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Jawale Chetan Suresh, Supriya Singh Gupta:

PRACTICAL HANDBOOK OF ZOOLOGY

F.Y.B.Sc. Zoology (ZO 123) According to S. P. P. University, Pune,

CBCS Syllabus w. e. f. 2019-20

Param Publication, India. 2016

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CONTENTS

Practical No. 1:

MUSEUM STUDY OF PHYLUM PROTOZOA: EUGLENA, PARAMOECIUM, AURELIA, PLASMODIUM SP.

Phylum protozoa(Greek. Protos-First; zoan-animals)

Characteristic features:

1. **Habit and habitat**: Phylum protozoa include all small, acellular cellular or unicellular, microscopic organisms. They are ***cosmopolitan*** in nature. These are either free living fresh water forms or parasitic organism.
2. **Organization:** Protozoans exhibits **protoplasmic grade** of organization.
3. **Shape and size**: Protozoans are minute, small microscopic organisms showing variable shape and size.
4. **Body covering**: Body of some protozoans is covered by thin plasma membrane. In some protozoan plasma membrane is modified into thick flexible pellicle which is protective in nature.
5. **Cytoplasm**: Body protoplasm is differentiated into outer, thin, clear and dense ectoplasm and inner, thick, fluid like, semitransparent endoplasm.
6. **Nuclei**: Number of nuclei varies in phylum protozoa. Some are uninucleated e.g *Amoeba*; some are binucleated e.g *Paramecium* and some are multinucleated e.g *Opalina*.
7. **Digestions:** Digestion is intracellular as the process of digestion takes place within the cell in food vacuoles.
8. **Nutrition**: Protozoans feeds by various following means

Holozoic, Holophytic, Saprozoic, Saprophytic or Mixotrophic.

9. **Respiration and excretion:** both systems are wanting so it is done through general body surface by simple diffusion.
10. **Circulatory System**: Cytoplasm helps in circulations of different substances within organism as they are unicellular in nature.
11. **Nervous system**: Nervous system is totally absent.

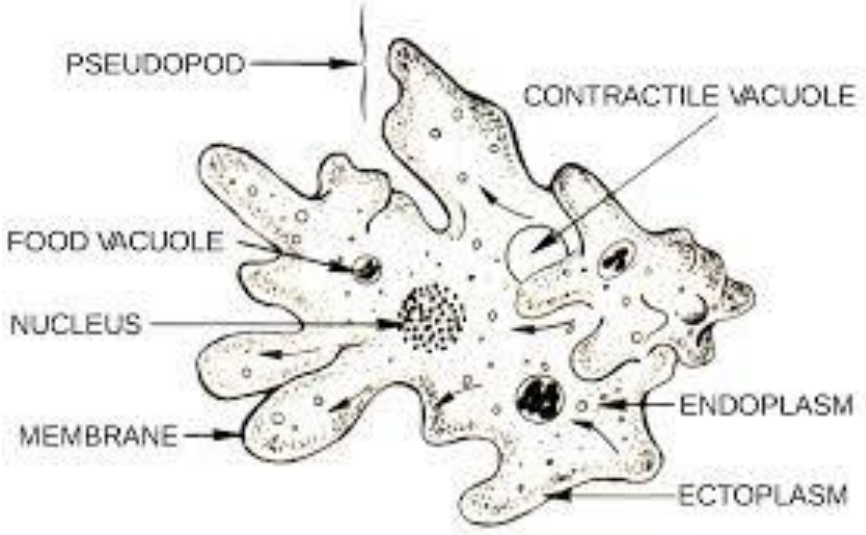
Reproduction: Protozoans reproduces both by asexual (Plasmotomy/ Fragmentation / Budding/ Binary fission/Multiple fission) as well as sexual (syngamy or conjugation or autogamy) method.

12. **Locomotion:** Different specialized organelles like flagella, cilia, pseudopodia are present for locomotion.
13. **Encystment:** It is an advanced character to overcome unfavorable climatic condition where organism forms a protective covering called cyst wall around the body.
14. **Osmoregulation:** Fresh water protozoans have a pair of contractile vacuole which helps in maintenance of water balance in cell body

Amoeba

Systemic Position

Kingdom	Protista	Unicellular Eukaryotes
Phylum	Protozoa	Unicellular, Primitive animals.
Sub Phylum	Sarco-mastigophora	Locomotion either by flagella or Pseudopodia
Class	Sarcodina	Creeping amoeboid forms with lobopodia as locomotory organ
Genus	*Amoeba*	



Comments:

1. Freshwater Protozoan.
2. It is colorless translucent and irregular in shape.
3. Locomotion is by formation of temporary finger like projections called- **pseudopodia**.
4. Nutrition is Holozoic.
5. Single nucleus and contractile vacuole are present.
6. Reproduction is by asexual method (Binary fission and multiple fission)

Euglena

Systemic Position

Kingdom	Protista	Unicellular Eukaryotes
Phylum	Protozoa	Unicellular, Primitive animals.
Sub Phylum	Sarco-mastigophora	Locomotion either by flagella or Pseudopodia
Class	Mastigophora	Plant like flagellates, food is

reserved as starch.

Genus *Euglena*

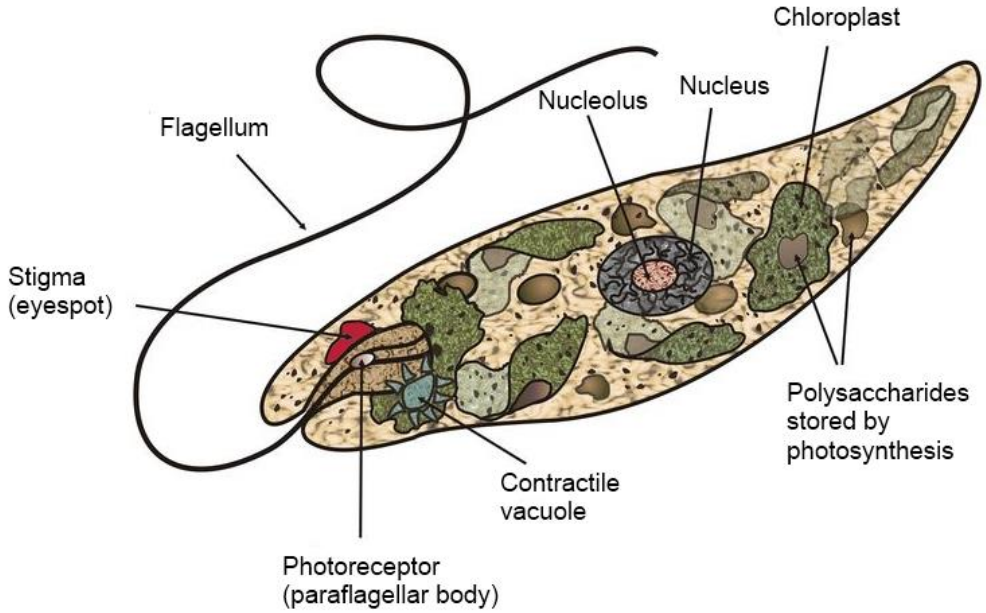


Fig: A diagram of Euglena

Comments:

1. Freshwater green flagellate.
2. Body is elongated spindle shaped with whip like single long flagella.
3. It measures 50 -100 micron in length.
4. Flexible and firm shape is attributed to pellicle.
5. It is a chloroplast bearing protozoan.
6. Nutrition is holophytic with starch as a food reservoir.
7. Reproduction is only by longitudinal binary fission.

Paramoecium

Systemic Position

Kingdom	Protista	Unicellular Eukaryotes
Phylum	Protozoa	Unicellular, Primitive animals.
Class	Ciliata	Cilia present over body as locomotory
Genus	*Paramoecium*	
Species	*caudatum*	

Comments:

1. It is commonly called as slipper animalcule.
2. Body shape is similar to the sole of a slipper with tapering posterior end and rounded anterior end.
3. Body is entirely covered with cilia and has elongated ciliary tuft at the caudal end.
4. Ventral side has an oral groove.
5. Cytoplasm is divided into ectoplasm and endoplasm.
6. Ectoplasm contains infra ciliary system, basal bodies and trichocyst.
7. Endoplasm contains two nuclei (macro and micro), two contractile vacuoles, food vacuoles and other eukaryotic organelles.
8. Locomotion is done by cilia.
9. Reproduction is either asexual (transverse binary fission) or sexual (conjugation/autogamy).

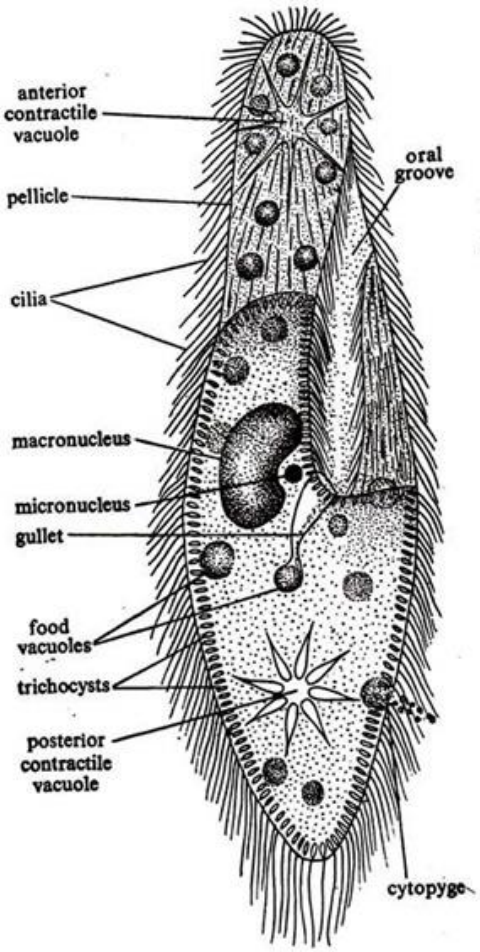


Fig. *Paramoeciumcaudatum*, showing internal organization

Plasmodium

Systemic Position

Kingdom	Protista	Unicellular Eukaryotes
Phylum	Protozoa	Unicellular, Primitive animals.
Class	Sporozoa	parasitic form, locomotory organelles absent, spores simple
Genus	*Plasmodium*	

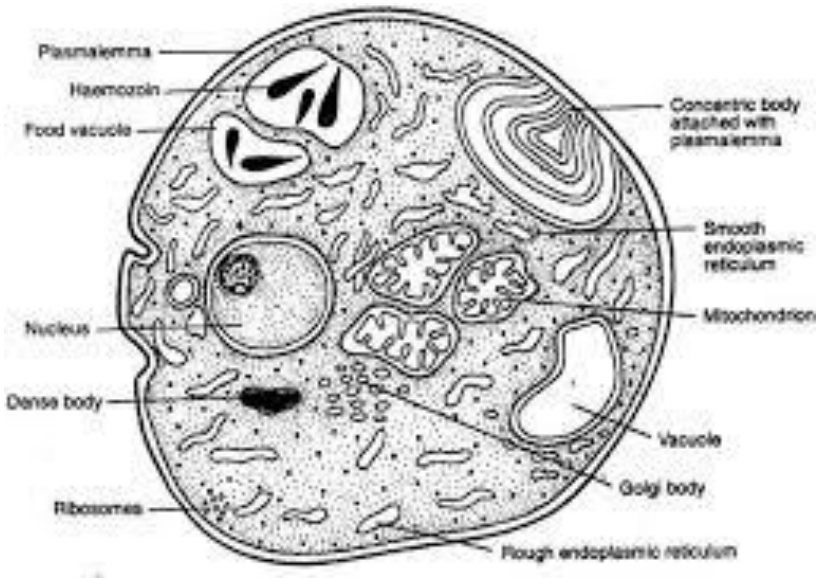


Fig: EM of Trophozoids of Plasmodium in RBC

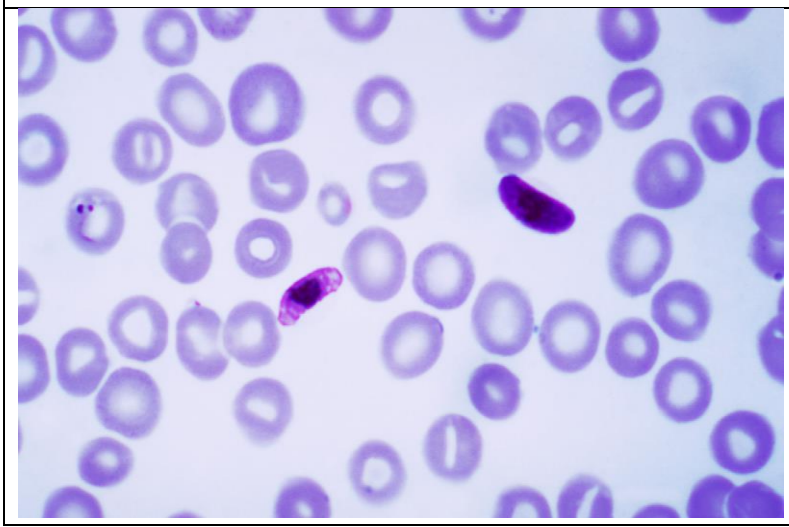


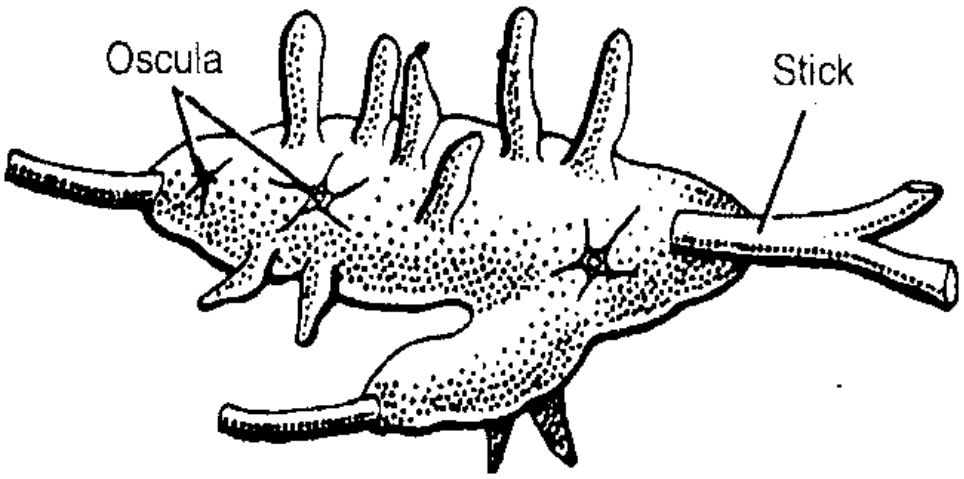
Fig:*Plasmodium falciparum in Human blood smear.*

Comments:

1. Plasmodium is commonly called as malarial parasite.
2. It needs two hosts to complete its life cycle i.e. man and female Anopheles mosquito.
3. Its infective stage to man is named Sporozoite.
4. Crypzoites are formed in liver, out of which some enters into R.B.Cs to undergo multiple fission to form merozoites. These merozoites transforms into male and female gametocytes. From blood they are sucked by female anopheles. Gametocytes in mosquito fuses to form a zygote, which forms sporozoites.

Spongilla

Phylum	Porifera	Pore bearing, cellular grade of organization
Class	Demospongia	Skeleton consist of sponging fibers or siliceous spicules or both.
Genus	***Spongilla***	



Comment:

1. It is a fresh water sponge found in lakes, ponds, streams etc.
2. It is green in colour due to the presence of a symbiont *Zoochlorellae* (green algae).
3. Body surface has numerous ostia and several osculate.
4. Endoskeleton is made up of siliceous spicules and spongin fiber.
5. Canal system is rhagon type.
6. Reproduction is by both sexual (gametes) as well as asexual (gemmules) mode.

Practical No. 2:

MUSEUM STUDY OF PHYLUM PORIFERA: SYCON, EUPLECTELLA, CHALINA,SPONGILLA.

Phylum Porifera (Greek :Poris-pores; fera- to bear, phylum of Sponges.)

