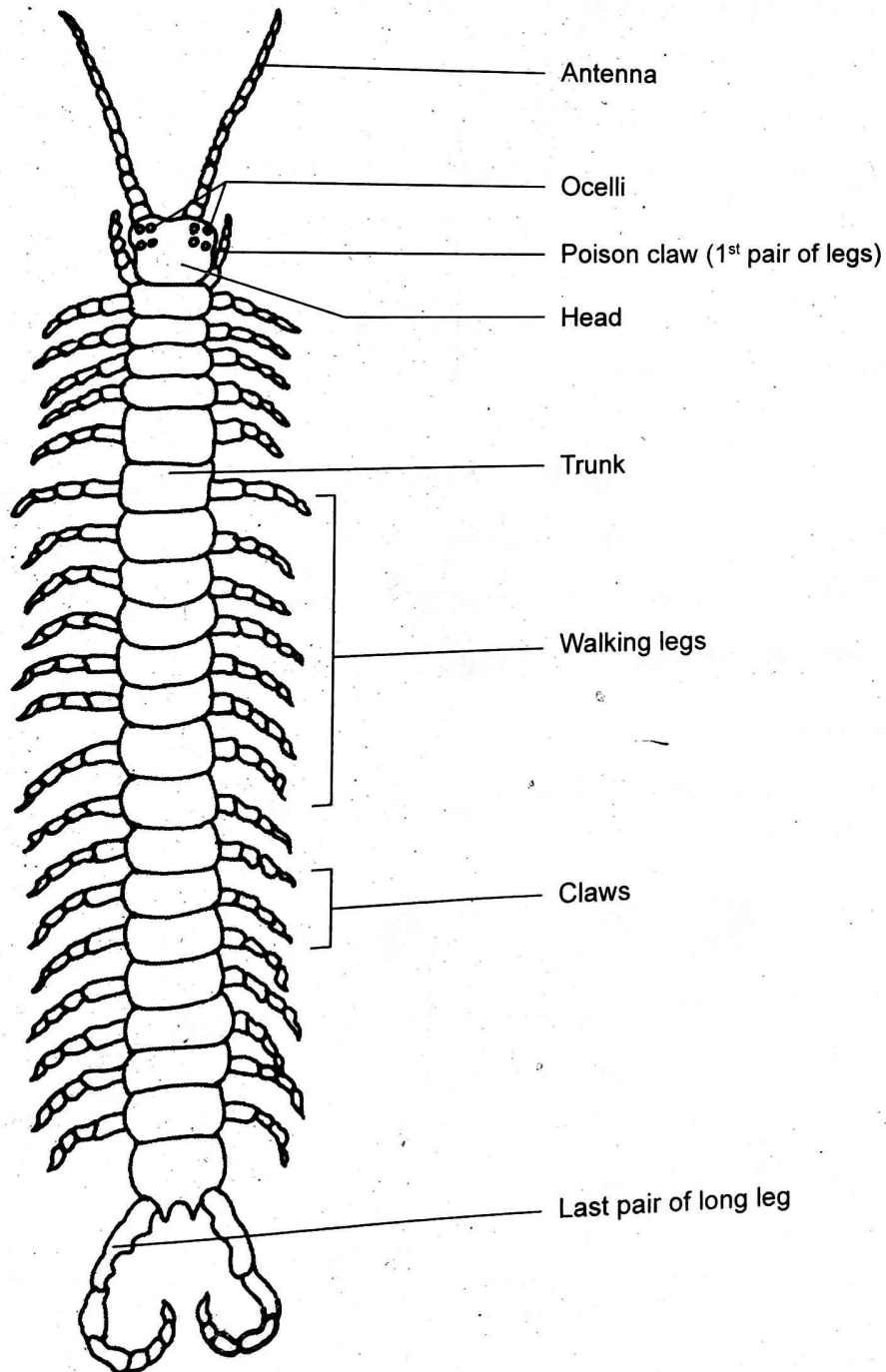
Students must remember

- Name the hundred and thousand legged arthropods.  
**Ans:** Hundred legged arthropod is centipede (*Scolopendra*) and thousand legged arthropod is millipede (*Julus*).
- Where does centipede found?  
**Ans:** Centipede is found in damp places like under bark, stones or rotten logs.
- What is the function of poisonous claw?  
**Ans:** The first pair of legs is modified into poisonous claws connected with poison glands too kill prey.

Date

# STUDY OF MUSEUM SPECIMEN

Kingdom - Animalia  
Phylum - Arthropoda  
Class - Myriapoda  
Genus - Scolopendra



Scolopendra (Centipede)

## COMMENTS ON MILLIPEDE

**Important character:** It possesses many pairs of jointed legs. They are called as "thousand leggers".

**Habitat:** It is a terrestrial and nocturnal animal generally found in damp places like under bark, stones or rotten logs. It is mostly herbivorous and saprophytic.

- Shape, size and colour:** Its body is elongated, cylindrical and about 15 cm long.
- Exoskeleton:** Body and appendages is covered externally by a hard chitinous exoskeleton.
- Body divisions:** The body is segmented and cylindrical and divisible into two parts – head and trunk.
- Head:** It is small which bears a pair of club-shaped antennae, a pair of eyes or ocelli and mouth appendages. There is no poison claw.
- Trunk:** It is long and has 40 or more segments. The first 4 segments form the thorax, except the first one called the **collum**, each bears a pair of legs. Other trunk segments bear 2 pairs of legs (called diplopoda)
- Stink glands:** On most of the truck segments, stink or odoriferous glands are present. Their secretions are toxic to other animals. Stink glands secrete foul smelling fluid which makes unpalatable to their enemies.
- Respiration:** It takes place by tracheae. Spiracles are arranged segmentally.
- Excretory organ:** Excretion takes place by 1 or 2 pairs of malphigian tubules.
- Reproduction:** They are unisexual. Sexual dimorphism is not distinct. Single gonad is present.
- Millipedes are sluggish and timid.** When touched or lifted they curl up in a spiral like a ball.

### Economic importance

These are herbivorous and saprophytic. Some attack living roots causing serious damage to plants in gardens and greenhouses.

### Viva Questions

Students must remember

- Why is *Julus* called millipede animals?

Ans: Millipede means million of legs. It means *Julus* has many pairs of legs than centipede. It consists of two pairs of legs in each segment called diplopoda.

- What is the function of stink glands?

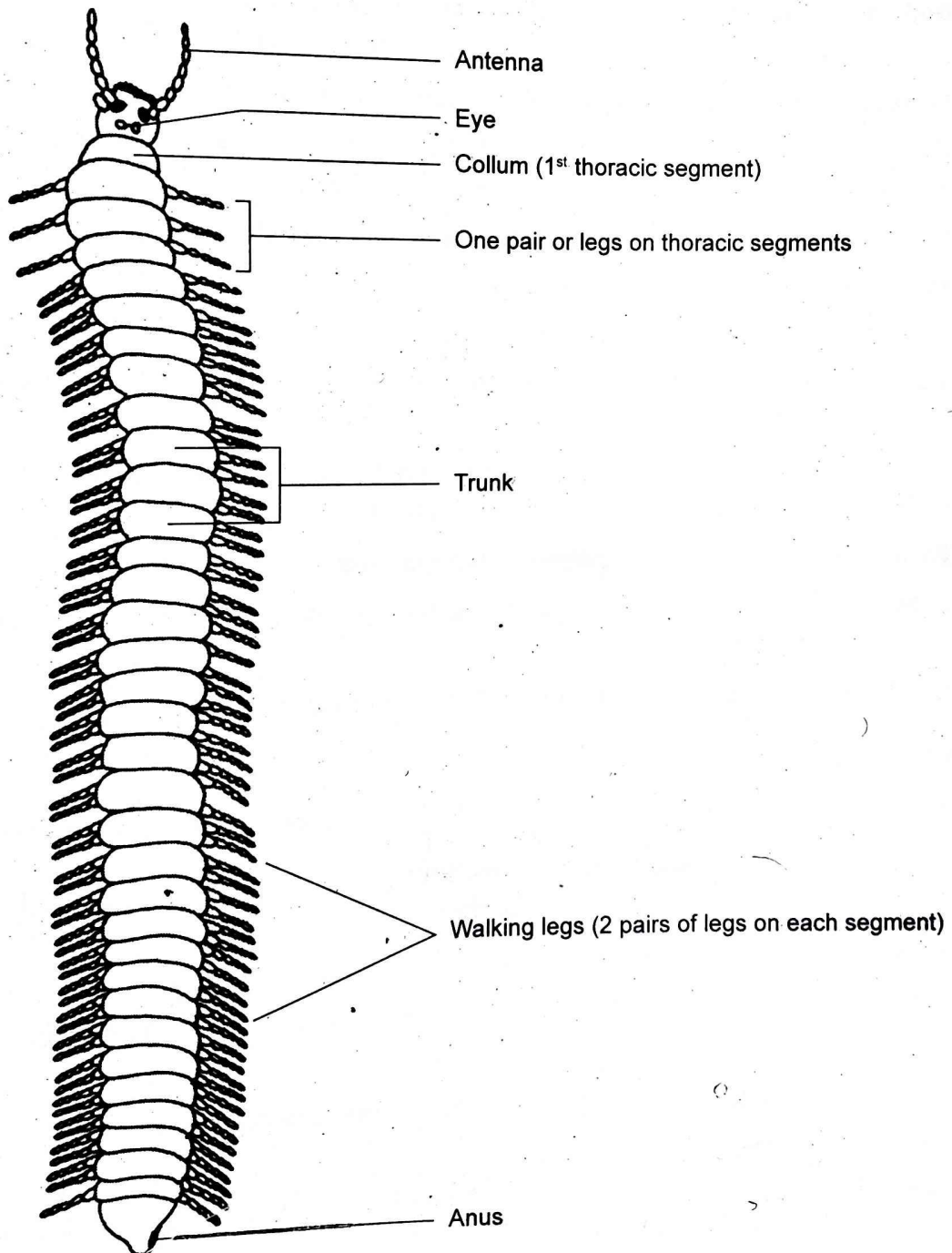
Ans: Stink glands secrete foul smelling fluid which makes unpalatable to their enemies.

S.No.	Centipede ( <i>Scolopendra</i> )	Millipede ( <i>Julus</i> )
1.	Each segment bears one pair of lateral appendages	Each segment bears two pairs of lateral appendages
2.	Head bears a pair of long antenna.	Head bears a pair of short antenna.
3.	First pair of leg is modified into poison claw.	Poison claw is absent.

Date

# STUDY OF MUSEUM SPECIMEN

Kingdom – Animalia  
Phylum – Arthropoda  
Class – Myriapoda  
Genus – Julus



Julus (Millipede)

## COMMENTS ON APPLE SNAIL

**Important character:** Body is soft, unsegmented and without appendages.

**Habitat:** Pila is a common freshwater apple snail found in ponds, lakes, paddy fields and rivers. It is a voracious, feeds upon plants. Pila also leads an amphibious life

- Structure:** Pila has a lemon- yellow coloured, spirally coiled, globose shell with 6 ½ whorls.
- The lowermost or the largest whorl has a large aperture which is tightly closed by an operculum when the snail is inside. Snail takes out its head and foot when operculum opens.
- Body division:** Body is externally protected by calcareous shell. Inside the shell, snail has a soft body with 4 distinct regions - head, visceral mass, foot and mantle.
- Head:** It bears a mouth, two pairs of tentacles and a pair of eyes.
- Foot:** It is a locomotary organ of snail. It is large, muscular and roughly triangular in shape when expanded. Foot has an operculum that closes the shell.
- Visceral mass:** is spirally coiled and contains the visceral or internal organs.
- Mantle** is a thin membrane that encloses a large cavity called mantle cavity.
- Symmetry:** Pila is asymmetrical due to coiling (called torsion).
- Respiration:** It takes place by gills or ctenidia (for aquatic respiration) and pulmonary sac (for aerial respiration), as it is amphibious.
- Circulatory system:** It is open type with many large blood spaces in the tissues. Blood is green due to presence of copper containing pigment called **haemocyanin**.
- Excretion:** It takes place by paired **metanephridia** or kidney.
- Sense organs:** These are eyes, tentacles, osphradium (water testing organ), statocysts (organ of equilibrium), etc.
- Reproductive system:** It is unisexual. Males are usually smaller.

### Economic importance

Pila is a voracious eater and feeds upon plants and make a great damage to the agricultural crops.

### Viva Questions

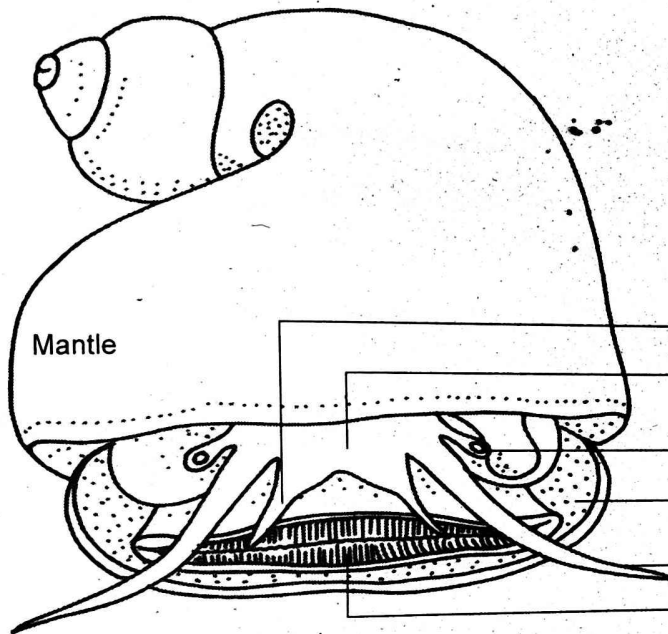
Students must remember

- What is the important character of phylum Mollusca?  
**Ans:** Mollusca is a phylum which bears animals which are soft and muscular.
- What is the locomotary organ of pila?  
**Ans:** The locomotary organ of pila is muscular foot, situated ventrally.
- Why is pila spirally coiled?  
**Ans:** Pila is spiral coiled due to torsion. Torsion is a twisting of internal organs through 180°. It makes the pila asymmetrical.
- Pila is called foes of farmers, why?  
**Ans:** Because, Pila feeds upon plants and makes a great damage to the agricultural crops.

Date

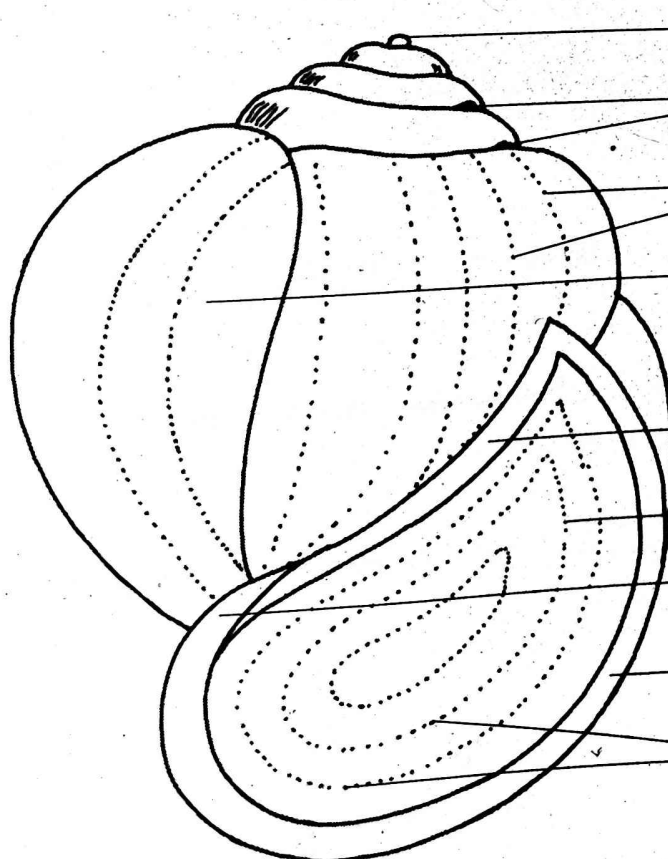
# STUDY OF MUSEUM SPECIMEN

Kingdom - Animalia  
 Phylum - Mollusca  
 Class - Gastropoda  
 Genus - Pila  
 Species - globosa



Mantle

First tentacle  
 Head  
 Eye  
 Operculum  
 Tentacle  
 Foot



Apex of shell  
 Sutures  
 Lines of growth  
 Body whorl  
 Inner or columellar lip  
 Operculum  
 Umbilicus  
 Outer lip  
 Lines of growth

Apple Snail

## COMMENTS ON GARDEN SNAIL (HELIX)

**Important Character:** Garden snail is a gastropod animal because its body is soft, muscular and unsegmented.

**Habitat:** It is a terrestrial mollusc living in the damp places mostly in the garden. It is nocturnal animal. It is a herbivorous feeding on plants.

### External features

- 1. Body:** Body is soft and muscular. It is externally covered by a hard calcareous coiled shell. The body is divisible into four parts - head, mantle, visceral mass and muscular foot.
- Body shell shows two conical spire with prominent line of growth.
- It is asymmetrical and triploblastic animal.
- Head:** It bears mouth and two unequal pairs of tentacles. The smaller pair acts as sensory organs. The longer pair of tentacles bear eyes at their tips.
- Foot:** The foot is the locomotory organ. It is muscular and situated ventrally. It helps in creeping movement.
- Visceral mass is the mass of internal organs. It is situated on the dorsal side of the body. Visceral mass is covered by mantle.
- Mantle:** It is the thin covering situated inner to the shell. It covers the visceral mass lying at the dorsal side of the body.
- Respiration:** Respiration takes place by pulmonary sacs.
- Genital pore:** It lies behind the tentacles.
- The sense organs are eyes and sensory tentacles.
- Reproduction:** It is an unisexual animals but the sexual dimorphism is not distinct.

### Economic importance

It is an agricultural pest as it feeds and damage the agricultural and garden crops causing great economic loss. It also acts as the intermediate host for some fluke parasites.

### Viva Questions

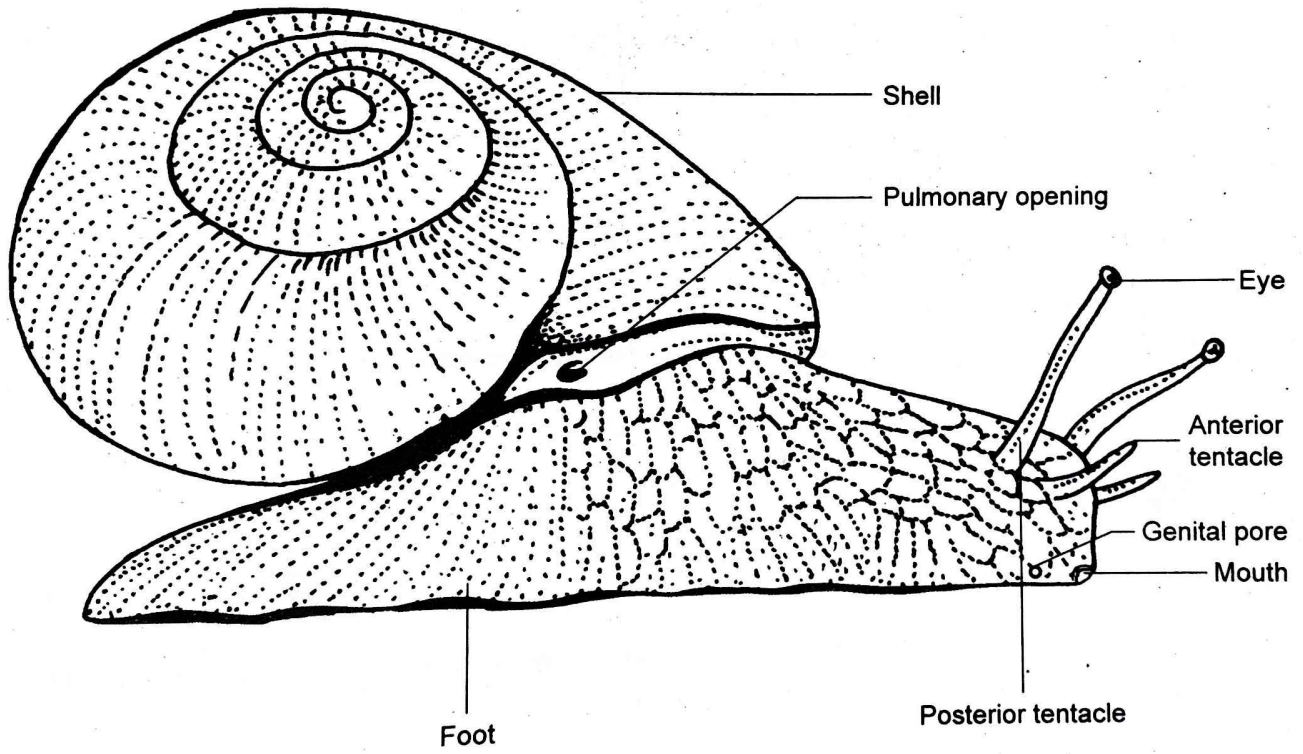
Students must remember

- Why is garden snail kept in phylum Mollusca?  
**Ans:** Because it is soft and muscular.
- Why is garden snail covered by calcareous shell?  
**Ans:** Calcareous shell protects the soft body from desiccation.
- What is the scientific name of garden snail?  
**Ans:** The scientific name of garden snail is Helix.

Date

# STUDY OF MUSEUM SPECIMEN

Kingdom - Animalia  
Phylum - Mollusca  
Class - Gastropoda  
Genus - Helix



Garden snail

## COMMENTS ON SLUG

**Important character:** Body is soft, unsegmented and without appendages. It is commonly known as "grey slug".

**Habitat:** Slug is a terrestrial gastropod living in gardens, moist woody region, and shady places. It is herbivorous and nocturnal. It is voracious and feeds upon succulent plants.

1. **Structure:** The body of slug is elongated without an external shell.
2. **Body division:** The soft body is divided into three distinct regions - head, visceral mass and muscular foot.
3. **Head:** It bears a mouth, one two pair of tentacles and a pair of stalked eyes.
4. **Foot:** It is a locomotary organ. The ventral muscular foot is broad, flat and used for creeping. Foot creeps on a self-secreted tract of mucus.
5. **Mantle:** The mantle is a small antero-dorsally placed shield with a pulmonary sac. It opens outside by a pulmonary aperture, meant for aerial respiration.
6. **Symmetry:** Slug is a bilaterally symmetrical.
7. **Respiration:** It takes place by pulmonary sac (for aerial respiration), as it is amphibious.
8. **Circulatory system:** It is open type with many large blood spaces in the tissues. Blood is green due to presence of copper containing pigment called **haemocyanin**.
9. **Excretion:** It takes place by paired **metanephridia** or kidney.
10. **Reproductive system:** It is unisexual. Males are usually smaller.

### Economic importance

Limax is nocturnal herbivore, feeding voraciously on seedlings, tender leaves or shoots. It damages the plants of gardens.

### Viva Questions

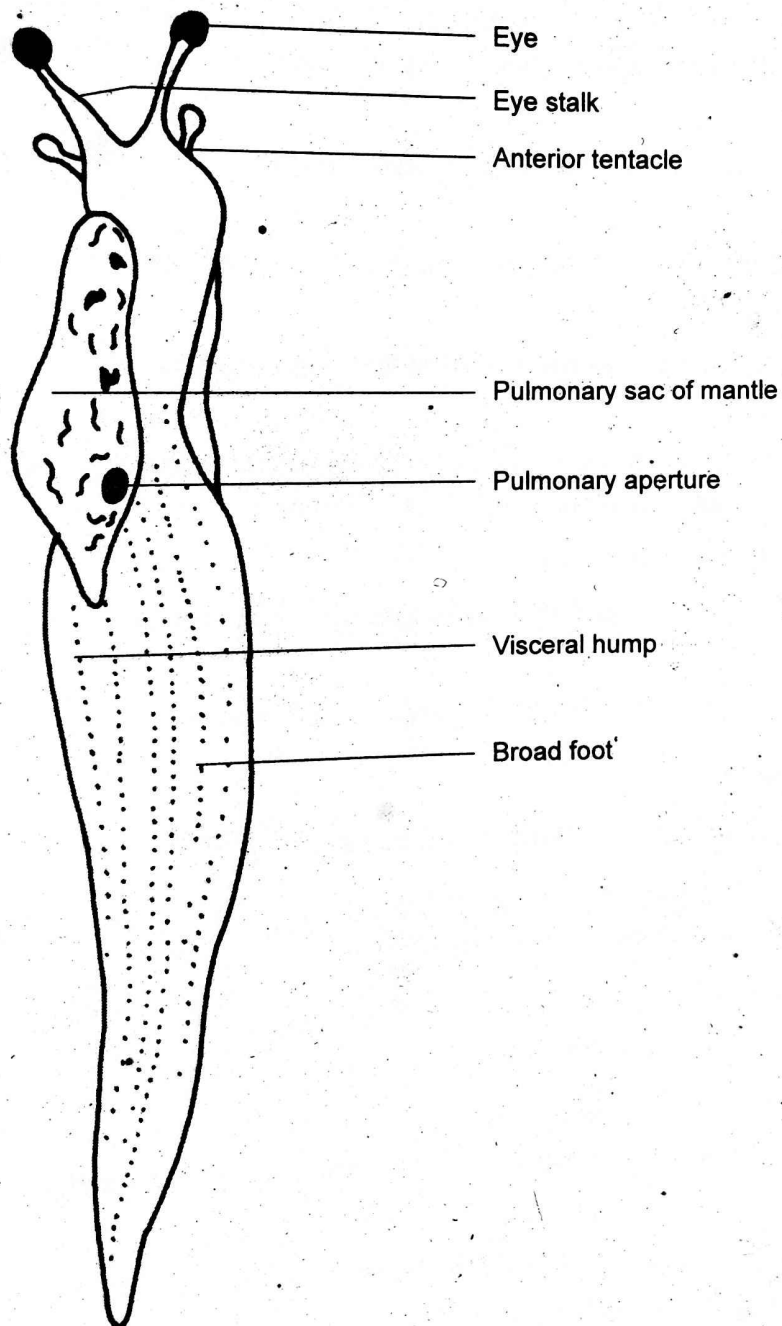
### Students must remember

1. Where does the slug found?  
**Ans:** Slug is a terrestrial gastropod living in gardens, moist woody region, and shady places.
2. What is the respiratory organ?  
**Ans:** The respiratory organ is pulmonary sac.
3. Why is slug called plant pest?  
**Ans:** Slug is voracious. It feeds upon succulent plants and makes a great damage to them.

Date

# STUDY OF MUSEUM SPECIMEN

Kingdom – Animalia  
Phylum – Mollusca  
Class – Gastropoda  
Genus – Limax



Limax

## COMMENTS ON STARFISH

**Important character:** Body possesses numerous spines.

**Habitat:** It is exclusively marine (not found in Nepal). It is free living, found on the sandy or rocky seashores. It adheres firmly to the substratum by its tube feet. It is carnivorous, feeding mainly on crustaceans, polychaetes and molluscs.

1. **Shape, size and colour:** Star fish is star shaped. It measures about 10-20 cm in diameter. Colour is variable according to shades of brown, yellow, orange, etc.
2. **Structure:** Starfish has a radially symmetrical, star-shaped flattened body covered with small spines.
3. **Body surface:** Body is antero-posteriorly flattened and hence has an oral surface and aboral surface. The oral (lower) surface has a centrally located mouth. The aboral surface has an anus and madreporite.
4. Body surface is marked by five radiating grooves called **ambulacral grooves** which run all along ventral surface of arm.
5. **Water vascular system:** Star fish has a unique water vascular system which helps in locomotion by providing hydraulic pressure mechanism.
6. **Tube feet:** Each arm has two rows of tube feet that help in locomotion, respiration, excretion, and capture of food.
7. **Respiratory system:** Respiration takes place by dermal branchiae present on the aboral surface. Some gaseous exchange also takes place through tube feet.
8. **Excretory organ** is absent.
9. **Reproduction:** Sexes are separated (unisexual). Fertilization is external. They have the remarkable power of regeneration.
10. **Development:** It is indirect through free swimming larval forms such as bipinnaria and auricularia.

### Economic importance

Starfish is used as the food for animals and human.

### Viva Questions

Students must remember

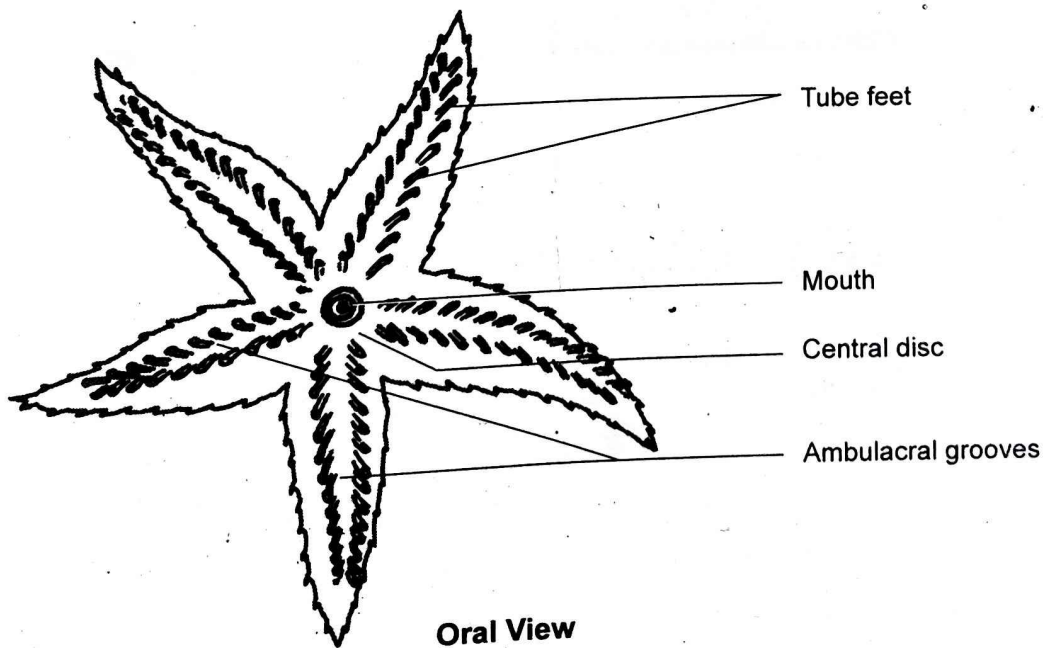
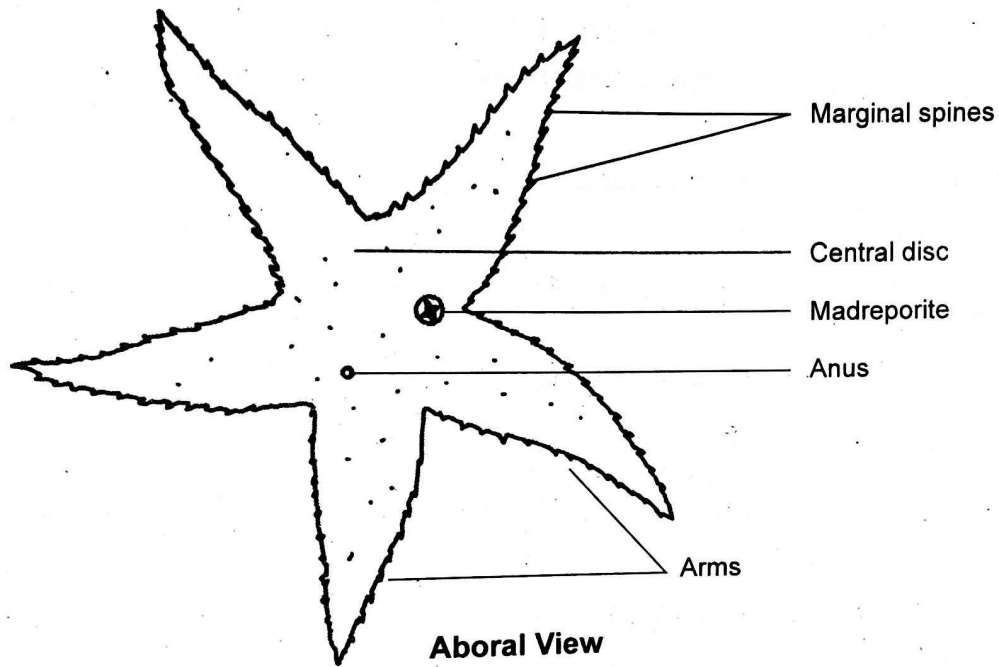
1. Why is called starfish?  
Ans: Because it looks like a star shape.
2. Why is it not found in Nepal?  
Ans: Because starfish is exclusively marine. There is no sea in Nepal.
3. Starfish is a radially symmetrical, how?  
Ans: Radially symmetrical means that the body can be divided into two equal parts when the body is cut from any radial planes passing through central axis,
4. What are tube feet?  
Ans: Tube feet are the locomotary organs found in each arm.

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Date

# STUDY OF MUSEUM SPECIMEN

Kingdom - Animalia  
Phylum - Echinodermata  
Class - Asterozoa  
Genus - Asterias



Starfish

## COMMENTS ON LABEO

**Habitat:** It is found in clear streams and rivers. The adults are herbivorous and feed on plants while the young ones are carnivorous. It is an oviparous fish.

1. **It is cold blooded or poikilothermic** (it means that the body temperature is not fixed but is variable according to the environment).
2. **Body form:** Body is streamlined or boat shaped and laterally compressed. It helps the fishes to swim.
3. **Exoskeleton:** Body except head is covered with overlapping cycloid scales.
4. **Head:** The head bears an anterior mouth and a pair of short barbules on its sides.
5. **Operculum:** The gills are covered with gill cover called operculum.
6. **Locomotion:** It takes place by paired (pectoral and pelvic fins) and unpaired fins (dorsal, anal, and caudal fins).
7. The caudal fin is forked which is symmetrical and homocercal.
8. **Respiratory system:** It takes place by gills. Gills are covered by an operculum.
9. **Circulatory system:** Heart is two chambered; one auricle and one ventricle. Heart is venous heart. Blood is red due to haemoglobin.
10. **Lateral line** is present on the lateral sides, detecting water pressure.
11. **Reproductive system:** Sexes are separated (unisexual). Fertilization is external.
12. **Development:** It is direct. Eggs develop into youngs.

### Economic importance

Rohu fish is used as the food for human. It is rich in protein.

### Viva Questions

Students must remember

1. What do you mean by cold blooded (Poikilothermic)?

**Ans:** Cold blooded means that the body temperature is not fixed but is variable according to the environment. When the temp. of water is high or low, then the temp. of animal is also high or low.

2. Differentiate between cartilaginous and bony fishes.

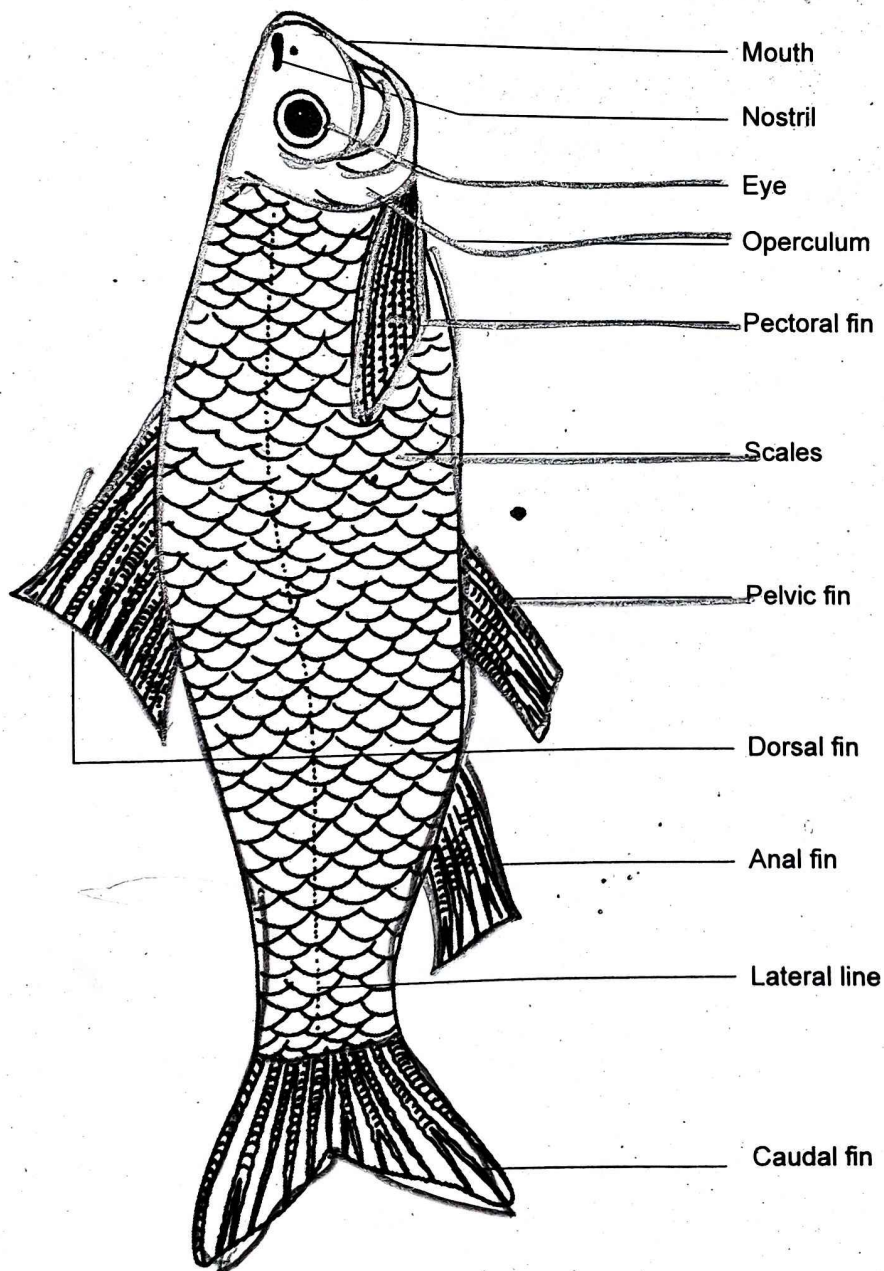
**Ans:** Differences are:

Cartilaginous fishes (Chondrichthyes)	Bony fishes (Osteichthyes)
1. They are mostly marine.	1. They are both freshwater and marine.
2. Endoskeleton is cartilaginous.	2. Endoskeleton is bony.
3. Mouth is ventral.	3. Mouth is terminal.
4. Body is covered with placoid scales.	4. Body is covered with cycloid or ctenoid scales.
5. No operculum. Spiracles present.	5. Gills are enclosed by operculum.
6. Swim bladder absent.	6. Swim bladder present.
Example – <i>Scoliodon</i> (dog fish), <i>Torpedo</i> (Electric fish), etc.	Example – <i>Labeo</i> (Rohu), <i>Catla</i> , <i>Exocoetus</i> (flying fish), <i>Hippocampus</i> (Sea horse), etc.

Date

# STUDY OF MUSEUM SPECIMEN

Kingdom - Animalia  
Phylum - Chordata  
Subphylum - Vertebrata  
Group - Gnathostomata  
Class - Pisces  
Genus - Labeo  
Species - rohita



Labeo

## COMMENTS ON SEA HORSE

**Habitat:** It is a marine bony fish found in Atlantic and Indian Oceans. It is an oviparous. It is cold blooded or poikilothermic.

- 1. Body form:** Body is divisible into three regions- head, trunk and tail.
- 2. Head** is large and produced into tubular snout. It bends at the right angle to the trunk like a snout of horse; hence the name is sea horse.
- 3. Eyes** are dorso-lateral at the base of snout and each can be moved independently of each other.
- 4. Mouth** is toothless in adults
- 5. Gills** are small and covered by gill cover called operculum.
- 6. Locomotion:** It swims vertically with the help of fan like dorsal fin. Pectoral fin is rudimentary. Pelvic, ventral and caudal fins are absent.
- 7. Trunk** and tail are externally protected by hard bony plates.
- 8. Tail** is prehensile without caudal fin. It is used for holding the sea weeds.
- The fish is said to produce a monotonous sound' which is quite frequent at the time of breeding season.
- 10. Reproductive system:** It is unisexual. Male possesses a brood pouch on the belly, where female deposits her eggs. The eggs are retained till hatching. Female does not have brood pouch.

### Economic importance

Sea horse is used as the food for human. It is rich in protein.

### Viva Questions

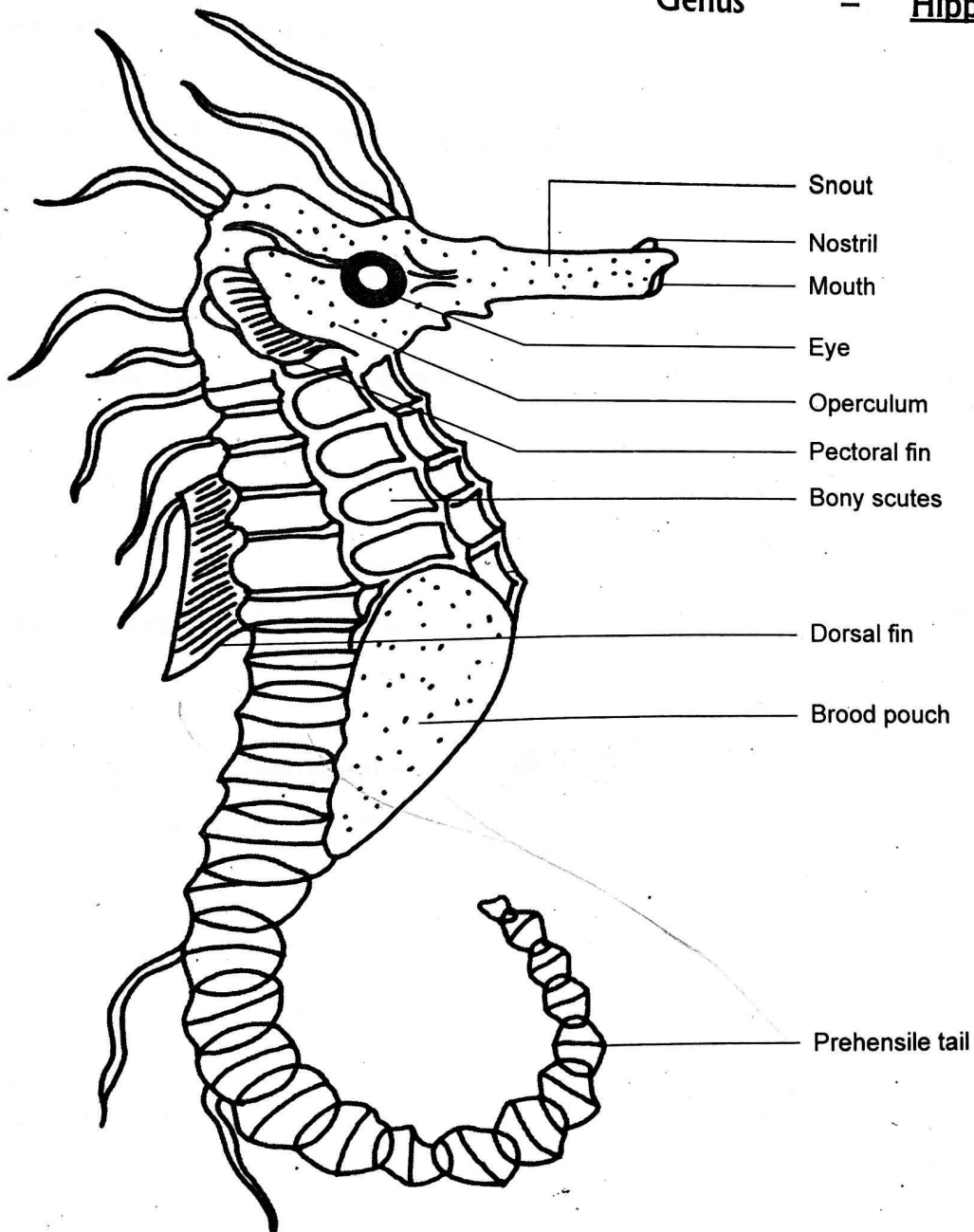
Students must remember

- Why is Sea-horse called so?  
**Ans:** Head of sea horse is large and produced into tubular snout. It bends at the right angle to the trunk like a snout of horse; hence the name is sea horse.
- What is the function of brood pouch?  
**Ans :** In case of male sea horse, a brood pouch is present on the belly, where in female deposits her eggs. The eggs are retained till hatching.
- What is the meaning of prehensile tail?  
**Ans:** Tail of sea horse is prehensile or coiled. It is used for holding the sea weeds.
- Why is called as a bony fish?  
**Ans:** Because the endoskeleton is bony.

Date

# STUDY OF MUSEUM SPECIMEN

- Kingdom – Animalia
- Phylum – Chordata
- Subphylum – Vertebrata
- Group – Gnathostomata
- Class – Pisces
- Genus – Hippocampus



Sea Horse

## COMMENTS ON FROG

**Important character:** It is amphibious; live both in water as well as on land.

**Habit and habitat:** It is amphibious; live both in water as well as on land. It is active during rainy season. During unfavourable conditions, frogs undergo **hibernation** (winter sleep) and **aestivation** (summer sleep) periods.

1. Frog is a **carnivorous** animal. It feeds on small insects, spiders, crustaceans and even on its tadpole and small frogs.
2. **Shape, size and colouration:** Frog is streamlined measuring about 10 cm long. Its colour at the dorsal side is green with black spots but ventral surface is almost white or slight yellowish in colour. The colouration helps them to be safe from their enemies.
3. **Body divisions:** Body is cylindrical, bilaterally symmetrical. It is divided into head and trunk. Neck is absent.
4. **Skin:** It is moist, thin, smooth, moist and glandular without any exoskeleton or scales.
5. **Head:** It is triangular and bears a pair of bulging eyes and external nostrils. Eyes are protected with **nictitating membrane**.
6. **Tympanum or ear drum:** On the either side of the head, behind the eye is a dark coloured circular area called **tympanic membrane** for hearing.
7. **Trunk:** The trunk bears 2 pairs of limbs. The front limbs are shorter, each with 4 digits and hind limbs are longer, each with 5 webbed digits.
8. **Cloacal aperture:** At the posterior end of the trunk is an opening called **vent** or cloacal aperture for the discharge of faeces, urine and gametes
9. **Respiration:** Frogs respire by skin, buccal cavity and lungs.
10. **Circulatory system:** Heart is three chambered; two auricles and one ventricle. RBCs are biconvex, oval and nucleated.
11. **Excretory system:** It takes place by mesonephric kidney.
12. **Reproductive system:** Unisexual; sexual dimorphism is distinct.
13. **Fertilization is external.** Development is indirect through tadpole larva.

### Economic importance

It is a carnivorous. It feeds on small insects, snail, slugs, spiders, etc. Therefore, It is great friend of farmers.

### Viva Questions

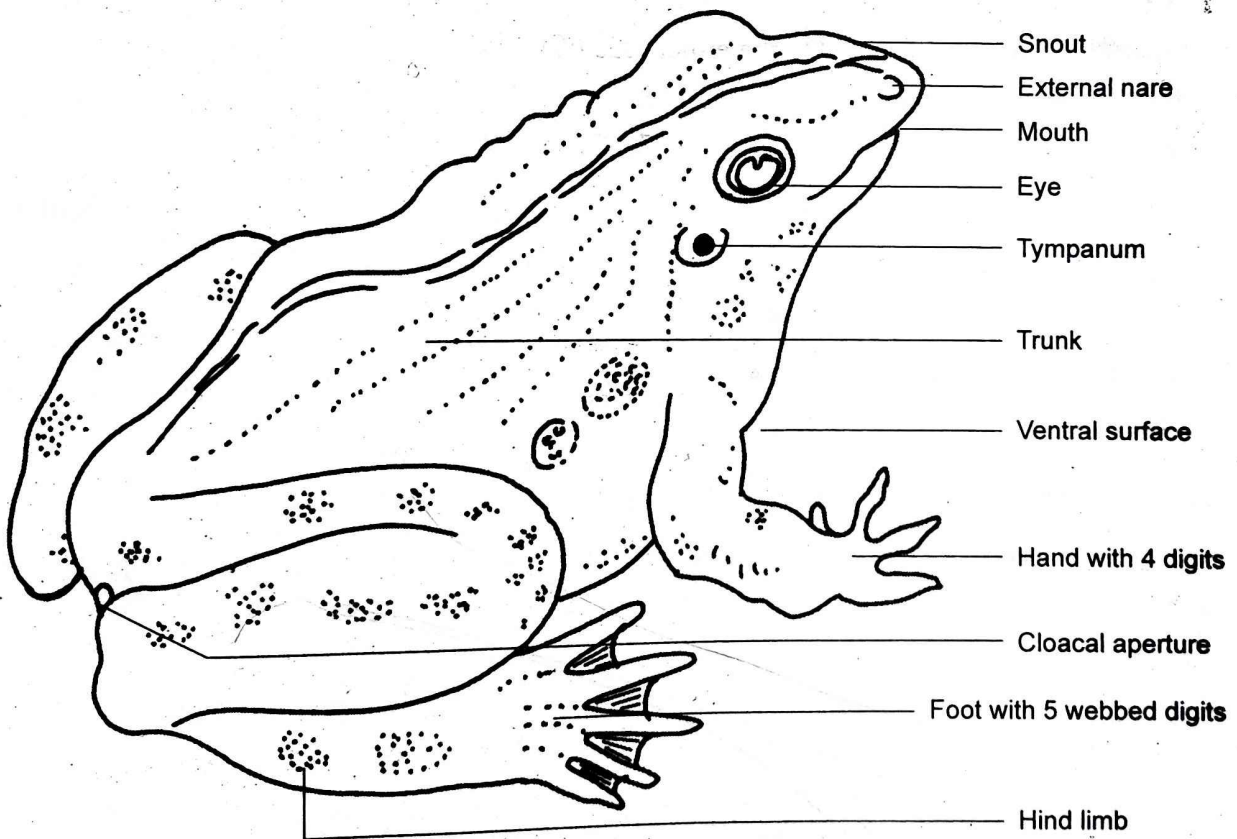
Students must remember

Male frog	Female frog
1. Smaller in size.	1. Larger in size.
2. Darker in colour	2. Lighter in colour.
3. Presence of vocal sacs.	3. Vocal sac absent.
4. Males are slimmer.	4. Females are stouter.
5. Males have copulatory organ.	5. Copulatory organ absent.

Date

# STUDY OF MUSEUM SPECIMEN

- Kingdom - Animalia
- Phylum - Chordata
- Subphylum - Vertebrata
- Group - Gnathostomata
- Class - Amphibia
- Genus - Rana
- Species - tigrina



Frog

## COMMENTS ON TOAD

**Important Character:** It is amphibious; live both on land as well as in water.

**Habit and Habitat:** It is mostly found on land (terrestrial) but it goes in water or moist place to lay eggs. It is nocturnal animals, and prefers to stay in dark shady places hiding under stones, crevices, etc. It is a **carnivorous** animal and it feeds on small insects,

- Shape, size and colouration:** Toad is streamlined measuring about 10 cm long. Its colour at the dorsal side is grey brown. The colouration helps them to be safe from their enemies.
- Body divisions:** Body is cylindrical, bilaterally symmetrical. It is divided into head and trunk. Neck is absent.
- Skin:** The skin on dorsal surface is rough, dry and warty.
- Head:** It is semicircular and bears a pair of bulging eyes, external nostrils and tympanum.
- Parotid glands:** There are two parotid glands just behind the each tympanum. These glands secrete poison secretion which makes it safe from enemies.
- Trunk:** The trunk bears 2 pairs of limbs. The front limbs are shorter, each with 4 digits and hind limbs are longer, each with 5 digits (webbed fingers absent).
- In toad, teeth are absent. Tongue is not bifid.
- Respiration:** Frogs respire by lungs.
- Circulatory system:** Heart is three chambered; two auricles and one ventricle. RBCs are biconvex, oval and nucleated.
- Excretory system:** It takes place by mesonephric kidney.
- Reproductive system:** Unisexual; sexual dimorphism is distinct.
- Fertilization is external. Development is indirect through tadpole larva.

### Economic Importance

It is a carnivorous. It feeds on small insects, snail, slugs, spiders, etc. Therefore, they are great friend of farmers.

### Viva Questions

Students must remember

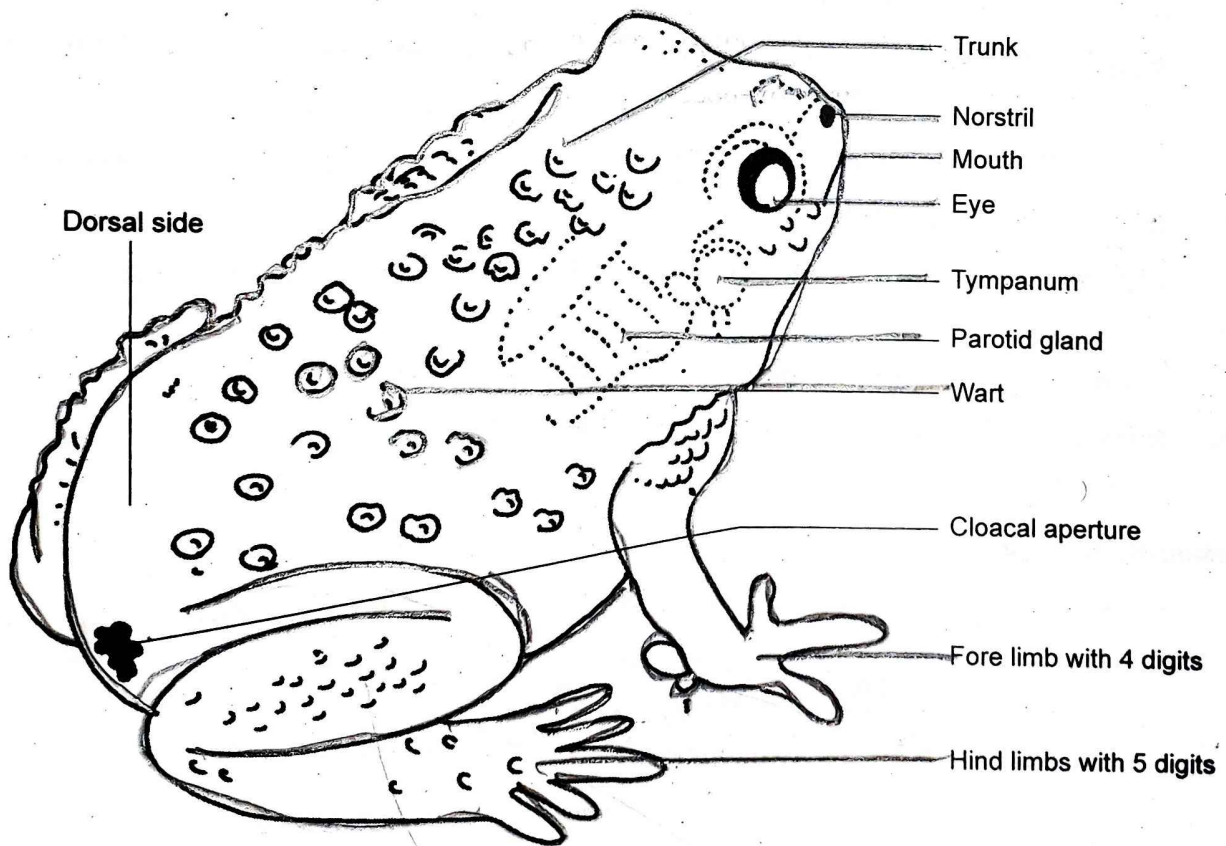
Table : Differences between frog and toad

Frog	Toad
1. Mainly live in water	1. Mainly live on land
2. Active during the day (diurnal)	2. Active during night (nocturnal)
3. Skin is moist, smooth	3. Skin is rough, dry and warty.
4. Poison gland is absent	4. Poison gland is present
5. Head is triangular	5. Head is semicircular.
6. Digits webbed	6. Digit - not webbed.

Date

# STUDY OF MUSEUM SPECIMEN

- Kingdom – Animalia
- Phylum – Chordata
- Subphylum – Vertebrata
- Group – Gnathostomata
- Class – Amphibia
- Genus – Bufo
- Species – melanostictus



Bufo (Toad)

## COMMENTS ON WALL LIZARD

**Important Character:** Wall lizard is elongated, broad, and a flattened body. It is a creeping animal.

**Habitat:** It is a common house lizard found on the walls and buildings all over the world, especially in warmer countries. It is mostly nocturnal and insectivorous. It hibernates in winter. It is poikilothermic (cold-blooded).

- 1. Skin:** Body is dry, rough and non-glandular. It is covered with minute scales.
- 2. Body divisions:** Body is elongated and flattened. It is divisible into three regions - head, trunk and tail.
- 3. Head:** It is triangular which bears a pair of nostrils, a pair of eyes, nostrils and external ear opening (tympanum). The eyes are permanently covered by a transparent membrane (no movable eyelids).
- 4. Locomotion:** They have two pairs of pentadactyle limbs. The fore limbs and hind limbs are well adapted for running and walking over the ceiling and on the walls without falling down. The digits are clawed and have spongy lamellae. When the lamellae are pressed on walls, vacuum is created which enable the lizard to stick to the surface.
- 5. Tongue** is short, sticky, slightly notched and protrusible. It is used to capture the insects.
- 6. Tail:** It is moderately long. It has a great power of autotomy. (Autotomy means wall lizard can break off its tail when attacked, to confuse the animals or to escape. The lost tail is regenerated later on.
- 7. Respiration:** It takes place by lungs.
- 8. Circulatory system:** Heart is incompletely divided four chambered. RBCs are nucleated, biconvex and oval.
- 9. Excretory system:** It takes place by metanephric kidney.
- 10. Reproductive system:** Sexes are separate. Male has copulatory organs. Fertilization is internal. It is oviparous.

### Economic Importance

It is an insectivorous. It is useful as it feeds on spiders and small insects.

### Viva Questions

### Students must remember

1. How do the wall lizards move on the walls?

**Ans:** The fingers of wall lizards are clawed and have spongy lamellae. When these lamellae are pressed on walls, vacuum is created which enables the lizard to stick to the surface. Hence, it is well adapted for running and walking over the ceiling and on the walls without falling down.

2. What is meaning of autotomy?

**Ans:** Autotomy is a phenomenon in which tail is voluntarily broken off. In wall lizard, when attacked, it breaks off its tail to escape from enemy (for self protection).

3. How does the wall lizard take food?

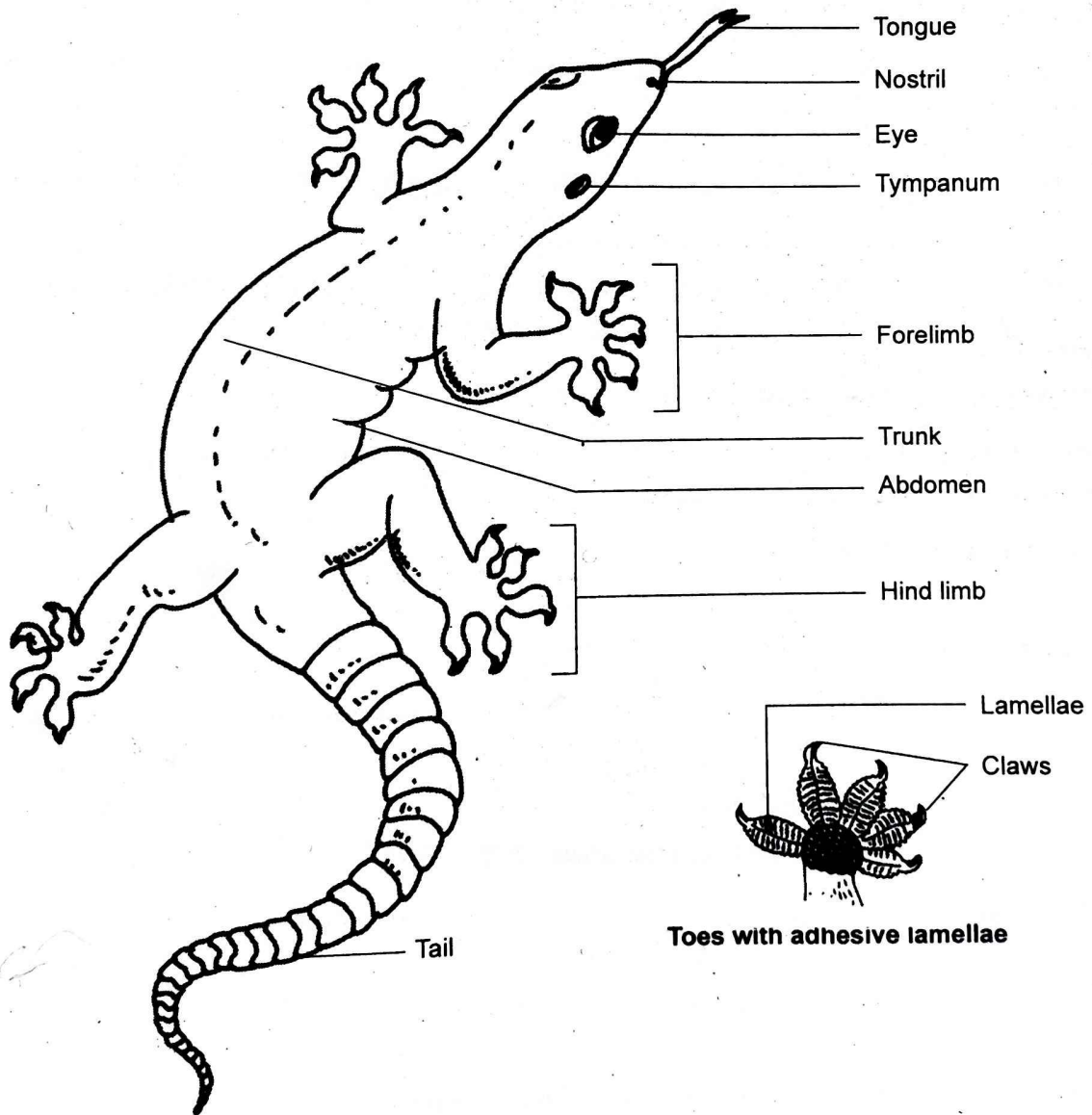
**Ans:** With the help of tongue. It is slightly notched and protrusible. It is used to capture the insects.

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Date

# STUDY OF MUSEUM SPECIMEN

- Kingdom — Animalia
- Phylum — Chordata
- Subphylum — Vertebrata
- Group — Gnathostomata
- Class — Reptilia
- Genus — Hemidactylus



Wall Lizard

## COMMENTS ON GREEN TURTLE

**Important Character:** Green turtle is a creeping animal.

**Habitat:** It is a marine animal commonly found in Indian, Pacific and Atlantic oceans. It is herbivorous, feeds mostly on sea-weeds. It comes to seashore or land to lay eggs. It is poikilothermic (cold-blooded). It hibernates during winter season.

- 1. Body covering:** Body encloses in a bony shell. It consists of dorsal convex carapace on the dorsal surface and flat plastron on the ventral surface. They are jointed by ligament.
- The shell is open at the anterior and posterior ends. Head, tail and fore limbs project from anterior opening and hind limbs and tail protrude from posterior opening.
- 3. Head:** It is triangular which bears a pair of nostrils, a pair of eyes, nostrils and external ear opening. Eyes are provided with eye lids and nictitating membrane.
- 4. Neck:** It is short. When animal is threatened with danger, the head, neck, limbs and tail are withdrawn into the shell.
- The jaws are without teeth but jaws are armed with horny sheaths which have sharp edges for cutting and tearing the food.
- 6. Locomotion:** It takes place by fore limbs and hind limbs which are modified into paddles well adapted for swimming. Fingers and toes are concealed under skin.
- 7. Respiration:** It takes place by lungs.
- 8. Reproduction:** Sexes are separate. It is oviparous. Sexual dimorphism is marked by the bigger sized female turtle than male.
- It comes out of sea to lay eggs. Hind limbs are used to gather and shovel the sand to cover the eggs.

### Economic Importance

Turtle is used as food and soup. It is a good source of protein and fat. The shells are equally used for ornaments. However, its paddles are used for leather goods and hand bags.

### Viva Questions

Students must remember

1. Where does the turtle found?

**Ans:** Turtle is a marine reptile.

2. What is carapace?

**Ans:** Carapace is a bony shell covering the dorsal body surface.

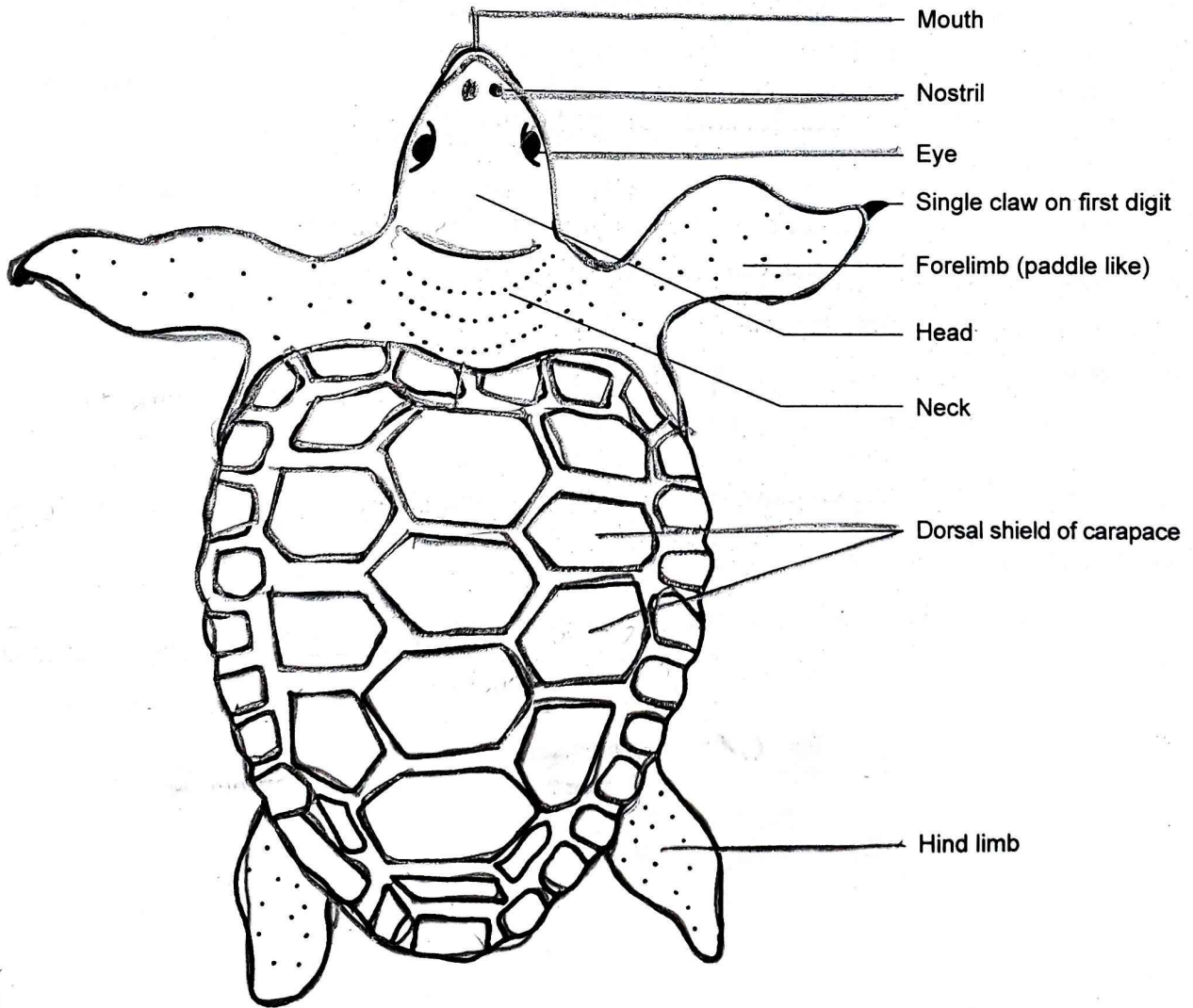
3. Why is turtle called cold-blooded animal?

**Ans:** Turtle can change the body temperature according to surroundings.

Date

# STUDY OF MUSEUM SPECIMEN

- Kingdom – Animalia
- Phylum – Chordata
- Subphylum – Vertebrata
- Group – Gnathostomata
- Class – Reptilia
- Genus – Chelone



Chelone (Green Turtle)

## COMMENTS ON PIGEON

**Important Character:** Body is covered with feathers, adapted to live in air.

**Habitat:** It is the most common bird, inhabits human dwellings and old buildings. It is a warm blooded (homeothermic) animal (body temp. is fixed). It is diurnal. It is a granivorous bird.

1. **Body form:** Body is streamlined. It is divisible into head, neck, trunk, and tail. Head is small and round. Neck is long and flexible. Tail is short and stumpy. Body is covered with feathers.
2. **Size and colour:** It measures about 25 cm in length. It has grey coloured feathers, with violet coloured beautiful neck. Eyes and feet are pink.
3. **Beak:** It is short, straight and pointed adapted for picking up grains. At the base of beak, there is a pair of nostrils. Beak is without teeth.
4. **Locomotion:** They have two pairs of limbs. The fore limbs are modified into wings for flying. There are two prominent black bars on the wings.
5. The hind limbs support the body, used for perching, walking and food capturing. Each leg has four digits; 3 directed forward and the first or **hallux** backward. Hence it is called **bipedal**.
6. **Skin:** It is dry and devoid of glands except **oil** or **preen glands** at the root of tail.
7. **Endoskeleton:** Bones are pneumatic or hollow and porous without bone marrow. It makes the body light.
8. **Respiratory system:** It takes place by spongy and inelastic lungs. It consists of many air sacs. It also reduces the weight of the body.
9. **Heart:** Heart is completely divided into four chambered (2 auricle and 2 ventricles).
10. **Excretory system:** It takes place by metanephric kidneys. Urinary bladder absent. They are uricotelic.
11. **Flight muscles** are well developed.
12. **Reproductive system:** Sexes are separated. Sexual dimorphism is often well marked.
13. **Fertilization** is internal, preceded by copulation and courtship. They are oviparous.

### Economic Importance

Pigeon is considered as the living symbol of peace, harmony and happiness all over the world.

### Viva Questions

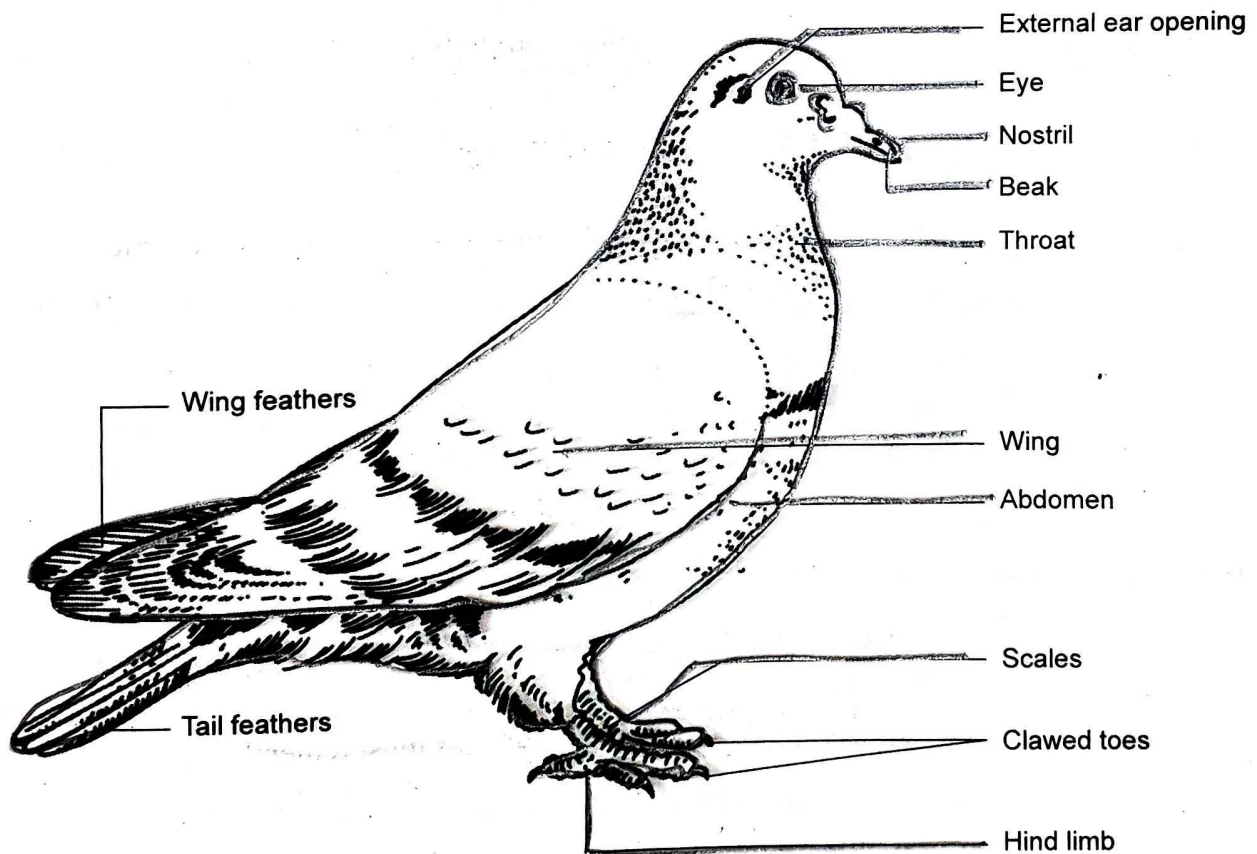
### Students must remember

1. Why is birds kept in class Aves?  
**Ans:** Because, the body is covered with feathers which are adapted to live in air.
2. What is meaning of warm blooded (homeothermic)?  
**Ans:** In case of warm blooded, the body temperature is fixed.
3. Why are the birds streamlined?  
**Ans:** Streamlined body minimizes the resistance in the air during flying.

Date

# STUDY OF MUSEUM SPECIMEN

- Kingdom – Animalia
- Phylum – Chordata
- Subphylum – Vertebrata
- Group – Gnathostomata
- Class – Aves
- Genus – Columba
- Species – livia



Pigeon

## COMMENTS ON PARROT

**Important Character:** Body is covered with feathers adapted to live in air. It is popular domestic cage bird.

**Habitat:** It inhabits in hollow tree trunk in the gardens or forests. It is diurnal. It is frugivorous feeding on fruits and grains. They are gregarious living in groups.