1. **Habit and habitat**: Poriferans are aquatic animals present in both fresh and marine water bodies.
2. **Shape and Size**: Body form is either vase- like, cylindrical, cup shaped, globular or irregular.
3. **Symmetry**: Most of the poriferans are **asymmetrical** in nature while few which are cylindrical or vase-like show radial symmetry.
4. **Colur**: Body colour varies greatly from grey, brown, yellow, green, red, pink or black.
5. **Organization:** Sponges areprimitive multicellular organism showing **cellular grade of organization.** Body of poriferans is made up of loose aggregation ofcells without tissue formation.
6. **Body Covering:** Body of poriferans is made up of two layers ectoderm (pinacoderm) is made up of cells called Pinacocytes, endoderm (choanoderm) is made up of cells called Choanocytes and an in between two is a noncellular layer called mesoglea.
7. **Coelom:** Coelom is absent and hence animals are commonly called Acoelomata. These organisms possess internal body cavity called spongocoel.
8. **Pores/Body opening:** Outer layer of the poriferans shows many small, minute opening called **ostia** through which water enters into the body continuously. Few large pores called **osculum** are also present through which water exit the body of organism.
9. **Skeleton:** Sponges show presence of internal organic skeleton in the mesoglea.It is seen as fine flexible fibers called**Spongin fibers** while in others it is in the form of thin needlescalled **spicules.** Spicules are made up of calcium carbonate or silica. Depending on the chemical nature they are called calcareous or silicious spicules. Spongin fiber is made up of protein-spongin.
10. **Canal System:** It is the space or canal through which water flows within sponge body. This helps in exchange of material between sponge and

outer environment. Water enters the sponges through ostia and through canal reaches Spongocoel. It moves out of body through anterior large opening called osculum

11. **Digestion:** MouthandaDigestive cavity are absent. Poriferans feed on the small micro-organsims which ethers their body by diffusion. Digestion is intracellular.
12. **Respiration:** Respiration is done by simple diffusion of gases (oxygen and carbon di oxide) between cells and water.
13. **Excretion:** Excretory product is Ammonia which is released out by simple diffusion in water, which is taken out of the body through osculum.
14. **Circulatory system:** TrueCirculatory system is absent.
15. **Nervous system:** Nervous system is absent.
16. **Reproduction:** reproduction is by either Asexual mode (Fragmentation/Budding/ gemmules) or Sexual mode**.** Poriferans are either unisexual/dioceous or Monoecious/ hermaphrodite in nature. Archeocytes in favourable conditions give rise to sex cells (either sperm or ovum).
17. **Fertilization:** Fertilization is internal and is always cross fertilization. Cleavage is holoblastic.
18. **Development:** Development is indirect i.e they show presence of free swimming larval stage (amphiblastula or Parenchymula) in their life cycle.

19. **Regeneration:** Regeneration is phenomenon of replacement of lost body parts by animals. It is very well developed in Poriferans.

Sycon

Phylum	Porifera	Pore bearing, cellular grade of organization
Class	Calcarea	endoskeleton of calcareous spicules
Genus	Sycon	

1. It is a Marine sponge.
2. Body is slender vase shaped measuring around 2-3 cms.
3. Body surface is perforated by numerous ostia and a large osculum at the free end.
4. Canal system is syconoid.
5. Reproduction is by asexual and sexual methods.

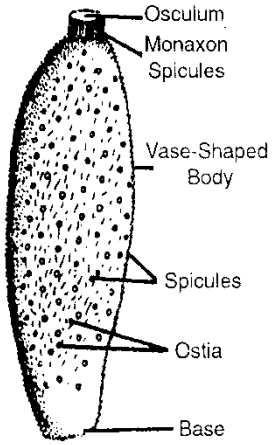


Figure :*Sycon*

Euplectella

Phylum	Porifera	Pore bearing, cellular grade of organization
Class	Hexactinelida	Skeleton consist of siliceous spicules
Genus	***Euplectella***	

Comment:

1. *Euplectella* is commonly called as venus flower basket
2. Numerous ostia are present on the long, curved, cylindrical body.
3. It is attached to the surface of mud and measures 15-30 cm in length.
4. A beautiful 3D interlaced network of 6 rayed spicules is present.
5. Osculum is closed with a sieve plate.
6. It displays an interesting commensal relation with shrimps. The young shrimp enters in the sponge to feed. It grows their and then trapped as the increased size of shrimp now doesn't allow it leave the spongocoel of *Euplectella*. This lifelong bonding has made it a popular wedding gift in Japan.

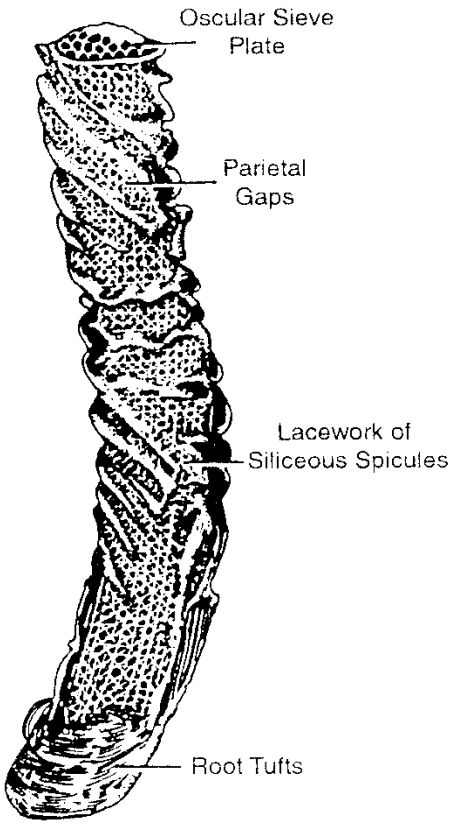


Fig. Euplectella

Chalina

Phylum	Porifera	Pore bearing, cellular grade of organization
Class	Demospongia	Skeleton consist of sponging fibers or siliceous spicules or both.
Genus	*Chalina*	

Comment:

1. It is commonly called as dead man's finger/mermaid's gloves.
2. It is yellow to red in colour.
3. Body surface is flat with finger like branches protruding.
4. Body surface has numerous ostia and several oscula.
5. Canal system is leucon type.
6. Reproduction is by both sexual (gametes) as well as asexual (budding /regeneration) mode.

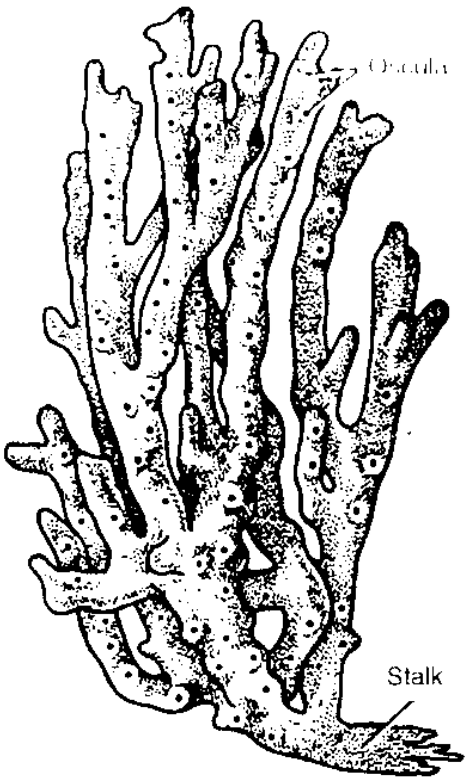


Fig: Chalina

Practical No. 3:

AIM: MUSEUM STUDY OF PHYLUM COLENTERATA: HYDRA, PHYSALIA, AURELIA, METRIDIUM

Phylum: Colenterata/ Cnidaria (knide–nettle; aria - like)

1. It is also called *coelenterata* (Greek: coel – cavity; enteron - intestine)
2. Habit and habitat: These are aquatic organism, most of them belonging to marine water except some organisms of class 'hydrozoa'. They are solitary/colonial and sedentary/free swimming organism.
3. Germ layer: These are diploblastic in nature showing presence of outer ectoderm and inner endoderm. In between these 2 layers a non-cellular jelly layer called *mesoglea* is present.
5. Body cavity: These organisms have 'coelenteron' on or *Gastro Vascular Cavity* (GVC).
6. Body form: They exhibit various body forms i.e. filamentous, fan-like, vase-like, umbrella-like or plant-like cylindrical.
7. Body wall: It is diploblastic. Body wall is made up of 2 layers, Outer ectoderm consisting of stinging cells, Inner endoderm or *gastroderm*and an intermediate acellular layer called mesoglea.
8. Coelom: Coelom is absent. Cnidarian are *acoelomates*.
9. Cnidoblast/Nematocysts/Stinging cells: These are modified epithelial cells which are present in cnidarians and are useful in offence or defense. These are also useful in adhesion and food capture.
10. Polymorphism: Coelenterates or cnidarians have 2 different types of Individuals called 'zooids'. They are either tube-like 'polyps' or saucer shaped 'medusae'.
11. Organization: Cnidarians exhibit tissue level of organization.
12. Digestion: digestion is extra cellular in the gastro vascular cavity, as the inner wall secretes digestive enzymes into GVC.
13. Respiration: Respiration is by general body surface by simple diffusion which helps in exchange of gases.
14. Circulation: Circulatory system is absent.
15. Excretion: Cnidarians are ammoniotelic in nature and excretes ammonia by diffusion. General body surface helps in elimination of excretory waste.
16. Nervous system: Diffused or scattered primitive unpolarized nerve cells or 'neuritis' are present which brings about control and co-ordinations in organism.

17. Skeleton: A horny or calcareous exoskeleton as well as endoskeleton is present in many organisms. Corals are formed by secretion calcareous exoskeleton.

Hydra

Phylum	Coelentrata	Aquatic, Tissue grade of organization, diploblastic and have two structural types (polyps and medusa).
Class	Hydrozoa	Mostly marine and both polyp and medusa forms are present,
Genus	Hydra	

Comments

1. ***Hydra*** is small, simple, fresh-water animals measuring 1-3 cm.
2. It is found in unpolluted fresh-water ponds, lakes, and streams.
3. *Hydra* has a tubular body anchored by a simple adhesive foot called the basal disc.
4. Mouth is present at one end called hypostome, which is surrounded by six to twelve tentacles.
5. Each tentacle bears highly specialized stinging cells called cnidocytes. Cnidocytes bears small specialized structures called nematocysts which shoot a dart-like thread containing neurotoxins to paralyze the prey.
6. Reproduction is by both sexual (gametes) and asexual (budding/regeneration) mode.

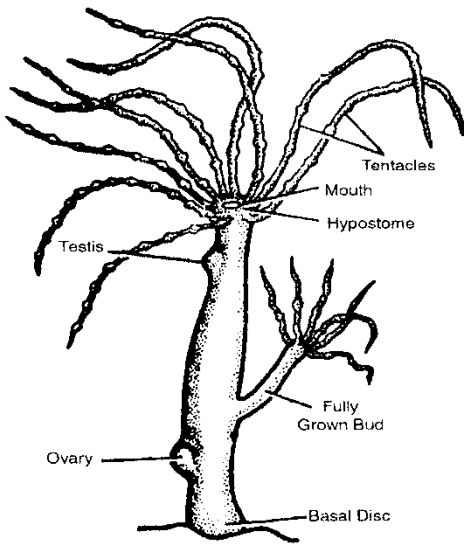


Fig. Hydra

Physalia

Phylum	Coelentrata	Aquatic, Tissue grade of organization, diploblastic and have two structural types (polyps and medusa).
Class	Hydrozoa	Mostly marine and both polyp and medusa forms are present,
Genus	*Physalia*	

Comment:

1. It is commonly called as Portuguese man of war.
2. *Physalia* has a gas-filled bladder called pneumatophore and long tentacles bearing cnidocytes.
3. Pneumatophore is filled with mostly (90%) nitrogen gas which is secreted by gas glands
4. It's a best example of polymorphism, exhibiting three kinds of zooids viz. gastrozooid (digestive zooids), gonozooids (reproductive zooids) and dactylozooids (defensive zooids).
5. It is poisonous as its nematocytes in long tentacles causes severe pain, skin rashes, fever and respiratory issue.

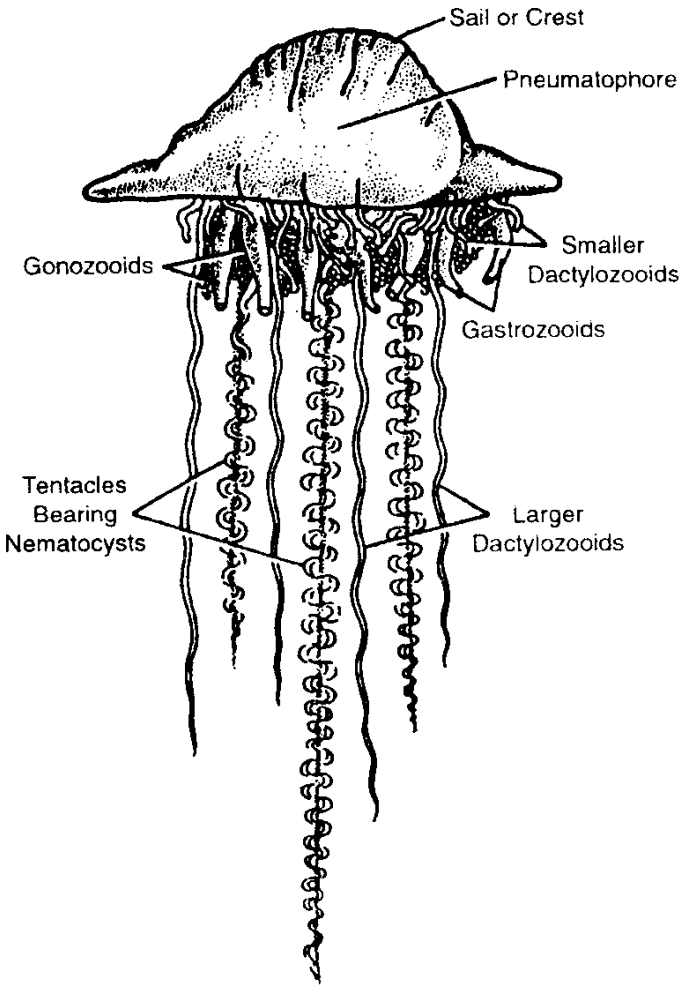
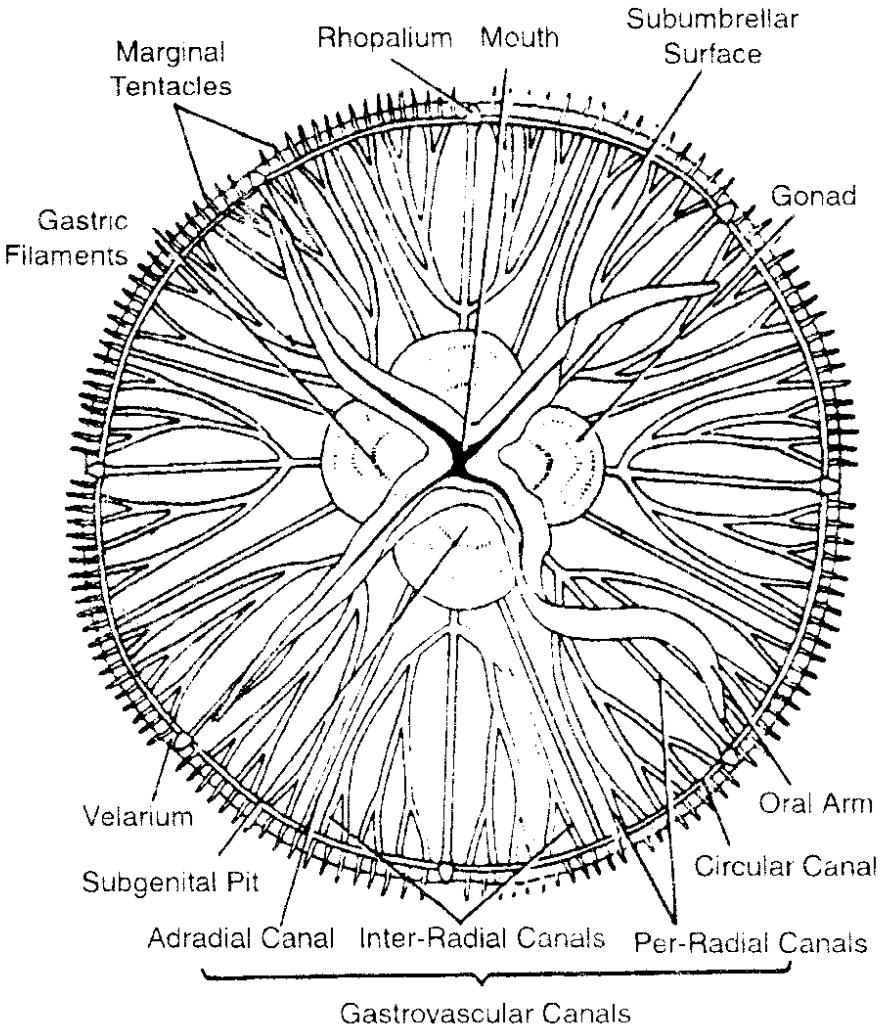


Fig. Physalia

Aurelia

Phylum	Coelentrata	Aquatic, Tissue grade of organization, diploblastic and have two structural types (polyps and medusa).
Class	Scyphozoa	Exclusively marine with well-developed medusoid form.
Genus	*Aurelia*	



Comment:

1. It is commonly called as jelly fish because of its gelatinous appearance.
2. Body is umbrella shaped with a diameter of almost 30cm.
3. Margin of an umbrella bears numerous marginal tentacles around it.
4. Mouth is present at sub umbrella region and is surrounded by four oral arms.
5. It is unisexual with four horse shoe shaped brightly coloured gonads.