- 1. Body form:** Body is streamlined. It is divisible into head, neck, trunk, and tail. Tail is short but provided with long feathers which help in steering.
- 2. Size and colour:** It measures about 12 cm in length. Body is covered with light green coloured feathers. The female is green all over, but the male has a rose pink collar and a black throat
- 3. Beak:** It is short, stout, and deeply hooked red coloured. It is modified for eating fruits and cracking nuts.
- 4. The fore limbs** are modified into wings.
- 5. The hind limbs** are adapted for climbing, clinging and grasping type. Toes are provided with claws.
- Parrots produce loud voices, can copy and speak some words like human. It can imitate the human speech.
- 7. Endoskeleton:** Bones are pneumatic or hollow and porous without bone marrow. It makes the body light.
- 8. Respiratory system:** It takes place by spongy and inelastic lungs. It consists of many air sacs. It also reduces the weight of the body.
- 9. Heart:** Heart is completely divided into four chambered (2 auricle and 2 ventricles).
- 10. Excretory system:** It takes place by metanephric kidneys. Urinary bladder absent.
- 11. Flight muscles** are well developed.
- 12. Reproductive system:** Sexes are separated. Sexual dimorphism is well marked. Female parrot is green all over, but the male parrot has a rose pink collar and a black throat

### Economic Importance

It is used as a pet, decorated in houses. It is also considered as the agricultural pest, damage the crops.

### Viva Questions

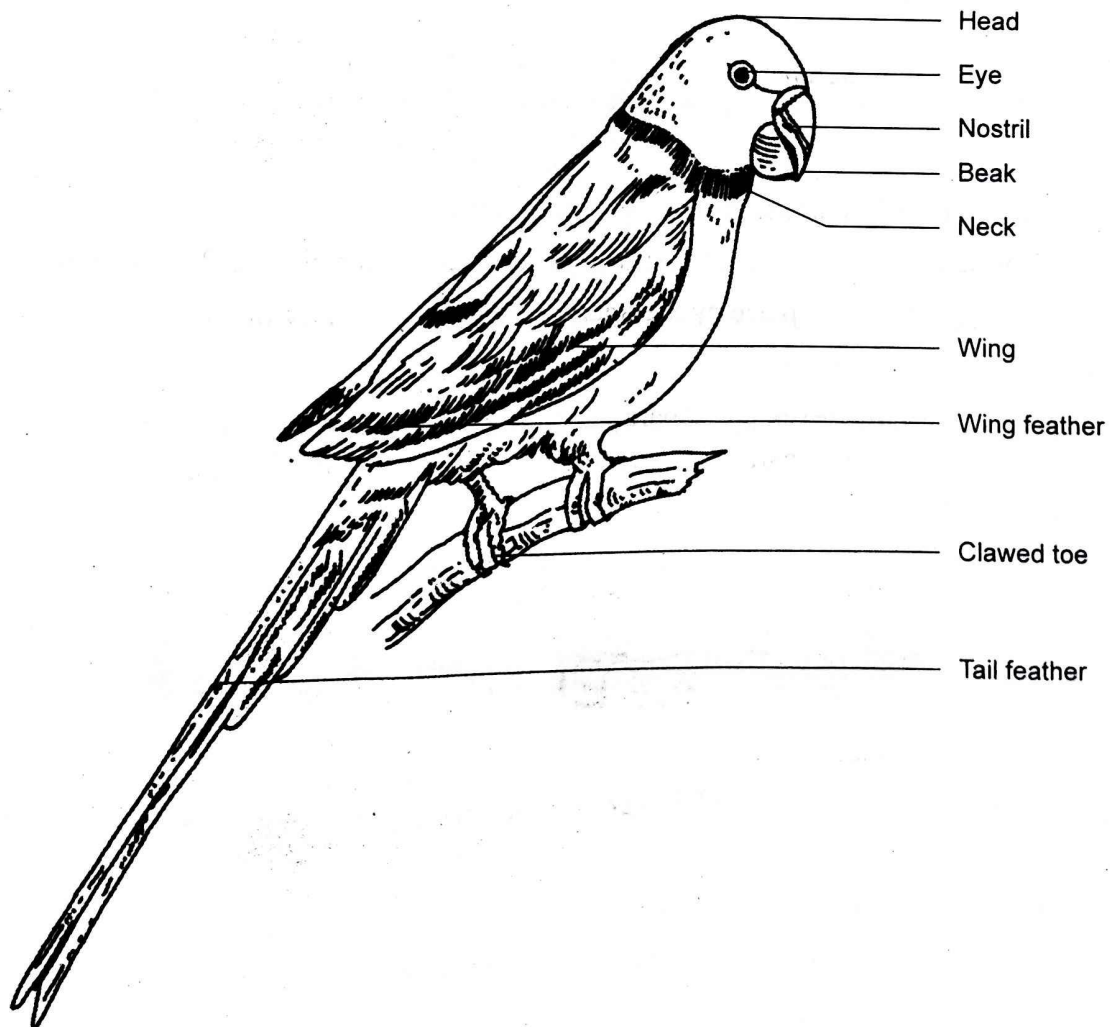
Students must remember

- What is pneumatic bone?  
**Ans: Bone is hollow and porous without bone marrow to make the body light.**
- What is meaning of frugivorous?  
**Ans: It is the feeding of fruits.**
- What is the function of feathers?  
**Ans: Feathers insulate the body and makes the body light.**
- How can the male and female parrots be distinguished?  
**Ans: The female is green all over, but the male has a rose pink collar and a black throat**

Date

# STUDY OF MUSEUM SPECIMEN

- Kingdom - Animalia
- Phylum - Chordata
- Subphylum - Vertebrata
- Group - Gnathostomata
- Class - Aves
- Genus - Psittacula
- Species - krameri



Parrot

## COMMENTS ON SQUIRREL

**Important Character:** Squirrel possesses fur, external pinna, and giving birth to young ones.

**Habitat:** It lives on trees or ground and it is an active runner. It is arboreal as well as terrestrial. It feeds on seeds, nuts, fruits, hence called frugivorous

1. **Body:** The body is divisible into head, neck, trunk and tail.
2. **Skin:** The body is covered with light grey soft fur.
3. The dorsal surface of the trunk has 3 to 5 longitudinal stripes of dark colour and grey stripes. However, these are absent on the ventral.
4. **Head:** It is elongated and conical produced into snout. It bears many long, stiff and sensory hairs called vibrissae at its tip.
5. Eyes and pinna are large and well developed.
6. **Teeth:** There are four incisors and molars. Canine and anterior premolars are absent. It is gnawing mammal with chisel shaped incisor.
7. Fore limbs are short and used for catching foods. Hind limbs have four clawed digits which help in climbing trees.
8. Tail is long and bushy. It acts as balancing organs during movement.
9. **Reproduction:** Sexes are separate. Sexual dimorphism is well marked. Male has the copulatory organs as penis. The testes are extra abdominal. However, the female has thoracic and abdominal nipples
10. **Fertilization:** Fertilization is internal. It is viviparous.

### Economic Importance

It causes a lot of damage to gardens and orchards. It destroys the fruits.

### Viva Questions

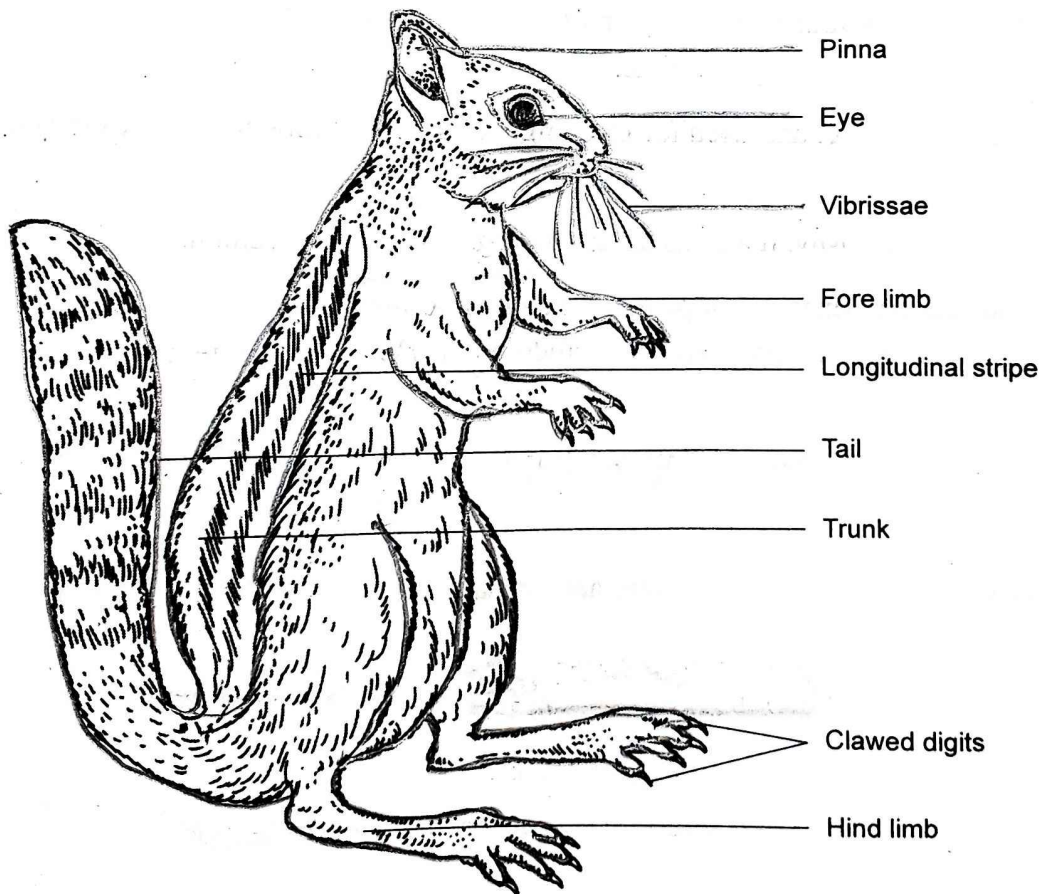
Students must remember

1. What are important characters of a mammal?  
**Ans:** Mammals are characterized by the presence of hair on the body, a pair of pinnae and mammary glands.
2. How do you recognize a squirrel as mammal?  
**Ans:** In case of squirrel, the dorsal surface of the trunk has 3 to 5 longitudinal stripes of dark colour and grey stripes. It is a frugivorous.
3. What is oviparous?  
**Ans:** Oviparous means the giving the young ones directly.

Boto

# STUDY OF MUSEUM SPECIMEN

- Kingdom – Animalia
- Phylum – Chordata
- Subphylum – Vertebrata
- Group – Gnathostomata
- Class – Mammalia
- Genus – Funambulus



Squirrel

## COMMENTS ON RABBIT

**Important Character:** Rabbit possesses fur, external pinna, and giving birth to young ones.

**Habitat:** It is found in fields, grasslands, burrows and open woodlands.

- Fussorial habit:** It is a fussorial animal living in the burrows. It digs a burrow, called a warren.
- Gregarious nature:** Rabbits are gregarious animals. They live and move in groups. It is crepuscular in nature as it comes out of burrows in dim light for feeding.
- Feeding:** They are herbivorous, feeding on green vegetation. They are also called coprophagous as they feed their soft night droppings without mastication.

### External Features

- Body:** The body is divisible into head, neck, trunk and tail.
- Skin:** The body is covered with soft white fur.
- Head:** It is large, pear shaped and produced anteriorly into snout. It bears mouth, external nares, eyes and many long stiff sensory hairs called vibrissae.
- Eyes** are large and protected by upper and lower eyelids along with eye lashes.
- Pinna** is large and flexible. It is movable independently to collect the sound.
- Fore limbs are short with claws. These are used for digging. However, the hind limbs are longer and used for running or leaping.
- Tail is long and bushy. It acts as balancing organs during movement.
- Reproduction:** Sexes are separate. Sexual dimorphism is well marked. Male has the copulatory organs as penis. The testes are extra abdominal. However, the female bears 4 to 5 pairs of well developed nipples.
- Fertilization:** Fertilization is internal. It is viviparous.

### Economic Importance

It causes a lot of damage to gardens and orchards.

### Viva Questions

Students must remember

1. What is meaning of fussorial?

**Ans:** Fussorial is a habit living the animal in burrows.

2. Define Coprophagous.

**Ans:** Coprophagous is a feeding habit, in which rabbit feeds the faecal matters.

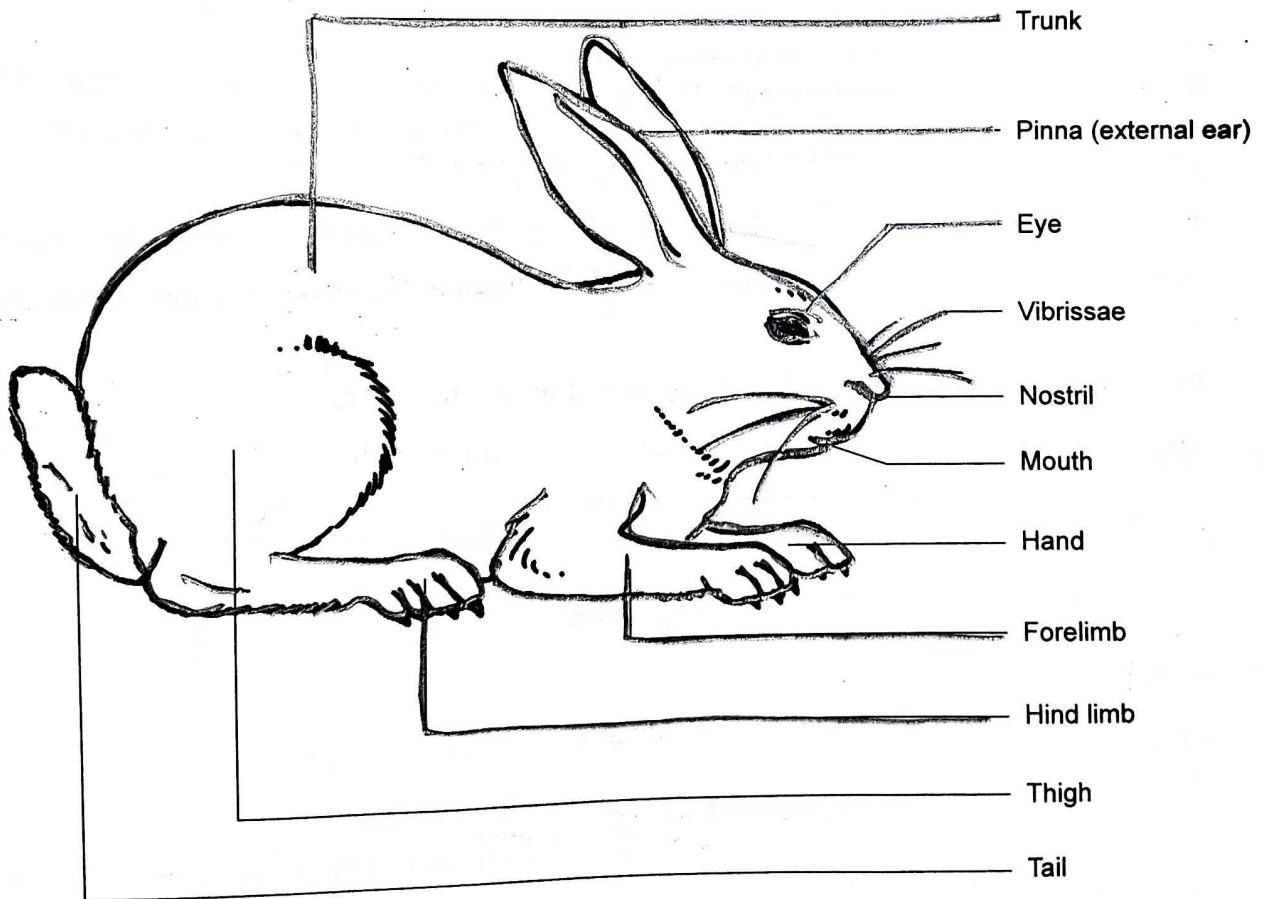
3. What is crepuscular?

**Ans:** Crepuscular means that the animal comes out in dim light. Rabbit is a crepuscular animal.

Date

# STUDY OF MUSEUM SPECIMEN

- Kingdom - Animalia
- Phylum - Chordata
- Subphylum - Vertebrata
- Group - Gnathostomata
- Class - Mammalia
- Genus - Oryctolagus



Rabbit

## COMMENTS ON BAT (RHINOLOPHUS)

**Important Character:** Bat is a mammal because it possesses fur, external pinna and giving birth to young ones.

**Habitat:** It is found hanging in old buildings and on the trees. It is nocturnal and insectivorous. They are gregarious; living in colony.

### External features

1. **Body:** Body is small. It is covered with grey coloured soft fur.
2. **Eyes** are small but vision is weak as the visual rods are poor.
3. **Pinna** is large and highly specialized to receive sound. It receives the ultrasonic sound waves.
4. The fore limbs are modified into wings. These wings are made up of fold of skin called patagia which are supported by clawed digits of fore limbs.
5. The hind limbs are short with five clawed digits. These help in hanging the bat to tree trunk and old buildings
6. It produces ultrasonic sound waves during flying. It helps in guiding flight path. When it finds any obstacle, the sound waves are reflected back and that are picked up by their ears. It has highly developed sonar or echoapparatus, a kind of radar.
7. It also uses ultrasonic sound for navigation. It has ability to catch flying insect during flight.
8. During day time, bats hang themselves on the branches of trees by their hind limbs, keeping head downwards.
9. The female gives birth to a single young one at a time

### Economic importance

It feeds on insects that help to control pests and minimize the economic loss.

### Viva Questions

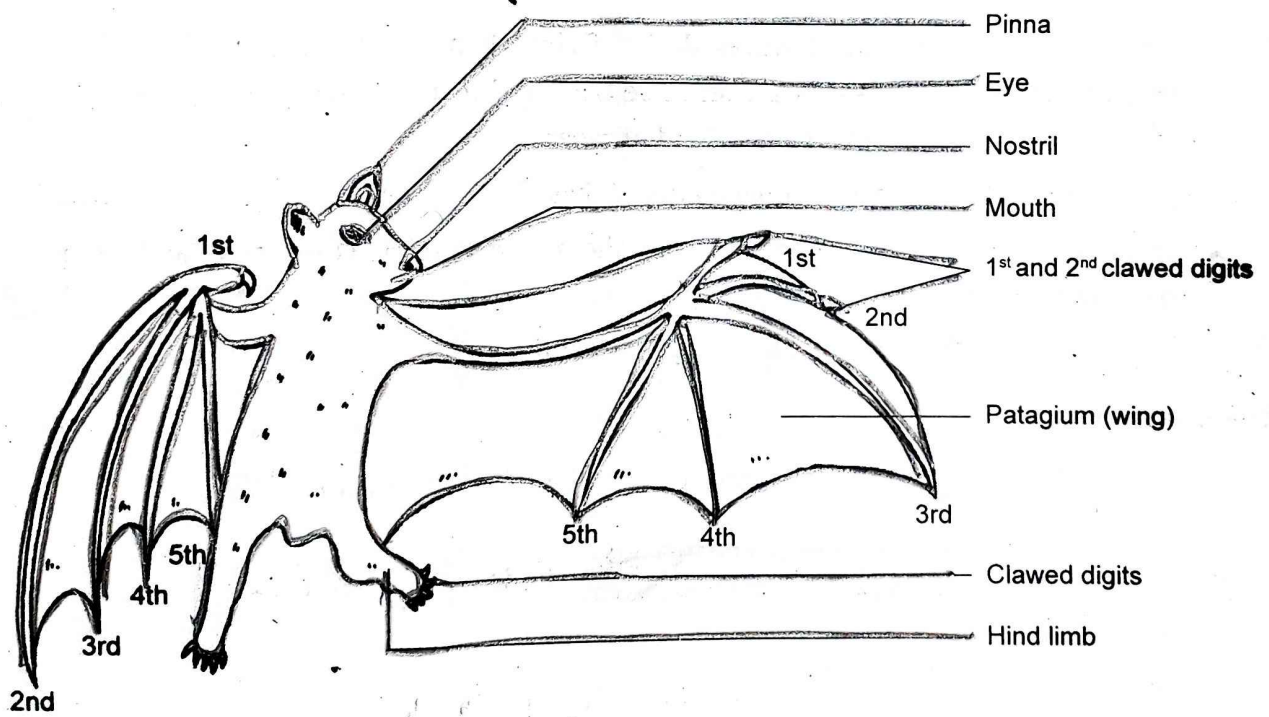
Students must remember

1. What is patagium?  
**Ans:** The patagium is a wing like structure made up of a fold of skin.
2. How do bats manage to avoid collision against objects in the dark?  
**Ans:** The bats produce ultrasonic sound waves which after striking the solid objects are reflected back. These sounds are received by ears as echos.
3. Why is bat not called as a bird?  
**Ans:** Because bat possesses mammalian characters such as presence of fur, external pinna and giving birth to young ones.
4. Where do the bats found?  
**Ans:** Bats are found hanging on the trees, crevices of old buildings.

Date \_\_\_\_\_

# STUDY OF MUSEUM SPECIMEN

Kingdom - Animalia  
 Phylum - Chordata  
 Subphylum - Vertebrata  
 Group - Gnathostomata  
 Class - Mammalia  
 Genus - Rhinolophus



Bat

## Viva Questions

Students must remember

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1. What is binomial nomenclature? Why do we underline the scientific names?  
**Ans:** It is the scientific system of naming an organism. It includes two names - the generic and the specific. The genus name is written first and begins with a capital letter, while the species name begins with a small letter. Both the names are either written in italic or underlined.
2. Why are protozoans called unicellular organisms?  
**Ans:** All the physiological and metabolic activities are performed by a single cell. Hence, protozoans are called unicellular organism.
3. What are the locomotory organs present in protozoans?  
**Ans:** The locomotory organs in protozoa are cilia, flagella and pseudopodia.
4. Name any parasite belonging to class sporozoa.  
**Ans:** Class sporozoa includes the organisms without locomotary organs. The example is Plasmodium sp which causes malaria in human.
5. What is the meaning of diploblastic? Give example.  
**Ans:** Diploblastic means that the body wall is composed of two cellular layers. The outer layer is called the ectoderm and inner layer is endoderm.
6. What is nematocyst?  
**Ans:** It is an oval bladder like structure found in the cnidoblast or nematoblast. It is filled with a poisonous fluid, the hypnotoxin. Hypnotoxin is a stronger poison than snake venom.
7. What is polymorphism? Which animal does it show?  
**Ans:** (Poly = many; morph = structure). When any animal exhibits more than two structures, called polymorphism. e.g., coelenterates. They show two forms - sexual form (called medusa) and asexual form (called polyp).
8. What is pseudocoel?  
**Ans:** It is a false body cavity developed from the blastocoel. It differs from the true coelom, because it is not lined with peritoneum. It is filled with pseudocoelomic fluid, which serves for the transport of food, oxygen and waste products. It is the characteristic feature of Aschelminthes.
9. What is metamerically segmentation?  
**Ans:** When the body is divided into externally and internally, it is called metamerically segmentation. Example - Earthworm or Leech.
10. What are the three basic chordate characters?  
**Ans:** Three basic chordate characters are:
  - a. Presence of notochord,
  - b. Nerve cord and
  - c. Pharyngeal gills slits.
11. What is agnatha?  
**Ans:** (a = not; gnatha = jaw). Higher chordate without jaws and paired appendages is agnatha. eg., Petromyzon.
12. What do you mean by gnathostomata?  
**Ans:** Gnathostomata is a group of higher chordate which possesses true jaws and paired appendages. Fishes, amphibians, reptiles, birds and mammals are the examples of gnathostomata.
13. What do you mean by tetrapoda?  
**Ans:** (tetra = four; poda = legs) Tetrapoda is a character of higher vertebrates which possess four limbs.
14. What is camouflage?  
**Ans:** It is the protective colouration by which animals able to hide from the notice of other animals. e.g., Frog.
15. Name the national bird of Nepal.  
**Ans:** Daphe (Lophophorus sp.).
16. Why do you say that whale is not a fish?  
**Ans:** Whale does not have fins, scales, lateral line and cold blooded. Therefore, it is not a fish. It respire by lungs, four chambered heart, warm blooded and give birth to young. It possesses mammalian characters.

## PREPARATION OF TEMPORARY SLIDES

In biological laboratory, temporary slides are prepared in water, normal saline and glycerine.

- A. **In water:** The small organisms like protista can be mount in water. When the mount is prepared in normal water, few drops of water containing the material to be examined. e.g., protistan like *Euglena*, *Amoeba*, *paramecium* etc. is kept on the slide and a cover slip is placed upon the slide and then it is examined under the microscope.
- B. **In normal saline:** When the mount is prepared in normal saline solution, the material to be examined is put in the normal saline solution upon the slide on which cover slip is placed and then studied under the microscope.
- C. **In glycerine:** In case of glycerine preparation the material is first of all washed in water and stained in aqueous eosin, then mounted in glycerine.

### Materials required for mounting

- |                      |                    |                              |
|----------------------|--------------------|------------------------------|
| 1. Slide             | 2. Cover-slip      | 3. Stain (Eosin or safranin) |
| 4. Brush             | 5. Watch glass     | 6. Glycerine                 |
| 7. Forceps or needle | 8. Cotton material | 9. Microscope                |

### Procedure for mounting

1. Clean the slide and cover-slip properly with neat cloth or cotton.
2. Draw a diagram of slide and sketch its diagonals in the rough paper to determine the centre of the slide.
3. Put a drop of mounting material like glycerine in the centre of the slide.
4. Observe the material and transfer it on the slide by a brush or forceps.
5. Place the cover-slip gently to keep one edge on the slide touching the mounting material and hold its other edge obliquely either with needle or forceps
6. Now gently lower down the needle or forceps till the coverslip completely touches the mounting material.
7. The excess material which comes around cover slip, should be washed with cotton soaked in xylol or absolute alcohol. Avoid the air bubbles by drying in heat.
9. Observe the prepared material in microscope and draw the diagram and label it.

### Precautions

1. The materials like slide, cover-slip, needles, brush etc. should be clean.
2. The material should be in the **centre of slide**. The cover-slip should be in the centre of material.
4. Avoid air bubbles. **Excess of mounting material** should not come out of the cover-slip.
6. Observe the **material in proper light**.

# Preparation of Temporary Slide of Striated Muscles of Frog

## Materials required

Following materials are required to prepare a temporary slide of striated muscles of a frog.

- |                   |             |               |
|-------------------|-------------|---------------|
| 1. Preserved frog | 2. Scissors | 3. Petri dish |
| 4. Watch-glass    | 5. Slide    | 6. Microscope |
| 7. Cover-slip     | 8. Safranin | 9. Glycerine  |
| 10. Pin           | 11. Water   |               |

## Procedure

1. Cut a piece of muscle from the thigh region of a frog by using a scissors.
2. Put the material in a petri dish and wash it properly in water.
3. Keep the muscle in 5% KOH solution for a few minutes.
4. Wash the material in flowing tap water to remove the KOH or impurities.
5. Tease the material with the help of two needles.
6. Select 5-6 fine fibres to observe. Stain all the selected fibres in safranin.
8. Now put glycerine on the centre of slide. Put the fibres gently on the slide with the help of brush.
10. Now cover the material with cover-slip with the help of needle. Observe material under microscope.

## Observation

1. These muscle show striations of alternating light and dark bands hence called striated or striped muscles.
2. These are being attached with bones so also called skeletal muscles.
3. It is under control of will so called voluntary muscle..
5. Each fibre is surrounded by an extremely thin covering called sarcolemma.
6. The sarcolemma encloses semi-fluid and highly contractile cytoplasm called sarcoplasm.
7. Many nuclei are present in the sarcoplasm between dark and light bands.
8. Each fibre is made up of a large number of longitudinal and parallel myofibrils.
9. Dark and light bands can be seen like a finger print in the microscope.

## Precautions

1. Use the pointed pin to tease the muscle very carefully.
2. Avoid too much staining. Select 2-4 fine muscle fibre for proper observation.

## Viva Questions

Students must remember

1. What are striped muscles?

**Ans:** Striped muscles are the voluntary muscles found in the limbs of vertebrates.

2. What are the bands present in striped muscles?

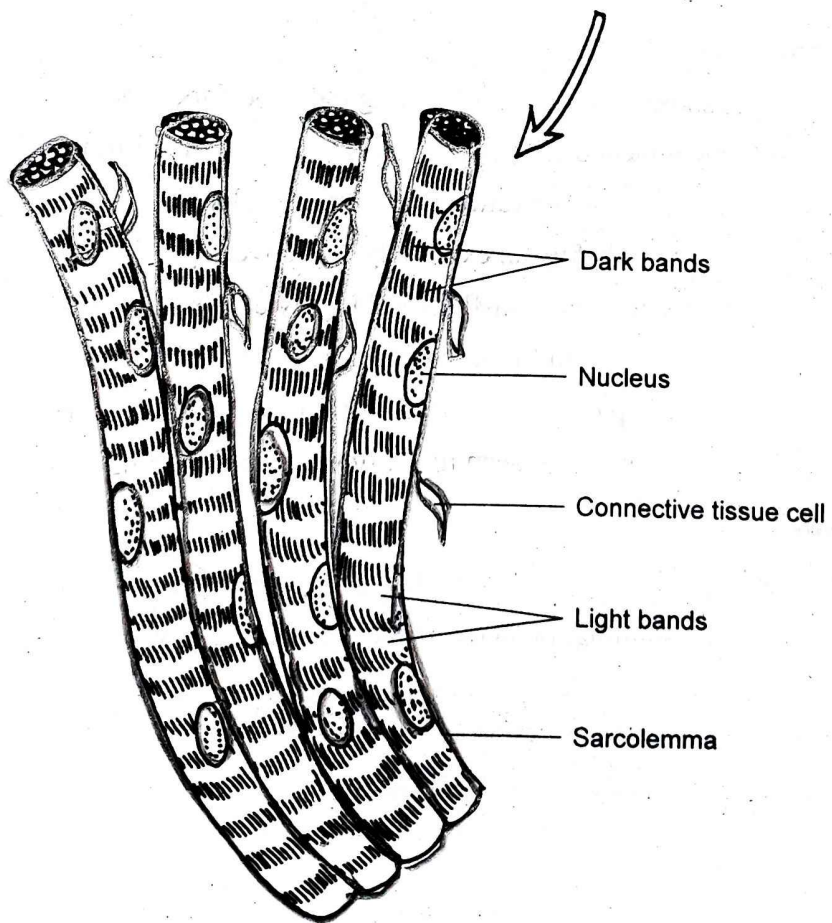
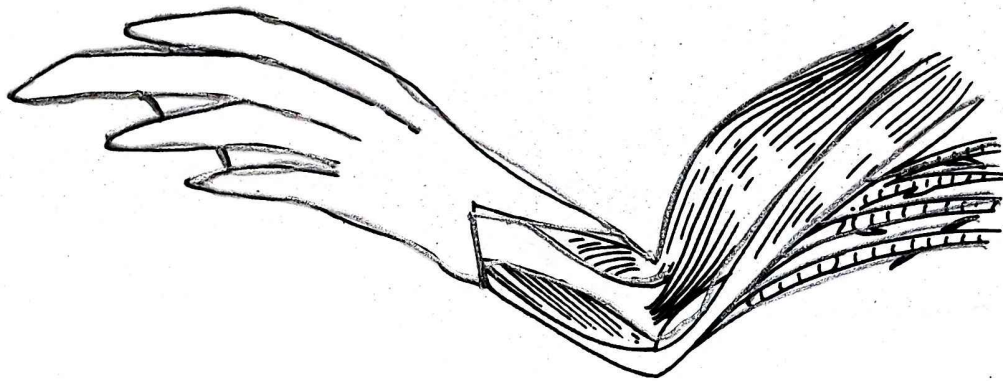
**Ans:** The bands are light and dark bands, arranged alternately.

3. What is acentric nucleus?

**Ans:** Acentric means that the nucleus is located at the periphery, not at the center.

Date

# PREPARATION OF TEMPORARY SLIDE OF STRIATED MUSCLE OF FROG



Striated Muscle of Frog

## Preparation of Temporary Slide of Setae of Earthworm

### Materials required

Following materials are required to prepare a temporary slide of a setae:

- |                      |                          |                |
|----------------------|--------------------------|----------------|
| 1. A earthworm       | 2. Petridish, water      | 3. Test-tube   |
| 4. Scissors or blade | 5. KOH 5%                | 6. Spirit lamp |
| 7. Brush             | 8. Glycerine             | 9. Microscope  |
| 10. Test tube holder | 11. Well-labelled figure | 12. Gloves     |

### Procedure

1. Cut a piece of square shaped, approx. 3 mm. integument from the ventral side of the body.
2. Wash the material in water to make it clean.
3. Put the material in the clean test-tube with the help of needle or brush.
4. Pour the 5% KOH solution carefully in the test-tube.
5. Boil the material 3-4 minutes till it turns yellowish in colour. Let allow the material to cool down.
7. Wash the material in water and spread it on the slide with brush.
8. Gently remove the muscles present on the inner surface.
9. Observe the material in microscope to ascertain the presence of setae,
10. Study the slide under the microscope. Draw a diagram and label it.

### Observation

1. The body of earthworm is segmented.
2. Setae are locomotory organs of the earthworm situated in each segment (except 1<sup>st</sup>, last and clitellum).
3. Seta is elongated s-shaped and faint yellow in colour, embedded in the setal sac of each segment.
5. The movement of seta is control by protractors and retractors muscle.
6. The protractor and retractor muscles are inserted in the base of each setal sac.
7. Each seta consists of the base, the body and the neck.
8. Setae and muscles (circular and longitudinal) contribute to the forward movement of the body.

### Precautions

1. Only boil the cleaned material properly. Excess boiling may dissolve the material.
3. Do not use the pointed needle to spread the material on the slide.
4. Be careful during boiling of material.

### Viva Questions

Students must remember

1. What are setae?

**Ans:** Setae are the locomotory organs of earthworm.

2. Where are setae found?

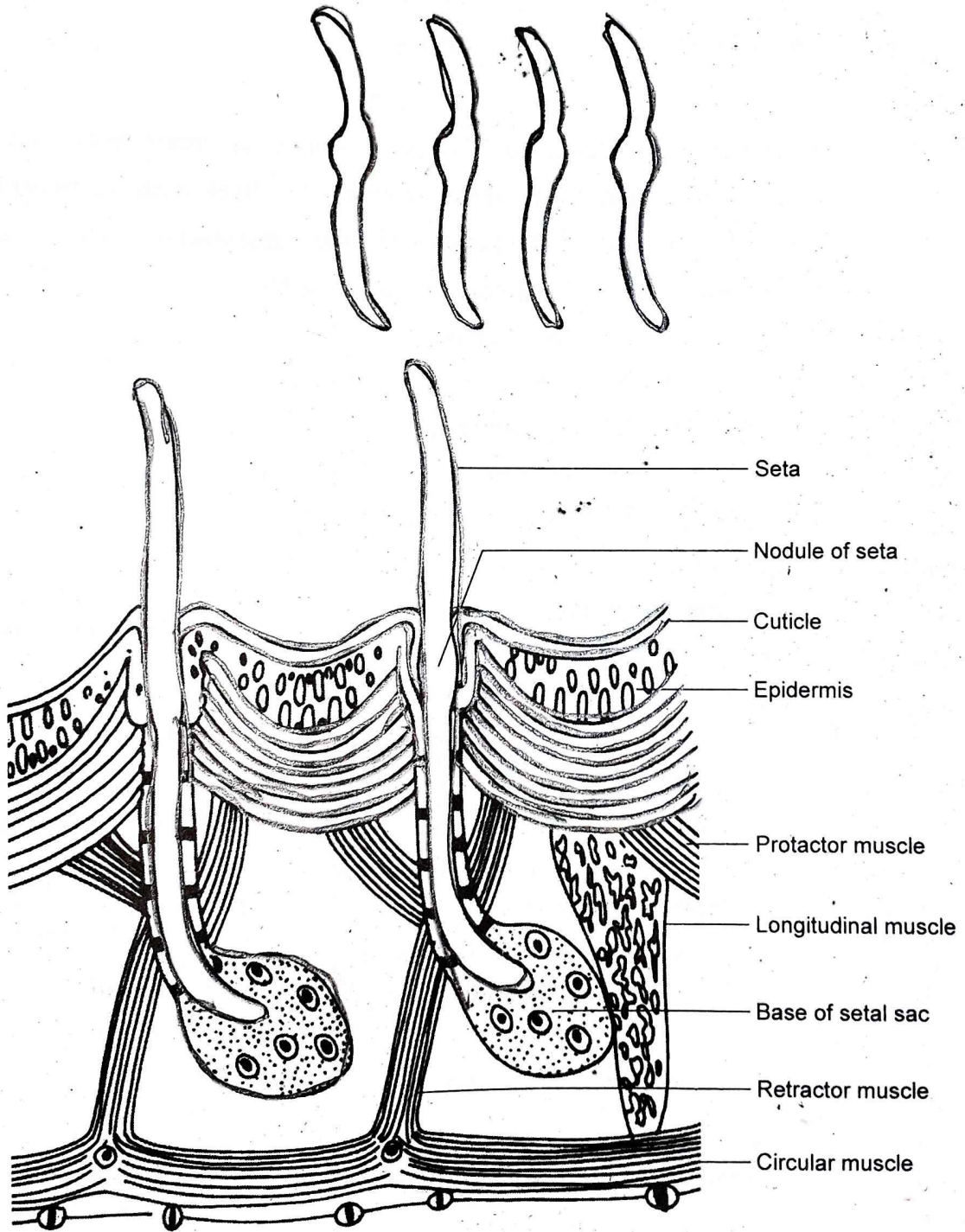
**Ans:** Setae are found in all segments except 1<sup>st</sup>, clitellum and last segment.