Metridium

Phylum	Coelentrata	Aquatic, Tissue grade of organization, diploblastic and have two structural types (polyps and medusa).
Class	Scyphozoa	Exclusively marine with well-developed medusoid form.
Genus	***Metridium***	

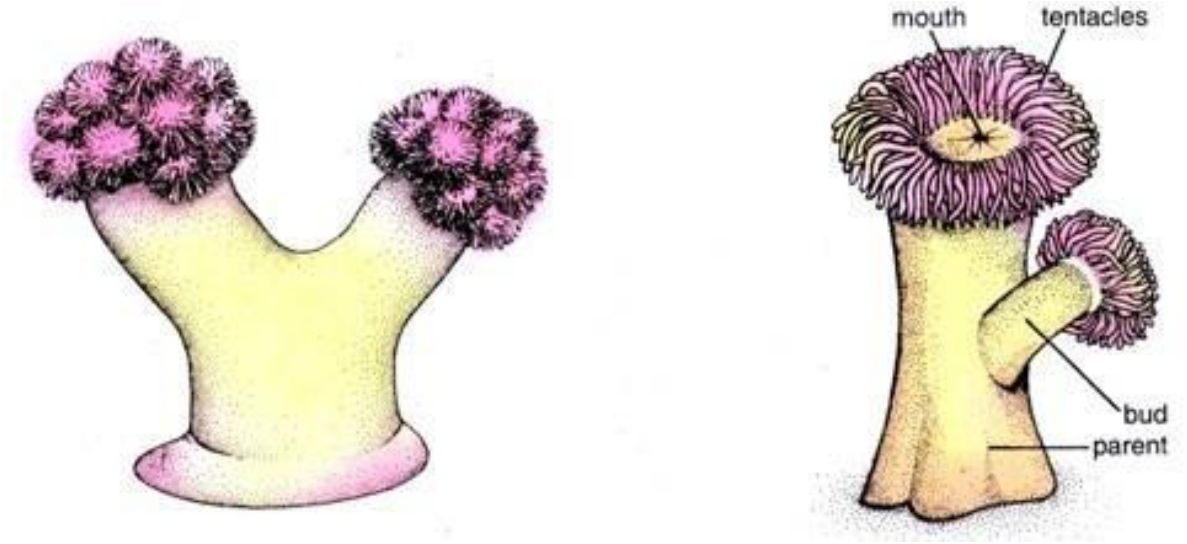


Fig. Metridium- binary fission and budding

1. It is commonly called as sea anemone.
2. It is large nonmotile and solitary.
3. Body is short, cylindrical and divided into pedal disc, column and oral disc.
4. It is attached to substrum by the basal disc.
5. Oral disc is flat with a slit like opening called mouth, which is surrounded by numerous tentacles
6. Metridium is unisexual with sexual reproduction by gonads and asexual by budding and regeneration.

Practical No. 4:

AIM: MUSEUM STUDY OF PHYLUM PLATYHELMINTHES: PLANARIA, FASCIOLA HEPATICA, TAENIA SOLIUM

1. Phylum platyhelminthes (Greek :Platy-Flat; Helminthes- worms)
2. Phylum includes flat worms. Body is soft dorso-ventrally flattened, leaf -like or tape- like. The term Platyhelminthes was proposed by Gegenbaur (1859).
3. Habit and habitat: Organisms classified in Phylum Platyhelminthes includes smooth, elongated, dorsoventrally flattened, leaf- like or tape-like worms commonly seen in fresh water bodies (E.g.*Planaria*) or in moist soil (E.g*Bipalium*). Worms are either free living or parasitic in nature.
4. Germ layers: These are triploblastic in nature i.e body is made up of three germ layers. Outer germ layer is ectoderm, middle is mesoderm and inner is endoderm.
5. Coelom: Body cavity is absent hence they are acoelomata.
6. Body size and shape: Organisms are microscopic to elongated measuring about 10-15 meters. Body is soft dorso-ventrally flattened, leaf -like or tape-like.
7. Body Covering: Outer body covering of free living platyhelminthes is made up of single layered epidermis while in the parasitic form this epidermis has been replaced with thick cuticle which is resistant to the digestive enzymes of host.
8. Organization: Phylum Platyhelminthes show an organ grade of organization.
9. Digestive system: digestive system is either incomplete or absent. They show presence of only mouth opening though anal opening is absent in free living platyhelminthes also. Intestinal parasitic platyhelminthes are surrounded with nutrients ready for absorption so, digestive system is totally absent in these forms.
10. Respiratory system: Free living platyhelminthes respire through general body surface while parasitic forms are anaerobic in nature.
11. Circulatory System: Circulatory system is absent.
12. Excretory System: Excretory system is made up of protonephridia
13. With flame cells or bulbs which opens outside the body through excretory pores.

14. Nervous system: Nervous system and sense organs are poorly developed. Nervous system is "ladder- like "consisting of brain, a pair of longitudinal nerve cord connected by many transverse connectives.
15. Reproductive system: Some free living forms show asexual reproduction, whereas parasitic form reproduce by sexual reproduction of which most forms are hermaphrodite (monoecious) and some bisexual in nature with well-developed complex reproductive organs.
16. Fertilization: Fertilization is internal.
17. Development: Development is direct or indirect. Indirect development is common in endoparasites.

Planeria

Phylum	Platyhelminthes	Triploblastic and dorso ventrally flattened worms
Class	Turbulleria	Mostly free living with ciliated epidermis
Genus	*Planeria*	

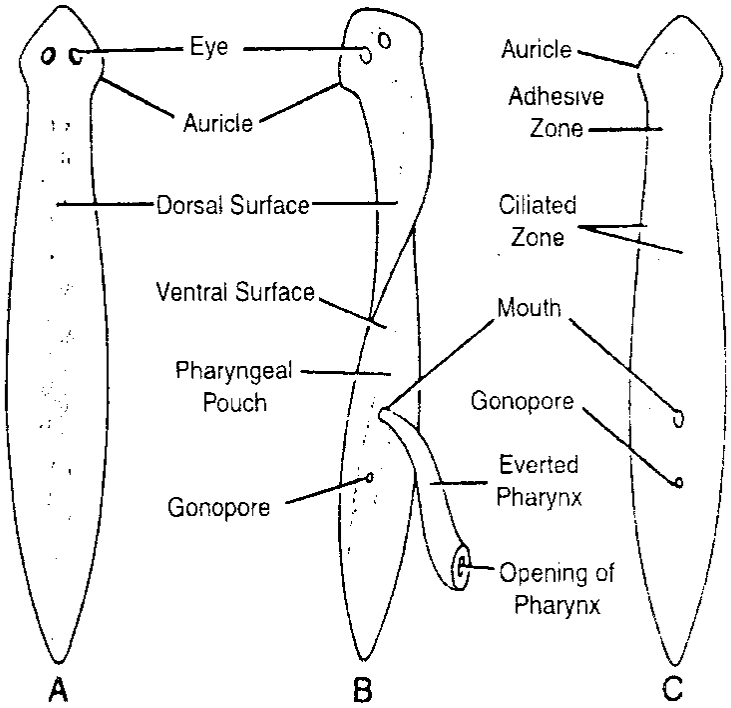


Fig. 6. *Planaria (Dugesia)*

Comments:

1. It is found in fresh water ponds, lakes, streams etc.
2. Body shape is flat elongated and bilaterally symmytrical.
3. It measures 1-1.5 cm.
4. Triangular head is present at anterior end of the body.
5. Head bears sense organs like eyes and auricles.
6. Digesyive system is incomplete.
7. Pharynx is protrosible.
8. Reproduction is by sexual and asexual (regeneration) mode.

Fasciola hepatica

Phylum	Platyhelminthes	Triploblastic and dorso ventrally flattened worms
Class	Trematoda	Unsegmented body covered with cuticle.
Genus	Fasciola	
Species	hepatica	

Comments:

1. Commonly called as liver fluke.
2. Body is flat leaf like.
3. Anterior end has a conical structure called as cephalic end, which bears mouth.
4. Mouth is surrounded by an oral sucker.
5. Large acetabulum is located little beneath the oral sucker.
6. Posterior end bears an excretory pore.

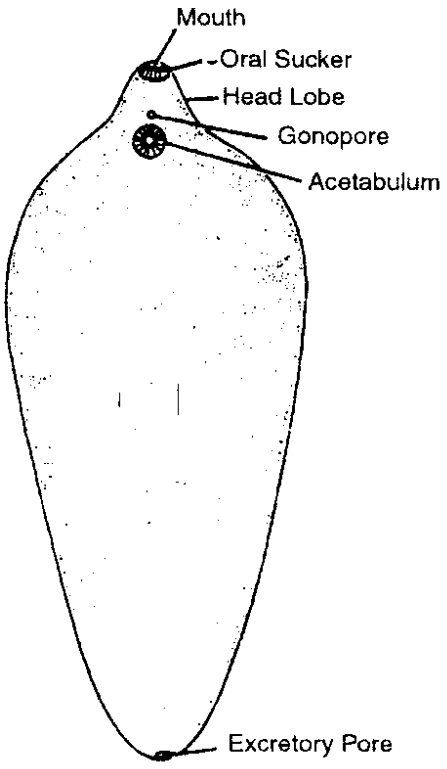


Fig. 13. *Fasciola.*

Taeniasolium

Phylum	Platyhelminthes	Triploblastic and dorso ventrally flattened worms
Class	Cestoda	Endoparasites , large segmented body covered with cutic
Genus	Taenia	
Species	solium	

Comments:

1. It is commonly called as tape worm.
2. It is an endoparasite with two hosts, one is man and other is pig.
3. Body is flattened and divided into scolex, neck and strobila.
4. Sclex bears four suckers covering all sides and a rostellum (rows of hooks) to cling the host's intestine.

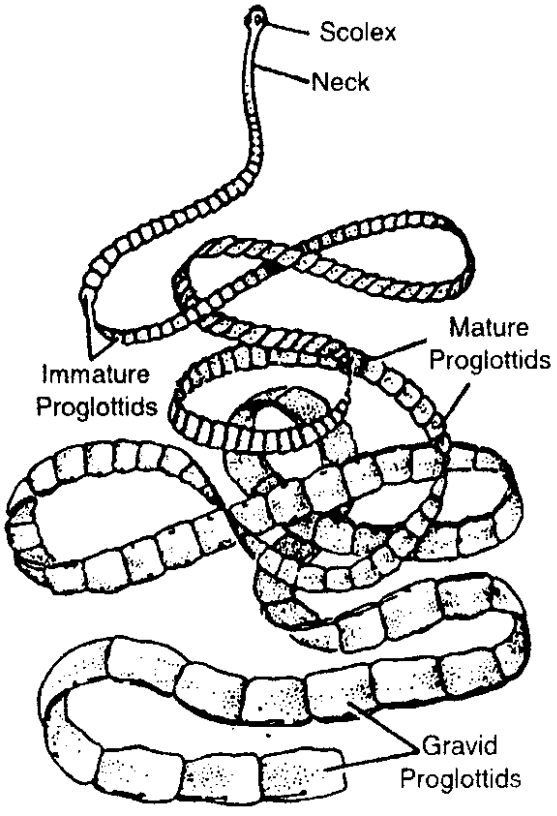


Fig. 19. *Taenia solium.*

5. Neck is an unsegmented part which keeps on generating new segments of proglottids.
6. Strobila region has around 800 plus proglottids.
7. Each proglottid contains male and female reproductive system.
8. Mature proglottids (gravid) contain fertilized eggs.

Practical No. 5:

STUDY OF PARAMOECIUM: CULTURE, EXTERNAL MORPHOLOGY, CONJUGATION AND BINARY FISSION.

A. Culture of *Paramoecium*

Paramecium is easy to culture under laboratory conditions. *Paramoecium* serve as one of the best eukaryotic model system for experimentation. Various cytological, cytochemical, toxicological, biochemical and many more practical can be observed in*Paramoecium*with an ease. Not only can this but it also be used as a feed for fish fry.

Primary culture:

1. Collect the water from the pond in a beaker during optimum temperature conditions
2. Place an inverted hibiscus flower in the partially submerged condition in a beaker.
3. Allow it to stand undisturb for 3-4 days.
4. Water will turn turbid after few days then observe the sample drop for the presence of *Paramecium* in it.

Sub culturing by Hay infusion:

1. Take tap water and boil hay in it for 15 mins.
2. After that add few grains of wheat in the boiling water and continue boiling for 15 more mins.
3. Allow it to cool down and then inoculate this medium with the 1 ml of Primary culture of *Paramoecium*.
4. Allow it to stand for few days (4-5) and then observe it for *Paramoecium* bloom.

External morphology:

- Size: *Paramoeciumcaudatum* is a minute microscopic organism. Just visible to necked eye as elongated. It measures from 170-350 micron.
- Shape: General appearance is like a sole of a slipper.
- Surface: The body is covered by numerous cilia, which originate from a thin but firm and flexible outer covering the " Pellicle " which is secreted by ectoplasm.

- It is formed of several hexagonal shape depressions on its surface. The centre of which give rise to cilium and the anterior and posterior margin has an opening for trycocyst.
- It is colourlesscuticular double membrane layer.

Conjugation:

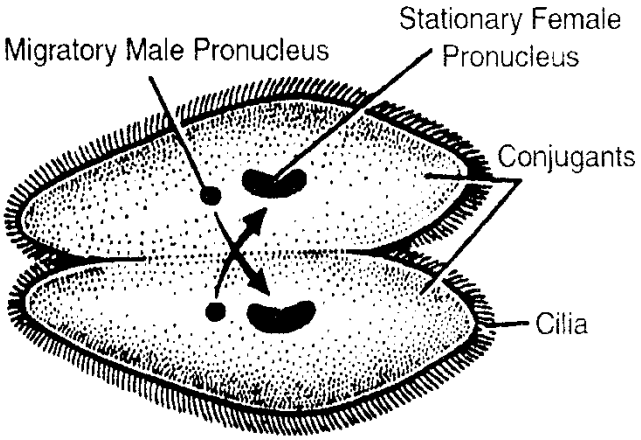


Fig. 32. *Conjugation in Paramecium*

- It is a parasexual mode of reproduction in *Paramoecium.*
- It is a temperory union of two individuals of same species for the purpose of exchanging a part of their micronuclearmaterial .
- A Pair called conjugants undergo many nuclear changes and finally after the exchange of micronuclei they separate and give rise to four daughter cells each .
- Conjugation has double significance for *paramecium*.
    - Rejuvenation :*Paramoecium*loses its vigor if binary fission continues for several generations. So to avoid the depressed Physiological and Morphological conditions, they undergo conjugation.
    - Hereditary Variation: Genetic signification lies in the production of variants, which may be better suited than others to survive in the changing condition of life .

Binary fission:

- In *Paramoecium*common type of reproduction is binary fission.
- It takes place during favourable condition.
- It stops feeding, becomes less active and develops two pores in the centre for future contractile vacuole.
- Oral groove disappears, micronucleus and macronucleus divides mitotically andamitotically respectively and in two nuclei each.
- It doubles the cilia and forms a new cytopharynx and cytostome for future posterior daughter cell from the original, which remains there for anterior daughter cell.
- A furrow appears in the centre which deepens and divides the paramecium into two Paramoecia of equal size (Proter and Opisthe).
- Each Paramoecia grows into adult.
- Time required is 2 hours and it may occur 2 to 4 times /day.