3. Why is muscle boil in KOH?

**Ans:** KOH dissolves the muscle not the setae. It makes the setae free from muscle.

Date

# PREPARATION OF TEMPORARY SLIDE OF SETAE OF EARTHWORM



Setae of earthworm

## Preparation of Temporary Slide of Human Cheek Cell

### Materials required

To obtain squamous epithelial cells of human cheek following materials are required

- |                          |                           |
|--------------------------|---------------------------|
| 1. Spatula or tooth pick | 2. Methylene blue (stain) |
| 3. Slide                 | 4. Glycerine              |
| 5. Cover slip            | 6. Microscope             |
| 7. Well labelled diagram | 8. Brush                  |

### Procedure

1. Obtain a clean and blunt instrument such as a spatula, wooden icecream spoon or a tooth pick.
2. To get the epithelial cheek cells, gently scrape inside your cheek with the blunt instrument.
3. Put the scraping on the surface of clean microscopic slide and spread it with the needle.
4. Add a drop of water and stain them by a drop of methylene blue.
5. Cover the stained cells with a cover slip gently.
6. Avoid the air bubbles and examine the cells under microscope.
7. First use low power to find some of the scrapings.
8. Then look at one of the cells under high power.
9. Draw the cheek cells and label it as fully as you can.

### Observation

1. They are small, hexagonal or irregular in shape and are found compactly arranged in group.
2. Each cell contains a centrally placed nucleus.
3. Large number of cells are seen with a thin cell membrane.
4. These cells are found in cheeks of human, in blood vessels, bowman's capsule and alimentary canal.
5. The cells are of single layer of flattened plate like hence called **simple squamous epithelium**.

### Precautions

1. To obtain the cells from the inner side of cheek use only blunt spatula to avoid cut and bleeding.
2. The obtained cells should be wash in water with few drops.
3. Avoid too much staining which makes the cells very dark.
4. Spread the scrapping gently with brush.
5. Handle the microscope and slide very carefully.

### Viva Questions

### Students must remember

1. Where is squamous epithelial cell found?

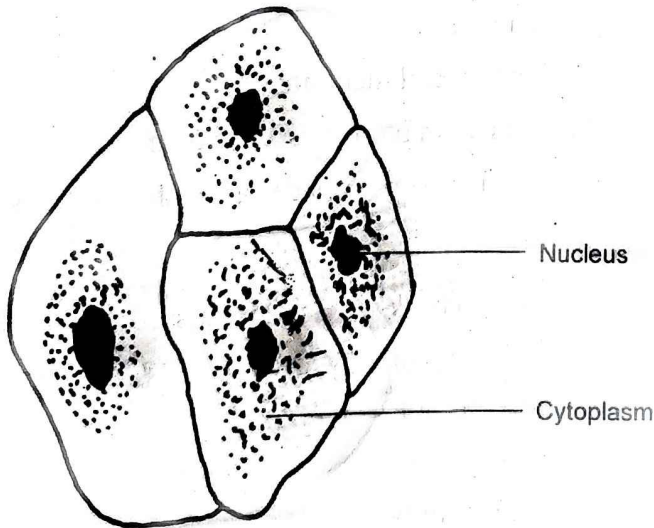
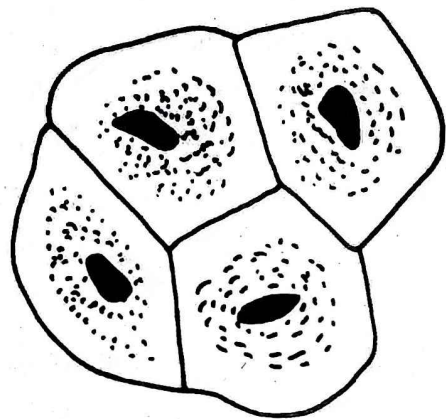
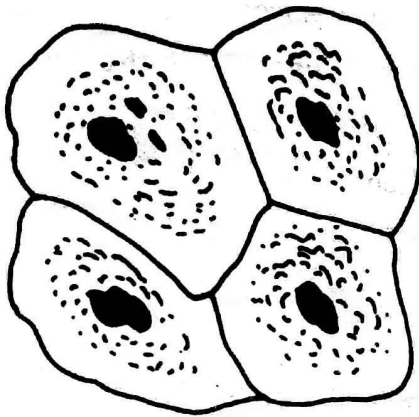
**Ans:** Squamous epithelial is found in buccal cavity, blood vessels, etc.

2. What is squamous epithelium?

**Ans:** Squamous epithelium consists of large, flat and polygonal cells.

Date

# PREPARATION OF TEMPORARY SLIDE OF SQUAMOUS EPITHELIAL CELLS OF HUMAN CHEEK



## 1. V.S. of Skin of Frog

The V.S. of skin of frog reveals the following structures:

1. Skin is formed by two distinct layers - the outer epidermis and inner dermis.
2. Epidermis is formed by two layers - (i) Outer - stratum corneum and (ii) Inner - stratum malpighi
3. Below stratum malpighi pigmented cells called chromatophores are present.
4. Dermis has two layers - (i) Outer - stratum spongiosum and (ii) Inner - stratum compactum.
5. Spongy layer consists of mucous glands, blood vessels, nerve fibres, poison gland, etc.
6. Compact layer is filled with vertical and horizontal muscle fibres.
7. Skin serves the functions as protective, respiratory, sensory and excretory.

### Viva Questions

Students must remember

1. What is the function of skin?

**Ans:** Skin serves the functions as protective, respiratory, sensory and excretory.

2. Name the glands present in the skin of frog.

**Ans:** The glands are mucous gland and poison gland.

## 2. T.S. of Oesophagus of Frog

### Comments

The T.S. of oesophagus of frog reveals the following structures:

1. Oesophagus is formed by four layers - serosa, muscularis, submucosa and mucosa.
2. Serosa is the outermost layer which is made up of a single layer of peritoneal cells.
3. Muscularis is the muscle layer below the serosa. It is formed by two muscle layers - an outer longitudinal and inner circular.
4. Submucosa is thick layer of connective tissue consisting of blood vessels.
5. Mucosa consists of many folds of simple ciliated columnar epithelium and some goblet cells.
6. Simple tubular glands are also seen in the mucosal layer.

### Viva Questions

Students must remember

1. How will you identify T.S. of oesophagus?

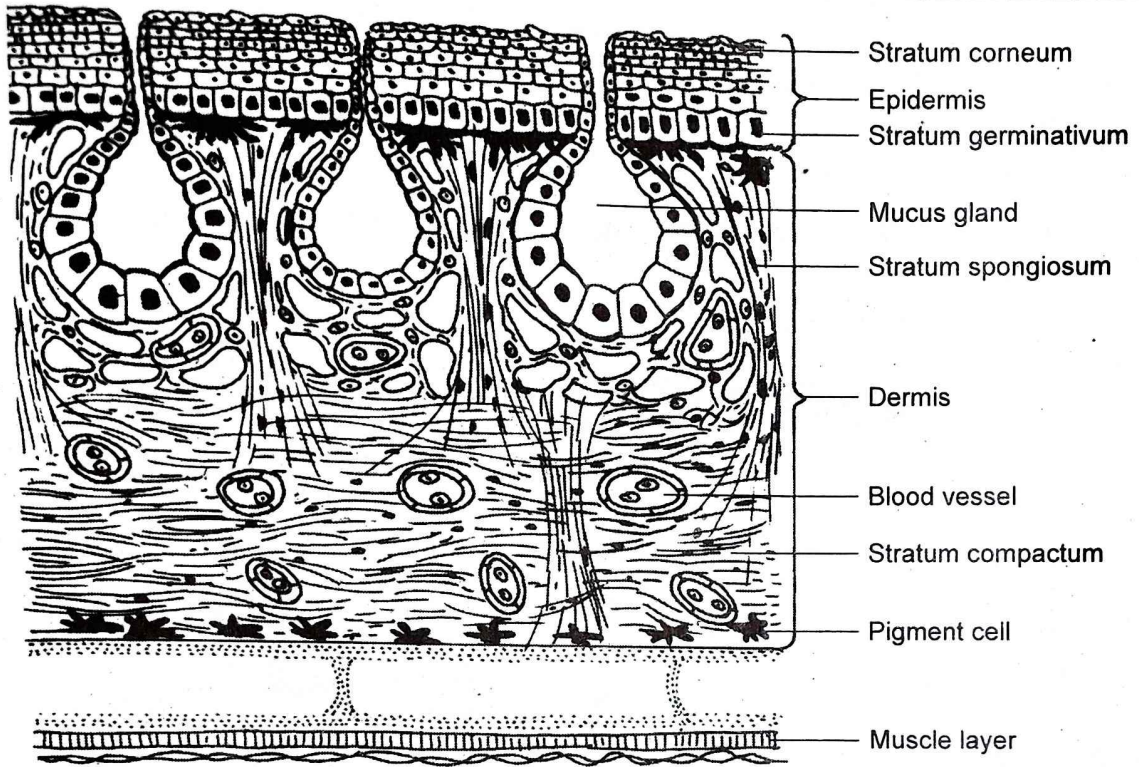
**Ans:** It possesses many mucosal foldings consisting of goblet cells which release mucus.

2. What is the function of oesophagus?

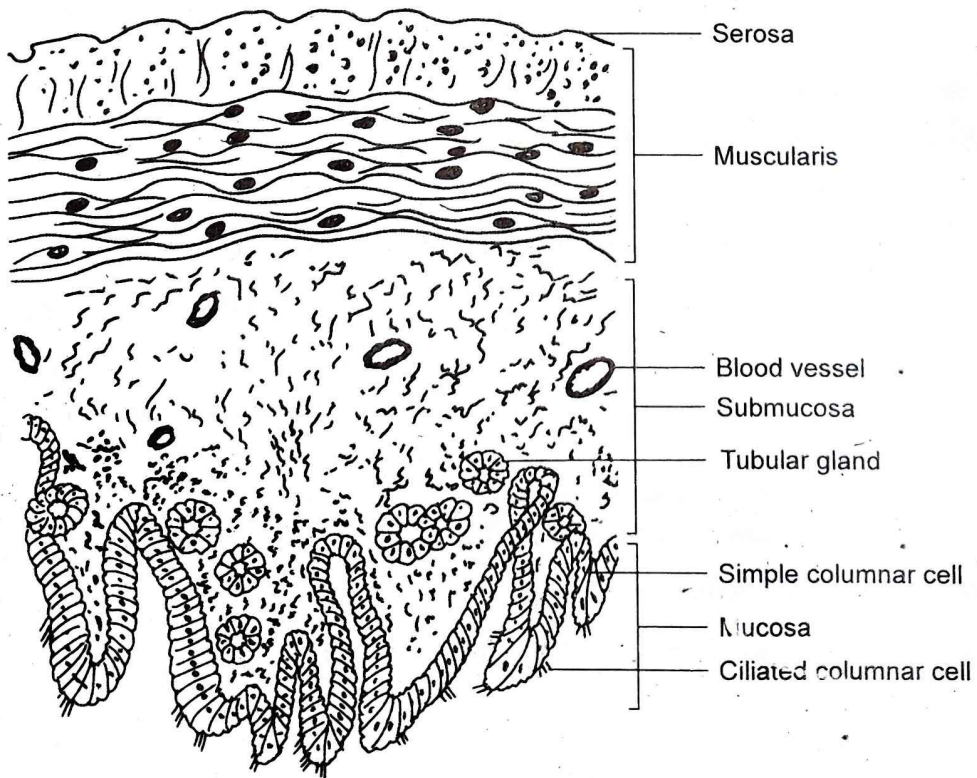
**Ans:** It functions as passage for food entrance into stomach.

Date

# STUDY OF HISTOLOGICAL SLIDES OF FROG



## V.S. of Skin of Frog



## T.S. of Oesophagus of Frog

### 3. T.S. of Stomach of Frog

The T.S. of stomach of frog reveals the following structures:

1. Stomach is composed of five layers - serosa, subserosa, muscularis, submucosa and mucosa.
2. Serosa is thin outermost layer which is made up of a single layer of peritoneal cells.
3. Subserosa is composed of thin layer of connective tissue containing some blood vessels.
4. Muscularis is the muscle layer below the subserosa. It is formed by a thick layer of circular muscle fibres.
5. Submucosa is thick layer of connective tissue consisting of blood vessels.
6. Mucosa consists of many folds of simple columnar epithelium containing simple tubular gastric glands.
7. Tubular gastric glands secrete pepsin enzyme and HCl in the stomach.

#### Viva Questions

Students must remember

1. How will you identify T.S. of stomach of a frog?

**Ans:** The stomach of a mammal is characterized by the presence of several layers of muscles. It also consists of gastric glands.

2. What is the function of stomach?

**Ans:** Stomach functions as the storage and digestion of foods.

### 4. T.S. of Duodenum of Frog

The T.S. of duodenum of frog reveals the following structures:

1. Duodenum is composed of five layers - serosa, subserosa, muscularis, submucosa and mucosa.
2. Serosa is thin outermost layer which is made up of a single layer of peritoneal cells.
3. Subserosa is composed of thin layer of connective tissue containing some blood vessels.
4. Muscularis is the muscle layer below the subserosa. It is formed by a thick layer of circular muscle fibres.
5. Submucosa is thick layer of connective tissue consisting of blood vessels.
6. Mucosa consists of many folds of simple columnar epithelium containing simple tubular gastric glands.
7. It consists of less number of villi.
8. The intestinal glands lie on the mucosal layer.

#### Viva Questions

Students must remember

1. How is T.S. of duodenum identified?

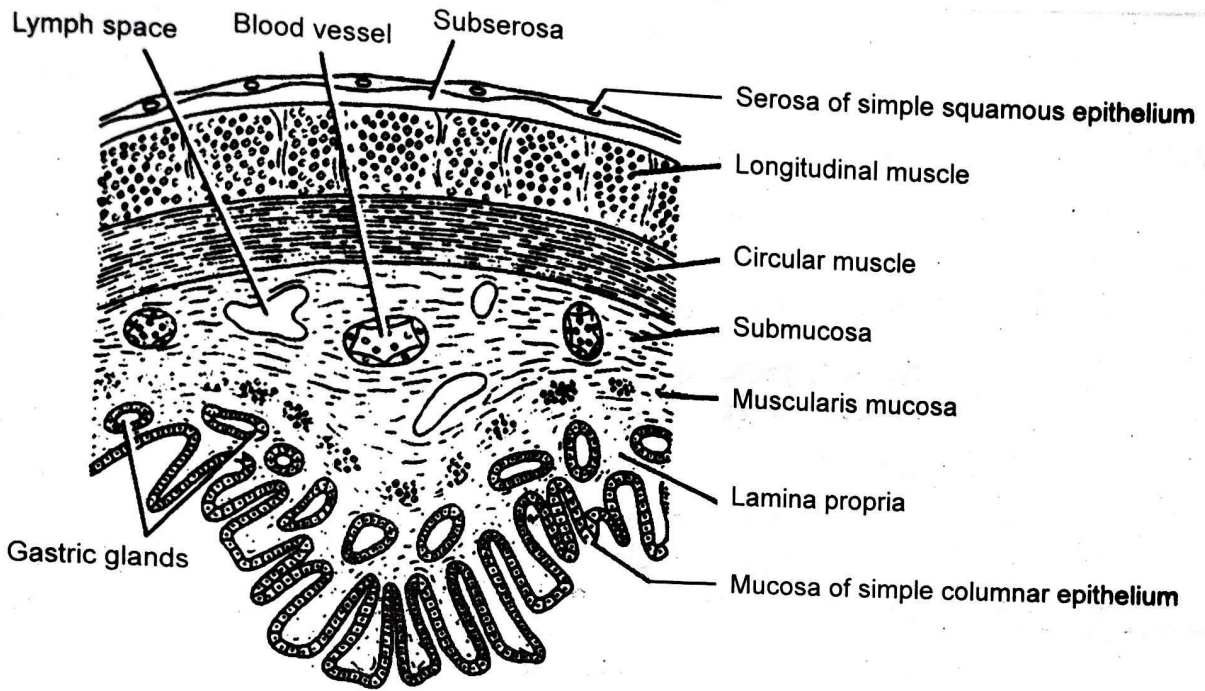
**Ans:** The internal structure of duodenum consists of less number of villi and numerous intestinal glands.

2. What is the function of duodenum?

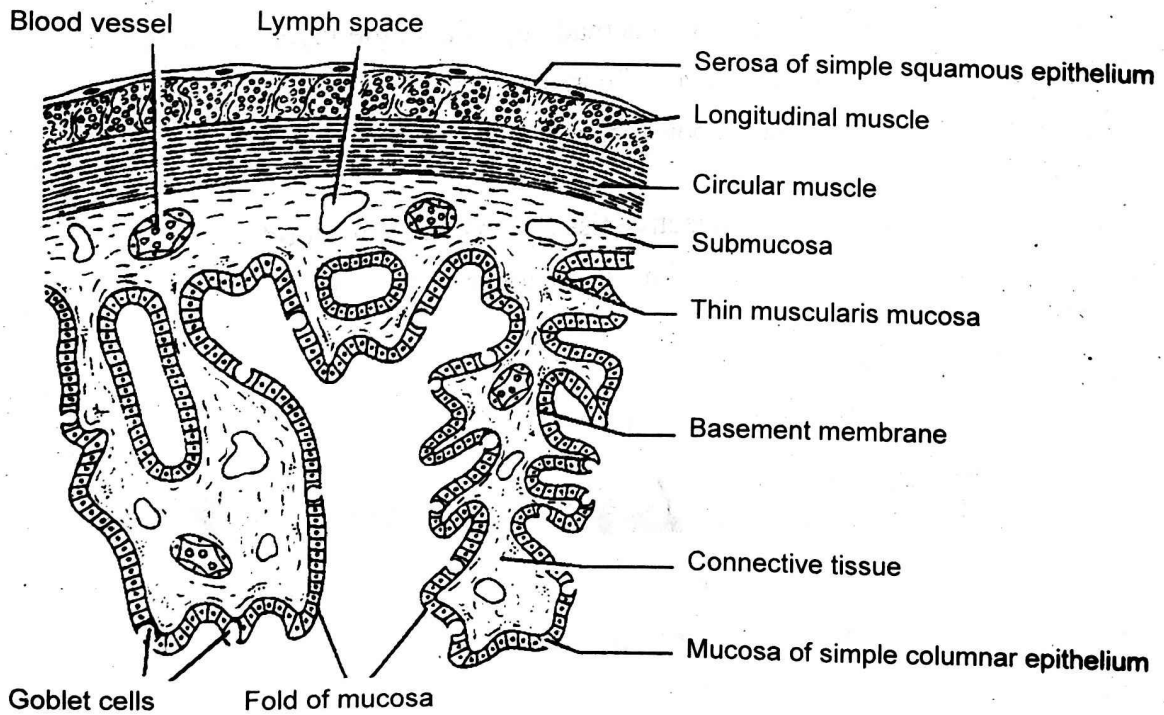
**Ans:** Its functions are to make complete digestion of foods.

Date

# STUDY OF HISTOLOGICAL SLIDES OF FROG



## T.S. of Stomach of Frog



## T.S. of Duodenum of Frog

## 5. T.S. of Ileum of Frog

### Comments

The T.S. of intestine of frog reveals the following structures:

1. Intesine is composed of four layers - serosa, muscularis, submucosa and mucosa.
2. Serosa is thin outermost layer which is made up of a single layer of peritoneal cells.
3. Muscularis consists of two layers - an outer thin layer of longitudinal muscle and inner thick layer of circular muscle fibres.
4. Submucosa is thick layer of connective tissue consisting of blood vessels and lymph spaces.
5. Mucosa consists of many folds of simple columnar epithelium called villi and goblet cells.
6. These villi increase the surface area for absorption.

### Viva Questions

Students must remember

1. How will you identify T.S. of ileum of a frog?

**Ans:** Its mucosa is made up of single layer of columnar cells which form several villi. In between the villi are present crypts of Liberkuhn.

2. What is the function of ilieum?

**Ans:** Ileum consists of villi which function as to absorb the digested foods.

3. What are the layers the ileum made up of?

**Ans:** Histologically, it is made up of 4 layers serosa, muscularis, submucosa and mucosa.

## 6. T.S. of Rectum of Frog

### Comments

The T.S. of rectum of frog reveals the following structures:

1. Rectum is composed of four layers - serosa, muscularis, submucosa and mucosa.
2. Serosa is outermost thin layer which is made up of a single layer of peritoneal cells.
3. Muscularis consists of two muscle layers - an outer thin layer of longitudinal muscle and inner thick layer of circular muscle fibres. This layer is much thicker than muscularis' of intestine.
4. Submucosa is a layer of connective tissue consisting of blood vessels and lymph spaces.
5. Mucosa consists of less folds of simple columnar epithelium containing numerous goblet cells.

### Viva Questions

Students must remember

1. How do you identify rectum under microscope?

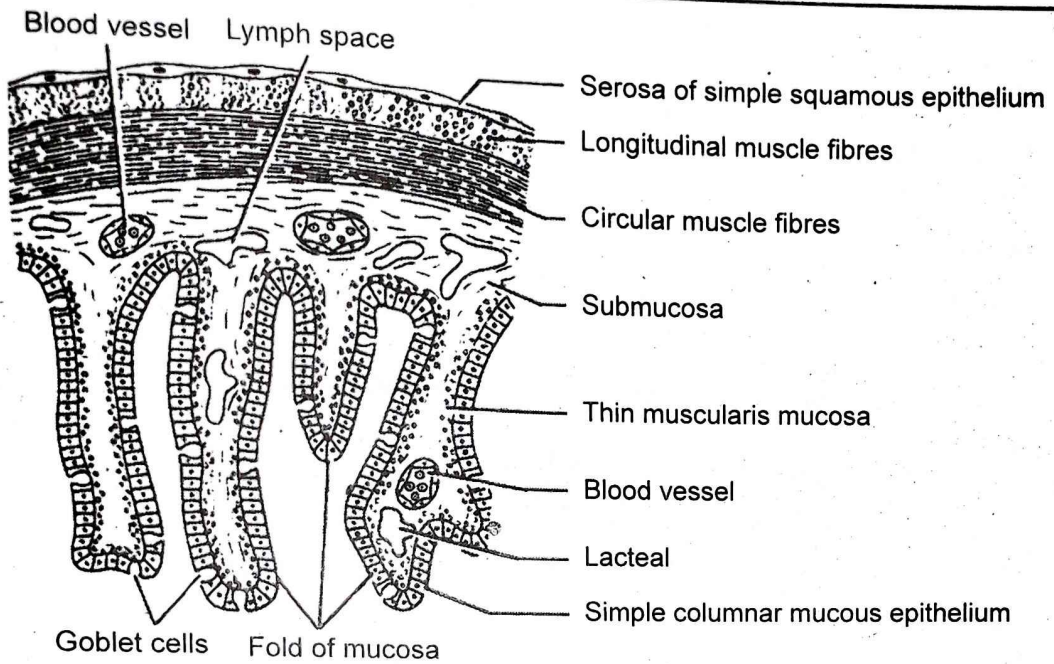
**Ans:** The internal structutre of rectum has less infolding or villi.

2. What is the function of rectum?

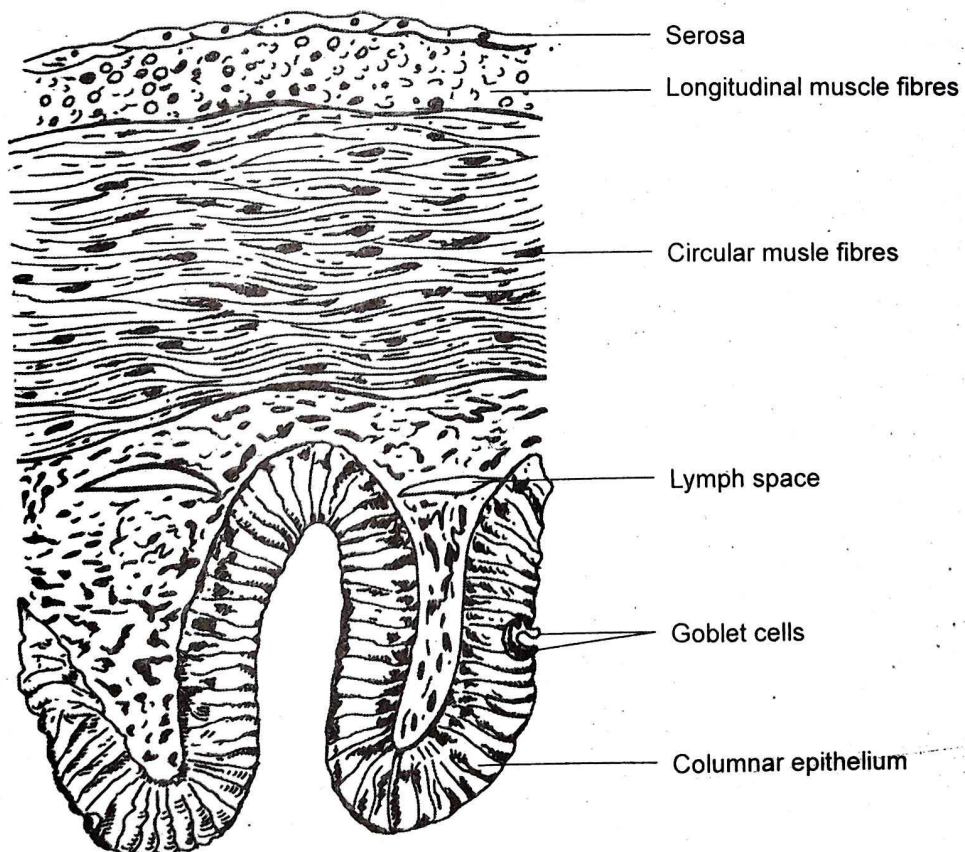
**Ans:** Rectum functions to store the undigested foods and egests out through cloaca.

Date

# STUDY OF HISTOLOGICAL SLIDES OF FROG



## T.S. of Ileum of Frog



## T.S. of Rectum of Frog

## 7. T.S. of Liver of Frog

The T.S. of liver of frog reveals the following structures:

1. It is made up of large number of hepatic lobules.
2. Each hepatic lobule has many polyhedral hepatic cells or acini.
3. Hepatic ducts and bile capillaries are seen in the spaces between the cells.
4. The hepatic cells secrete greenish and alkaline fluid, the bile.
5. Bile are collected in the gall bladder through bile canaliculi. Many bile canaliculi unite to form the bile duct.
6. Liver cells also store glucose by converting it into glycogen.

### Viva Questions

Students must remember

1. How will you identify T.S. of liver of a frog?

Ans: It consists of polyhedral hepatic cells (acini) arranged in long chains.

2. What is the function of liver in digestion?

Ans: Liver functions as to secrete bile which is responsible for converting the acidic food s into alkaline food.

## 8. T.S. of Pancreas of Frog

The T. S. of pancreas. of frog reveals the following structures:

1. It is formed by large number of pancreatic lobules or acini.
2. Each lobule is composed of secretory cells consisting of a small central lumen.
3. Islets of Langerhans are present in between the lobules.
4. Blood capillaries are found in or around the islets of Langerhans.
5. Pancreas acts as exocrine as well as endocrine glands.
6. Pancreatic cells produce pancreatic juice and islets of Langerhans produce insulin and glucagon hormones.

### Viva Questions

Students must remember

1. How will you identify T.S. of pancreas of a frog?

Ans: It consists of numerous lobules or acini bounded together by connective tissue. Islet of Langerhans is present in between acini.

2. What is the function of pancreas?

Ans: Pancreas functions as to release pancreatic juices such as amylase, lipase and trypsin.

3. Name the hormones released from pancreas.

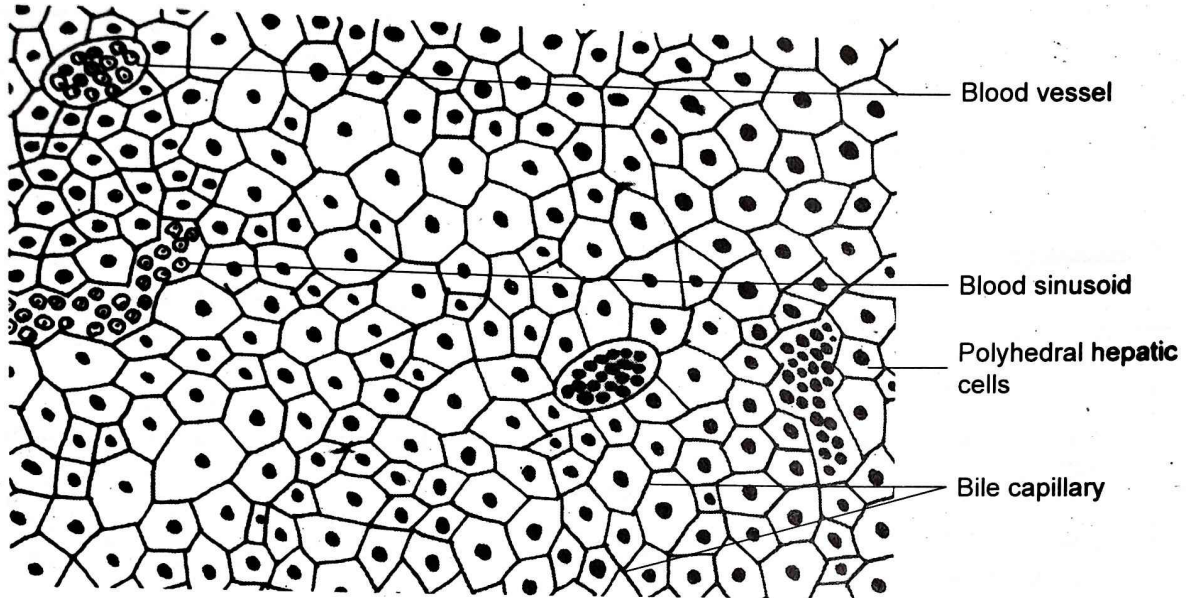
Ans: The hormones released from pancreas are insulin and glucagon.

4. Why is pancreas called as exocrine and endocrine glands?

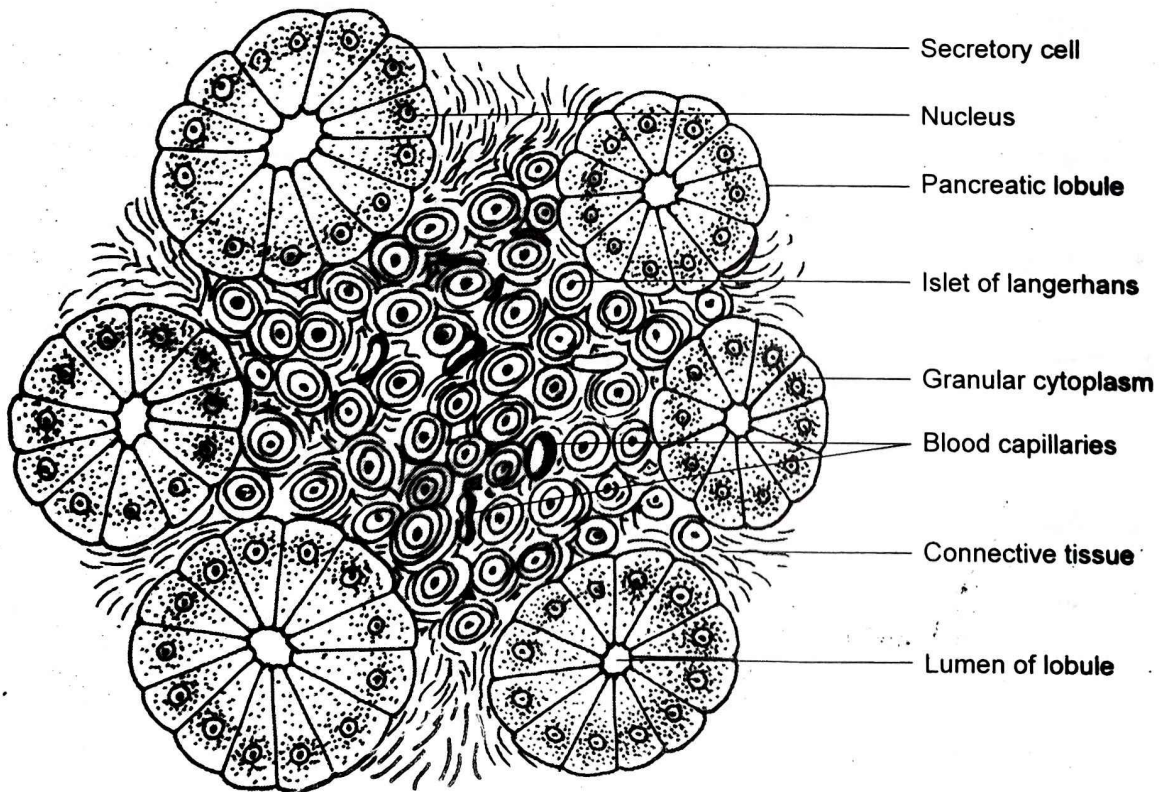
Ans: Because it functions as to release both digestive enzymes and hormones.

Date

# STUDY OF HISTOLOGICAL SLIDES OF FROG



## T.S. of Liver of Frog



## T.S. of Pancreas of Frog

## 9. T.S. of Lung of Frog

### Comments

The T.S. of lung of frog reveals the following structures:

1. The outermost layer of lung is lined with a peritoneal layer.
2. Below this layer, there is a layer of unstriated muscles and connective tissues are present.
3. The lung cavity is divided into many air cavities or alveoli by many irregular septa or trabeculae.
4. The septa or trabeculae are lined with ciliated columnar cells.
5. The walls of trabeculae are richly supplied with blood vessels.
6. Lungs are used in the exchange of gases.

### Viva Questions

Students must remember

1. How will you identify T.S. of lungs of a frog?  
**Ans:** It is formed of numerous cup-shaped cavities called pulmonary alveoli with thin walls. These alveoli open in alveolar sac.
2. What is the function of lung?  
**Ans:** Lungs function as to exchange the respiratory gases -  $O_2$  and  $CO_2$ .
3. Name the outer layer protecting lungs.  
**Ans:** Lungs are externally protected by pleural membrane.

## 10. T.S. of Kidney of Frog

### Comments

The T.S. of kidney of frog reveals the following structures:

1. The outermost layer of kidney is peritoneum. It is composed of peritoneal cells.
2. It is composed of large number of long and coiled uriniferous tubules.
3. Some cup shaped double walled structure called Bowman's capsules are present.
4. Efferent and afferent arterioles are seen in Bowman's capsule.
5. The blood vessels from renal arteries and veins are seen in the kidney.
6. Kidney performs excretion and osmoregulation in functions.

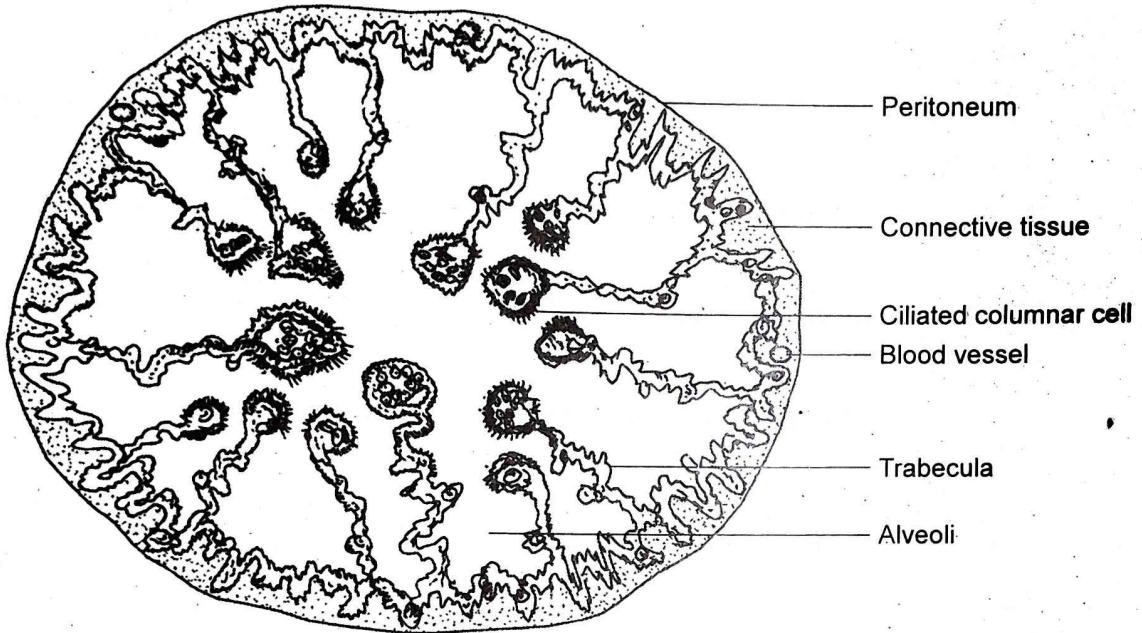
### Viva Questions

Students must remember

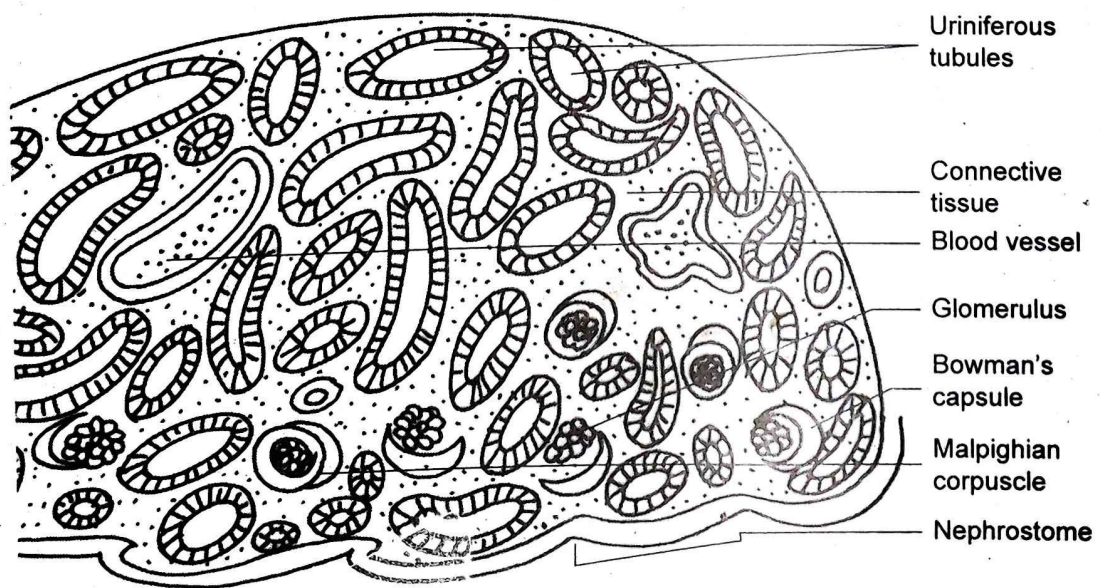
1. How will you identify T.S. of kidney of a frog?  
**Ans:** It consists of rounded Bowman's capsule with glomerulus, convoluted tubule, Henle's loop, and collecting tubules.
2. Name the unit of kidney.  
**Ans:** Kidney is composed of numerous uriniferous tubules which are called unit of kidney.
3. What is the function of kidney?  
**Ans:** Kidney functions as the filtration of blood to remove the waste substances from the body.
4. Name the layer that protects the kidney.  
**Ans:** Kidney is externally protected by peritoneum.

Date

# STUDY OF HISTOLOGICAL SLIDES OF FROG



## T.S. of Lung of Frog



## T.S. of Kidney of Frog

## 11. T.S. of Testis of Frog

The T.S. of testis of frog reveals the following structures:

1. Testis is composed of numerous seminiferous tubules.
2. Each seminiferous tubule is lined with germinal epithelium.
3. The germinal epithelium produces spermatozoa by the process of spermatogenesis.
4. The tubule consists of different stages of development of sperms such as spermatocytes and spermatids.
5. In between the tubules, there are interstitial cells and blood vessels scattered in the connective tissue.
6. Interstitial cells secrete male hormone, androgen.

### Viva Questions

Students must remember

1. How will you identify T.S. of testis of a frog?

**Ans:** It consists of numerous seminiferous tubules lined by germinal epithelium.

2. What is the function of sertoli cells?

**Ans:** Sertoli cells are present in between germinal epithelium. Their secretions provide nourishment to the developing sperms.

3. Name the unit of testis.

**Ans:** The unit of testis is seminiferous tubule.

## 12. T.S. of Ovary of Frog

The T.S. of ovary of frog reveals the following structures:

1. The outermost layer is the theca externa.
2. Theca externa is lined with germinal epithelium which produces ova by the process of oogenesis.
3. Ovary consists of numerous ova of different developmental stages.
4. Each ovum is surrounded by follicular cells.
5. A fully matured ovum has a nucleus and yolky cytoplasm surrounded by a theca interna.

### Viva Questions

Students must remember

1. How will you identify T.S. of ovary of a frog?

**Ans:** It consists of numerous graffian follicles which develop ova.

2. Name the layers that protect egg.

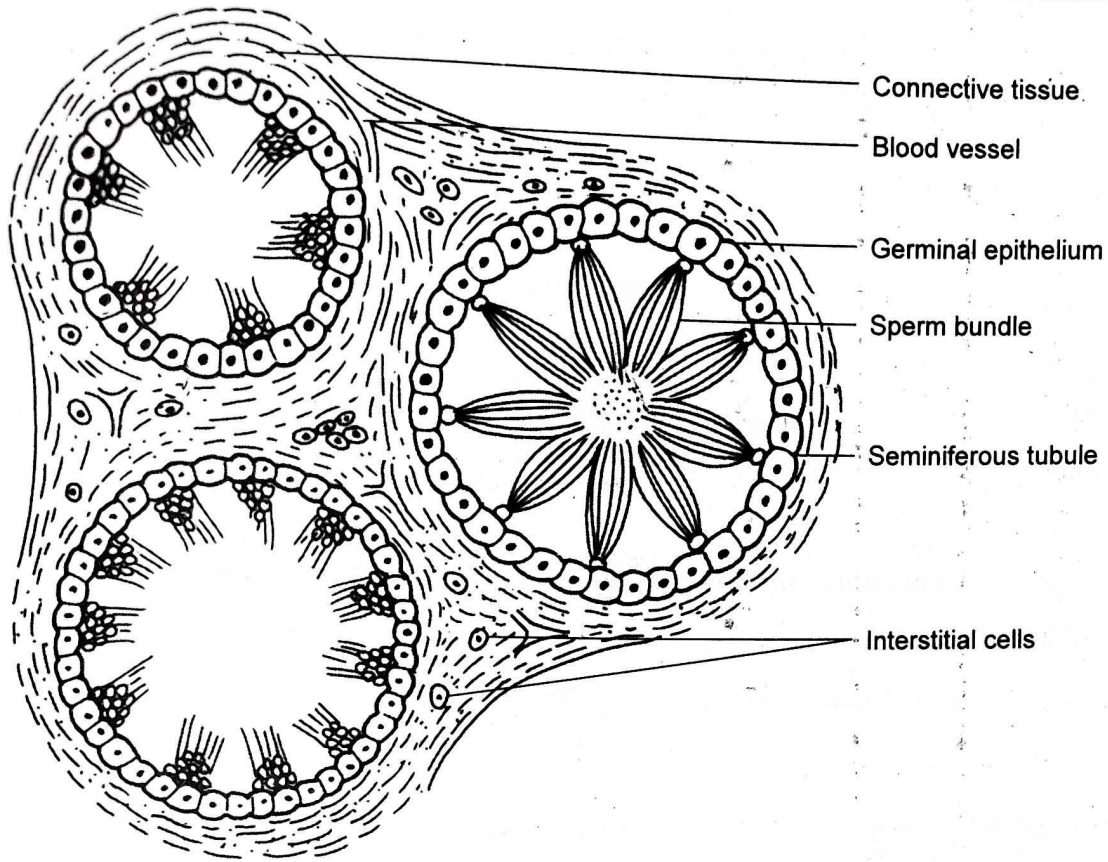
**Ans:** Eggs are externally protected by theca externa and theca interna.

3. What is the meaning of process of oogenesis?

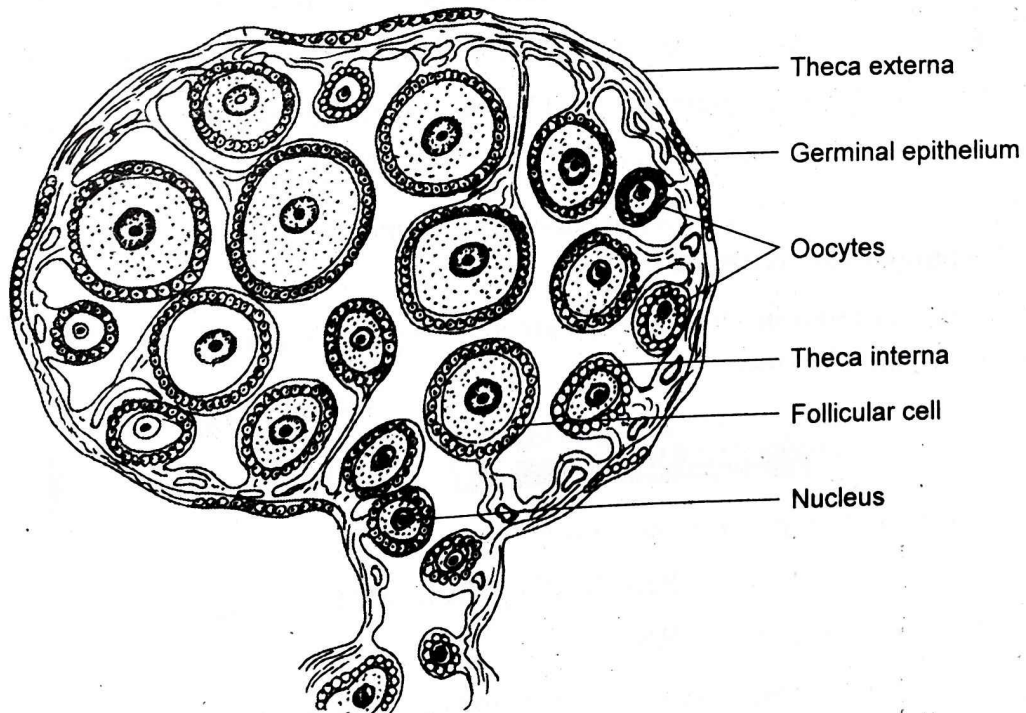
**Ans:** Oogenesis is the process of formation of eggs.

Date

# STUDY OF HISTOLOGICAL SLIDES OF FROG



T.S. of Testis of Frog



T.S. of Ovary of Frog

## 13. T.S. of Spinal Cord of Frog

### Comments

The T.S. of spinal cord of frog reveals the following structures:

1. The spinal cord is surrounded by two membranes - outer durameter and inner piameter.
2. Spinal cord is composed of two kinds of nervous tissues - outer white matter and inner grey matter.
3. Grey matter forms the H-shaped area.
4. A central canal is found in the centre of grey matter.
5. The grey matter gives rise to two dorsal and two ventral horns.

### Viva Questions

Students must remember

1. What is spinal cord?

Ans: Spinal cord is the extended part of the brain. It runs below the vertebral column.

2. What is the function of spinal cord?

Ans: Spinal cord functions as to control many voluntary and involuntary activities of the animals.

## 14. Blood of Frog

### Comments

The blood of frog reveals the following structures:

1. The blood of frog is composed of three types of corpuscles - RBC, WBC and platelets.
2. RBCs or erythrocytes are oval and nucleated. These are large in number.
3. RBCs consist of a pigment called haemoglobin (Hb) which makes the blood red.
3. WBCs or leucocytes are colourless, larger in size and irregular.
4. Various types of leucocytes such as lymphocytes, monocytes, acidophils, basophils and neutrophils are observed.
5. Blood platelets or thrombocytes are spindle shaped and few in number. These are responsible for clotting of blood.

### Viva Questions

Students must remember

1. What are the types of blood in frog?

Ans: Blood possesses - RBC (erythrocytes), WBC (leucocytes), and platelets.

2. What is the function of RBCs?

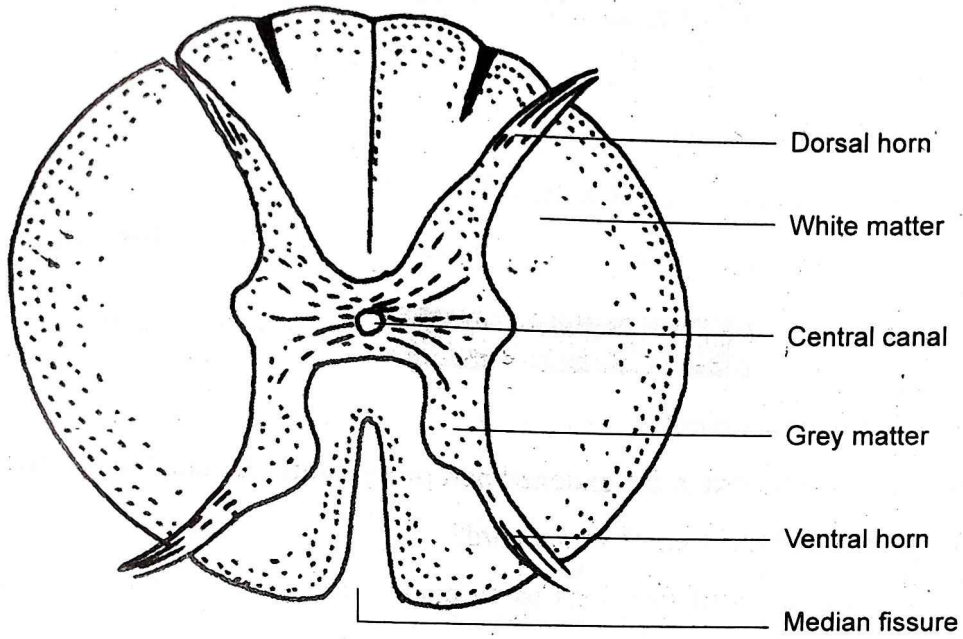
Ans: RBCs contain a red pigment called haemoglobin which transport oxygen in the body.

3. What makes the blood red?

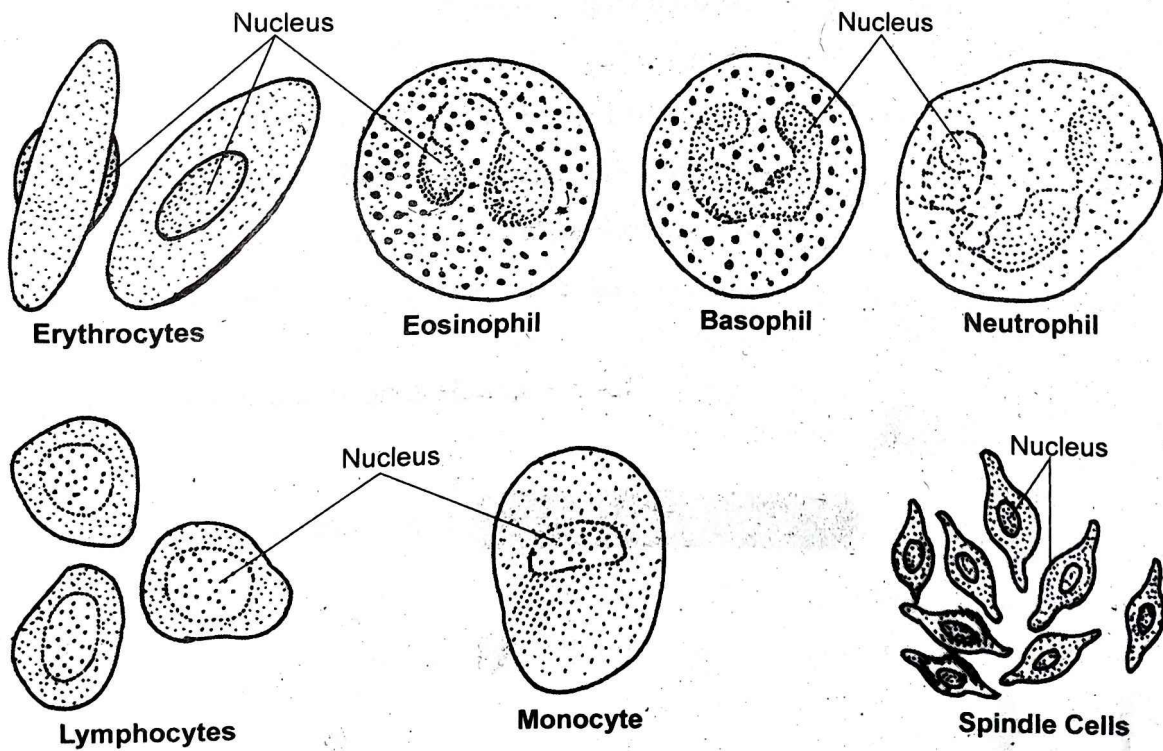
Ans: RBC contains haemoglobin pigment which makes the blood red.

Date

# STUDY OF HISTOLOGICAL SLIDES OF FROG



## T.S. of Spinal Cord of Frog



## W.M. of Blood of Frog

## Adaptational Features of Labeo rohita

Labeo rohita (Rohu fish) is freshwater fish found in ponds, rivers and streams. It shows primary aquatic adaptation. The adaptational features of Labeo are as follows -

1. **Streamlined body** – Body of Labeo is spindle shaped and laterally compressed suited for active swimming in water. It offers little or no resistance in swimming.
2. **Presence of fins** – Locomotion takes place by paired and unpaired fins. The paired fins (pectoral and pelvic) and unpaired fins (dorsal, anal and caudal) act as paddles to propel the body and to control the direction of movement. The fins give stability and control direction of movement.
3. **Respiration by gills** – The respiratory organs are gills, which are covered by a gill-cover (operculum) and are well suited for gaseous exchange in water.
4. **Scales** – Body of Labeo is covered with cycloid scales. These scales protect the body from external injury and water current.
5. **Cold-blooded nature** – It is a cold blooded or poikilothermic animal. It means that body temperature is not fixed but is variable according to the environment. It enables the animals to survive in any surrounding temperature.
6. **Swim or air bladder (Hydrostatic device)** – In Labeo, swim bladder or air bladder is found inside the body. It is an outgrowth of alimentary canal. It serves as hydrostatic organ, help in floating. In others, it functions in breathing.
7. **Lateral line system** – Lateral line is a receptor organ situated on both lateral sides of the body. It contains a row of sense organs which detect the pressure and temperature changes caused by mechanical disturbances in the surrounding water.
8. **Presence of nictitating membrane** – Eyes are provided with a third eye-lid or nictitating membrane which protect the eyes from dirty water and ensure clear vision in water.

### Viva Questions

### Students must remember

1. Why do fish not survive on land?

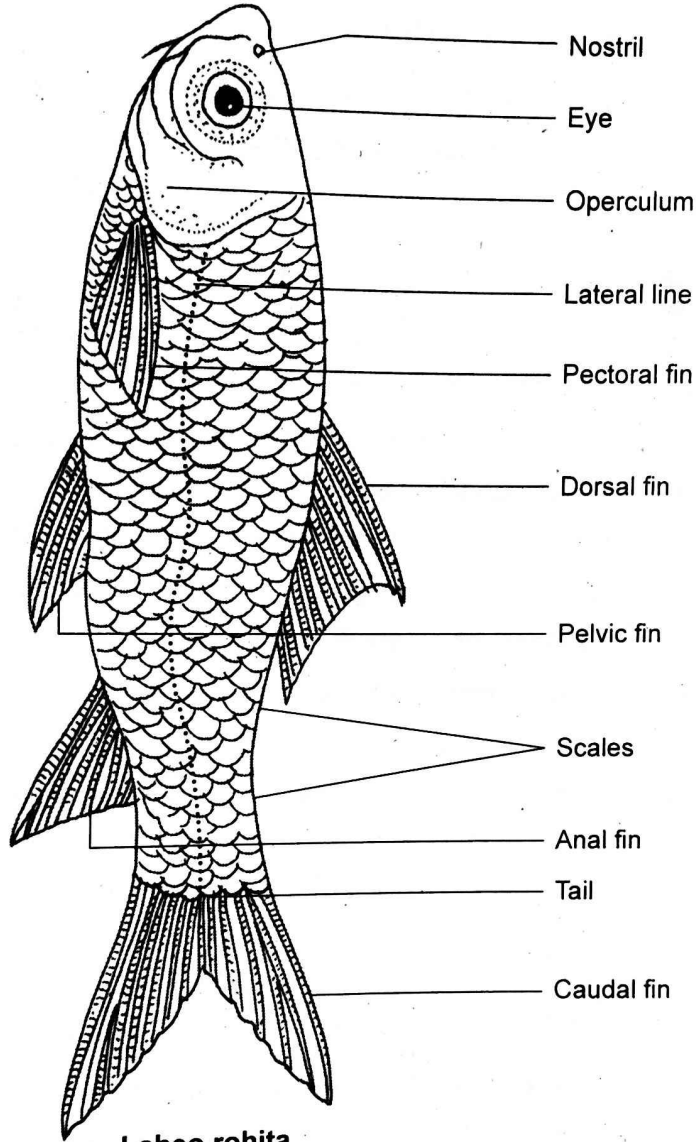
**Ans** Because fish can't respire on land. It can take only the oxygen dissolved in water.

2. Why do fishes survive in cold or hot water?

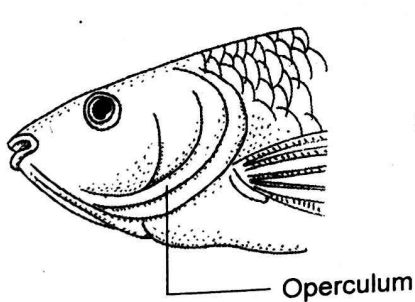
**Ans:** Fish is a cold blooded or poikilothermic animal. The body temperature of fish is not fixed. It changes according to the changes in the temperature of water. Thus, it enables the fish to survive in any surrounding temperature.

Date

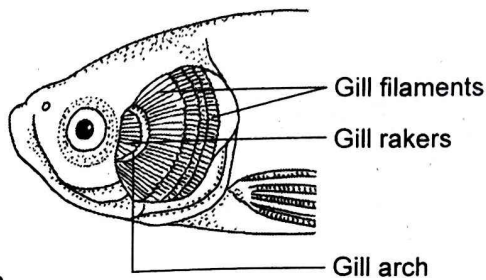
# STUDY OF ADAPTATIONAL FEATURES OF LABEO



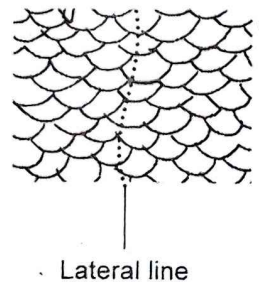
**Labeo rohita**



**Head showing operculum**



**Head showing gills**



**Scales and lateral line**

## Adaptational Features of Exocoetus

Flying fish (Exocoetus) is a marine fish. It shows both primary aquatic adaptation and secondary aerial adaptation. The adaptational features of Exocoetus are as follows –

### Aquatic adaptational features of Exocoetus

1. **Streamlined body** – Its body is spindle shaped and laterally compressed suited for active swimming in water. It offers little or no resistance in swimming.
2. **Scales** – Body of Exocoetus is covered with cycloid scales. These scales protect the body from external injury and water current.
3. **Mouth** is wide having teeth on both jaws.
4. **Respiration by gills** – The respiratory organs are gills, which are covered by a gill-cover (operculum) and are well suited for gaseous exchange in water.
5. **Cold-blooded nature** – It is a cold blooded or poikilothermic animal. It means that body temperature is not fixed but is variable according to the environment. It enables the animals to survive in any surrounding temperature.
6. **Swim or air bladder (Hydrostatic device)** – A swim bladder or air bladder is found inside the body. It serves as hydrostatic organ, help in floating. In others, it functions in breathing.
7. **Lateral line system** – Lateral line is a receptor organ situated on both lateral sides of the body. It contains a row of sense organs which detect the pressure and temperature changes caused by mechanical disturbances in the surrounding water.
8. **Presence of nictitating membrane** – Eyes are provided with a third eye-lid or nictitating membrane which protect the eyes from dirty water and ensure clear vision in water.

### Volant adaptational features of Exocoetus

1. **Enlargement of pectoral fin** – In Exocoetus, pectoral fins are very large and highly developed like wings. These are placed high up on lateral sides of head. These are also used as parachutes, to sustain the fish to make great leaps out of water. It may cover about 10 to 20 meters for upto 10 seconds.
2. **The pectoral fins** are kept folded against body while fish is in the water.
3. **Tail** – The tail of Exocoetus is hypoblastic, i.e. the ventral lobe of tail fin is larger than the upper lobe. It helps to fish at the time of leaping.

### Viva Questions

Students must remember

1. Why is Exocoetus called flying fish

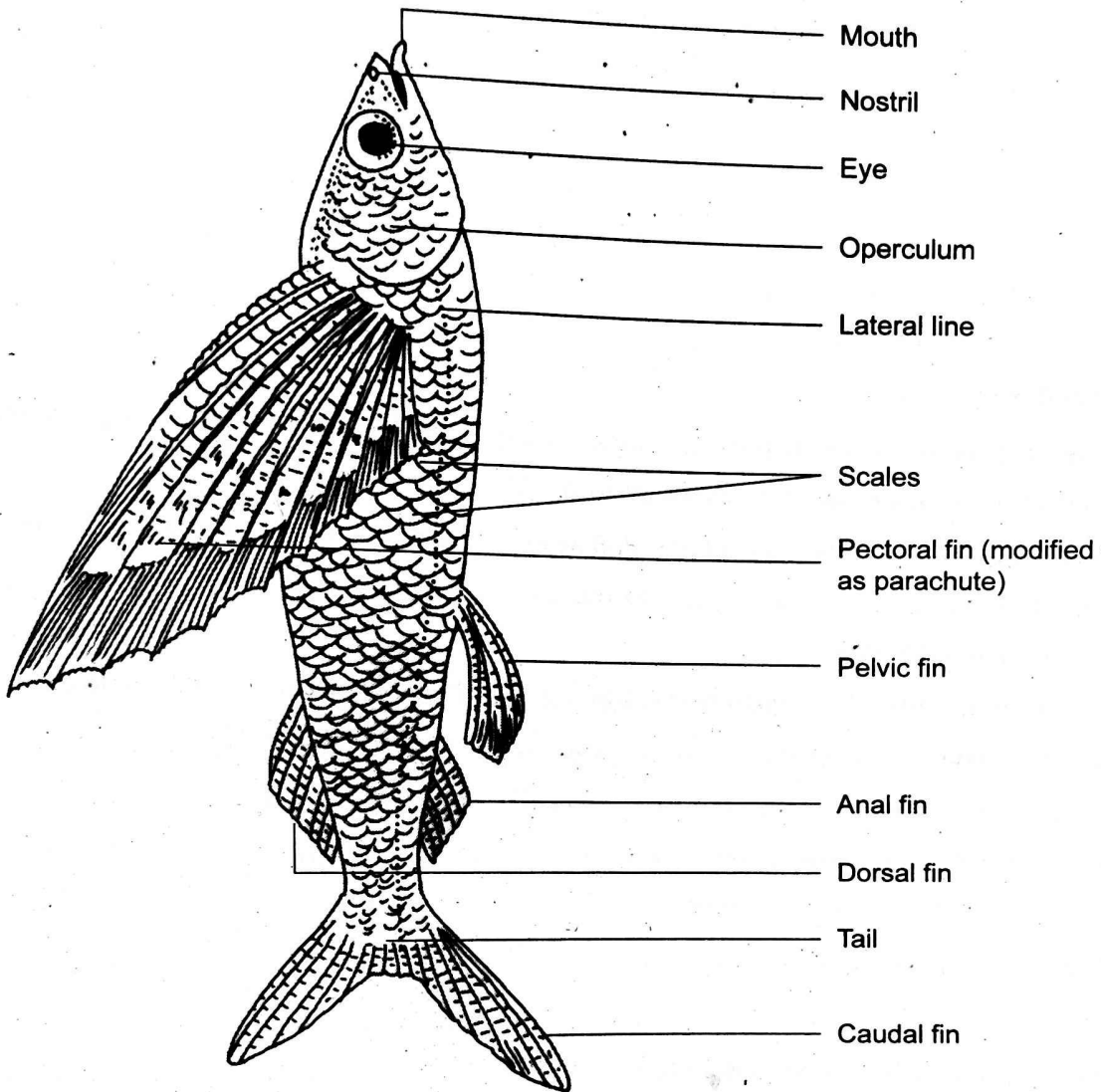
**Ans:** Because Exocoetus can fly or leap about 10 to 20 meters in the water.

2. What is the function of lateral line in fish?

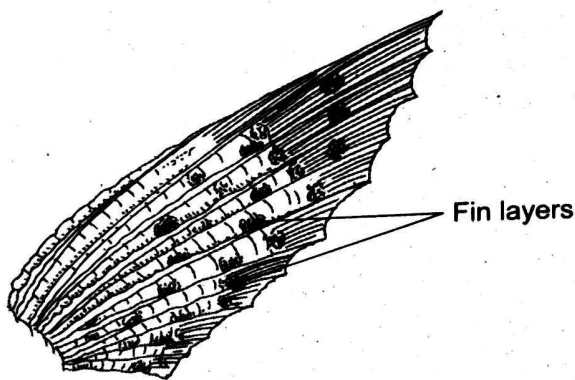
**Ans:** Lateral line contains a row of sense organs which detect the pressure and temperature changes caused by mechanical disturbances in the surrounding water.

Date

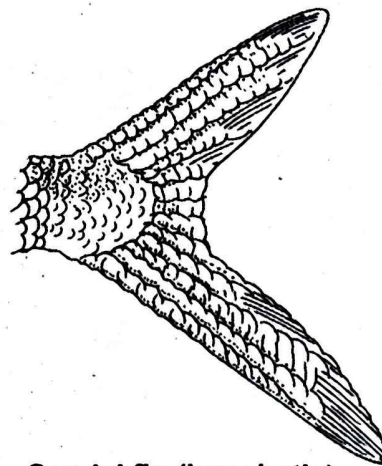
# STUDY OF ADAPTATIONAL FEATURES OF EXOCOETUS



***Exocoetus sp***



**Pectoral fin**



**Caudal fin (hypobatic)**

## Adaptational Features of Rana tigrina

Frog (Rana tigrina) is an amphibious animal. It can survive in both fresh water and moist land. It is common in and near, pools, ponds, marshes, lakes and streams. The adaptational features of frog are as follows –

1. **Spindle shaped body** – Its body is spindle shaped suited for active swimming in water. It offers little or no resistance in swimming.
2. **Body Colouration** – The colour of the body at the dorsal side is green with black spots but ventral surface is almost white or slight yellowish. Its colour is due to its **chromatophore** cells. This type of colouration harmonises with that of surrounding environment. It helps the frog to be safe from their enemies.
3. **Eyes** – There are two prominent and bulging of eyes placed laterally almost on the top of the head. The eyes enable the frog to look in all directions and to see above the water when it is swimming. These are protected by third eye lid called nictitating membrane. It is thin, transparent and freely movable.
4. **Cold blooded nature** – The frog is cold blooded i.e. poikilothermic animal. Its body temperature does not remain constant but fluctuates with that of environment. However, during extreme winter or summer, frogs, it undergoes winter sleep called **hibernation** or summer sleep, called **aestivation**.
5. **Mucous glands** – The skin possesses mucous glands which secretes mucus to keep the skin moist or slippery. It helps the frog to slip away from the catches of enemies. It also helps in the cutaneous respiration.
6. **Webbed digits** – The hind limbs have **webbed toes**. The greatly elongated, powerful and webbed legs of the frog are admirably adapted for swimming and jumping.
7. **Tongue** – The tongue is long, protrusible, sticky and bifid. It helps in capturing the preys in water and on land.
8. **Respiration** – Frog is an amphibian animal. It respire by skin when it is water (called cutaneous respiration), but when it is in on land, it respire by lungs (pulmonary respiration) or buccal cavity (buccopharyngeal respiration).

### Viva Questions

Students must remember

1. Why do frogs undergo winter and summer sleep, even though it is cold blooded?

**Ans:** Frog is a cold blooded animal. But, during extreme cold or hot, frogs cannot survive. Therefore, they undergo hibernation (winter sleep) and aestivation (summer sleep) to be safe from unfavourable conditions.

2. When does the frog produce croaking sound?

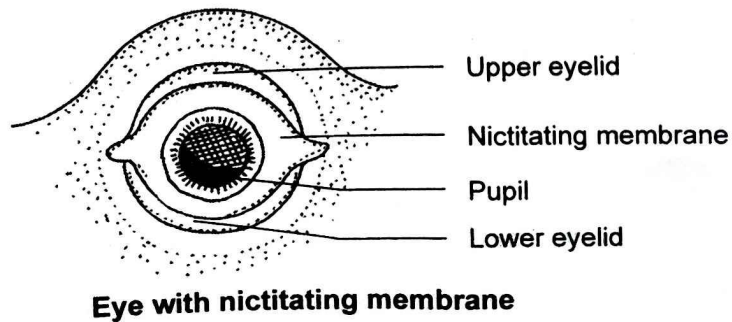
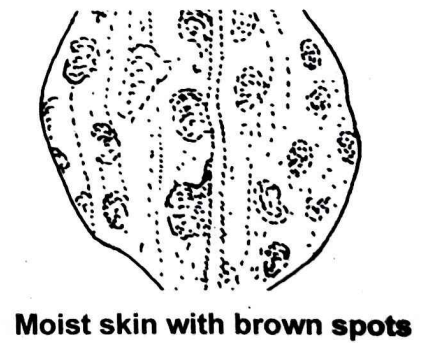
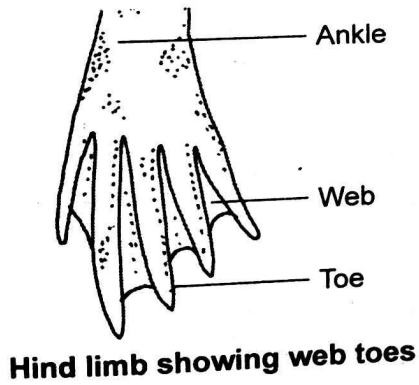
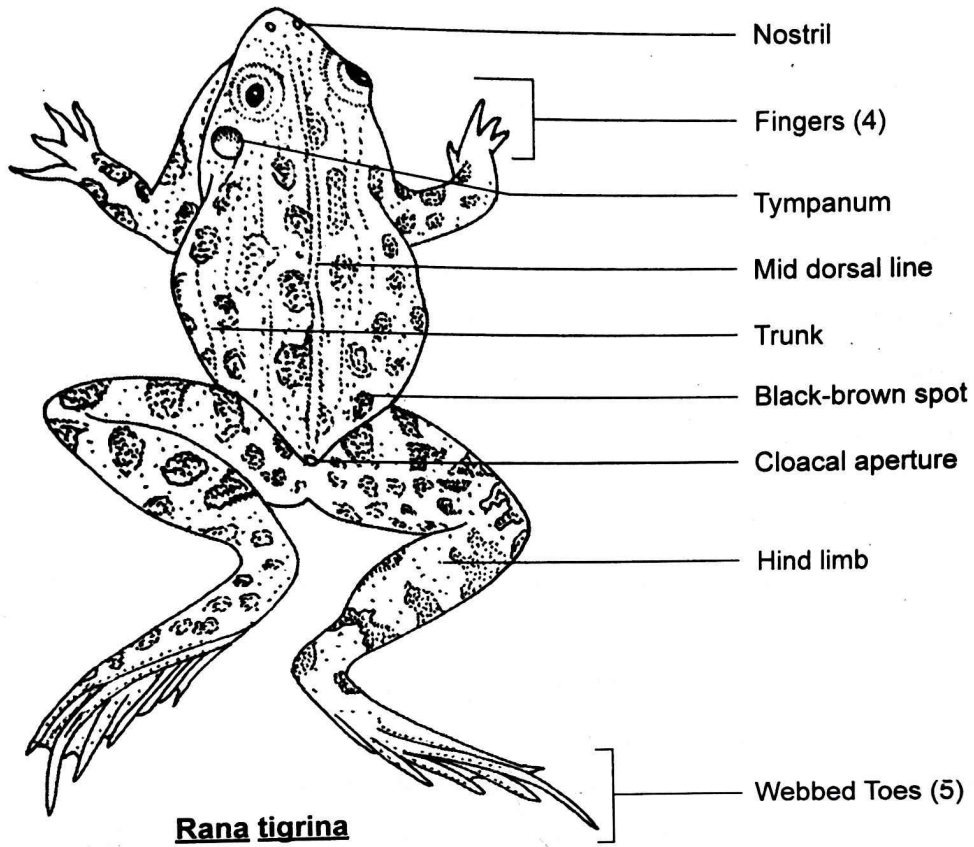
**Ans:** During breeding season, frogs produce croaking sound to attract female frogs.

3. How do frogs respire when it is in water?

**Ans:** Frog is an amphibian animal. When it is water, it respire by skin (cutaneous respiration) but when it is in on land, it respire by lungs (pulmonary respiration)

Date

# STUDY OF ADAPTATIONAL FEATURES OF RANA TIGRINA



## Adaptational Features of Hyla

Hyla is commonly known as tree frog. It is found in moist places. It can climb easily on the trees or rocks. Therefore, it shows arboreal mode of adaptation. The adaptational features of tree frog are as follows:

1. **Spindle shaped body** – Its body is spindle shaped suited for climbing on the trees.
2. **Body Colouration** – The colour of the body is generally green. However, it can change its body colour according to surroundings. This process is called mimicry.
3. **Cold blooded nature** – The frog is cold blooded i.e. poikilothermic animal. Its body temperature varies according to changes in the environment.
4. **Limbs** - The fore limbs are shorter than hind limbs. Fore limbs are with 4 toes without web. However, the hind limbs have 5- toes which are webbed..
5. The apex of each toe is swollen to form a glandular adhesive pad or disc. It enables the animal in climbing a tree.
6. An extra cartilage between two last phalanges gives a better grip.
7. On the ventral surface like belly and throat, there are many minute apertures called hygroscopic apertures. Tree frog can absorb water by these apertures which is as adaptation for its arboreal life.
8. It possesses a large vocal sac which helps in making a very loud voice.