Practical No. 6:

STUDY OF PERMANENT SLIDES:

Spicules In sponges:

Spicules are small needle like structures made up of either calcium carbonate or of silica. Calcareous spicules are composed of calcium carbonate with Na, Mg and So_4 in trace amount. Silicious spicules are composed of clear, glass like silica called opal ($H_2Si_2O_7$). Spicules are secreted by specialized cells in mesoglea called scleroblast. These spicules are scattered in a random overlapping pattern in the gelatinous mesoglea to give strength and support.

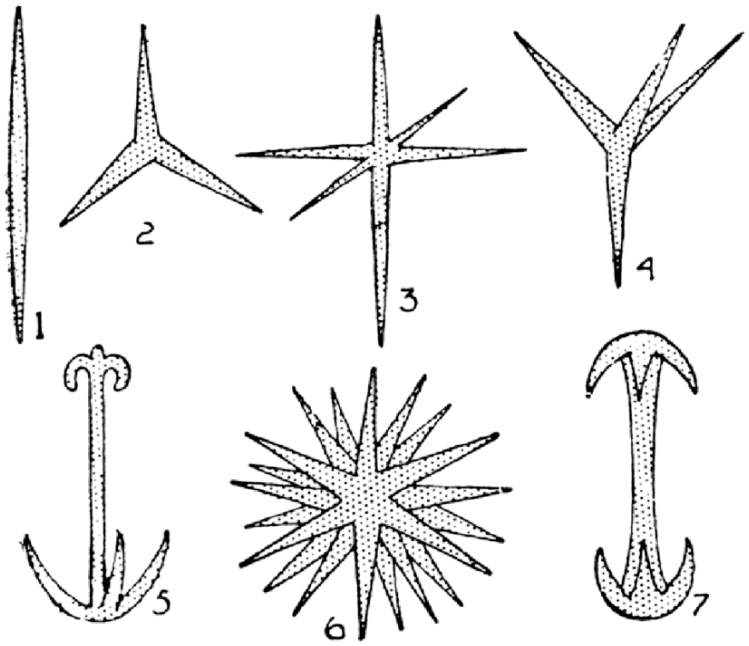


Fig.sponge spicules of various forms.

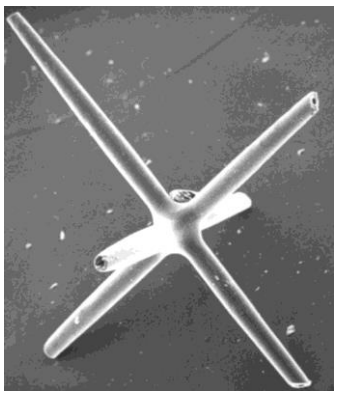


Fig. Six-pointed spicule from a siliceousglass sponge 400 micron

Spicules can be distinguished into two major types viz. Megascleres (supporting/essential spicules) and Microscleres (non supporting spicules).

Megascleres:

a. Monoaxon: rod like megascleres with single axis.

Monoactinalmonoaxon: single end pointed.

Diactinalmonoaxon: It has both the ends pointed.

b. Tetraxon: It has four rays originating from same point.
c. Triaxons: It has three axons intersecting at right angles.
d. Polyaxon: Megascleres with several axis radiating from center.
e. Spheres: These are megascleres formed of round concentric spheres.
f. Desma: These are formed by the consecutive deposition of silica in irregular layers over the monoaxon or tetra axon spicules.

Microscleres:

a. Spires: These are curved or spiral microscleres. Common shapes are ‘C’ or ‘S’.
b. Asters: These are either mono axons with solo actine from which numerous spines originates or these are polyactine in which many actins actually radiates from the center.

Gemmules In sponges:

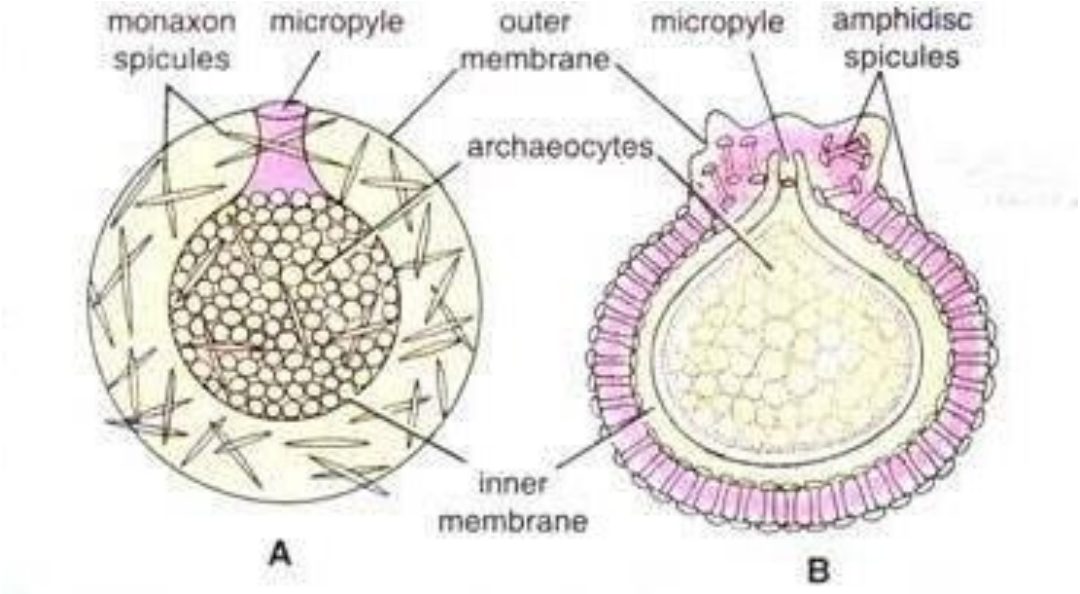


Fig. A- Gemule of Spongilla, B- Gemmule of Ephydatia

Gemmules are the endogenous buds responsible for the asexual reproduction in sponges. Gemmules are formed under unfavorable conditions like drought, cold or any other stress. Gemmules are tough spherical structures with a dormant cluster of totipotent embryonic cells (archaeocytes) along with the nurse cells (trophocytes).this central mass is surrounded by motile amoebocytes which secretes a double membranous chitinous layer around the structure with spicules embedded in it. A fully matured gemmule has a micropyle to escape when favorable conditions return.

T.S. of Sycon

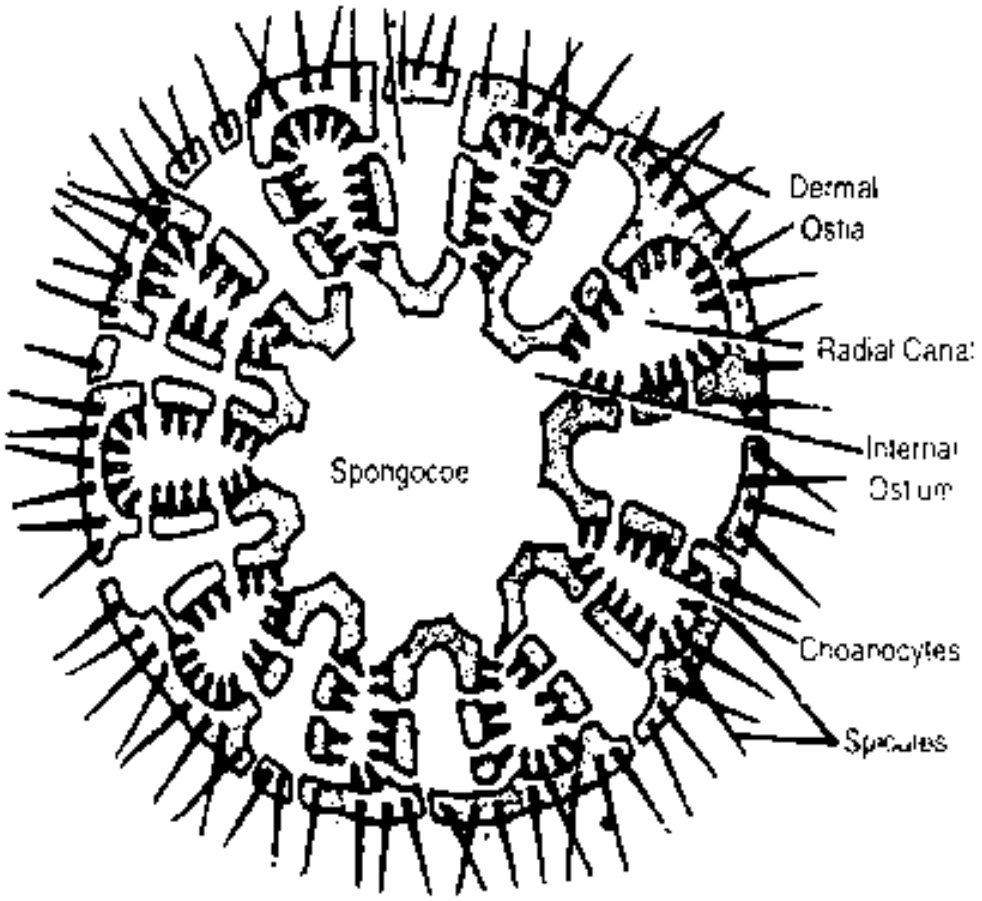


Fig. T.S. of Sycon

1. Transverse Section of sycon is circular showing diploblastic wall.
2. Endoderm consist of flagellated choanocytes.
3. Mesoglea has monoaxon spicules, amoebocytes, archaeocytes and scleroblast cells.
4. Ectoderm consist of pinacocytes lining the pores (ostia).
5. Ostia opens into incurrent canals which opens into radial canals through prosopyles and radial canals opens into spongocoel through apopyles.

T.S. of hydra

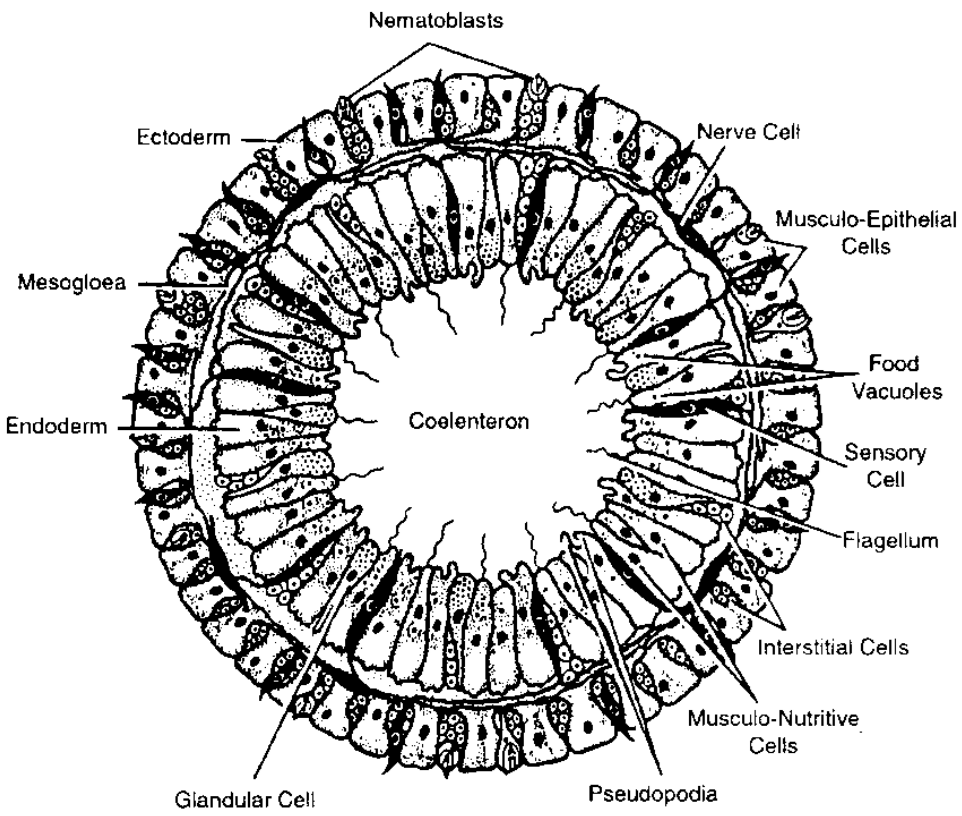


Fig. T.S. of Hydra

1. Body wall is diploblastic with outer ectoderm and inner endoderm with interim cellular mesoglea.
2. Ectoderm consists of nerve cells, interstitial cells, muscle cells and nematoblasts over tentacles.
3. Endoderm consists of nutritive cells, gland cells, secretory cells and interstitial cells.
4. Central body cavity surrounded by endoderm is called coelenterons.

Taeniasolium: Scolex

1. Anterior end of the *Taeniasolium* bears a comparatively very minute head of diameter 1mm called scolex.
2. Scolex is a region fully adapted for clinging purposes.
3. It bears four suckers covering its all four sides.
4. At anterior most region between four suckers is place a rostellum.
5. Rostellum consists of two circling rows of hooks with around 30 hooks in each.

6. Internally scolex consists of spongy mesenchyme with a nerve ring.

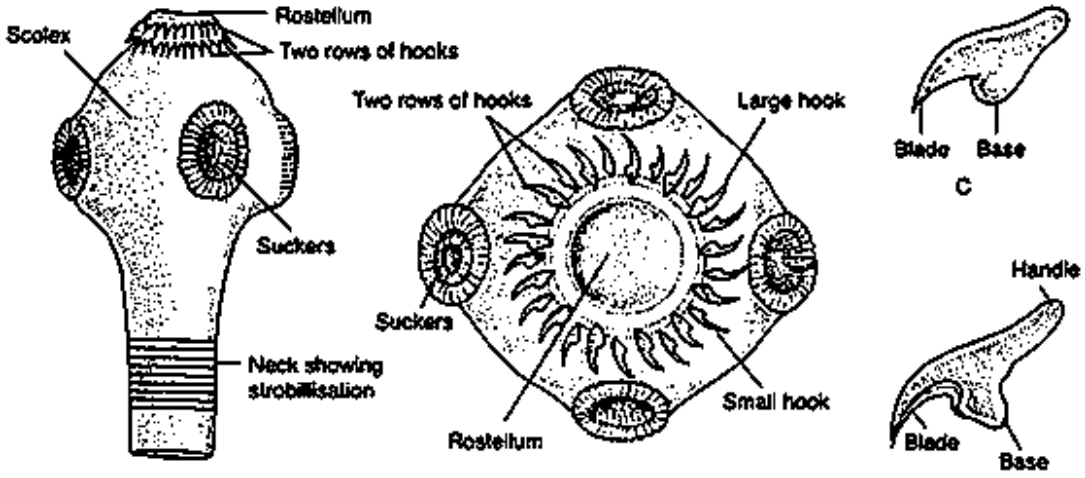


Fig. Scolex, Dorsal view of scolex with small and large hook

***Taeniasolium*: Gravid proglottids**

1. *Taeniasolium* is monoecious.
2. Strobila region of *Taenia* has numerous proglottids, each with a complete reproductive set of male and female.
3. Three types in proglottids: immature (under developed reproductive system), mature (developed reproductive system) and gravid (fertilized eggs).
4. Gravid proglottids are present towards posterior end of strobila.
5. Gravid consists of branched and extended uterus filled with fertilized eggs.
6. The reproductive organs are absorbed in the system.
7. Oldest gravid contains numerous fertilized eggs.
8. The gravids are detached from the strobila region by the process of apolysis and are passed on along with feces.

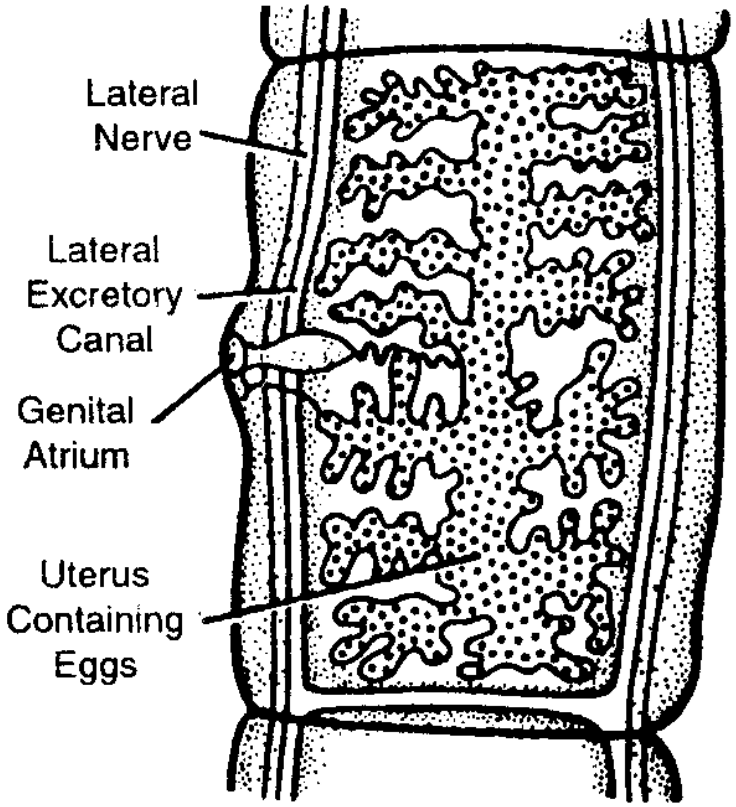


Fig. TaeniaSolium: Gravid proglottid

Practical No. 7

Identification of any three museum specimen with help of taxonomic identification key.