### Viva Questions

Students must remember

1. Why is Hyla called tree frog?

**Ans:** As it lives on trees, hence called tree frog.

2. What makes the tree frog to live on trees?

**Ans:** Tree frog bears glandular adhesive disc or pad on the tips of digits of hind limbs which enables it to climb on trees.

3. What is the meaning of arboreal adaptation?

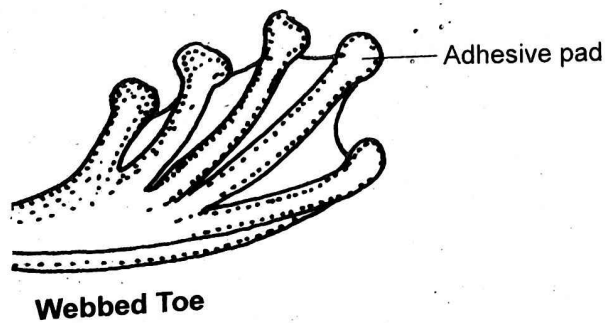
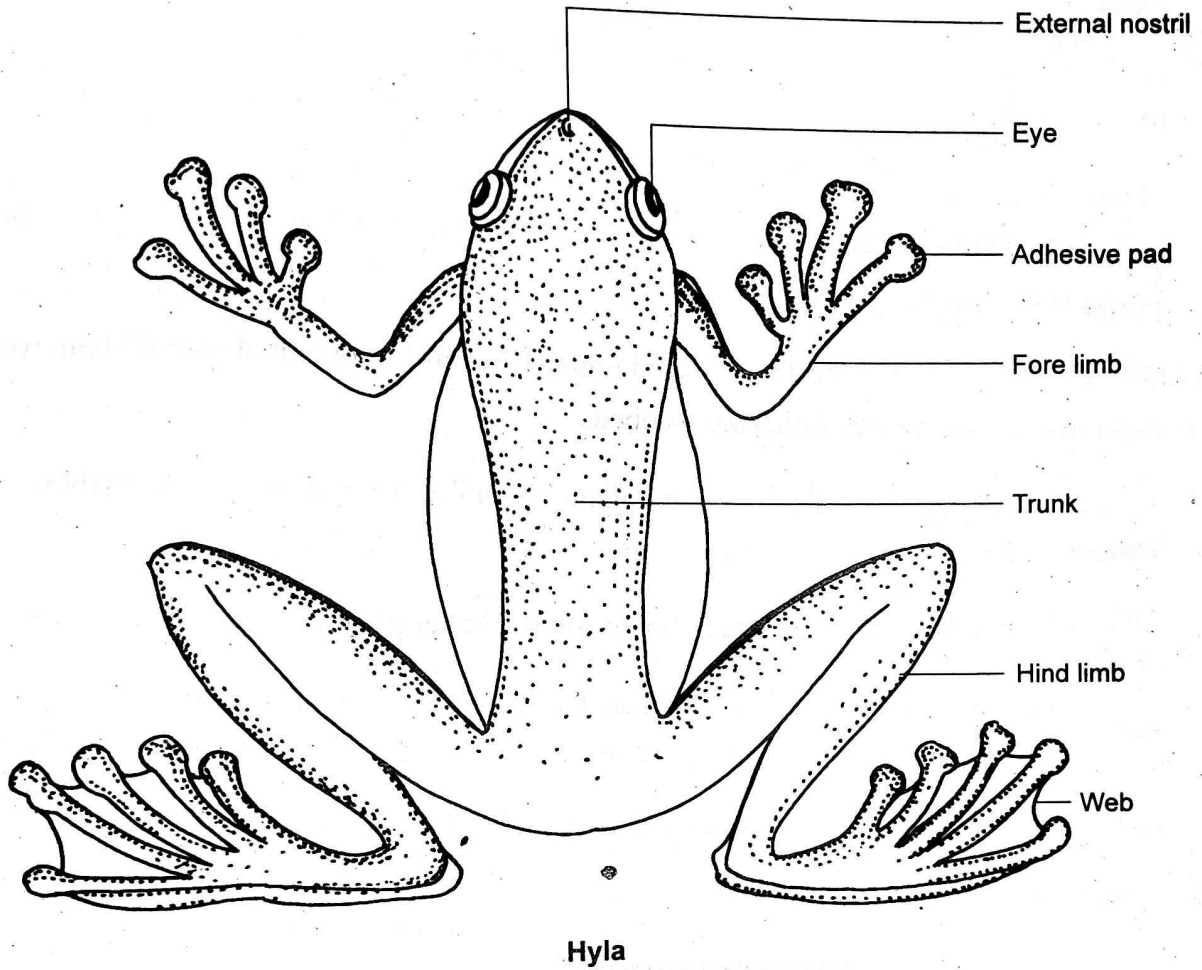
**Ans:** Arboreal adaptation is type of adaptation in which animal can climb on the trees or rocks.

4. Why is tree frog kept in the amphibia, although it lives on trees.

**Ans:** Tree frog lives on the trees. But at the same time, it also enters in water at the time of breeding.

Date

# STUDY OF ADAPTATIONAL FEATURES OF HILA



## Adaptational Features of Hemidactylus

**Wall lizard (Hemidactylus)** is an arboreal animal. It shows the arboreal (scansorial) adaptation). It can climb on the walls. The adaptational features of wall lizard are as follows:

1. **Stout body contour** – The body contour of wall lizard is stout, thorax is subcircular and ribs much curved.
2. **Dry skin** - The skin is dry and covered by epidermal scales. Scales protect the body and prevent loss of water from skin.
3. **Strong girdle bones** – Due to arboreal habits, shoulder girdle (pectoral girdle) is especially strong to support weight of the body.
4. **Limbs** – The fore and hind limbs are clawed. Its fingers possesses spongy lamellae on its ventral side which create vacuum when presses on walls. This vacuum helps in attachment on the walls.
5. **Presence of neck** – The presence of neck between the head and trunk provides mobility to the head and, therefore, enhances the efficiency of eyes in locating its enemies or its preys.
6. **Tongue** – Tongue is long and protrusible. It is used to catch insects or prey.
7. **Colour** – The body colour of wall lizard is matching with the ceiling colour of houses. It can protect them from enemies.
8. **Tail** – Tail of wall lizard is moderately long. It can break or cut off at an unossified part when its tail is catch by any enemy or predator. It is a means of self protection. The cut tail regenerates again. The process of cut off its tail and regenerating the tail is called autotomy.
9. **It is nocturnal** and is often seen in night near light.

### Viva Questions

Students must remember

1. How does the wall lizard adjusted to move on wall?

**Ans:** The wall lizard is adjusted to move on wall due to vacuum created by lamellae when pressed on walls. Its digits possess spongy lamellae on its ventral side which create vacuum when presses on walls. This vacuum helps in attachment on the walls.

2. In what way, wall lizard escape from enemies?

**Ans:** When any enemy catches the tail of wall lizard, then it cuts off its tail and run way. It is a means of self protection. This is called autotomy.

3. What type of adaptation shown by wall lizard?

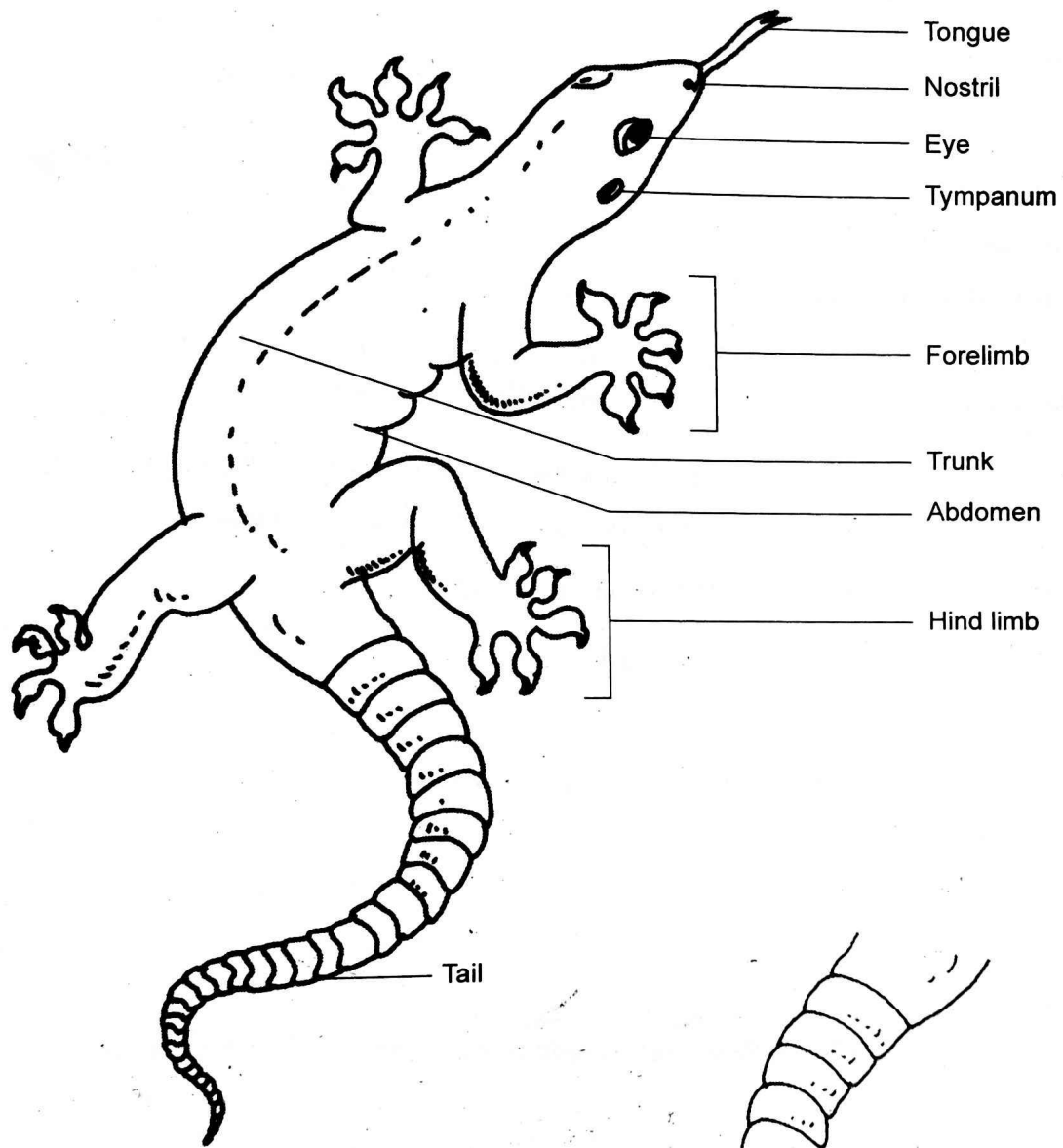
**Ans:** A wall lizard shows arboreal or scansorial or climbing adaptation.

4. Define the term nocturnal.

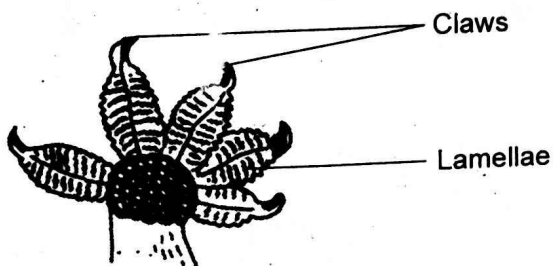
**Ans:** Nocturnal is a term meaning the animals active in the night.

# STUDY OF ADAPTATIONAL FEATURES OF HEMIDACTYLUS

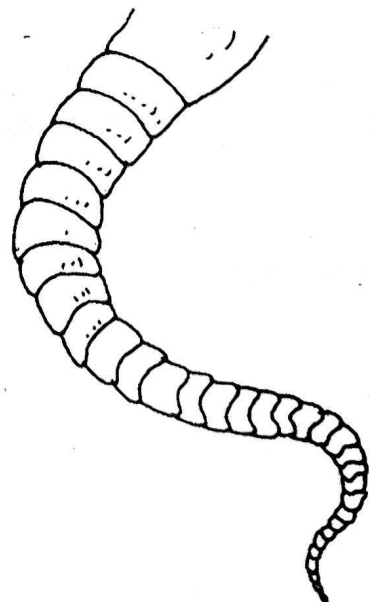
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**Hemidactylus**



**Toes with spongy lamellae**



**Tail**

## Adaptational Features of Columba livia

**Pigeon (Columba livia)** is a true flying bird. It shows Volant (aerial) adaptation. It can fly for a long time, covering long distance and even at high altitude. The adaptational features of pigeon are as follows –

1. **Streamlined body** – Body is spindle shaped or streamlined which provides least resistance to air during flight. It increases the speed in the air.
2. **Presence of feathers** – Body is covered with feathers. Structurally, it consists of a basal quill or calamus and distal rachis or shaft. The rachis bears a series of lateral barbs and barbules connected with each other by barbicels forming for a sort of net. Feather act as blanket to insulate the body. It also makes the body light.
3. **Presence of wings** – The fore limbs are modified into wings as in the birds. Wings act as powerful propelling organs.
4. **Pneumatization of bones** – Bones are pneumatic (i.e., hollow bones having air filled containing many air cavities). These are useful in buoyancy during flight. They also provide lightness to the body.
5. **Presence of air sacs** – Air sacs are present in the lungs. These make respiration efficient and lighten the specific gravity. These are useful in buoyancy during flight. These are also useful in compensating oxygen during flight at high altitude.
6. **Developed flight muscles** – In pigeon and other birds, the flight muscles are strongly developed. These connect with wings. It help in flight for long time without being tired.
7. **Presence of keel** – Keel is used for the attachment of pectoral muscles. Pectoral girdle is very rigid to control the force of the muscles. Birds fly continuously without being tired.
8. **Brain and sense organs** – The brain of birds has well developed cerebrum and enlarged optic lobes. The eyes are large and have sclerotic plates to resist variable air pressure.
9. **Short tail** – The short tail of a bird bears a series of tail feathers arranged in a fan-like manner. It serves as a rudder in steering and as a counter balance in perching.
10. **Reduction in the body weight** – For flying, body weight must be reduced. Body weight can be reduced in following ways – (i) complete loss of teeth, (ii) lack of urinary bladder, (iii) extensively fused vertebrae (iv) single ovary.
11. **Perching ability** – The hind limbs are adapted for perching ability to rest on trees without falling down.

### Viva Questions

Students must remember

1. What is the meaning of volant adaptation?

**Ans:** Volant adaptation is a type of adaptation in which the animals are adapted to fly in the air. The examples are birds, bats, etc.

2. What is pneumatic bone?

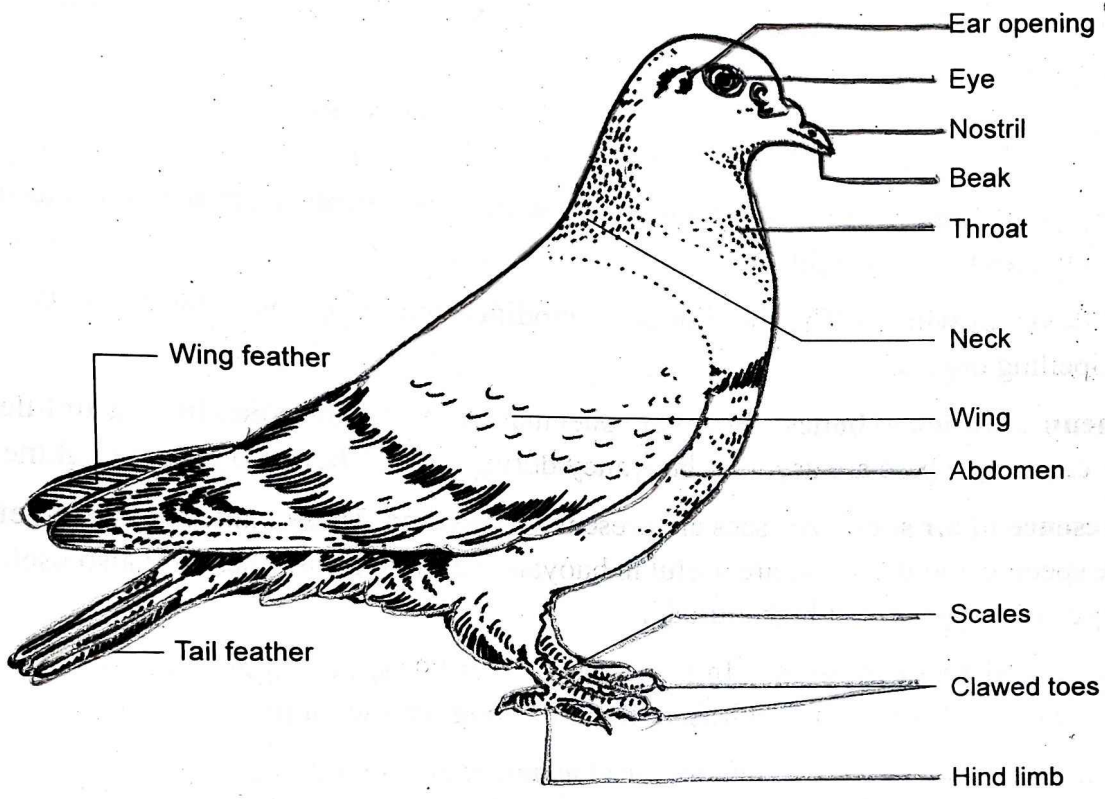
**Ans:** In birds, bones are pneumatic. It means the bones are hollow filled with air. It is useful in buoyancy during flight. It also provides lightness to the body.

3. What makes the birds light?

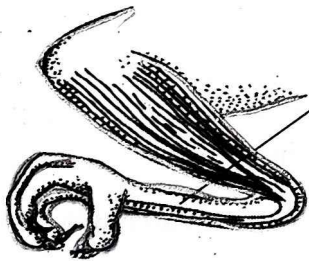
**Ans:** Mainly presence of air sacs, lack of urinary bladder, pneumatic bones, etc

Date

# STUDY OF ADAPTATIONAL FEATURES OF COLUMBA

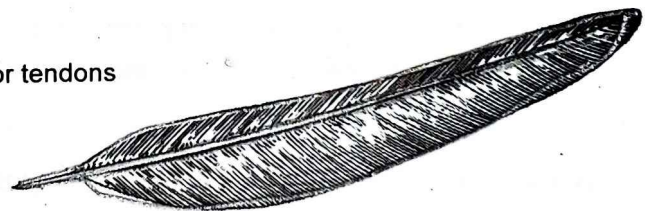


Columba livia

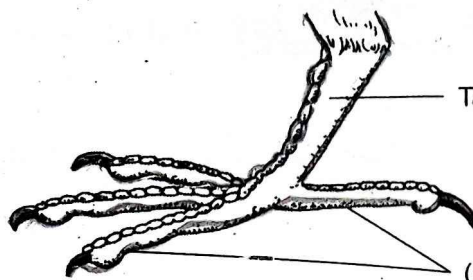


Hind limb with flexed toes

Combined flexor tendons



Quill



Tarso - metatarsus

(1 - 4) Clawed toes

Toes of hind limb (3 + 1)

## Adaptational Features of Rhinolophus

**Bat (Rhinolophus)** is a flying mammal. It shows the aerial (volant) adaptation. The adaptational features of bat are as follows –

1. Body is streamlined or spindle shaped which provides least resistance to air during flight. It increases the speed in air.
2. Body is small. It is covered with grey coloured soft fur.
3. The fore limbs are modified into wings. These wings are made up of fold of skin called patagia which are supported by clawed digits of fore limbs. These help in flying. It also act as powerful propelling organs.
4. The hind limbs are short with five clawed digits. These help in hanging the bat to tree trunk and old buildings
5. It produces ultrasonic sound waves during flying. It helps in guiding flight path. When it finds any obstacle, the sound waves are reflected back and that are picked up by their ears. It has highly developed sonar or echoapparatus, a kind of radar.
6. It also uses ultrasonic sound for navigation. It has ability to catch flying insect during flight.
7. During day time, bats hang themselves on the branches of trees by their hind limbs, keeping head downwards.
8. Eyes are small but vision is weak as the visual rods are poor.
9. Pinna is large and highly specialized to receive sound. It receives the ultrasonic sound waves.

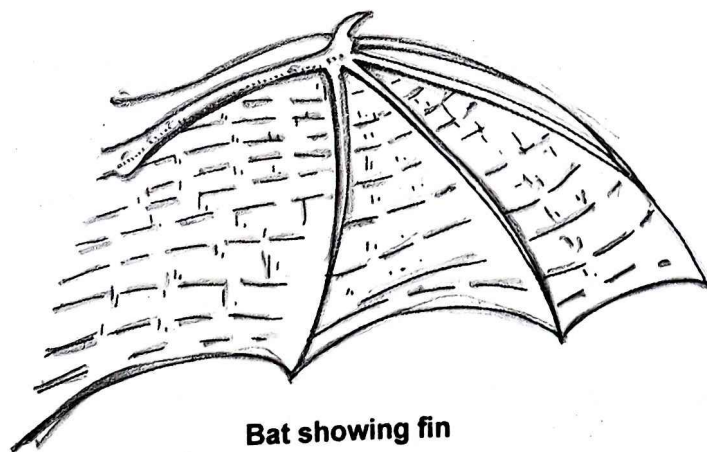
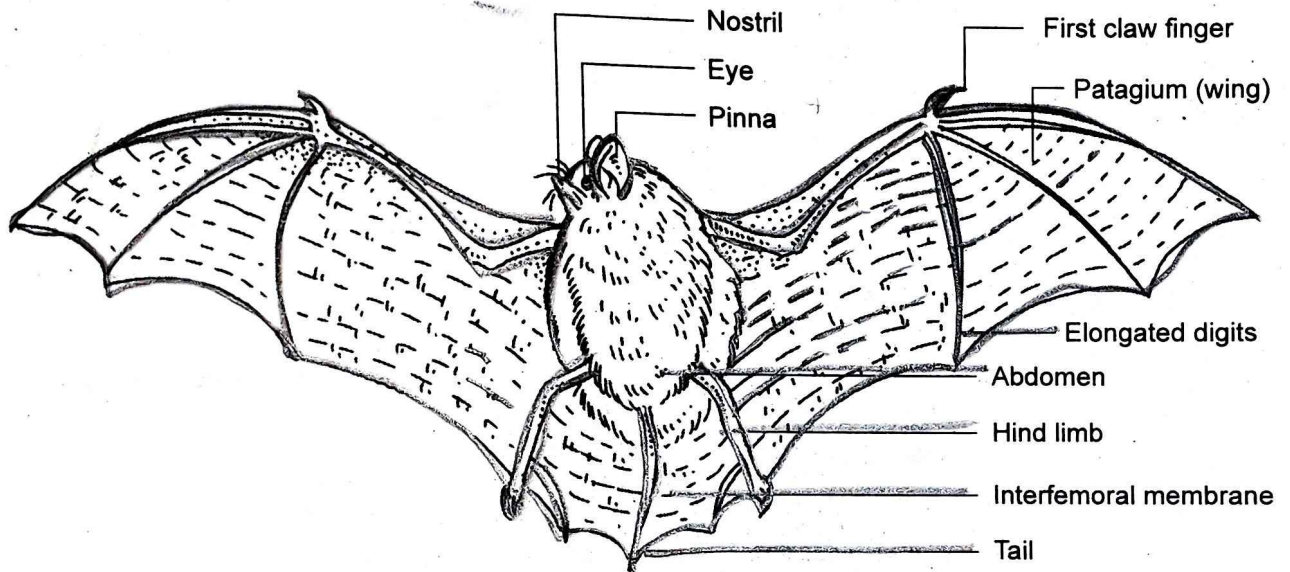
### Viva Questions

Students must remember

1. What type of adaptation shown by bat?  
**Ans:** Bat shows both volant (aerial) adaptations as it can fly and also arboreal adaptation as it lives on trees.
2. What is difference between bird wings and bat wings?  
**Ans:** Bird wings are made up of feathers but bat wings is called made up of a fold of skin called patagium.
3. How does the bat fly in the night?  
**Ans:** In the night during flight, bats produce ultrasonic sound waves which after striking the solid objects are reflected back. These sounds are received by ears as echos. In this way, bats fly in night without getting any obstacle.
4. What is patagium?  
**Ans:** Patagium is a wing made up of a fold of skin which helps in flying.
5. Why the bat do not see in the night?  
**Ans:** Because visual rods are poor.

Date

# STUDY OF ADAPTATIONAL FEATURES OF BAT



Bat showing fin

## Viva Questions

Students must remember

1. What is adaptation?

**Ans:** It is the process of adjustment of animals to live successfully in a particular environment.

2. What type of adaptation is shown by flying fish?

**Ans:** Primary aquatic adaptation and passive flying adaptation.

3. What are the adaptational features of primary aquatic animals?

**Ans:** (i) Body is stream-lined, (ii) Body is covered with scales, (iii) Gills for respiration, (iv) cold blooded, (v) paired and unpaired fins for locomotion, etc.

4. Why is Exocoetus called flying fish?

**Ans:** Pectoral fins are greatly enlarged to form a wing like structure which act as parachute. It may leap upto 6 meters in air.

5. Name the adaptational features of a frog?

**Ans:** (i) Body is stream-lined, (ii) Skin is smooth and moist, (iii) cold blooded, (iv) webbed limbs for locomotion, etc.

6. What type of adaptation does wall lizard show?

**Ans:** Arboreal adaptation. It can climb on the wall.

7. How can wall lizard climb on the wall?

**Ans:** Each digit has two rows of lamellae on ventral side. Wall-lizard moves on walls due to vacuum created as the lamellae are pressed gently on the surface of walls.

8. Define the term autotomy with example.

**Ans:** Tail contains intervening unossified zones between vertebrae which are easily broken and then regenerated. This is called autotomy. Tail is an organ of defense. It is found in wall lizard.

9. What type of adaptation does birds show?

**Ans:** Volant or aerial adaptation.

10. What are the adaptational features of active volant animals?

**Ans:** (i) Body is covered with feathers, (ii) body is streamlined which provides least resistance during flight, (iii) fore-limbs are modified into wings, which act as powerful propelling organs, (iv) bones are pneumatic (i.e., hollow bones having air cavities). These are useful in buoyancy during flight, (v) flight muscles are well developed, etc.

11. What type of adaptation is shown by bat?

**Ans:** Bat exhibits both aerial and arboreal modes of adaptation

12. What are the adaptational features of bat?

**Ans:** (i) Body is covered with fur (hairs) to insulate the body, (ii) body is spindle shaped or streamlined which provides least resistance air during flight, (iii) fore limbs are modified into wing, made up of a fold of skin called patagia supported by ribs, (v) Bones are light. Sternum is keeled, help in flying.

13. What is echo-location?

**Ans:** During flight, it produces ultrasonic sound waves (sound of high frequency) which are reflected back after striking some objects and perceived by ears. This is called echo-location.

## DISSECTION OF ANIMALS

### Dissection of Earthworm

#### Why do we select the earthworm as our first subject for dissection?

The earthworm is cosmopolitan in distribution and is a lower invertebrate which has a simplified pattern of structure. A study of the earthworm's anatomy will therefore provide us with a key for unlocking the secrets of structure in higher forms of invertebrate animal life and will also furnish some clues to understanding man's anatomy.

#### External features

For our first dissection, study the external features by selecting a preserved and fully-grown specimen of earthworm. After selecting the specimen study and identify the following preferably by using a hand lens (5X to 10X).

1. Note that the dorsal (upper) side has a darker colouration than the ventral (lower) side.
2. Dorsal blood vessel is seen throughout the dorsal surface of the body.
3. Nearer to the anterior (front) end than to the posterior (back) end of the worm is thick cylindrical collar (clitellum) which is used in reproduction is situated in 14th to 16th segments.
4. The fleshy lobe (prostomium) over the mouth serves to give a cushioning effect to the sensory endings of the earthworm.
5. The locomotory organs called setae which enable the earthworm to move about on the ground are found only on the ventral (lower) side.
6. Each segment (somite) is partially separated from its neighbour by a thin wall, called the septum.
7. The earthworm breathes through its moist skin. The pores help to keep the skin moist. The pores can be seen with the aid of a hand lens or with a dissecting microscope.

#### Materials required

Following materials are required to observe the external features of the earthworm:

- i. A preserved earthworm.
- ii. Hand lens.
- iii. Well-labelled diagram.
- iv. Forceps.
- v. Dissecting dish and pin.
- vi. Gloves.

## Observation

1. **Shape:** The body of Pheretima is elongated, nearly cylindrical and somewhat tapering at both the ends. Thus its form of body plan is well-adapted to its burrowing mode of life.
2. **Size:** A mature worms measures 150 mm or so in length and 3 to 5 mm in width. The thickest part being a little behind the anterior end.
3. **Colouration:** It is dark brown in colour due to porphyrin which comes from the chlorophyll in the decaying vegetable matter on which the earthworm feeds. The dorsal surface is darker than the ventral.
4. **Division of the body:** Body is divided into many segments called metameres. The number of segments varies from 100 to 120 rings or annuli.
5. **Other important structures:**
  - a. **Prostomium:** It is a small fleshy, sensory lobe extending over mouth.
  - b. **Mouth:** It is semi-circular in shape lies ventrally in the first segment known as peristomium.
  - c. **Clitellum:** In a mature worm, there is a prominent circular band of glandular tissue known as clitellum. It is dark brown in colour. It lies in the 14<sup>th</sup>, 15<sup>th</sup> and 16<sup>th</sup> segments. This band plays an important part to form cocoon in which fertilization takes place.
  - d. **Setae:** It is situated ventrally in each segment, except first, last and clitellum regions. Setae are an elongated 'S' shaped and point backwards. This type of arrangement is known as perichaetine. It helps to move around and hold fast to burrow. Each seta is situated in the setal sac.
  - e. **Female genital pore:** A single female genital or oviducal aperture is present ventrally on the 14<sup>th</sup> segment in level with the surface of the clitellum. It can be seen only as a light coloured patch.
  - f. **Male genital pore:** The paired male genital pore are crescentic in outline and lie on the ventral surface of the 18<sup>th</sup> segment, one on each side of the median line.
  - g. **Genital papillae:** These are paired pores situated in 17<sup>th</sup> and 19<sup>th</sup> segments.
  - h. **Dorsal pores:** Along the mid-dorsal line in the inter segmental grooves are a series of minute opening the dorsal pores, which lead directly to the coelom.
  - i. **Anus:** It is a small opening lies in last segment called anal segment.
  - j. **Dorsal blood vessel:** It is longitudinal line and is seen throughout the dorsal surface.

## Arranging Specimen for Dissection

Before going to dissect we must know the arrangement of an organism for successful dissection. Remember following points for arranging the organism before dissection.

### Materials required

For a good dissection following materials are required:

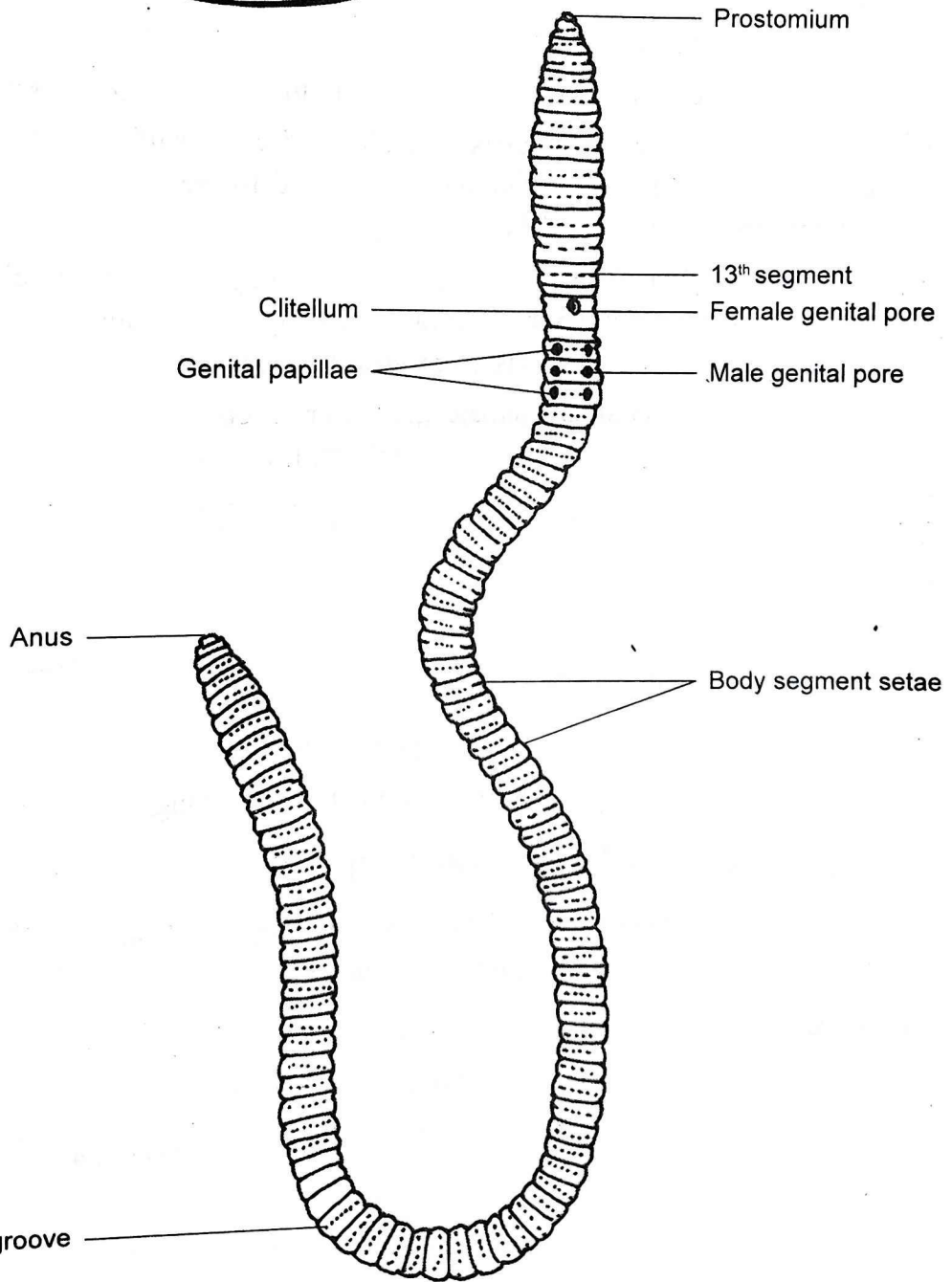
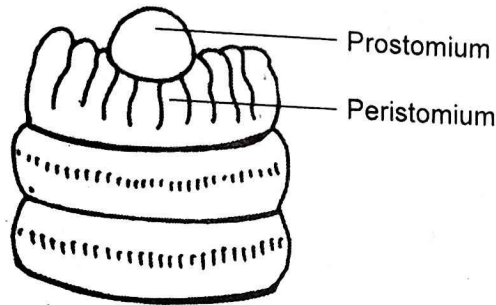
- |                              |                             |            |
|------------------------------|-----------------------------|------------|
| i. Dissecting pan.           | ii. Well preserved material |            |
| iii. Dissecting box and pin. | iv. Water.                  | v. Gloves. |

### Procedure

1. Take a dissecting tray. Fill it with water. Place specimen on dissecting pan with its ventral side down.
2. Extend the specimen to form a straight line.
3. Put a dissecting pin through the prostomium and another through the anal segment.

Date

# DISSECTION OF EARTHWORM



External Feature of Earthworm

## Dissect the Earthworm to Expose the General Anatomy

### Procedure

1. Fill the tray with water to submerge the earthworm. Take a preserved earthworm and fix it in the centre of dissecting pan dorso-ventrally. Dorsal surface can be easily identified by the presence of visible dorsal blood vessel. Take a small scissors and gently make a longitudinal incision in the mid dorsal line beginning at anus up to the anterior end. Be careful to cut through skin, incision must not be deeper, it will burst the alimentary canal. Beginning at anus, cut through septa on each side of intestine with sharp tipped scalpel or razor blade. Roll back body wall, gently pin obliquely each side to dissecting pan to expose all organs.

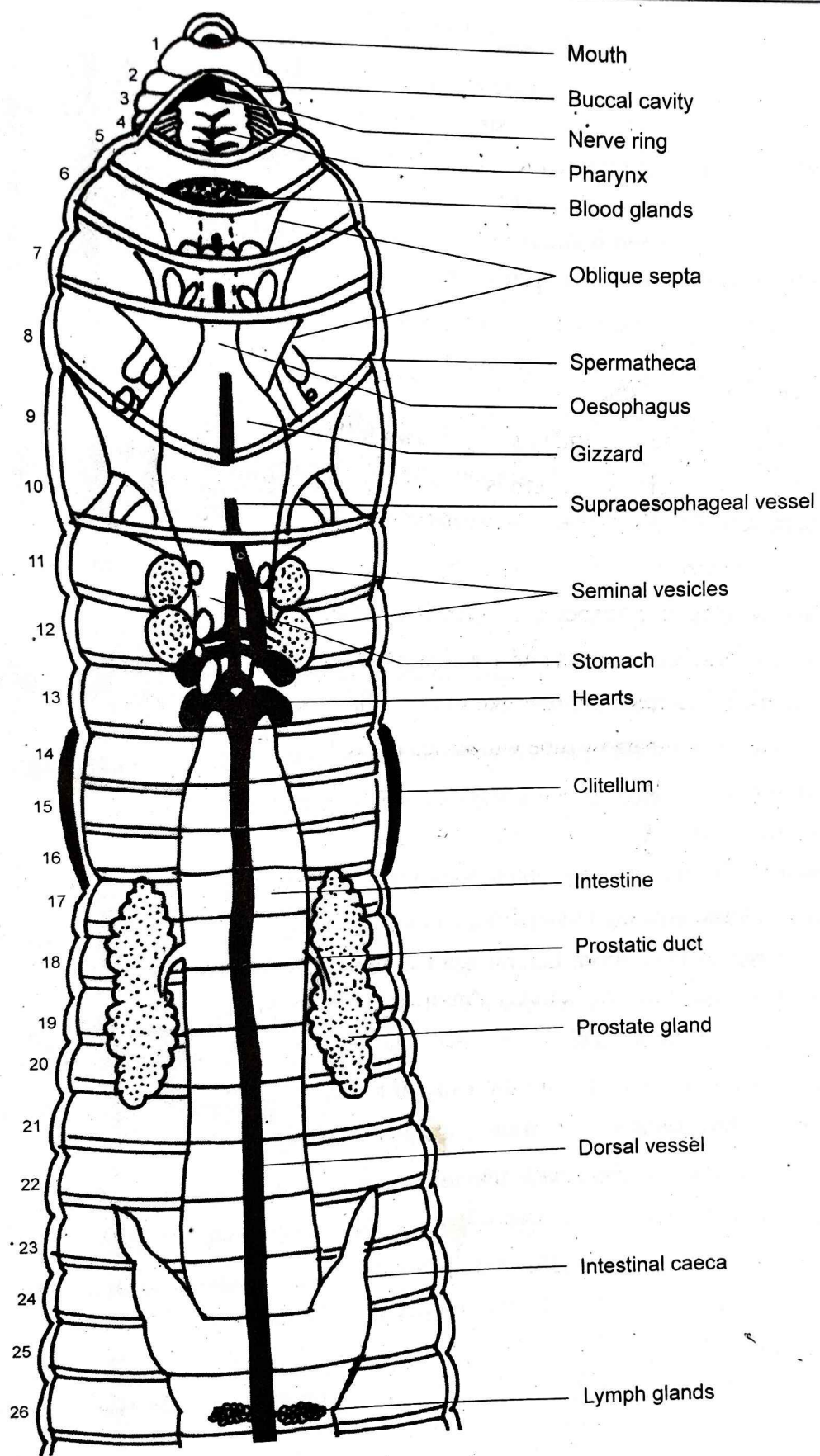
### Observation

After successful dissection, you can study and identify the following structures:

1. **Digestive organs:** The alimentary canal shows following parts:
  - a. Mouth: A semi-circular mouth is situated in the 1<sup>st</sup> segment at the anterior end of the peristomium just beneath the hood like prostomium.
  - b. Buccal chamber: The buccal chamber lies in the first three segments.
  - c. Pharynx: It is pear-shaped and extends up to the 3<sup>th</sup> and 4<sup>th</sup> segment.
  - d. Oesophagus: It is a narrow tube which extends from the 5<sup>th</sup> to 8<sup>th</sup> segment.
  - e. Gizzard: It is a spherical ball like thick walled muscular structure situated in 8<sup>th</sup>- 9<sup>th</sup> segments.
  - f. Stomach: It is a narrow tube which lies in the 9<sup>th</sup> to 14<sup>th</sup> segment.
  - g. Intestine: It is a long, broad and thin walled which lies from the 14<sup>th</sup> to the last anal segment.
  - h. Intestinal caeca: In the 26<sup>th</sup> segment two lateral finger like outgrowths arise from the intestinal walls known as intestinal caeca, which runs anteriorly up to 22<sup>nd</sup> segment.
2. **Blood:** It is closed type i.e. blood flows in the vessels. Following blood vessels are seen.
  - a. Heart and anterior loop: Lateral heart is found in 7<sup>th</sup>, 9<sup>th</sup> and supra oesophageal heart is in 12<sup>th</sup> and 13<sup>th</sup> segments respectively. Anterior loops are situated in 10<sup>th</sup> and 11<sup>th</sup> segments.
  - b. Dorsal blood vessel: This blood vessel lies above the ali. canal from anterior to posterior end.
  - c. Sutra-intestinal vessel: It lies over the stomach from 9<sup>th</sup> to 13<sup>th</sup> segments.
  - d. Supra-oesophageal vessel: It runs laterally to ali. canal from anterior end to the 13<sup>th</sup> segment.
3. **Excretory System:** The most well developed septal nephridia and pharyngeal nephridia are seen.
4. **Reproductive system:** Following reproductive organs are seen:
  - a. Spermatheca: The four pairs of flask shaped spermatheca are situated in 6<sup>th</sup> to 9<sup>th</sup> segments.
  - b. Seminal vesicles: The two pairs of seminal vesicles are situated in 11<sup>th</sup> and 12<sup>th</sup> segments.
  - c. Testes: Two pairs of testes are situated in 10<sup>th</sup> and 11<sup>th</sup> segment.
  - d. Testis sac encloses the testes which are situated in 11<sup>th</sup> and 12<sup>th</sup> segment
  - e. Ovary: A pair of white ovaries situated in 12<sup>th</sup> and 13<sup>th</sup> segment.
  - f. Prostate gland: A pair of white prostate gland is situated in 17<sup>th</sup> to 20<sup>th</sup> segments.
  - g. Accessory gland: Two pairs of accessory glands are situated in 17<sup>th</sup> and 19<sup>th</sup> segments.

Date

# DISSECTION OF EARTHWORM



General Anatomy of Earthworm

## Dissect the Earthworm to Expose the Digestive System

### Materials required

Following materials are required to dissect the digestive system of Earthworm:

1. A preserved earthworm.
2. Dissecting tray.
3. Dissecting pin.
4. A fully equipped dissecting box.
5. A well-labeled diagram.
6. Gloves.

### Procedure

1. Take a dissecting tray and fill it with water.
2. Select a well preserved earthworm and fix it gently in tray dorso-ventrally with the help of pin.
3. Gently make a longitudinal incision on mid dorsal blood vessel up to the anterior end.
4. With the help of needle make the septa free from the body wall.
5. Gently place the pins obliquely in the dish through the segments - 2, 4, 6, 8 and so on.
6. Open the 26<sup>th</sup> segment to display the intestinal caeca.

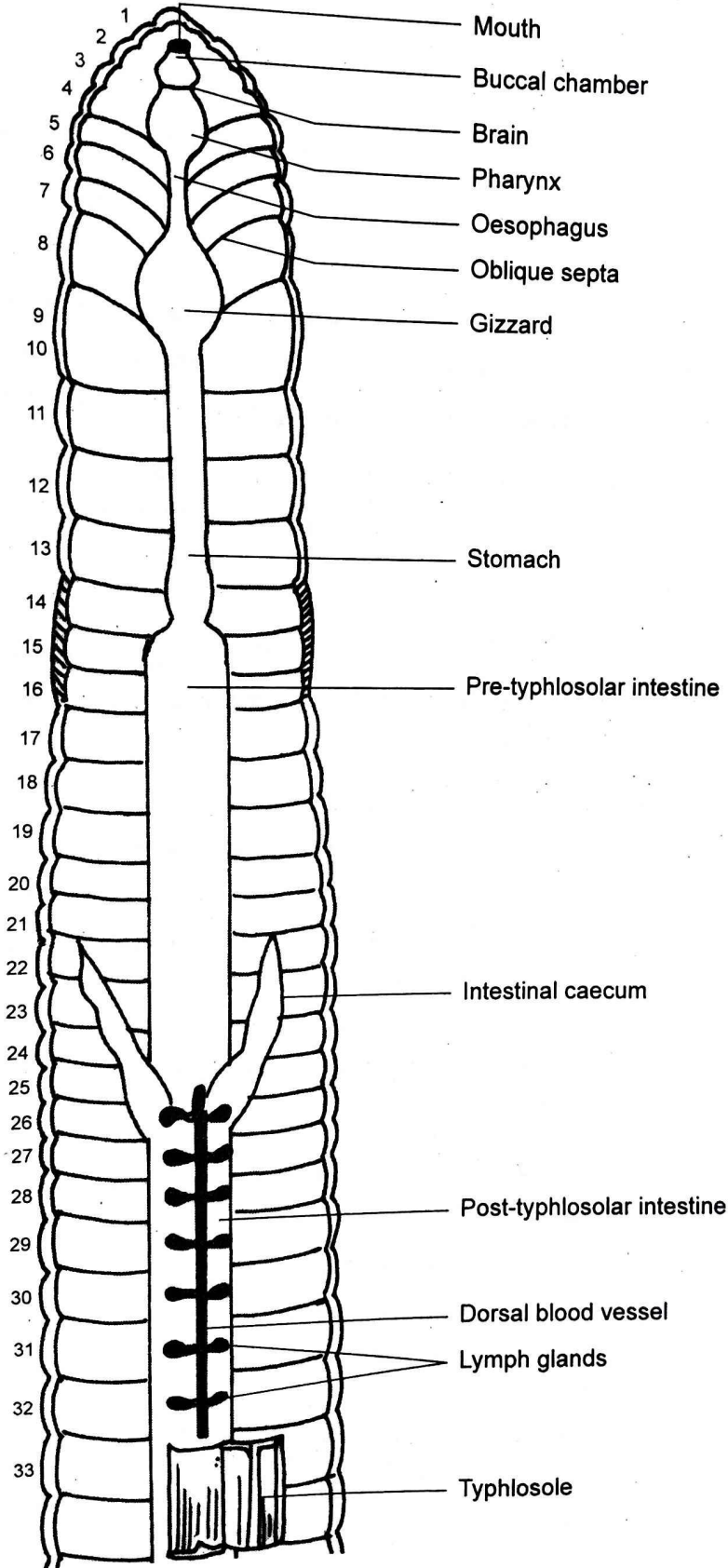
### Observation

Alimentary canal is straight and is situated from 1<sup>st</sup> to last segment. It consists of following parts:

1. **Mouth:** A semi-circular mouth is situated in the 1<sup>st</sup> segment at the anterior end of the peristomium just beneath the hood like prostomium.
2. **Buccal-cavity:** It is a short tube lies in the first three segments. Its wall are highly muscular.
3. **Pharynx:** It is pear shaped structure and extends up to the 3<sup>rd</sup> and 4<sup>th</sup> segments. Its wall is very thick and highly muscular.
4. **Oesophagus:** It is a narrow tube which extends from the 5<sup>th</sup> to the 8<sup>th</sup> segments. Its walls are quite thin.
5. **Gizzard:** It is a spherical ball like hard walled muscular structure situated in the 8<sup>th</sup> and 9<sup>th</sup> segment. Gizzard acts as a grinder and cuts the large food particles into smaller pieces.
6. **Stomach:** It is a glandular and narrow tube lies in the 9<sup>th</sup> to 14<sup>th</sup> segment. Sphincter muscles are found at its anterior and posterior end.
7. **Intestine:** It is a long., broad and thin walled tube like structure which lies from the 14<sup>th</sup> to the last anal segment. The intestine is divisible into three parts.
  - a. **Pre-typhlosolar region:** This is the anterior part of the intestine which extends from the 15<sup>th</sup> to 25<sup>th</sup> segments. Intestinal caeca are found at its proximal end.
  - b. **Typhosolar region:** This is the mid portion of the intestine found in 26<sup>th</sup> to the next twenty-five segments. In this region intestinal fold is found known as typhlosole. Due to the presence of typhlosole the absorption surface of the intestine increases many times.
  - c. **Post-typhlosolar region:** This is the posterior region of the intestine lying in the last few segments of the body. It is also known as rectum.
8. **Intestinal Caeca:** In the 26<sup>th</sup> segment two lateral finger like outgrowths arise from the intestinal walls known as intestinal caeca. They extent anteriorly up to 22<sup>nd</sup> segment.

Date

# DISSECTION OF EARTHWORM



Alimentary Canal of Earthworm

## Dissect the Earthworm to Expose the Reproductive System

The earthworms are potandrous i.e. male sex cells ripen much earlier than the female cells. So the self fertilization is prevented. The male reproductive system of earthworm consists of following parts:

- |                                   |                                   |
|-----------------------------------|-----------------------------------|
| 1. Two pairs of testes            | 2. Two pairs of testes sacs       |
| 3. Two pairs of seminal vesicles. | 4. Two pairs of vasa deferentia   |
| 5. One pair of prostate gland.    | 6. Two pairs of accessory glands. |

- Testes:** There are two pairs of testes situated in the 10<sup>th</sup> and 11<sup>th</sup> segments. Each testes is minute white body and is made up of 4-8 finger like process.
- Testes sacs:** There are two pairs of testes sacs which encloses the testes. The testes sacs are yellow in colour. The cavities of the two testes sacs of the same segment communicates with each other. On their inner sides, the testes sacs enclose the ciliated spermiducal funnel. Posteriorly the testes sacs are communicated with the seminal vesicles.
- Seminal vesicles:** Seminal vesicles are also two pairs and are oval shaped. The first pair is situated in the 11<sup>th</sup> segment and other pair in 12<sup>th</sup> segment. The maturation and storage of the sperms take place in the seminal vesicles.
- Vasa-deferentia:** There are two pairs of long tube like structure called vasa-deferentia which starts as funnel shaped structure called spermatic funnel. Two vasa-deferentia, of one side run close to each other and extend from 12<sup>th</sup> to 18<sup>th</sup> segment.
- Prostate gland:** There is a pair of large, irregular shaped and white coloured prostate gland. It is situated on each side of the intestine from 17<sup>th</sup> to 20<sup>th</sup> segments. In the 18<sup>th</sup> segment, a short and muscular prostatic duct arises from each gland which joins the two vasa deferentia.
- Accessory gland:** In the 17<sup>th</sup> and 19<sup>th</sup> segment there are two pairs of rounded accessory glands.

### Female reproductive system

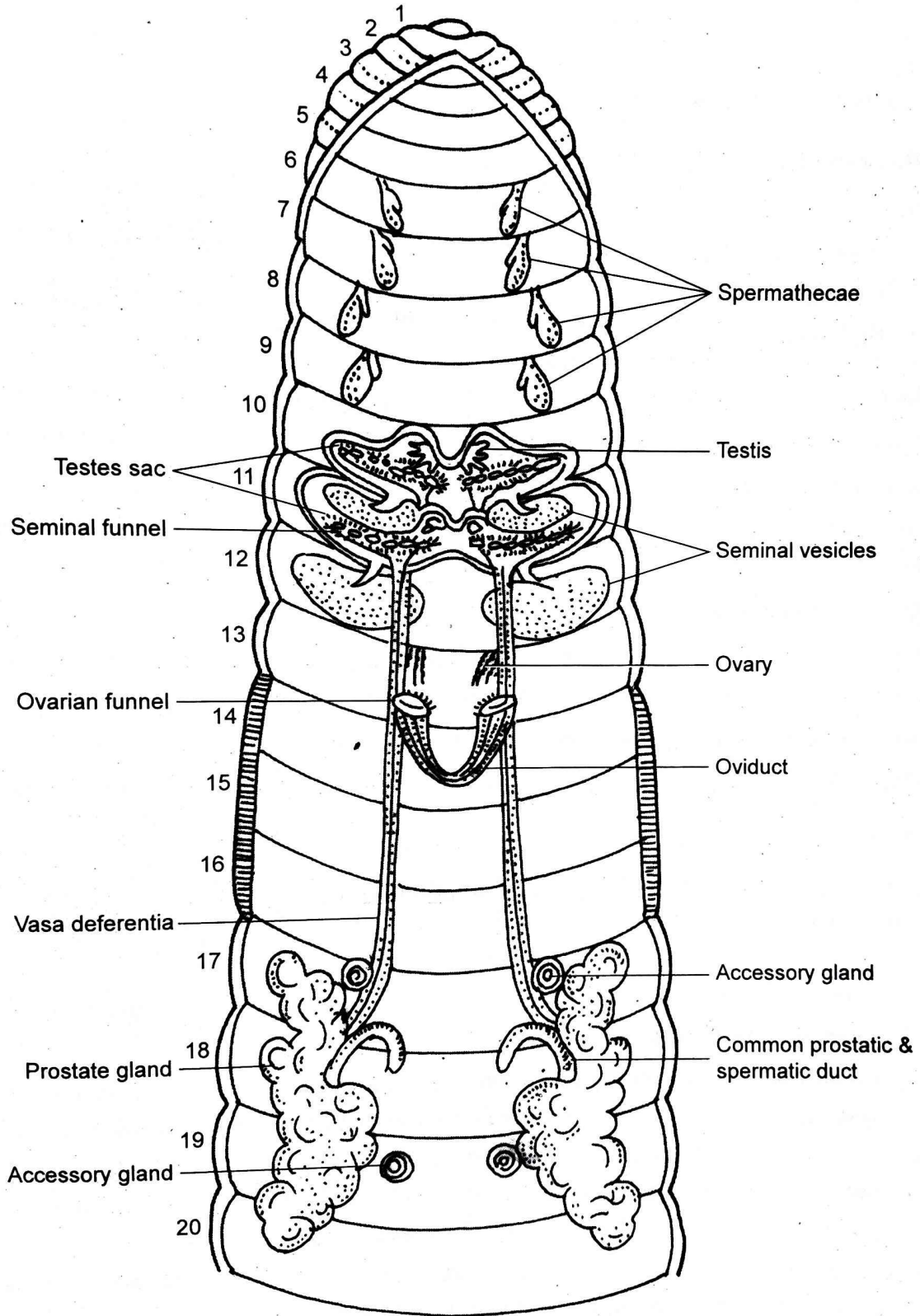
The female reproductive system consists of following organs:

1. A pair of ovaries
2. A pair of oviducts
3. Four pairs of spermatheca

- Ovary:** There is a single pair of ovaries which are situated below the alimentary canal on each side of the ventral nerve cord and are attached to the hinder part of the septum between 12<sup>th</sup> and 13<sup>th</sup> segments. Each ovary is a white mass made up of large number of finger shaped ovarioles. The eggs are arranged in a linear manner in the ovarioles.
- Oviduct:** There is a pair of short oviducts which start as funnel shaped structures called oviducal funnel provided with cilia. These oviducts run from 13<sup>th</sup> to 14<sup>th</sup> segment where both unite or converge to open outside ventrally by means of female genital pore.
- Spermatheca:** There are four pairs of flask shaped spermatheca found in the 6<sup>th</sup>, 7<sup>th</sup>, 8<sup>th</sup> and 9<sup>th</sup> segments. They open ventro-laterally in the inter septum between 5/6<sup>th</sup>, 6/7<sup>th</sup>, 7/8<sup>th</sup> and 8/9<sup>th</sup> segments. They are responsible for storing sperms during copulation.

Date

# DISSECTION OF EARTHWORM



Reproductive Organs of Earthworm

## Dissect the Earthworm to Expose the Nervous System (Nerve-Ring)

It may be surprising to learn that the lowly worm has a brain. Of course, it is neither as magnificent nor as complex as man's brain but it does enable the earthworm, to a limited degree, to learn from its experiences.

Just what is a brain? It is a centre of nerve cells that helps to co-ordinate the activities of an animal. In the earth worm the brain is connected with the double ventral nerve cord. The brain and trunk lines have nerves which branch off to all parts of the body. In any animal the nervous system is the most difficult to dissect. This is equally true for the earthworm.

### Materials required

Following materials are required for exposing the nerve ring of an earthworm:

- |                             |                    |
|-----------------------------|--------------------|
| 1. Well preserved earthworm | 2. Dissecting tray |
| 3. Dissecting box and pin   | 4. Water           |
| 5. Well-labelled diagram    | 6. Gloves          |

### Procedure

1. Pin down the selected earthworm dorso-ventrally in the dissecting pan.
2. Fix the pin at anterior end very carefully to save the brain or the nerve centre.
3. Make a longitudinal incision in the body in the mid-dorsal line from the 10<sup>th</sup> segment right up to the anterior end.
4. Not to cut deeply specially in the 3<sup>rd</sup> segment of anterior region where the brain ring is located.
5. Gently release the flaps of body wall from the septa with needles and pin down in dissecting tray.
6. Gently cut across the ventral nerve cord at least half of an inch behind the sub-pharyngeal ganglia.
7. Carefully cut the buccal chamber and pull it out.
8. Gently clear the remaining bits of connective tissue with the help of needles.

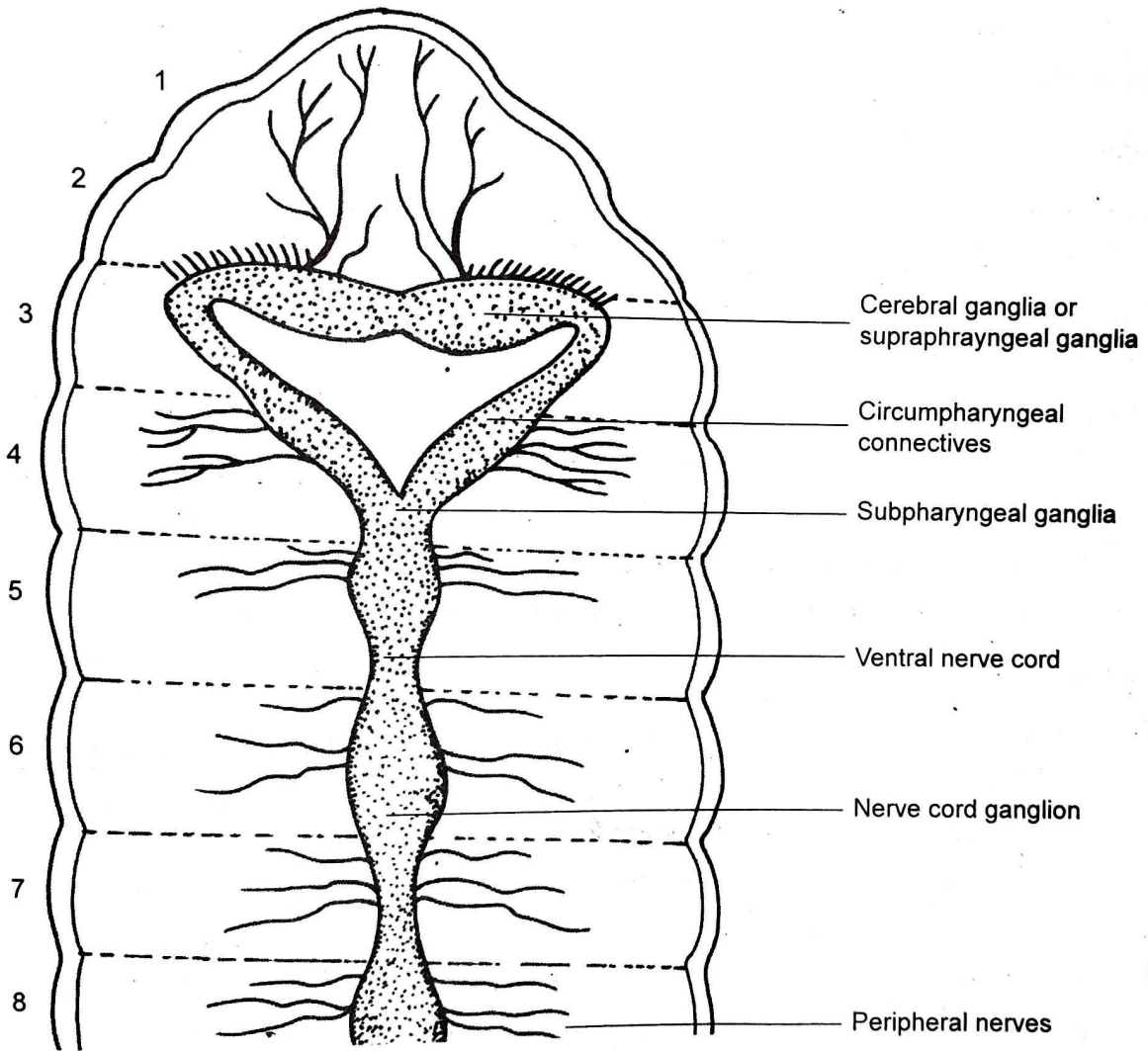
### Observation

The nervous system of earthworm consists of central nervous system and peripheral nervous system.

1. **Central Nervous System:** The central nervous system consists of a pair of supra-pharyngeal ganglia, circum pharyngeal connectives, sub-pharyngeal ganglia and nerve cord.
  - a. **Supra-pharyngeal ganglia:** It is a paired fused mass of ganglia which are also called brain. It is situated in the 3<sup>rd</sup> segment between buccal cavity and pharynx.
  - b. **Circum-pharyngeal connectives:** From the brain or supra-pharyngeal ganglia a pair of circum-pharyngeal connectives arise laterally which encircle the pharynx and meet with a paired mass of sub-pharyngeal ganglia lying ventrally in the 4<sup>th</sup> segment.
  - c. **Sub-pharyngeal ganglia:** The sub-pharyngeal ganglia are the pair fused mass of ganglia which are situated below the pharynx in the 4<sup>th</sup> segment.
  - d. **Nerve Cord:** It is a long rod like structure arises from the base of the sub-pharyngeal ganglia and runs ventrally up to the posterior end. The nerve cord is actually two in number but they are fused. The nerve cord has a pair of fused ganglia as swelling in each segment from 5<sup>th</sup> to last segment.
2. **Peripheral nervous system:** Peripheral nervous system consists of large number of nerves which arises from central nervous system.

Date

# DISSECTION OF EARTHWORM



Nervous System of Earthworm Showing Nerve Ring

## Dissection of Frog

### Study the External Features of Frog to Dissect Various Organs

The structures which are visible on appearance of the body is generally known as external features. It help us to distinguish from one to another as it denotes the size, shape, texture and colouration.

#### Materials required

Frog, dissecting tray, water, gloves.

#### Procedure

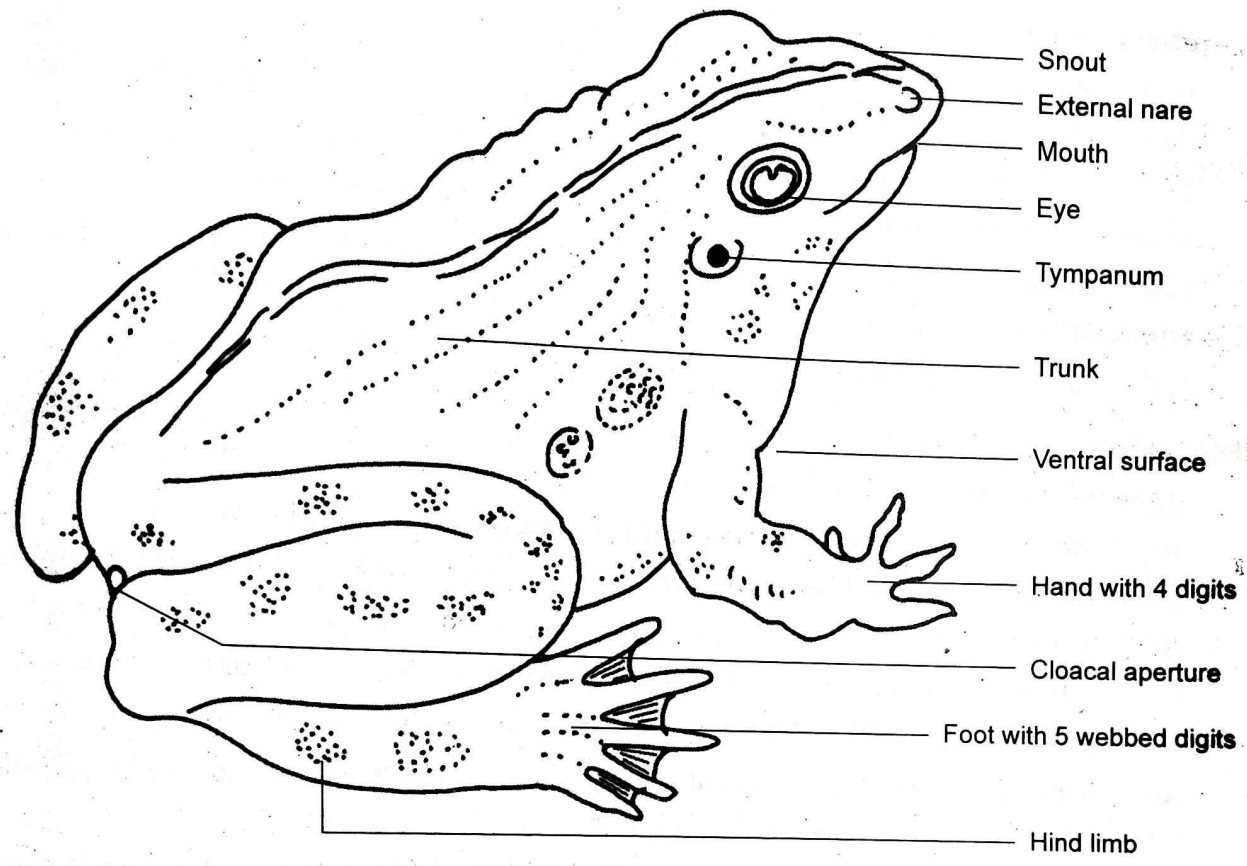
To know the external features select a male or a female frog. Put it in a dissecting dish and properly wash the animal as it was preserved in chloroform because it makes your eyes irritate.

#### Observation

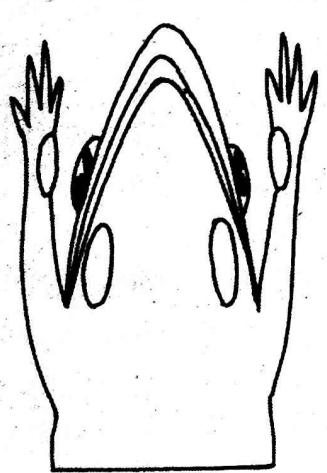
1. **Head:** The 'head is almost triangular and somewhat flattened with forwardly directed blunt apex called snout. The blunt snout is helpful for digging the mud during hibernation and aestivation. The head bears following structures:
  - a. **Mouth:** It is wide terminal' opening, extending from tip. of the snout to the ear drum' on either side of the head. It lacks lips and cheeks but bounded by upper and lower jaws.
  - b. **Nostrils or external nares:** There are two small openings called nostrils or external nares on the anterior end of the snout, just above the mouth for the purpose of breathing. These open in the buccal cavity through the internal nares and allow only air to enter this cavity.
  - c. **Eyes:** There are two prominent and bulging of eyes placed laterally almost on the top of the head. The eyes enable the frog to look in all directions and to see above the water when it is swimming. Each eye is guarded by two eyelids; a thick slightly immovable upper eyelid and a movable lower eyelid. The lower eyelid is formed of a lower eyelid proper below and a nictitating membrane above.
  - d. **Tympanum or ear drum:** There is no external ears in frog but on either side of the head, behind the eye is a dark coloured circular area called tympanic membrane or tympanum which is a part of the ear.
2. **Trunk:** The head is continuous posteriorly with a broad and flattened trunk. When the frog is resting, a characteristics hump is formed on the dorsal surface of the trunk. At the posterior end of the trunk is an opening called vent or cloacal aperture, which is a common opening for the discharge of faeces, urine and gametes (sperms or ova). It contains fore limbs and hind limbs.
  - a. **Fore limbs:** The fore limbs are shorter and consist of three distinct parts, namely the upper arm (brachium), fore arm (antebrachium) and hand (manus). The hand consists of a carpus, metacarpus and four digits. The digits are provided with copulatory pads in male (Develops during breeding season).
  - b. **Hind limbs:** Each hind limb consists of three parts a proximal thigh (Femur), middle (shank), and the distal foot. The foot has a long ankle, a sole and five nail less but webbed toes or digits. The greatly elongated, powerful and webbed legs of the frog are admirably adapted for swimming and jumping.

Date

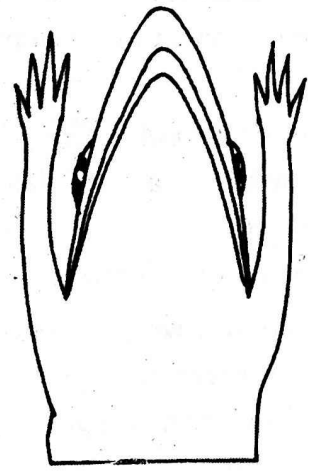
# DISSECTION OF FROG



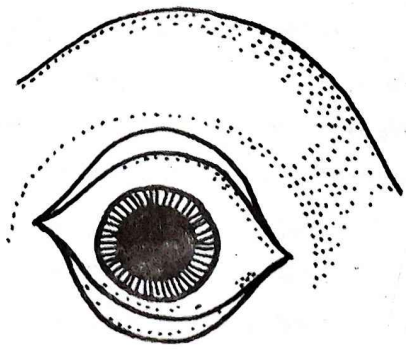
Frog (Adult)



Head (Female)



Head (Male)



Eye with Nictitating Membrane

## Dissect the Frog to Expose the General Anatomy

### Procedure

1. Place the frog in the dissecting pan ventro-dorsally i.e. ventral side facing upwards.
2. Fix the frog in a dissecting pan by pinning the limbs.
3. First give a median longitudinal incision in the skin and cut through the muscular body wall from the cloacal region to the pectoral girdle and pin the skin on both sides.
4. Also cut the skin of the hind legs up to thigh to expose the muscles. Pull skin back firmly with forceps.
6. Free the skins on both sides so as to expose the body wall. Roll all skin flaps back and pin each side to pan. Cut a small opening through muscular wall with scalpel or razor.
7. Insert rounded tip of scissors into incision, hold scissors almost parallel to body. Continue cut to point where sternum begins. Gently remove the peritoneum to show the visceral organs.
8. Cuts must be very shallow or internal organs must not be damaged.

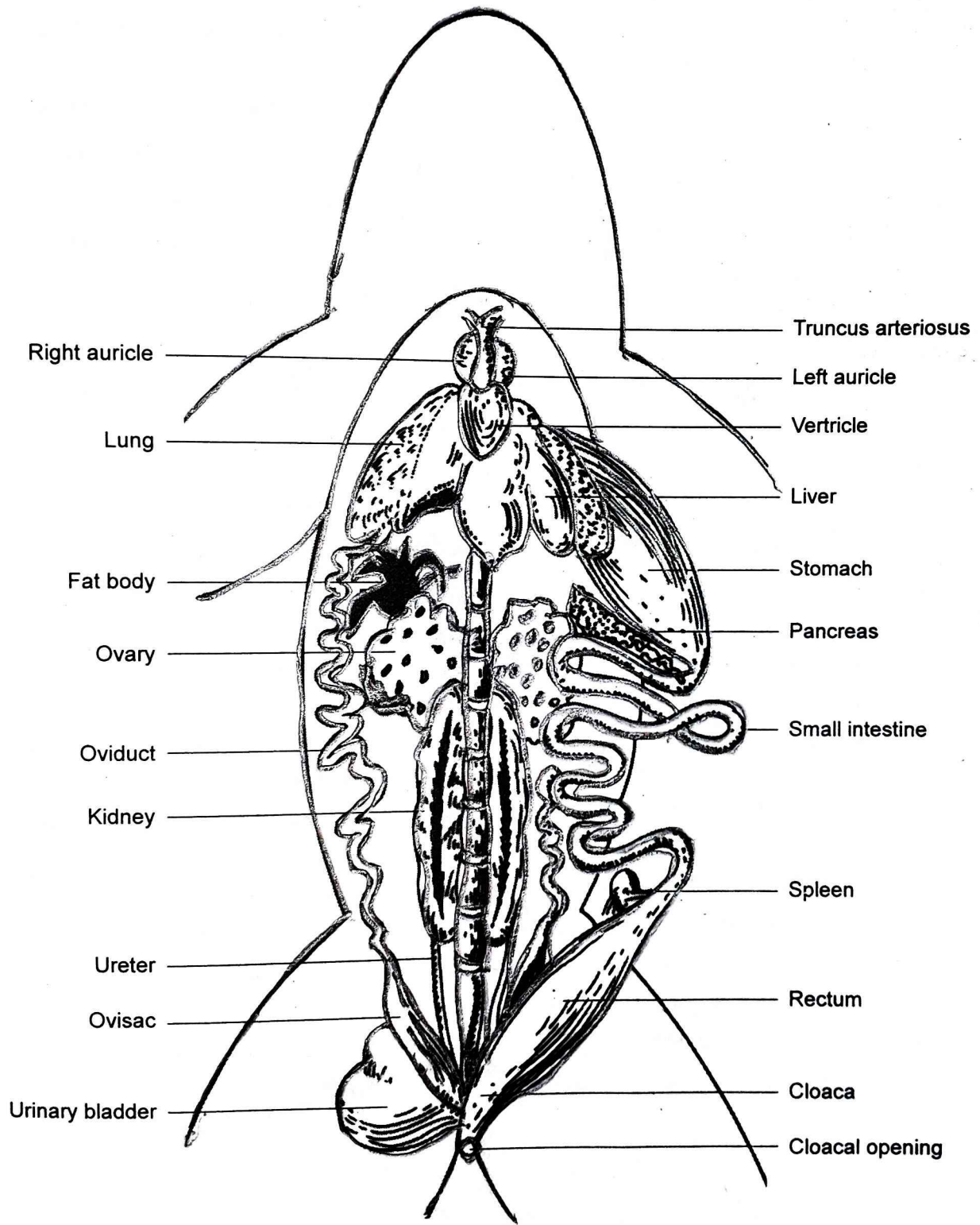
### Observation

1. Heart: It is muscular and triangular in shape. It is situated in mid-ventral line and is covered by a double walled sac like structure called pericardium.
2. Liver: It is a compact reddish brown bilobed organ and is situated at the sides of the heart. The two compact lobes i.e. right and left remain connected by a narrow bridge of liver tissue.
3. Lungs: There is a pair of elastic, thin-walled spongy sacs lying at the sides of the heart.
4. Gall bladder: It is a small greenish lobe lying between the two lobes of liver.
5. Alimentary canal: The alimentary canal of frog is long, coiled tube which opens anteriorly by mouth and posteriorly by cloacal aperture. It includes following parts:
  - i. Oesophagus: Due to absence of neck, it is short but wide tubular structure behind the buccal cavity.
  - ii. Stomach: It lies behind the oesophagus represents the most expanded part of the alimentary canal. It is white in colour. It is wide anteriorly and narrows posteriorly.
  - iii. Duodenum: It is the first part of intestine and 'U' shaped. It is a narrow tube and runs forward to lie parallel to the stomach.
  - iv. Ileum: It is the second part of intestine, which is long, thin-walled and narrow tube.
  - v. Large intestine: It is short but much wider tube. It is also known as rectum.
6. Pancreas: It is long, flattened, irregularly lobed and light yellow in colour. It lies in the mesentery between the duodenum and stomach.
7. Spleen: It is a small rounded body attached with the large intestine by mesenteries.
8. Kidney: The kidneys are dark red and somewhat flattened organs. They are situated just beneath the vertebral column, one on each side of dorsal aorta.
9. Fat bodies: It is yellow coloured, finger like structure lying at the anterior end of each kidney.
10. Urinary bladder: It is thin-walled sac like structure. It opens into the cloaca.
11. Testes: There is a pair of yellow coloured oval shaped testes in male frog. It lies ventrally to the anterior and outer side of the kidney.
12. Ovaries: There are small blackish irregular shaped lobulated ovaries in the female frog. It occupies the same position as the testes in male frog.