A Key to Some Common Animal Taxa

It is relatively easy to identify most commonly found animals into their proper phylum and even class by using only some of the major external or obvious internal characteristics of a specimen. Most identification is done using a *dichotomous* key in which you are presented with a choice. The results of each choice directs you to a new choice. The process continues until you arrive at the appropriate taxon. Any such *dichotomous* key has its limitation. So to reach final conclusion you must verify results with specific characteristics.

1a. Body covered with numerous small pores, radially symmetrical or irregular,one or more large openings ……**Phylum Porifera**

1b. Not as above, if pores present they are in 5 rows, usually symmetrical, usually with digestive tract …..2

2a. Body with radial or bi-radial symmetry …..3

2b. Body with bilateral symmetry ……10

3a. Body mostly soft and gelatinous, cylindrical or umbrella shaped or sometimes spherical, body partsusually in divisions of 4, 6, or 8…..**Phylum Cnidaria….. 4**

3b. Body usually hard and spiny or with leathery skin, body parts in multiples of 5, some with branched tentacles, rows of tube-feet usually visible 7

4a. Body gelatinous, umbrella or bell shaped…… 5

4b. Body cylindrical, with tentacles surrounding the mouth, usually sessile, sometimes individuals very small, colonial, and embedded in stone-like or leather-like secretions 6

5a. Small to microscopic, with 4 or 8 canals radiating out from centre of body…..**Class Hydrozoa**

5b. Large, sometimes with scalloped margines, branching canals….**Class Scyphozoa**

6a. Body small to microscopic, usually in plant-like branching colonies….**Class Hydrozoa**

6b. Much larger, ring of tentacles often retracted or not easily visible……..**Class Anthozoa**

7a. Body with no arms, hard skeleton sometimes with a thin soft "skin" or no rigid skeleton but bodywall leathery and flexible……..8

7b. Body with arms radiating out from centre, no distinct head, skeleton of hard plates covered by thin soft skin….. 9

8a. Body spherical or flattened disc with moveable spines extending from surface….**Class Echinoidea**

8b. elongated leathery, sac-like body with branching tentacles at one end…….**Class Holothuroidea**

9a. Arms sharply set off from a central 'disc', no grooves or tube feet visible on underside ofarms….. **Class Ophiuroidea**

9b. Arms not sharply set off from central area, arms with deep grooves filled with tube feet on ventral surface of arms ……**Class Asteroidea**

10a. Body with internal skeleton, including skull of bone and/or cartilage, If no apparent bone thenbody with 5 or 6 distinct pairs of gill slits on each side near the head….. 32

10b. No distinct internal skeleton, no distinct skull or vertebrae…… 11

11a. Body slender, wormlike or leaflike with no obvious segments, no shell and no appendages 12

11b. Body not as above, if wormlike then having appendages or segments or both 17

12a. Body flattened, no proboscis extending from mouth…..**Phylum Platyhelminthes**... 13

12b. Body cylindrical in cross-section, covered in tough cuticle…… 15

13a. Body long ribbonlike and apparently segmented with segments getting larger at hind end, from end an attachment organ with hooks and/or suckers …..**Class Cestoda**

13b. Body not as above, mouth and digestive tract present…. 14

14a. Round suckers present, sometimes with hooks, around mouth and about a third of the way downthe body, body often leaf-like in shape….. **Class Trematoda**

14b. No attachment organs present, head sometimes triangular, two 'eyes' sometimes present….**Class Turbellaria**

15a. Body relatively thin and narrow, mouth, often with three 'lips' and/or syringe-like' stylet atanterior end, 'lateral lines' visible through the cuticle on each side of the animal …..**Phylum … Nematoda**

15b. Not as above 16

16a. Body extremely long and narrow, often coiled, often dark reddish color, hind end with 2 or 3 lobes…. **Phylum Nematomorpha**

16b. Body much shorter and wider, mouth with spiny proboscis……..**Phylum Acanthocephala**

17a. Small, body slender and torpedo shaped with lateral and caudal fins, mouth with numerousbristles and spines……. **Phylum Chaetognatha**

17b. Not as above ……18

18a. Body soft and unsegmented, some may secrete one or more shells….. 19

18b. Body definitely segmented, sometimes wormlike, with or without paired appendages 25

19a. Soft, unsegmented body with no external rigid covering…. 20

19b. Body soft and unsegment and completely or partially enclosed by 1or 2 shells or covered on the dorsal surface by several plates… 21

20a. Soft, unsegmented body with large eyes, with arms and tentacles surrounding mouth andextending from head, may have a flexible or rigid endoskeleton … **Phylum Mollusca, Class -- Cephalopoda**

20b. soft wormlike unsegmented body with distinct head containing 2 pairs of tentacles……**Phylum…. Mollusca, Class Gastropods**

21a. Animal with a single shell…… 22

21b. Animal with 2 or more shells (valves) ……..23

22a. Shell tubular, straight or slightly curved and open at both ends... …….**Phylum Mollusca, ClassScaphopoda**

22b. Shell usually coiled, spiral, or tentlike, distinct head with 1 or 2 pairs of antennae, dark colored radula inside mouth used to scrape algae. ……**Phylum Mollusca, Class Gastropoda**

23a. Animal completely enclosed by two shells (valves) …….24

23b. Shell consists of 8 dorsal plates, ventrally surrounded by a leathery mantle, in some the mantle completely covers and obscures the plates. …….**Phylum Mollusca, Class Polyplacophora**

24a. Animal completely enclosed by two shells (valves)(dorsal and ventral), the ventral shell usually larger, long stalk extends out of the hinge surface of the shell for attachment, or if soft tissue is gone a prominent hole visible where the stalk would have exited.

…….**Phylum Brachiopoda**

30b. Animal complete enclosed by two lateral shells (valves) joined by ligamentous hinge, right and left paired gills, thick muscular foot able to extend out from between the two shells, no thick stalkfor attachment but may by numerous thin strong threadlike fibres for attachment……..

Phylum….Mollusca, Class Bivalvia.

25a. Body wormlike and obviously segmented along its length, if it has appendages on any segments they are short and flaplike and not "jointed" appendages … **… Phylum Annelida**... ….26

25b. Segmented body covered by rigid plates surrounding each segment, some segments with paired jointed appendages……..**Phylum Arthropoda**

28

26a. Each segment with a pair of flaplike appendages and conspicuous bristles (setae) and spines **Class Polychaeta**

26b. Each segment without appendages or conspicuous spines…. 27

27a. Body with numerous apparent segments, round suckers at each end of animal or sometimes just at the posterior end, a pair of small eyes usuall visible on the anterior end..**Class Hirudinea**

27b. No suckers present, no appendages, some spines present but may be inconspicuous. …..**ClassOligochaeta**

28a. Body elongated, with trunk consisting of many similar segments bearing paired appendages, head with paired eyes and one pair of antennae 29

28b. Body not as above ……30

29a. Most apparent body segments with two pairs of legs each…….

…….**Class Diplopda**

29b. Most body segments with one pair of legs each, first body segment behind the head with prominent "poison fangs"…..**Class Chilopoda**

30a. Body usually divided into three parts - a head, thorax and abdomen, conspicuous head with largecompound eyes and one pair of antennae, three pairs of walking legs on thorax…….**Subphylum- Hexapoda**

30b. Body divided into 2 major parts - a cephalothorax with eyes, mouthparts and walking legs, and a thorax….. 31

31a. Two pairs of antennae (one pair might be inconspicuous), usually large compound eyes, usually more than 4 pairs of walking appendages on cephalothorax and also appendages on the abdomen…. **Subphylum Crustacea**

31b. No antenna, 4 pairs of walking legs on cephalothorax…. **Subphylum Chelicerata**

32a. Aquatic species, with or without scales, body with rigid and or moveable fins 33

32b. Not as above 35

33a. Aquatic species, mouth without closable jaw, no paird fins on body... **Class Agnatha**

33b. Aquatic species, mouth with closable jaw, usually with two pairs of fins 34

34a. Aquatic species, cartilaginous skeleton, mouth ventral, placoid or tooth like scales or no scales, 5to 7 pairs of prominent gill slits near the head, paird fins only slightly moveable ….. **Class- Chondrichthyes**

34b. Aquatic species, usually with bony skeleton, with or without scales, if scales not placoid scales,single opening for gills, covered by bony operculum, both pairs of fins freely moveable….**Class-Osteichthyes**

35a. Skin with scales at least in some areas ……36

35b. Skin without scales …..37

36a. Skin covered with horny, epidermal scales, sometimes covering bony plates, paired limbs usually with 5 toes or limbs absent, lungs, not gills **Class-Reptilia**

36b. Most of skin covered with feathers, scales on legs only, forelimbs adapted for flying, toothless, horny beak….**Class - Aves**

37a. Skin usually covered with fur, in some hair is very scarce but still present, skin usually with sweat, oil and scent glands, females with mammary glands to nurse young….**Class- Mammalia**

37b. Skin naked (no scales, feathers or fur), often moist or slimy, sometimes dry and warty …… **ClassAmphibia**

Answer sheet

Name: Class: Roll.No.

Identifying Animal Phyla

Use the key provided to identify different animals that are provided for you. Complete the table below. Refer the animal classification guide (Library) to find a common name. Complete the Table and submit at end.

Specimen No.	Sequence used to identify animal	Phylum	Subphylum or Class (if listed)	Common Name of Taxon
	1a>2b>3a>4b	Echinodermata	Asteroidea	starfish
1				
2				
3				
4				
5				
6				

Practical No. 8.

Visit to Zoological survey of India/ Museum/National Park.

THE ZOOLOGICAL SURVEY OF INDIA (ZSI)

The Zoological Survey of India (ZSI) was established by government of India "Ministry of Environment" on 1st July, 1916 to encourage exploration and research aptitude leading to the advance research of the rich fauna of India and our understanding of it.

The history of this survey dates back to 1875 as a small section of zoology in the Indian Museum at Calcutta. With the continuous and sincere efforts of the staff the research was expanded and now it is one of the leading organization in Zoological fauna oriented research programs including aquatic forms. The survey is a custodian of the National Zoological Collections, comprising of over millions of identified specimens from Protozoa to Mammalia.

Initial assemblage of the Zoological collections was done from a century old former Museum (1814 -1875) of the Asiatic Society of Bengal and Zoological Section of the Indian Museum (1875-1916) in Calcutta. With the advancement of technology and interest in the life sciences the expansion program was initiated. The Survey has developed into a major National Institution and till date it has established 16 Regional and Field Stations. The survey is caring out intensive field explorations in different parts of the country to study various fields of zoology. Taxonomy is a primary role of this survey however recently the survey has ventured into the integrated research programs including, population studies, cytotaxonomy, ecology, wildlife and zoogeography, animal and behavior. The survey has its own reputed journal also in which the outcome of their exploration and research is been published.

MUSEUM

National Museum of Natural History, New Delhi

Photo: bit.ly/1V6fcH8

The National Museum of Natural History was first opened for public in 1978 at New Delhi. It is a pioneer concept of that time. It was established with an aim of conserving the rich flora and fauna of India. It organizes several educational programs, film shows, guided tours, vacation programs publications etc to spread the awareness and create interest in people. The museum has an enormous and rich library which can cater the need of all the naturalist, zoologist and even a common person by offering books on natural history, wildlife and ecology. There are three galleries in the museum: Gallery 1 is on "Introduction to Natural History", Gallery 2 is on "Nature's Network: Ecology", Gallery 3 is on "Conservation".

Apart from these galleries, the museum has Discovery and Activity Rooms and even temporary exhibitions on various themes can be witnessed from time to time.

Place: FICCI Building, Barakhambha Rd., Tansen Marg, New Delhi
Visit Timings: 10:00 a.m. to 5:00 p.m (Closed on Monday and National Holidays)

Regional Museum of Natural History, Mysore

Photo: bit.ly/1U41iUE

The Regional Museum of Natural History was established in 1995 at Mysore. The museum was established with the sole aim of spreading awareness in the people about floral, faunal and geological wealth of the southern region of India. This museum also focuses on ecological interrelationship among plants and animal and environment related issues. The museum also conduct student centric programs on curriculum-based studies in biology and geology. There is an enormous gallery with several sections on Biological Diversity and Life through the Ages. The museum provides us an opportunity to explore nature with the help of models, translites, AV aids, diorama, and thematic, interactive and participatory exhibits.

Where: it is located on the bank of Karanji Lake, and with the backdrop of Chamundi hills, **(**Siddhartha Nagar), Mysore.

Visit Timings: 10.00 am to 5.00 pm (Monday and National Holidays Closed)

Rajiv Gandhi Museum of Natural History, SawaiMadhopur

Photo: bit.ly/1RFB4tT

Rajiv Gandhi Museum of Natural History is a recent achievement inaugurated in 2014. This museum is a crucial center for environmental education and public awareness on conservation of nature and natural resources in the country. It is an enormous museum with three storied display exhibiting the rich flora, fauna, mineral wealth and the geology of the western region and western arid region of India. The museum is established with the intention of imparting an understanding of the diversity of life on earth and our dependence upon nature and the obligation to maintain our ecological heritage. Informative short films, tiger head trophies and exclusive paintings are the highlights of this museum.

Where: Ramsinghpura, Sawaimadhopur, located about 9kms from SawaiMadhopur in Rajasthan

Visit Timings: 10.00 am to 5.00 pm (Monday and National Holidays Closed)

Natural History Museum, Thiruvananthapuram

Photo: bit.ly/1mgj5gF

Natural History Museum in Thiruvananthapuram was established in 1964. This two-storied museum nurtures a rich Indian collection of ethnographic items, animal skeletons; stuffed animals as well as birds. Museum also carries the personal collection of General Cullen which comprises minerals and books. The Museum has several galleries each exhibiting a specific category of animal kingdom. Therefore a person can enjoy individual galleries for invertebrates, Mammals, birds, vertebrates and even their skeletons. Museum houses a library and a laboratory also. The Ethnology Gallery provides visitors an insight into the races of mankind along with their place of origins, their distribution and distinctive characteristics.

Where: Palayam, Thiruvananthapuram, located in the vicinity of famed Napier Museum.

Visit Timings: 10.00 am to 5.00 pm (Tuesday to Sunday) and 10.00 am to 1.00 pm (Wednesday)

Regional Museum of Natural History, Bhubaneshwar

Photo: bit.ly/1RFBj8k

The Regional Museum of Natural History opened the exhibits for public viewing in 2004. The museum imparts the basic knowledge and importance of the rich wildlife in India. The museum was established with an aim of spreading the awareness about the significance of flora, fauna and conservation of our natural resources. The museum exhibits the enormous biodiversity of Orissa, the North East and the Andaman and Nicobar Islands. This exhibits illustrates the biodiversity richness of these different regions under a same roof, familiarizing people with the natural heritage of the state as well as the country. The museum has several galleries emphasizing on the conservation of nature and natural resources and represents the ecological interrelationship among plants and animals. Museum has made provisions for visually challenged students, to feel the exhibits of animals. The museum arranges several programs for schools and colleges to promote awareness for biodiversity and environment. Major eye catcher of the museum is a skeleton of Baleen Whale which is believed to be the largest in India.

Where: Acharya Vihar, Bhubaneshwar, Madhya Pradesh.

Visit Timings: 10.00 am to 5.00 pm (Monday and National Holidays Closed)

Natural History Museum, Bahadurpur

This museum is a treat for an eye of a wildlife lover. It caters the need of people who want to explore the various aspects of history with regard to animal kingdom. The museum exhibits wonderful displays of taxidermy showing stuffed dummies of the extinct as well as the living animals. It also displays the artifacts related to animals. Zoological Park in the vicinity of the museum is an additional advantage to the people as they can see the real animals in real time zoological park along with their detailed history in the museum.