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# DISSECTION OF FROG



General Anatomy of Frog Showing Viscera

## Dissect the Frog to Expose the Digestive System

### Procedure

1. Pin the frog in dissecting pan ventro-dorsally.
2. Place matchstick close to tip of jaws so that you will be able to move the tongue.
3. Gently dissect the frog and carefully remove the visceral organs.
4. Gently insert the scissors in mouth and carefully cut the layer of lower jaw and make separate it from upper jaw. Pull it one side to observe oesophagus.
5. Lift tongue with forceps near glottis and observe its attachment to the floor of the mouth.
6. Gently lift and turn the liver lobes towards the head to reveal the gall bladder and its tubes.
7. Remove the lungs or turn it upward to expose the stomach and oesophagus.
8. On this way, gently remove all the unnecessary part like mesentery and carefully clear all parts like intestine, rectum, spleen, cloaca, and cloacal aperture.

### Observation

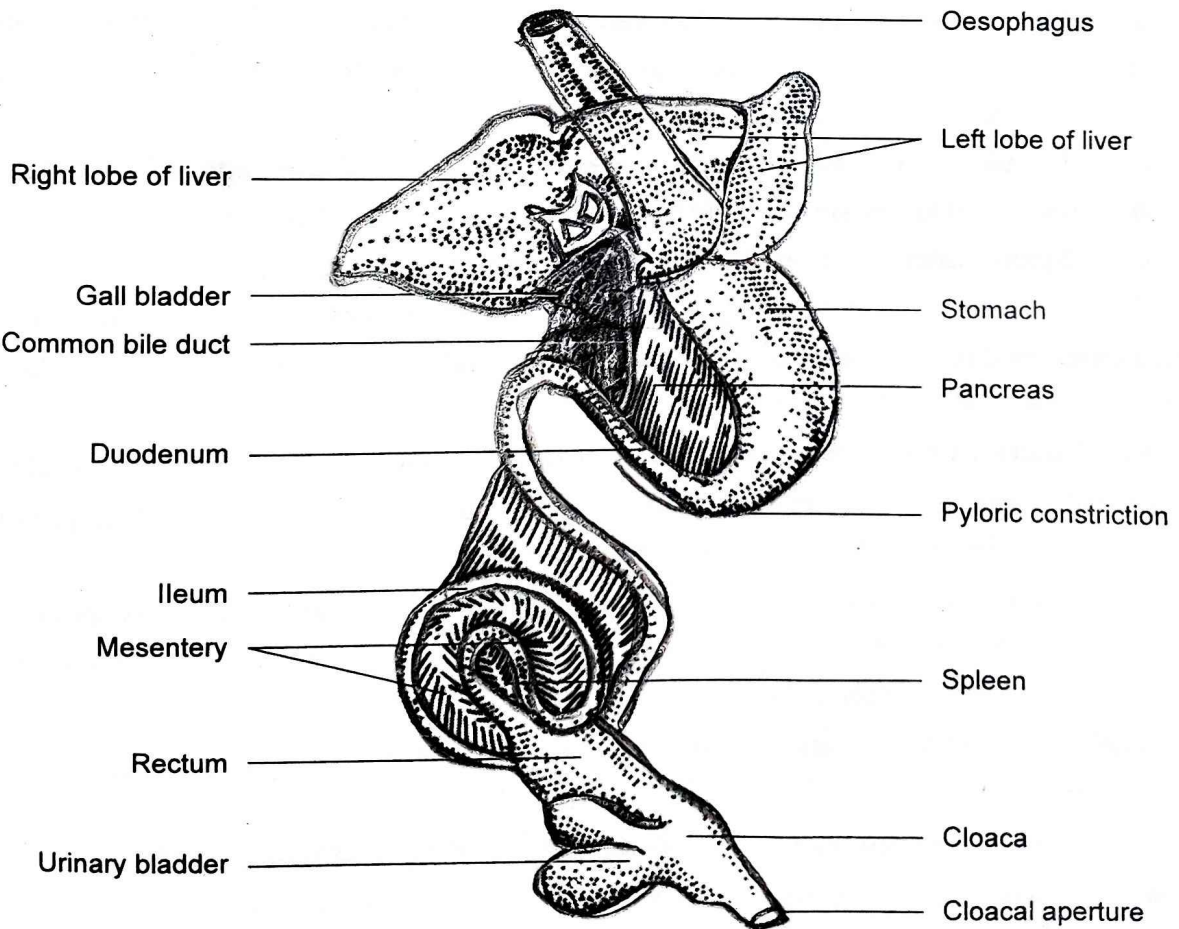
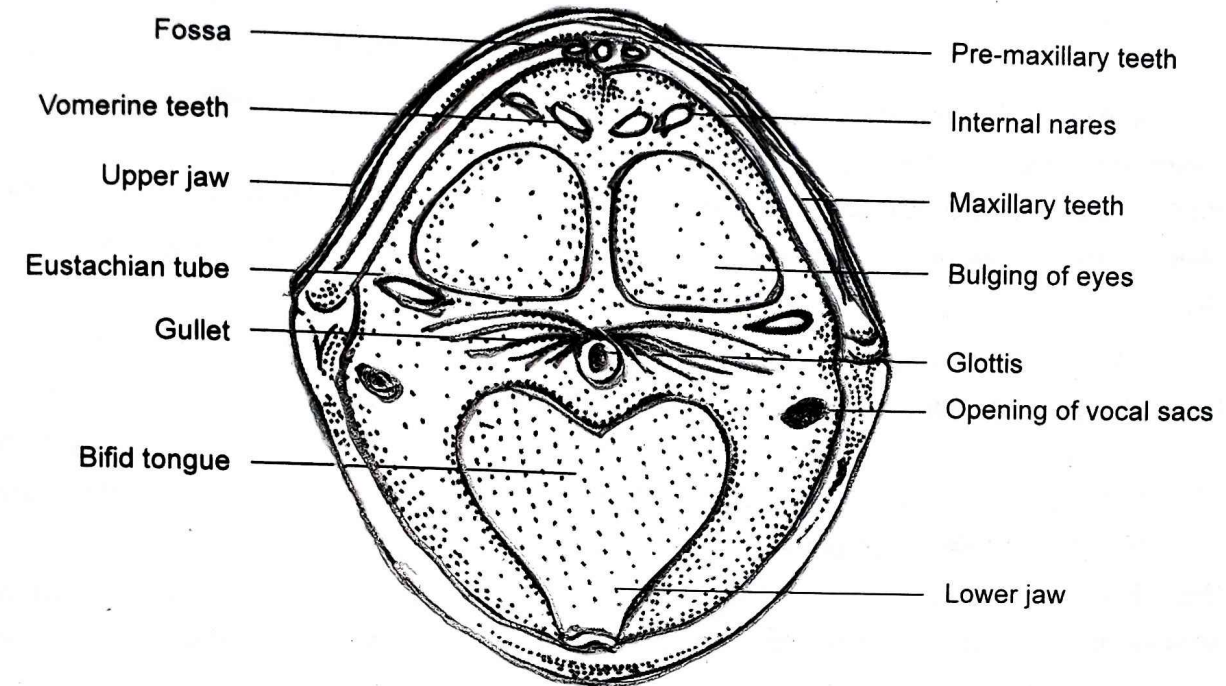
The digestive system of frog consists of a long coiled tubular alimentary canal and its associated digestive glands.

**Alimentary canal:** It consists of following parts:

- |                                  |                              |
|----------------------------------|------------------------------|
| 1. Bucco pharyngeal cavity       | 2. Oesophagus                |
| 3. Stomach                       | 4. Duodenum                  |
| 5. Ileum                         | 6. Large intestine or rectum |
| 7. Cloaca with cloacal aperture. | 8. Digestive glands.         |
1. Bucco-pharyngeal cavity: The mouth leads into buccal cavity, which narrows posteriorly into the pharynx. It is divided into upper and lower jaw.
    - a. Upper jaw: It is fixed. There is following structures situated on the upper jaw: Maxillary teeth, vomerine teeth, internal nares, eustachian tube and eye ball.
    - b. Lower jaw: It is movable. Following structures are situated on it: tongue, glottis, vocal sac in male and gullet.
  2. Oesophagus: Due to absence of neck the oesophagus is short.
  3. Stomach: It is thick walled sac like.
  4. Duodenum: It is 'U' shaped.
  5. Ileum: It is a long tubular and coiled structure..
  6. Rectum: It is short but wide chamber.
  7. Cloaca: It is a small area which opens outside by cloacal aperture.
  8. Digestive glands: There are four digestive glands:
    - a. Gastric gland: It is situated in the inner surface of the stomach.
    - b. Liver: It is largest of all glands and is situated in the anterior region of the abdominal cavity.
    - c. Pancreas: It is long, flattened, irregularly lobed and yellow in colour. It is situated between the stomach and duodenum.
    - d. Intestinal gland: It is found in the inner surface of the intestine.

# DISSECTION OF FROG

Date \_\_\_\_\_



Alimentary Canal of Frog with associated Glands

## Dissect the Frog to Expose the Arterial System of Frog

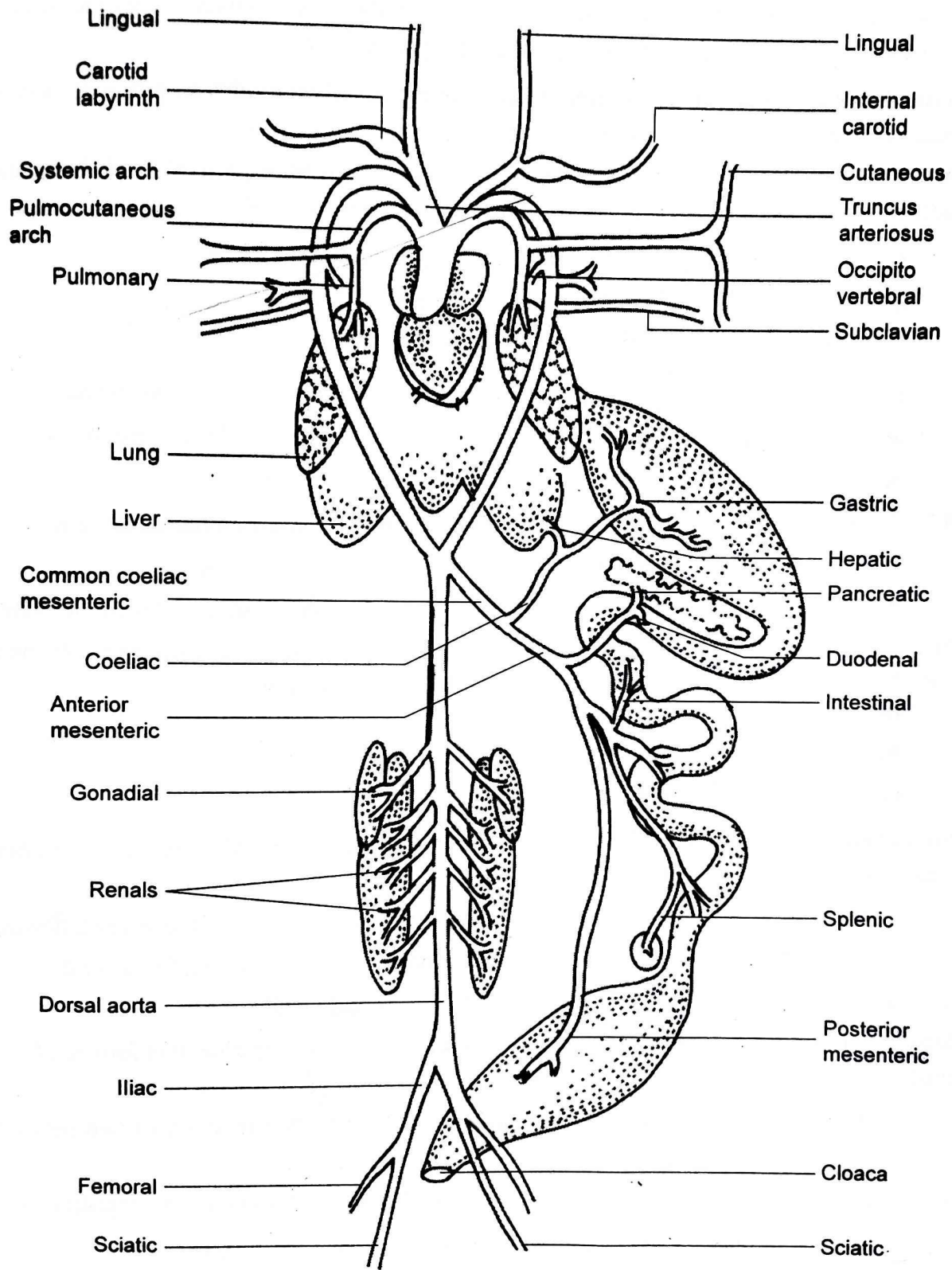
### Observation

Three arches of Arterial system are:

1. **Carotid arch:** It arises anteriorly from each aortic trunk and divides into two arteries:
  - a. Lingual or external carotid artery supplies the blood to the tongue and lower jaw.
  - b. Carotid or internal carotid artery supplies the blood to the brain, orbit, roof of the buccal cavity and skull. It has a swelling at its origin point called carotid labyrinth.
2. **Systemic arch:** It is the largest of all three arches. It arises from the middle part of each aortic trunk. Each of the systemic arch arises upward then bend downward so as to meet with each other below the heart at the median line to form the dorsal aorta. Branches of systemic arch are as follows:
  - a. Before joining each systemic arch gives off three arteries:
    - i. Oesophageal artery arises inward from each systemic arch and supplies the blood to oesophagus.
    - ii. Occipito-vertebral artery arises externally from upper part of each systemic arch and supply the blood to the lower portion of the skull (head, jaws) and vertebral column along with spinal cord.
    - iii. Sub-clavian artery arises externally just - below the occipito-vertebral artery and supply the blood to the shoulder and arm of the fore limbs.
  - b. Branches of dorsal aorta: Just near meeting of two systemic arches before forming a dorsal aorta there arises a branch coeliaco - mesentery artery which gives two branches: coeliac and anterior mesenteric.
    - i. Coeliac artery arises upwards and gives two branches:
      - a. Hepatic artery supplies to the liver.
      - b. Gastric artery supplies the blood to the stomach.
    - ii. Anterior mesenteric artery divides into following four branches that all enters in small and large intestine and have got their name according to their respective parts.
      - a. Duodeno-pancreatic artery supplies the blood to the duodenum and pancreas.
      - b. Intestinal artery supplies the blood to the different parts of the small intestine.
      - c. Splenic artery supplies the blood to the spleen.
      - d. Posterior mesenteric artery is long branch and supplies the blood to the rectum.
  - c. Branch emerges directly from the dorsal aorta: The dorsal aorta runs backward and when it comes at the level of gonad and kidney it gives 4 to 6 pairs of arteries. They are renal and gonadial.
    - i. Renal arteries are 4 to 6 pairs emerge directly from dorsal aorta and supply the blood to the kidney.
    - ii. Gonadial artery is one pair, also emerges directly from the dorsal aorta and supplies the blood to the gonad (Testes in male and ovary in female).
  - d. Branch formed by the division of dorsal aorta: The dorsal aorta runs posteriorly and bifurcates into two branches called iliac arteries. Each of the iliac arteries gives off the following arteries:
    - i. Epigastric artery supplies the blood to the dorsal wall of the abdomen.
    - ii. Hypogastric artery supplies the blood to urinary bladder.
    - iii. Femoral artery supplies the blood to hind limb.
    - iv. Sciatic artery supplies the blood to lower portion of the hind limbs.
3. **Pulmo - cutaneous arch:** Innermost arch which divides into two branches:
  - a. Cutaneous artery carries the deoxygenated blood to the skin.
  - b. Pulmonary artery carries the deoxygenated blood to the lungs.

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# DISSECTION OF FROG



Arterial System of Frog

## Dissect the Frog to Expose the Venous System

### Observation

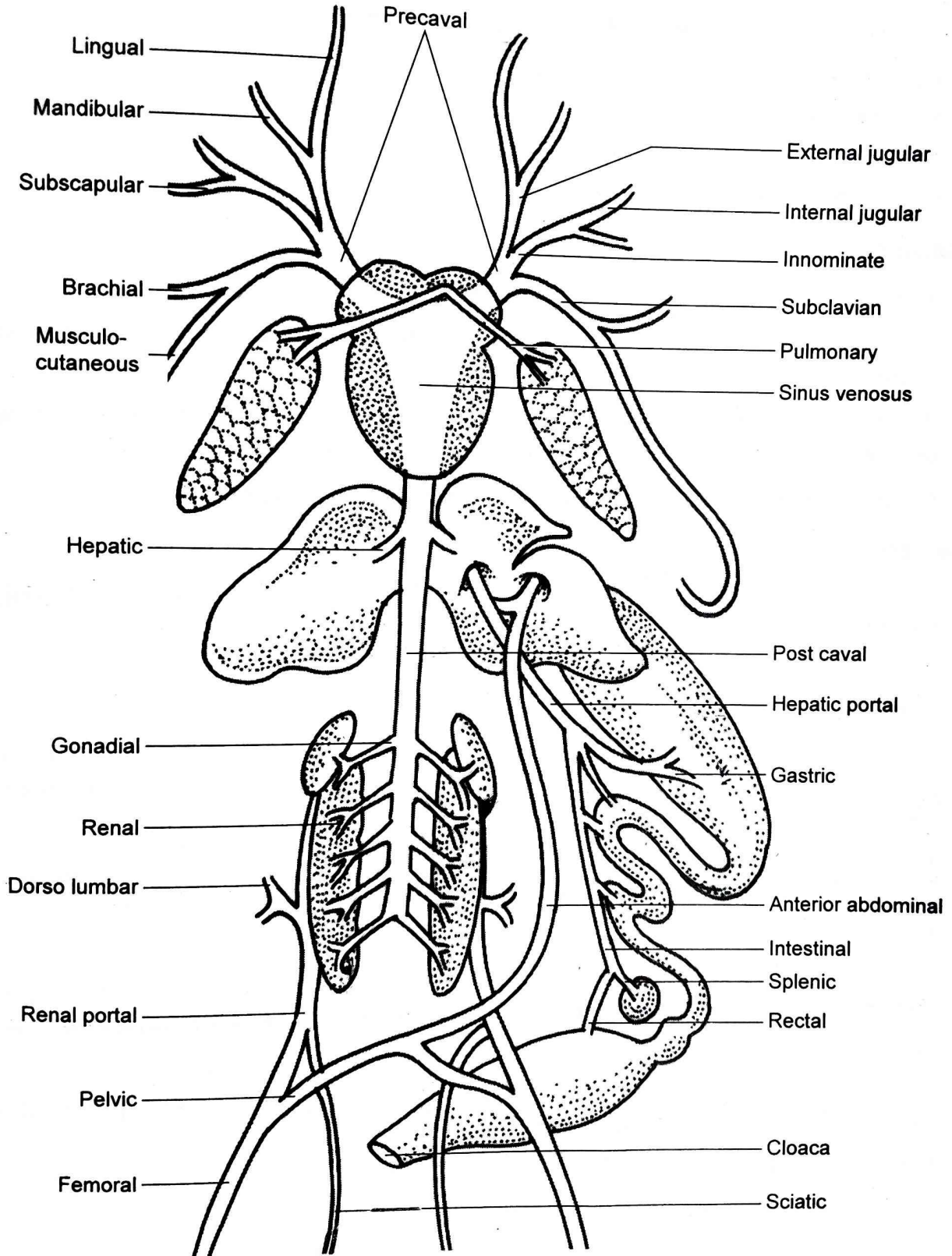
Venous system consist of following parts:

- A. Pulmonary venous system:** It consists of two pulmonary vein which brings the oxygenated blood from the lungs to the heart, which opens into the right auricle.
- B. Systemic venous system:** It consists of two anterior venacava known as precavals and one posterior venacava known as postcaval.
1. Precavals are two large veins and collect the blood from anterior parts of head, body and forelimbs. Each precaval is further formed by the union of three veins:
    - i. External jugular vein: It is formed by the lingual and mandibular.
      - a. Lingual vein collects the blood from the mouth and tongue.
      - b. Mandibular vein collects the blood from lower jaw.
    - ii. Innominate vein: It is formed by, the union of subscapular and internal jugular.
      - a. Subscapular vein collects the blood from arms and shoulder of fore limbs.
      - b. Internal jugular collects the blood from brain, eye and skull.
    - iii. Subclavian vein: It is formed of union of brachial and musculo-cutaneous vein.
      - a. Brachial vein collects the blood from arm pit and fore limbs.
      - b. Musculo-cutaneous vein collects the blood from skin and muscles of the body.
  2. Post-caval is a median vein opens into the posterior end of sinus venosus and collects blood from liver, kidney, viscera and hind limb. It receives the following vein:
    - a. Hepatic veins (Right and left) from liver.
    - b. Renal veins from the kidneys.
    - c. Gonadial vein from the gonads (ovary or testes).
- C. Portal venous system:** Those veins which collect the blood and not directly pour in the heart together constitute portal venous system. It includes renal portal and hepatic portal system.
1. Renal Portal System: It collects the blood from all parts of the hind limbs. It receives following branches:
    - i. Sciatic vein collects the blood of skin and muscles of thigh region of hind limb.
    - ii. Dorso-lumbar vein collects the blood from dorsal body wall.
  2. Hepatic portal system: It collects the blood from all parts of the intestine. It is formed of the following veins:
    - i. Anterior abdominal vein is a median vein and formed by the union of two pelvic vein and a ventral branch of femoral veins.
    - ii. Hepatic portal vein is a large vein and collects blood from stomach, intestine, spleen etc. It receives the following veins:
      - a. Gastric vein from the stomach.
      - b. Intestinal vein from the intestine.
      - c. Duodenal vein from duodenum.
      - d. Splenic vein from spleen.

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# DISSECTION OF FROG



Venous System of Frog

## Dissect the Frog to Expose the Male Urino-Genital System

Frog is unisexual animal so, the male and female frog is differ from one another.

### Materials required

- i. A well preserved male frog.
- ii. Dissecting tray.
- iii. Well-labelled diagram
- iv. Gloves
- v. Fully equipped dissecting box and pin.

### Procedure

1. Take a freshly preserved frog and wash it properly in water.
2. Fix the frog ventro-dorsally in dissecting tray and dissect the male frog and expose the visceral organ as done fore general anatomy.
3. Properly cut and remove the oesophagus and intestine from the body or shift the alimentary canal on one side.
4. Observe all the parts of male urino-genital system with the help of diagram.

### Observation

The male reproductive system is consists of the following organs: Testes, vasa-efferentia, ureter and seminal vesicle.

#### 1. Testes

The testes are a pair of yellow coloured oval bodies. It is about 1.5 to 2.5 cm long. It is encircled by a double fold of peritoneum which is known as mesorchium, and lies ventrally to the anterior and outer side of the kidney. The testis is composed of a mass of tubules called seminiferous tubules or crepts.

#### 2. Vasa-efferentia

From the inner margin of each testes arise 10-12 fine ducts called vasa-efferentia. It connects the testes to the kidney. In'the kidney, the vasa efferentia open into Bidder's canal.

#### 3. Ureter

It is a tubular duct arises from each kidney and runs posteriorly to open into the cloaca by separate aperture. In male frog, the ureter is also called urinogenital duct because it carries both urine and sperms.

#### 4. Seminal vesicle

Urinogenital duct is slightly enlarged after emerging out from kidney. This part is known as seminal vesicle. The sperms are collected in it before copulation.

#### 5. Urino-genital duct

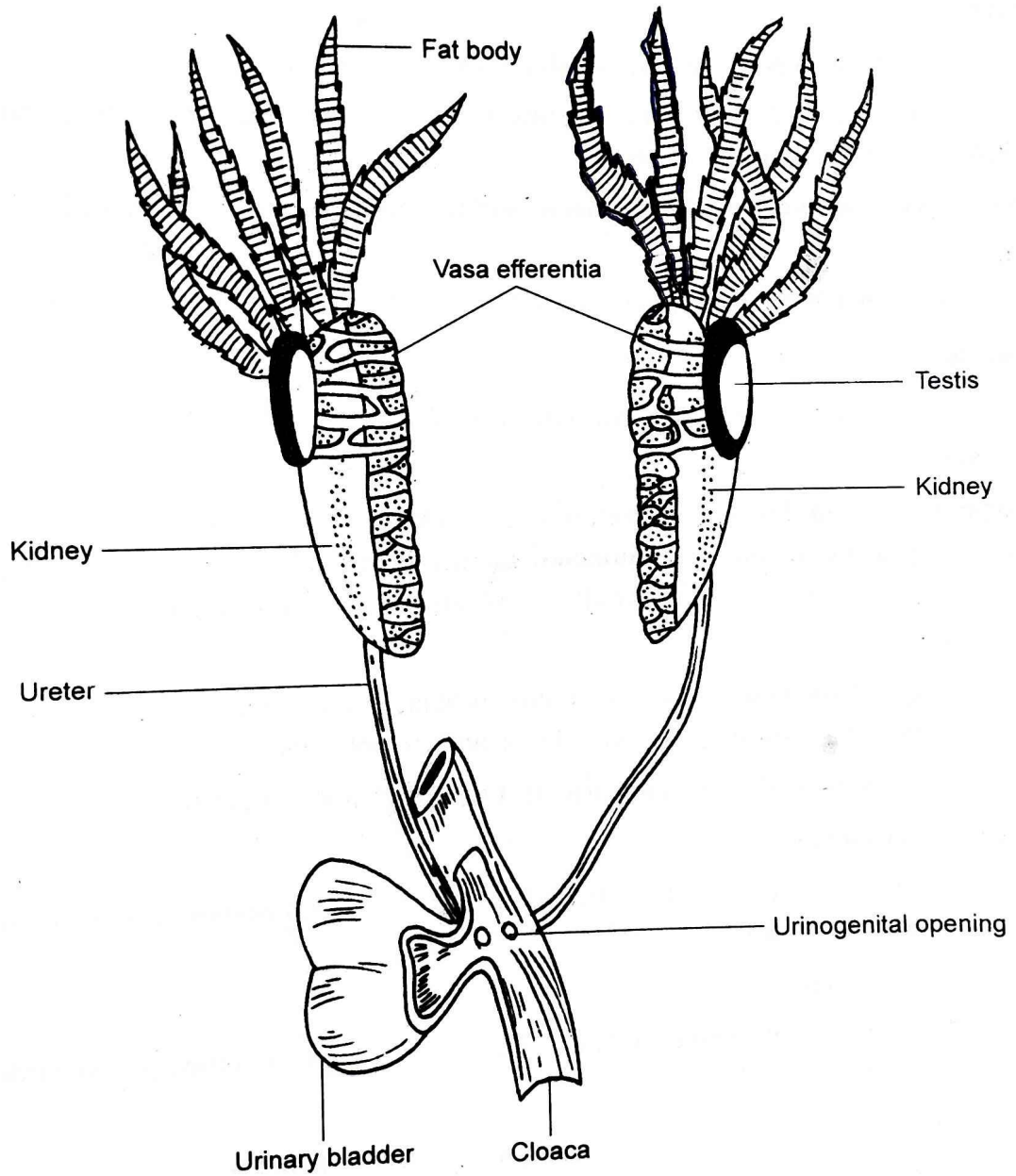
It is long and straight tube arising from the base of the kidney. It runs posteriorly. Both urinogenital ducts commonly open into rectum where the male gametes release out in water through cloacal opening. There is no anus in frog.

Urino-genital duct is the common duct which carries both sperms and urine. Similarly, cloaca is a common opening which releases faecal matter, urine and gametes.

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# DISSECTION OF FROG



## Dissect the Frog to Expose the Female Urino-Genital System

### Materials required

- i. A well preserved female frog
- ii. Dissecting tray and pin
- iii. Well equipped dissecting box
- iv. Well-labelled diagram v. Gloves

### Procedure

1. Take a freshly preserved frog and wash it properly in water.
2. Fix the frog ventro-dorsally in dissecting tray and dissect the female frog and expose the visceral organ as done fore general anatomy.
3. Properly cut and remove the oesophagus and intestine from the body or shift the alimentary canal on one side.
4. Observe all the parts of female urino-genital system with the help of diagram.

### Observation

The female reproductive system consists of the following organs: Ovaries, oviduct and uteri.

#### 1. Ovaries

Ovaries are paired thin walled hollow bag, blackish irregular shaped lobulated structure. They are covered by a membrane of peritoneum known as mesovarian. During the breeding season they become full of eggs. So, they cover almost full area of abdominal cavity. Ovaries produce eggs or ova.

#### 2. Oviducts

On each side of the body cavity is a coiled tubular oviduct which extends close to the lungs. Each oviduct opens by oviducal funnel near lungs and oesophagus.

Each oviduct is divided into three parts- (i) Oviducal funnel, (ii) Middle region and (iii) Uterus.

##### a. Oviduct funnel

It is a wide opened structure situated near the lungs and oesophagus. The ciliated wide opening is known as ostium.

##### b. Middle region

It is the coiled tubular part. Glands present in it secrete albumen which hardens the ova.

##### c. Uterus

The middle region near the cloaca is wide and forms uterus. It is the thin walled structure.

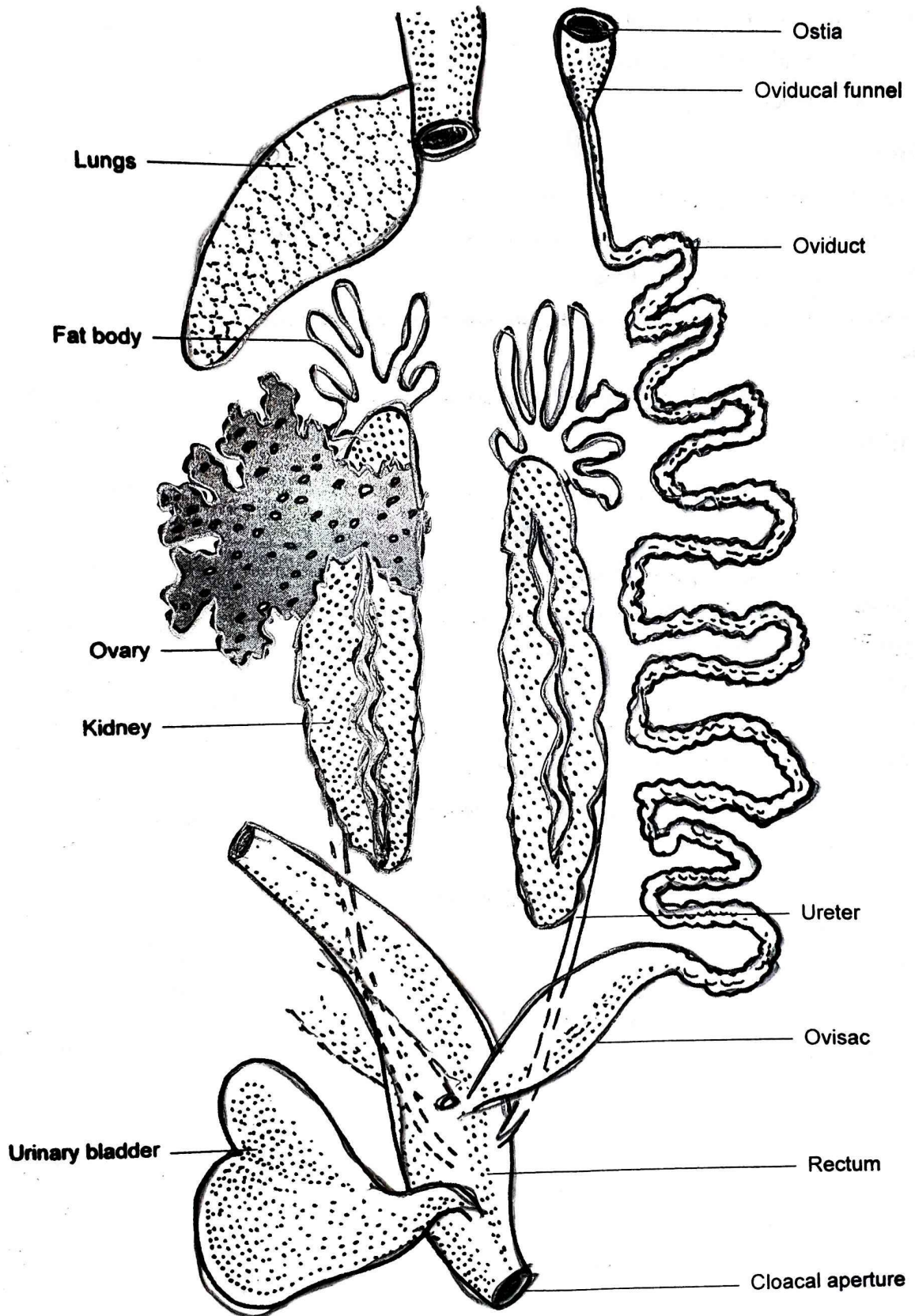
#### 3. Uteri

The oviduct at the middle region near the cloaca is wide and forms an uterus. It is thin walled structure. The two uteri commonly open in the cloaca.

The eggs formed in the ovary. When the eggs are matured, ovary becomes blackish. It ruptures releasing the eggs in the coelom. The eggs are collected by the cilia present in the ostium of oviduct. These are conducted through the oviduct and get collected in the ovisac. Finally eggs are released out in water in the form of spawn.

# DISSECTION OF FROG

Date



Female Urino-Genital System of Frog

**Viva Questions**

Students must remember

1. What is the first segment of earthworm called?  
**Ans:** The first segment of earthworm is called peristomium.
2. Where is the clitellum of earthworm situated?  
**Ans:** The clitellum of earthworm is situated in 14<sup>th</sup>, 15<sup>th</sup> and 16<sup>th</sup> segment.
3. Where is the gizzard situated?  
**Ans:** The gizzard is situated in 8<sup>th</sup>, 9<sup>th</sup> segment.
4. Where is the intestinal caeca situated?  
**Ans:** The intestinal caeca is situated from 26<sup>th</sup> to 22<sup>nd</sup> segments.
5. What is the function of typhlosole region?  
**Ans:** The typhlosole increases absorptive surface of the intestine.
6. Where is the brain situated?  
**Ans:** The brain is situated in the 3<sup>rd</sup> segment.
7. What forms the nerve ring?  
**Ans:** Supra-pharyngeal ganglia and sub pharyngeal ganglia form the nerve ring.
8. From where the segmental ganglion arises?  
**Ans:** Segmental ganglia arise from the ventral nerve cord.
9. Where is spermatheca situated?  
**Ans:** Spermatheca are situated in 6<sup>th</sup>, 7<sup>th</sup>, 8<sup>th</sup> and 9<sup>th</sup> segments.
10. In which segment testes are found?  
**Ans:** Testes are found in 10<sup>th</sup> and 11<sup>th</sup> segment.
11. Where are ovaries situated?  
**Ans:** Ovaries are situated in 12<sup>th</sup> and 13<sup>th</sup> segments.
12. What forms the cocoon?  
**Ans:** The glandular band of clitellum forms the cocoon.
13. How can you distinguish the male and female frog?  
**Ans:** There is vocal sacs in male and nuptial pad develop during breeding season.
14. Which type of limb is found in frog?  
**Ans:** The limb of frog is pentadactyle.
15. What is the function of teeth in frog?  
**Ans:** The teeth of frog helps in closing the mouth and not allow the prey to escape out.
16. Which type of tongue is found in frog?  
**Ans:** The tongue of frog is bifid and protrusible, (anteriorly attached and posteriorly free).
17. How many chamber of heart is found in frog?  
**Ans:** Heart of frog is three chambered, two auricles and a ventricle.
18. Where is the heart situated in frog?  
**Ans:** The heart in frog is situated in the pericardial cavity.

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