Place: It is situated inside Nehru Zoological Park in Bahadurpur, Telangana, **Visit Timings:** 10.00 am to 5.00 pm (Mon to Fri) and 2.00 pm to 5.00 pm (Sunday)

Natural History Museum, Chandigarh

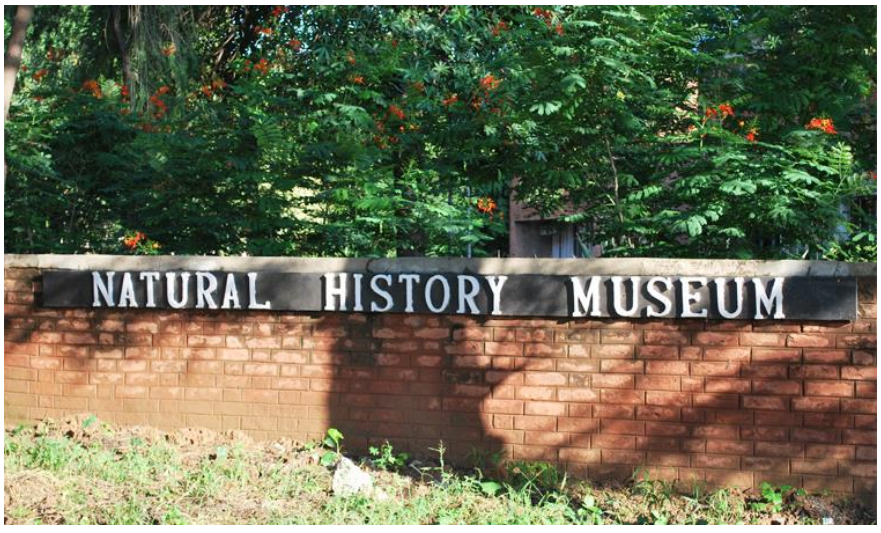


Photo: bit.ly/1NBXhoV

The museum was established in 1973 at Chandigarh, Punjab. The museum was established with an aim of imparting knowledge on the importance of wildlife and its correlation with our existence. The Natural History Museum is enormous with five sections displaying biodiversity. This museum features a dedicated

section on extinct Dinosaurs and other section exhibits the Evolution of Man, displaying different stages of primate evolution. The third section exhibits the evidences and models from the Cyclorama –The Evolution Life, in this illustrations of the origin of earth, evolution of life from unicellular organism to multicellular plants and animals through different time zones like Archeaozoic, Paleaozoic, Permian, Devonian, Triassic, Jurassic, Oligocene, Miocene and Pleistocene periods have been displayed. The fourth section focusses on informative and interesting visuals related to the depiction of nature in art in various mediums like embroidery art. Around 62 articles of embroidery deal with the various forms available in Nature. The fifth and sixth section in the museum exhibits Manuscripts, providing evidences in the text form that emphasize various aspect of human and animal evolution.

Where: Sector 10, Chandigarh, Punjab.

Visit Timings: 10.00 am to 4.30 pm (Monday and Gazetted Holiday Closed)

Bengal Natural History Museum, Darjeeling

Photo: bit.ly/1Ywzyi4

The Bengal Natural History Museum was established in 1915, making it one of the oldest museum in India. Initially the museum started with the exhibits of diverse collection of butterflies and birds. However today, the museum illustrates a huge collection exhibiting the biodiversity of real organism including birds with nests and eggs, reptiles, fishes, mammals and insects. The museum shows a taxidermy unit which specializes in curing, stuffing and exhibiting the birds and animals for display in the glass cabinets. The exhibits are divided into two sections. The first section exhibits majestic birds like Himalayan Brown Wood Owls, Northern spotted owlet, Northern Brown Fish

Owl, pheasants, fly catchers and woodpeckers displayed in their artificially created natural settings. It includes around 820 specimens of birds including 400 native species of that area. The other side of the museum one can notice a large collection of birds' eggs. The other section of the museum exhibits around 110 types of bird's eggs. Along with it a good collection of nests of various sizes, various species of snakes and fishes can also be seen.
Place: 10 mins walk from Chowrasta Mall, Darjeeling.

Visit Timings: 9.00 am to 5.00 pm (Monday and National Holidays Closed)
Baghel Museum, Bandhavgarh

Photo: bit.ly/1NBX7Om
The Baghel Museum is a personal collection of Maharaja of Rewa. The museum has gained its popularity for keeping the belongings of Shikargarh, or a game preserve that wildlife lovers surely want to explore at Bandhavgarh. The museum has exhibited stuffed body of first white tiger, hunting equipment as well as military equipment.
Where: It is Located at a short distance from Bandhavgarh National Park, Bandhavgarh.
Visit Timings: 10:00 am to 03:00 pm and 05:00 pm to 08:00 pm (Open all days)

Corbett Museum, Kaladhungi

Photo: bit.ly/1ZoKo6O

Corbett Museum is the one of the most popular wildlife museums in India. Corbett Museum exhibits the belongings of Jim Corbett including plaques, life size oil paintings, history of Jim Corbett and his family and some of his furniture. The museum has also exhibited certain articles of his like gun, cap, bag, fishing net, and manuscripts of his last hunting expedition. It is a small but enlightening exhibit where people can learn about one of the earliest wildlife conservationists in India and his change of thought and thereafter his influential work.

Where: Kaladhungi, about 50kms from Ramnagar, Uttarakhand
Visit Timings: 8.00 am to 6.00 pm (Summer) and 8.00 am to 5.00 pm (Winter)

Kanha Museum, Kanha National Park

Photo: bit.ly/1RFBe4K

Kanha Museum is an explicit reflection of the rich wild life at Kanha National park. The museum is oriented to cater the need of wildlife lovers to get

acquainted with the topography and diversity of the park. There are different attributes and activities of the park and the tribal culture of Madhya Pradesh one can be witness here in details.

Where: Kisli Gate, Kanha National Park.

Visit Timings: 9.00 am to 6.00 pm

NATIONAL PARK.

National parks in India are the category II protected areas as per the recommendations of International Union for Conservation of Nature. According to the Indian Ministry of Environment & Forests, a national park is an area that can be notified by the state government to be constituted as a National Park, for the reason of its ecological, faunal, floral, geomorphological, or zoological protection & propagation. No human activity is allowed nside the national park with the exception of few permitted by the Chief Wildlife Warden of the state under the conditions given in CHAPTER IV, WPA 1972".

The first national park in India was Jim Corbett Park earlier known as Hailey National Park. It was established in 1936 in Uttarakhand. By 1970, there were only five national parks in India. In 1972, Wildlife Protection Act and Project Tiger was introduced to safeguard the habitats of reliant species. In 1980, this was reinforced by the federal legislation which strengthened the protection of wild life

Situation improved drastically leading to 104 national parks till May 2019 covering the category II protected area of 40,501.13 km^2.

Tadoba National Park

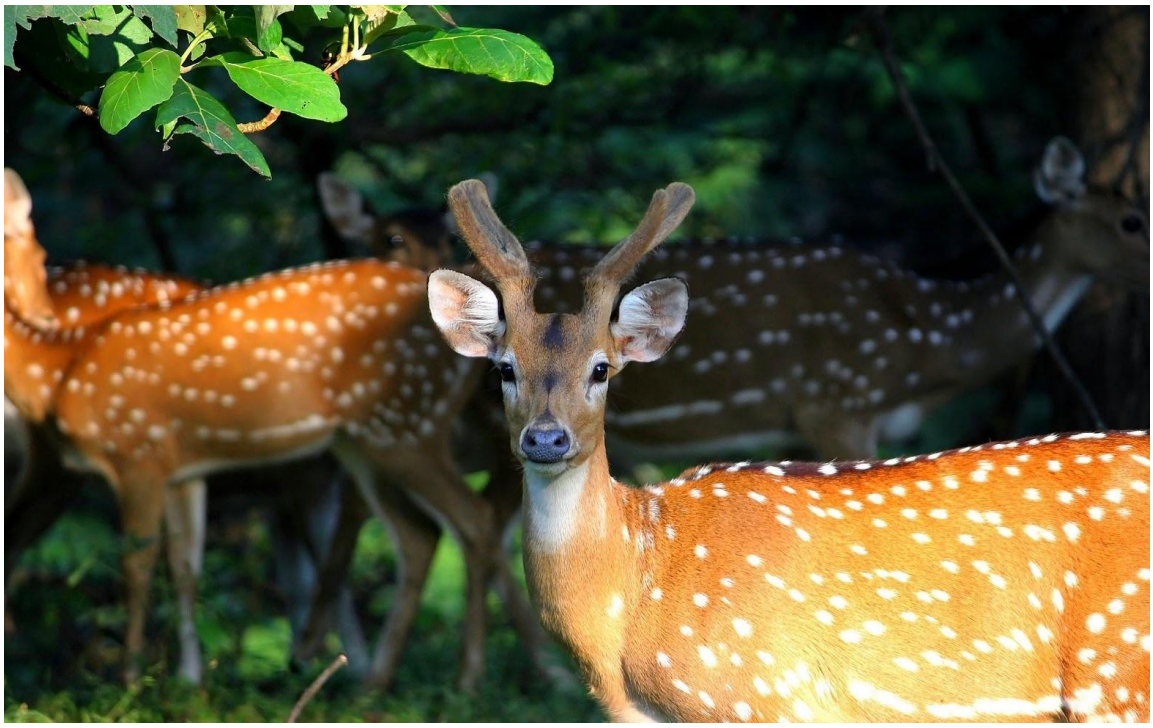
Tadoba National Park, is the oldest and the largest tiger reserve, situated in the Chandrapur district of Maharashtra. Todoba national park is a dense teak forest

which is known for its spectacular tiger-sighting safaris. Along with tigers it is also a home to **Indian leopards**, **Honey Badgers**, ***Sambars***, snakes like cobras and **Russell's Vipers**. The Tadoba Park has a lake that harbors a florishing crocodile population. The reserve is also known to be a favorite spot for ornithologists due to its exotic bird sighting. This national park is a heaven for wildlife lovers.

Nearest airport: Nagpur, Maharshtra

Best time to visit: October to May

Pench Tiger Reserve



It is a national reserve which covers the area of two adjoining states of Maharshtra and Madhya Pradesh. It is one of the premier tiger reserves in the country. It is popular for its astonishing tiger sightings and is very famous amongst the wildlife lovers. This park is an inspiration for the setting for Rudyard Kipling's 'The Jungle Book. Pench National Park is also rich in other fauna like **Golden Jackals**, wild cats, wolves etc.

Place : near Nagpur **Best time to visit:** October to June

Gugamal National Park (Melghat Tiger reserve)

This National Park is an integral part of the Melghat Tiger reserve. It houses a diverse wildlife including **Bengal Tigers**, **Indian Leopards**, **Sloth Bears**, **Indian Jackals**, **Striped Hyenas**, **Barking Deer** and **Wild Boars**. It also exhibits floral biodiversity. The sanctuary is an amazing place to experience the beauty of nature landscape. It's an amazing place for nature lover and wild life admirer.

Place: Located in the Amravati district of Maharashtra, nearest airport is Nagpur.

Best time to visit: October to June.

Karnala Bird Sanctuary

Karnala bird sanctuary is located in the surroundings of the Karnala fort. Inspite of covering a smaller area it houses almost 200 species of exotic birds with few

native birds. These migratory birds are a visual treat to the bird watchers. This place is a true heaven for ornithology enthusiasts. Some native bird species of Western Ghats, includes birds like **Malabar Grey Hornbill**, **Malabar Parakee**t and **White-cheeked Barbet** along with certain rare species such as the **Three-toed Kingfisher**, **Ashy Minivet** and **Rufous-bellied Eagle**. **Place:** Located in the Raigad district near Matheran, **nearest airport is** Mumbai **Best time to visit:** October to April

Nagzira

Nagzira Wildlife sanctuary is rich in biodiversity housing tigers, sambars, wild boars, sloth bears and mouse deer; reptiles including **Indian Rock Python**, **Indian Cobra**, **Checkered Keelback** and **Russell's Viper** along with several endangered species of birds. It is even rich in the biodiversity of amphibians including **Tree-frog** and **Bullfrog**, there is a blessing in disguise for this sanctuary as it is not well known it has maintained its natural biodiversity and beauty. The Nagzira reserve is pristine and indeed beautiful. **Place:** Located near the Gondia district of Maharashtra, **Nearest airport:** Nagpur. **Best time to visit:** October to June.

ANIMAL ECOLOGY

Practical No. 1

Estimation of dissolved oxygen (DO) content in the given water sample by Winkler's method.

Theory: Dissolved oxygen (DO) determination quantifies the amount of dissolved (or free) oxygen available in water. Aquatic organisms such as fish, crustaceans, mollusks and aerobic bacteria need dissolved oxygen to survive. When dissolve oxygen level in water reduces, the environment becomes less capable of sustaining living forms and even aerobic bacteria which are involved in the decomposition of sewage waste do not survive. The concentration of dissolved oxygen can be easily and accurately determined by the method of Winkler (1888).

Principle: Dissolved oxygen in water doesn't reacts with KI directly; therefore manganese hydroxide is used as an oxygen carrier. $Mn(OH)_2$ (manganese hydroxide) is produced by the reaction of KOH with $MnSO_4$. $Mn(OH)_2$ reacts with dissolved molecular oxygen to form a brown colored precipitate of $MnO(OH)_2$ (manganic oxide). This manganic oxide then reacts with concentrated sulphuric acid to liberate nascent oxygen, which results in oxidation of KI to I_2. This liberated iodine is then titrated against standard sodium thiosulphate solution using starch as an indicator. Thiosulphate reduces iodine to iodide ions and itself gets oxidized to tetrathionate ion.

Reactions:

$$\mathbf{2KOH + MnSO_4 = Mn(OH)_2 + K_2SO_4}$$

$$\mathbf{2Mn\,(OH)_2 + O_2 = 2MnO\,(OH)_2}$$

$$\mathbf{MnO\,(OH)_2 + H_2SO_4 = MnSO_4 + 2H_2O + [O]}$$

$$\mathbf{2KI + H_2SO_4 + [O] = K_2SO_4 + H_2O + I_2}$$

$$\mathbf{2S_2O_3^{2-} + I_2 = S_4O_6^{2-} + 2I^-}$$

Chemical preparation:

1. **Sodium thio**Sulphate**(0.025N):** Dissolve 24.82g of $Na_2S_2O_3.5H_2O$ in a preboileddistelled water and make up the volume to 1 liter. Add a pellet of NaOH or 0.4 g of borax as stabilizer. This is 0.1 N stock solution dilute

it four times to have 0.025N solution. Store it in a brown coloured glass bottle.

2. **Alkaline iodide solution**: dissolve 175g of KOH and 37.5 g of KI in 250ml of preboiled distilled water, or 125g Sodium hydroxide and 33.75gsodium sodium iodide in distilled water and dilute it to 250ml.
3. **Manganoussulphate solution:** Dissolve 120g of $MnSO_4.4H_2O$/ 100g of $MnSO_4.2H_2O$/ 91g of $MnSO_4.H_2O$ in 200ml distilled water and heat it to dissolve maximum salt, filter when it is cool.
4. **Starch solution:** add 6g of starch in small amount of water, make the volume upto 1 liter. Boil this emulsion for few minutes and let it settle overnight. Take the supernatant and preserve it by adding 1.25g salicylic acid.
5. **H_2SO_4 conc.**

Procedure:

1. Fill the water sample in a 100-300 ml glass stopper bottle. There should not be any bubbling or trapping of airbubbles after putting the stopper.
2. Add 1 ml of each MnSO4 and alkaline KI solutions well below the surface through the walls. Use separate pipettes for these solutions. Appearance of brown precipitate indicates the presence of oxygen in the sample.
3. Mix the contents by inverting bottle. Keep the bottle and see if any precipitates settle down. If there is no precipitate then mix it again.
4. Allow the precipitate to settle down.
5. add 2ml of concentrated H_2SO_4 and mix it by inverting the bottle for almost 40 times to dissolve the precipitate.
6. Allow the sample to stand for few mins.
7. Remove 50-100 ml or whole contents in a conical flask for titration, avoiding any entry of oxygen through bubbling. Titrate the contents within one hour of dissolution of precipitate with $Na_2S_2O_2$ solution using few drops of starch as indicator. At the end point, the initial dark blue black colour changes to colourless.

Calculate dissolve oxygen as follows:

When the whole contents have been titrated:

$$\text{Dissolve oxygen as mg/L} = \frac{(\text{ml x N})\ of\ \text{Na2S2O3 X 8 X 1000}}{\text{V}}$$

When only a part of content has been titrated:

$$\text{Dissolve oxygen as mg/L} = \frac{\text{used volume of titrant} \times 1000 \times 0.2}{\text{Volume of sample}}$$

Where, 0.2 value represents, 1ml of sodium thiosulphate equivalent to 0.2 mg of O_2

Practical No. 2:

Estimation of water alkalinity from given water sample.

Theory: Alkalinity of water is the measure of acid-neutralizing or buffering capacity of water. Alkalinity in water is due to the presence of bicarbonate, carbonate, and hydroxide ions, which provides buffering capacity to water. Buffering capacity works by absorbing positively charged hydrogen ions by using negatively charged bicarbonate and carbonate molecules, which resist any substantial change in the pH. Therefore, a water sample with high alkalinity will have more resistance towards any change in pH.Generally acids are added to the water from rain, snow or though soil sources whereas, alkalinity increases as water dissolves rocks containing calcium carbonate such as calcite and limestone.

Alkaninity of water is important for the aquatic species as alkalinity helps in maintaining the pH of water. Generally alkalinity is buffered but acid shock may occur in spring when acid snows melt, thunderstorms or acid rain enter the stream. If increasing amounts of acids are added to a body of water, the water's buffering capacity is all used up. Sensitive species and young one's are to be affected first though this impact grows further with the food chain as when food species disappear, even bigger and resistant species are affected.The safe limit of alkalinity for sustaining aquatic life should be at least 20 mg/L.
Principle: There are five possible conditions of alkalinity carbonate, bicarbonates, hydroxide ion, carbonate + hydroxide, carbonate + bicarbonate. Alkalinity is determined by titrating the water sample with strong acid.

Requirements: Burette, conical flasks, beakers, weighing balance, measuring cylinder.

Reagents:

1. **Phenolphthalein indicator solution:**
   Dissolve 0.5g phenolphthalein in 50 ml of ethyl alcohol and add 50 ml of distilled water. Add 0.02N NaOH drop wise until a faint pink color appears.
2. **Standard sulphuric acid:** (0.02N): prepare stock solution, 0.1N by diluting 3 ml of conc. H_2SO_4 to 1 L. Dilute 200ml of 0.1N stock solution

to 2000ml with carbon dioxide free water to give 0.02N solution. This must be standardized against Na_2CO_3

3. **Methyl orange indicator solution:** Dissolve 0.5g methyl orange in 2 liters of distilled water.
4. **Procedure:**

   Phenolphthalein alkalinity: Take 50 /100ml of water sample and four drops of phenolphthalein indicator solution. If a pink color appears (indicates the presence of carbonate) titrate against standard H_2SO_4 (0.02N) until color disappears. pH 8.3 and record ml of acid used.

   Total alkalinity: (by methyl orange indicator method)

   If no pink color appears after adding phenolphthalein or after phenolphthalein titration, add two drops of methyl orange indicator and titrate to a faint orange at pH 4.6 (and pink at below4 pH). Record total used standard acid in ml.

   Calculations:

   I. phenolphthalein alkalinity as mg $CaCO_3$/L= ml standard acid ×1000/ml of sample

   II. Total alkalinity as mg $CaCO_3$/L= total ml standard acid×1000/ml of sample

Practical No. 3 & 4:

Study of animal community structure, determination of density, frequency and abundance of species by quadrat method.

Quadrat Sampling in Population Ecology

Background

Estimating the abundance of organisms.

Ecology is often referred to as the "study of distribution and abundance". This being true, we would often like to know how many of a certain organism are in a certain place, or at a certain time. Information on the abundance of an organism, or group of organisms is fundamental to most questions in ecology. However, we can rarely do a complete census of the organisms in the area of interest because of limitations to time or research funds. Therefore, we usually have to estimate the abundance of organisms by sampling them, or counting a subset of the population of interest.

For example, suppose you wanted to know how many snails there were in the forests. It would take a lifetime to count them all, but you could estimate their abundance by counting all the snails in carefully chosen smaller areas on the forest.

Accuracy vs. Precision.

Obviously, we would like our method for sampling the population to produce a good estimate. A "good "estimate should maximize both precision and accuracy. Accuracy refers to how close to the true mean (μ) our estimate is. That is, if we somehow could know the true number of snails residing on forest, we could compare our estimate to it and find out how accurate we are. Obviously, we would like our estimate to be as close to the true value as possible. In addition, we would like to avoid any bias in our estimate. An estimate would be biased if it consistently over- or under-estimated the true mean. Bias may arise in many ways, but one frequent source is by the selection of sample plots that are nonrandom with respect to the abundance of the target organism. For example, if we looked for snails at forest only in sunny, dry open fields, our estimate would probably be much lower than the true abundance. Random sampling avoids this source of bias. A random sample is one where

every potential sample plot within the study area sample has an exactly equal chance of being chosen for sampling. Random sampling is not the same as haphazard sampling. True random sampling usually requires the use a random number table, or a random number generator. In addition to obtaining an accurate, unbiased sample, we are also concerned with the precision of our estimates. Precision refers to the repeatability of our estimates of the true sample mean. If we were to estimate snail abundance many times and got nearly the same estimate each time, we would say that our estimate was very precise. Note that it is possible to have accuracy without precision and vice versa.

Some of the factors that affect precision are:

1) Measurement error. In the real world, it is important to count organisms carefully and lay out plots accurately for good estimates of density. This is not a concern here however, because the computer will be laying out the plots and counting the plants.

2) Total area sampled. In general, the more are a sampled, the more precise the estimates will be, but at the expense of additional sampling effort.

3) Dispersion of the population. Whether the population tends to be aggregated, evenly spaced, or randomly dispersed can affect precision. Note that the dispersion pattern of the same population may be different at different spatial scales (e.g., 1 x1 m plots vs 100 x 100 m plots).

4) Size and shape of quadrates. The size and shape of the plots can affect sampling precision. Often, the optimal plot size and shape will depend on the dispersion pattern of the population.

Various experiments protocols for Community Structure Study:

1. Aim of the Experiment:

To determine the minimum size of the quadrat by species area-curve method.

Requirements:

Nails, cord or string, meter scale, hammer, pencil, notebook.

Method:

i. Prepare a L-shaped structure of 1 × 1 meter size in the given area by using 3 nails and tying them with a cord or string.

ii. Measure 10 cm on one side of the arm L and the same on the other side of L, and prepare 10 x 10 sq. cm area using another set of nails and string. Note the number of species in this area of 10 x 10 sq. cm.

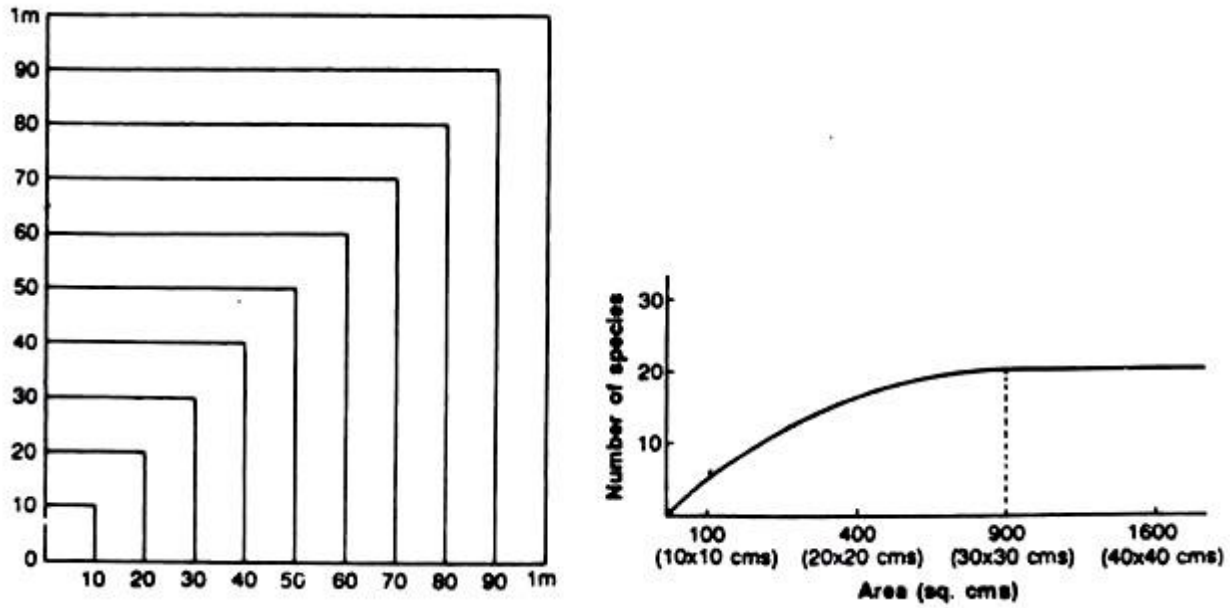


Fig. A. Procedure for determining minimum required size of the quadrate.

B. Species area curve to determine the size of the quadrate.

iii. Increase this area to 20 × 20 sq. cm and note the additional species growing in this area.

iv. Repeat the same procedure for 30 × 30 sq. cm, 40 × 40 sq. cm and so on till 1 × 1 sq. metre area is covered (Fig. 67) and note the number of additional species every time.

Record your data in the following table:

No.	Area	Total no. of species
1.	10 × 10 sq. cm	
2.	20 × 20 sq. cm	
3.	30 × 30 sq. cm	
4.	40 × 40 sq. cm	
:	:	
10.	100 × 100 sq. cm	

v. Prepare a graph using the data recorded in the above table. Size of the quadrates is plotted on X- axis and the number of species on Y-axis (Fig. B).

Observations:

The curve starts flattening or shows only a steady increase (Fig. B) at one point in the graph.

Results:

The point of the graph, at which the curve starts flattening or shows only a steady or gradual increase, indicates the minimum size or minimum area of the quadrate suitable for study.

2. Aim of the Experiment:

To study communities by quadrate method and to determine % Frequency, Density and Abundance.

Requirements:

Meter scale, string, four nails or quadrate, notebook.

(i) Frequency:

Frequency is the number of sampling units or quadrates in which a given species occurs.

Percentage frequency (%F) can be estimated by the following formula:

$$\%\ \text{frequency (F)} = \frac{\text{Number of quadrats in which the species occurred}}{\text{Total number of quadrats studied}} \times 100$$

(ii) Density:

Density is the number of individuals per unit area and can be calculated by the following formula:

$$\text{Density (D)} = \frac{\text{Total number of individuals}}{\text{Total number of quadrats studied}}$$

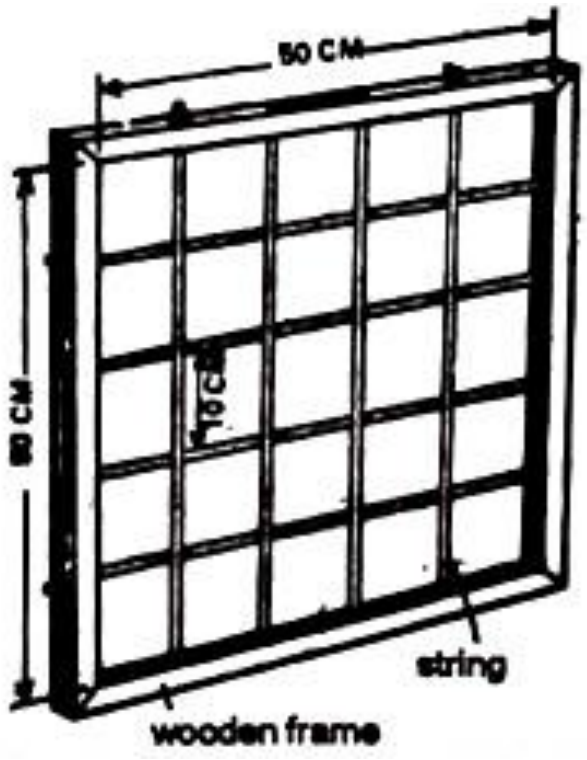


Fig. A wooden quadrate of 50 x 50 cm

(iii) Abundance:

Abundance is described as the number of individuals per quadrate of occurrence.

Abundance for each species can be calculated by the following formula:

$$\text{Abundance (A)} = \frac{\text{Total number of individuals}}{\text{Number of quadrats of occurrence}}$$

Method:

Lay a quadrate (Fig. 68) in the field or specific area to be studied. Note carefully the plants occurring there. Write the names and number of individuals of plant species in the note-book, which are present in the limits of your quadrate. Lay at random at least 10 quadrates (Fig. 69) in the same way and record your data in the form of Table 1.

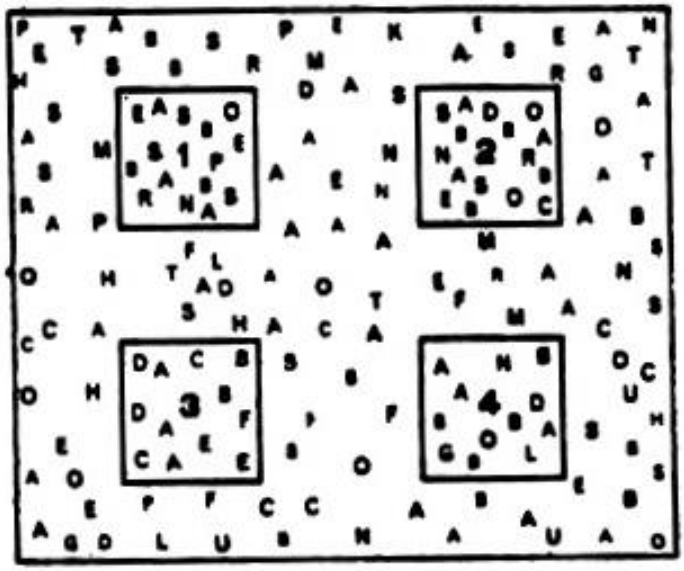


Fig. Sketch of an artificial field showing four quadrates (1-4)

In Table,1 % frequency, density and abundance of Cyperus have been determined. Readings of the other six plants, occurred in the quadrates studied, are also filled in the table. Calculate the frequency, density, and abundance of these six plants for practice. (For the practical class take your own readings. The readings in Table 1 are only to explain the matter).

Observations:

See Table 1

Results:

Calculate the frequency, density, and abundance of all the plant species with the help of the formulae given earlier and note the following results:

(i) In terms of % Frequency (F), the field is being dominated by…

(ii) In terms of Density (D), the field is being dominated by…

(iii) In terms of Abundance (A), the field is being dominated by…

Observations:

Table 1: Size of quadrate: 50cm × 50cm = 2500 cm^2

S. No.	Name of plant species	Number of individuals in quadrat number										Total number of quadrats of occurrence	Total number of quadrats studied	Total number of individuals	% Frequency (F)	Density (D)	Abundance (A)
		1	2	3	4	5	6	7	8	9	10						
1.	*Cyperus*	10	9	7	0	0	3	8	15	0	7	7	10	60	70%	6	8.57
2.	*Cassia*	0	0	2	0	3	0	5	0	6	10						
3.	*Cynodon*	50	0	7	41	6	0	0	8	0	5						
4.	*Eclipta*	0	0	4	0	3	0	0	1	0	2						
5.	A	0	0	0	0	2	0	0	1	3	0						
6.	B	5	10	1	0	0	0	3	1	0	2						
7.	C	3	5	0	0	2	1	8	0	2	0						

3. Aim of the Experiment:

To determine minimum number of quadrates required for reliable estimate of biomass in grasslands.

Requirements:

Meter scale, string, four nails (or quadrate), note book, graph paper, herbarium sheet, cello tape.

Method:

i. Lay down 20-50 quadrates of definite size at random in the grassland to be studied, make a list of different plant species (e.g., A-J) present in each quadrate and note down their botanical names or hypothetic numbers (e.g., A, B, C,…, J) as shown in Table 2.

ii. With the help of the data available in Table 2, find out the accumulating total of the number of species for each quadrate.

Table 2:showing the accumulating total of the number of species for each quadrat.

Name of Species	Quadrat Number												
	1	2	3	4	5	6	7	8	9	10	11	12	...
A	+	+	–	–	+	+	–						
B	+	+	+	+	+	+	–						
C	+	–	–	–	+	+	+						
D		–	+	+	–	+	+						
E					–	–	–						
F						–	+						
G							+						
H						+	–						
I							–						
J						+	–						
Accumulating total number of species	3	4	4	4	5	8	10						

iii. Now take a graph paper sheet and plot the number of quadrates on X-axis and the accumulating total number of species on Y-axis of the graph paper.

Observations and results:

A curve would be obtained. Note carefully that this curve also starts flattening. The point at which this curve starts flattening up would give us the minimum number of quadrats required to be laid down in the grassland.

4. Aim of the Experiment:

To study frequency of herbaceous species in grassland and to compare the frequency distribution with Raunkiaer's standard frequency diagram.

Requirements:

Quadrat, pencil, note-book, graph paper.

Method:

i. Lay 10 quadrats in the given area and calculate the percentage frequency of different plant species by the method and formula given above in Exercise No. 2.

ii. **Arrange your data in the form of following Table 3:**

Table 3: reading for % frequency of different species

S. No.	Name of species	Number of quadrats studied										Total number of quadrats of occurrence	Total number of quadrats studied	% Freq-uency
		1	2	3	4	5	6	7	8	9	10			
1.	*Cyperus rotundus*	+	+	+	–	+	–	+	–	+	+	7	10	70%
2.														
3.														
4.														
5.														
6.														

Raunkiaer (1934) classified the species in a community into following five classes as shown in Table 4.4:

Table 4. Classes of species in a community according to Raunkiaer (1934).

Class	Frequency
A	1–20%
B	21–40%
C	41–60%
D	61–80%
E	81–100%

Arrange percentage frequency of different species of the above Table.3 in the five frequency classes (A-E) as formulated by Raunkiaer (1934) in Table 4.

Draw a histogram (Fig.) with the percentage of total number of species plotted on Y-axis and the frequency classes (A-E) on X-axis.

This is the frequency diagram (Fig):

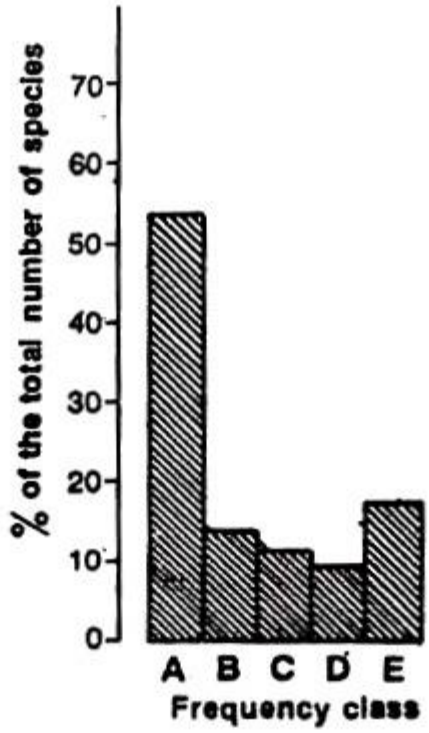


Fig. Histogram showing the normal frequency diagram

Observations and results:

The histogram takes a "J- shaped" curve as suggested by Raunkiaer (1934), and this shows the normal distribution of frequency percentage. If the vegetation in the area is uniform, class 'E' is always larger than class 'D'. And in case class 'E' is smaller than class 'D, the community or vegetation in the area shows considerable disturbance.

5. Aim of the Experiment:

To estimate Importance Value Index for grassland species on the basis of relative frequency, relative density and relative dominance in protected and grazed grassland.

Requirements:

Wooden quadrate of 1×1 meter, pencil, notebook.

What is Importance Value Index?

The Importance Value Index (IVI) shows the complete or overall picture of ecological importance of the species in a community. Community structure study is made by studying frequency, density, abundance, and basal cover of species. But these data do not provide an overall picture of importance of a species, e.g., frequency gives us an idea about dispersion of a species in the area but does not give any idea about its number or the area covered.

Density gives the numerical strength and nothing about the spread or cover. A total picture of the ecological importance of a species in a community is obtained by IVI. For finding IVI, the percentage values of relative frequency, relative density, and relative dominance are added together, and this value out of 300 is called Importance Value Index or IVI of a species.

Relative frequency (RF) of a species is calculated by the following formula:

$$\text{RF} = \frac{\text{Number of quadrats in which a species occurs}}{\text{Total number of all the species in the quadrat}} \times 100$$

Relative density (RD) of a species is calculated by the following formula:

$$\text{RD} = \frac{\text{Total number of individuals of a particular species in all quadrats}}{\text{Total number of individuals of all the species in all quadrats}} \times 100$$

Relative dominance of a species is calculated by the following formula:

$$\text{Relative dominance} = \frac{\text{Total basal area of a particular Relative species in 5 quadrats}}{\text{Total basal area of all the species in 5 quadrats}} \times 100$$

Basal area of a plant species is calculated by the following formula:

Basals area of a species = $p\ r^2$

where p = 3.142, and r = radius of the stem

Method:

i. Find out the values of relative frequency, relative density and relative dominance by the above-mentioned formulae.

ii. Calculate the IVI by adding these three values:

IVI = relative frequency + relative density + relative dominance.

Results:

Arrange the species in order of decreasing importance, i.e., the species having highest IVI is of most ecological importance and the one having the lowest IVI is of least ecological importance.

6. Aim of the Experiment:

To determine the basal cover, or vegetational cover of one herbaceous community by quadrate method.

Requirements:

Wooden quadrate of 1×1 m, Vernier-calliper, pencil, notebook.

Method:

i. Lay a wooden-framed quadrate of 1 x 1 meter randomly in a selected plot of vegetation and count the total number of individuals of the selected species inside the quadrate.

ii. Cut a few stems of some plants of this individual species and measure the diameter of the stem with the help of Verniercalliper.

iii. Calculate the basal area of the individuals by the formula:

Average basal area = πr^2 where r is the radius of the stem.

iv. Take 5 readings, arrange them in tabular form and find out the average basal area by the above formula.

v. Lay the quadrate again randomly at another place and note the same observations in the table.

vi. Lay about 10 quadrats in the same fashion and each time note the total number of the species and average basal area of the single individual.

Observations and results:

(a) For finding the average basal area, divide the sum of average basal area in all quadrats with the total number of quadrats studied.

(b) For finding the total basal cover of a particular species multiply the average basal area of all observations with the density of that particular species as under:

Basal cover of a particular species = Average basal area x Density (D) of that species.

The basal cover of a particular species is expressed in… sq. cm/sq. meter.

7. Aim of the Experiment:

To measure the vegetation cover of grassland through point-frame method.

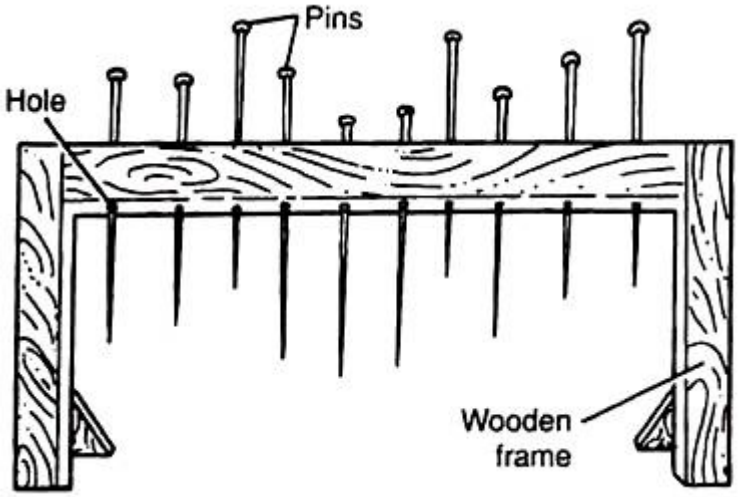


Fig. Point-frame apparatus

Requirements:

Point-frame apparatus, graph paper sheet, herbarium sheet, cello tape, note-book.

Point-frame apparatus:

A point-frame apparatus is a simple wooden frame of about 50 cm long and 50 cm high in which 10 movable pins are inserted at 45° angle. Each movable pin is about 50 cm long.

Method:

i. Put the point-frame apparatus (with 10 pins) at a place in the vegetation of grassland (Fig.) and note down various plant species hit by one or more of 10 pins of the apparatus. Treat this as one sampling unit.

ii. Now put the apparatus at random at 10-25 or more places and note down each time the various plants species in a similar fashion. In case three plants of any species touch three pins in one sampling unit put at a place, the numerical strength of that particular species in this sampling unit will be three individuals. Write this value against the species below this sampling unit.

Observations and results:

Note down the details in the form of following Table 5:

S.No.	Name of the species	Number of places where point frame apparatus in put 1 2 3 4 5 6 7 8 9 10	Total number of places at which species occurred	Total number of places at which apparatus was put	Frequency (%)	Frequency class to which species belongs
1.	*Cyperus rotundus*	+ – + + + + + + + +	9	10	90%	E
2.	*Cynodon dactylon*	+ + + + – – + + + +	8	10	80%	D
3.						
4.						
:						
:						
25.						

Now calculate the percentage frequency of each species as already done in Exercise No. 2. Allocate the various species among five frequency classes (A, B, C, D, E) mentioned in Exercise No. 4, find out the percentage value of each frequency class and prepare a frequency diagram as done in Exercise No. 4. Compare the thus-developed frequency diagram with normal frequency diagram.

Results:

Find out the three most frequently occurring species in the area studied. Also find out whether the vegetation is homogeneous or heterogeneous. Also try to determine the density values of individual species. Also find out at each place

the total number of individuals of each species being hit by 10 pins of the point-frame apparatus.

8. Aim of the Experiment:

To prepare a list of plants occurring in a grassland and also to prepare chart along the line transect.

Requirements:

Two nails, 25 feet cord.

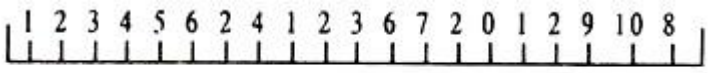
Method:

i. Prepare a 25 feet long line transect in a selected grassland by tying each end of a 25 feet cord to the upper knobs of two nails.

ii. Note down the names of the plant species whose projection touches one edge of the cord along the line transect, and assign all of them a definite number (e.g., 1,2,3,4, …etc.).

iii. Take several such samples at regular or irregular intervals in the grassland along the line transect.

iv. Also record the plant species from different grassland types in the similar fashion.



Species along a line transect.

Observations:

Record your data in the following Table 4.6 in the form of the following manner:

Table 4.6 : Species and their number along the line transect in different localities

S.No.	Name of species	Locality No. 1				Locality No. 2				Locality No. 3			
		I	II	III	Total	I	II	III	Total	I	II	III	Total
1.	*Cynodon dactylon*												
2.													
3.													
4.													

Result:

Table 4.6 gives the complete list of plants occurring in the selected grassland. Also find out the name of the species represented in maximum number in each locality.

These data will also provide a clear picture of the dominant species of the grassland in a particular area.

STUDENT PERFORMANCE PROTOCOL FOR STUDY OF ANIMAL COMMUNITY STRUCTURE, DETERMINATION OF DENSITY, FREQUENCY AND ABUNDANCE OF SPECIES BY QUADRAT METHOD.

Lay down the quadrat in the area that need to be studied. In each quadrat note down the various types of species and the number of individuals of each species.

Observation and calculations:

Frequency(%)= Total number of quadrat in which species has occurred × 100
Total number of quadrats studied

Frequency class: On the basis of percent frequency, various species are then divided into five frequency classes (Raunkaier, 1934) as follows,

% Frequency	Frequency class
0-20	A
21-40	B
41-60	C
61-80	D
81-100	E

Value of each frequency class as percent of the total number of species:

$$\textbf{Value of A} = \frac{\text{Total number of species belonging to class A}}{\text{Total number of species}}$$

$$\textbf{Density per unit area} = \frac{\text{Total number of individuals of the species} \times 100}{\text{Total number of quadrats studied} \times \text{area of single quadrat}}$$

$$\textbf{Abundance} = \frac{\text{Total of individuals of the species}}{\text{Total number of quadrats in which the species has occurred}}$$

Table: Field data

Sr. No.	Name of the species	Quadrate laid down				Total number of individuals of the species	Total number of quadrate in which species occurred	Total number of quadrates studied	Frequency (%)	Frequency class	Density	Abundance
1												
2												
3												
4												

Practical No. 5:

Study of microscopic fauna of fresh water ecosystem (from pond).

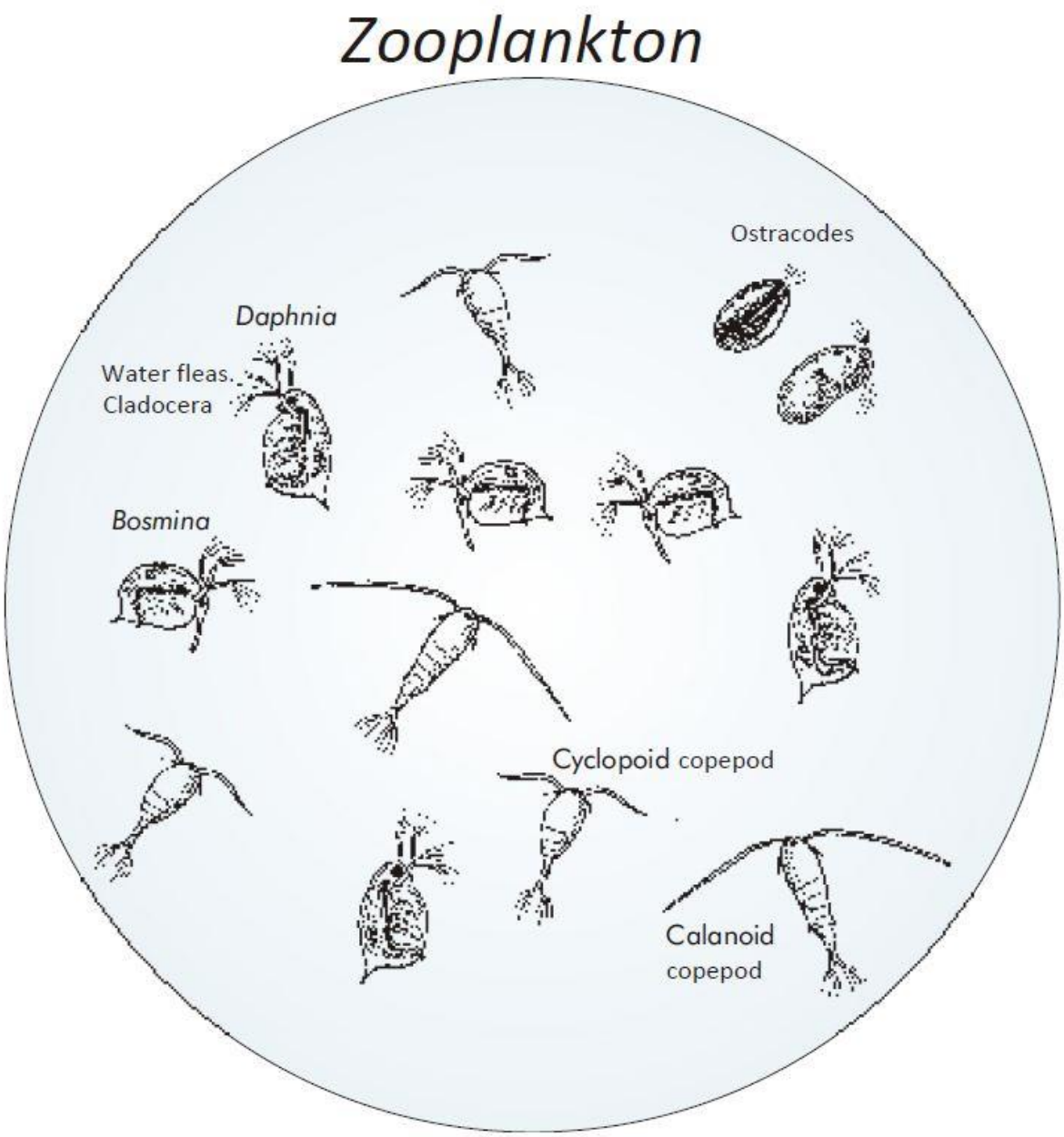
The microscopic fauna is an important component of the freshwater pond biodiversity which is responsible to sustain the large number of macro organism in that ecosystem. Microscopic Freshwater fauna serves as a crucial link in the food chain. The planktons are minute, microscopic organisms of plants & animal origin. They spend their whole life in the water. For their movement, they depend on the mercy of physical conditions of the water body and environment e.g. depth, water current, wind, light, air etc.

Collection method:

1. Use plankton net of mesh size 35 micron for the collection of microorganism from all major categories.
2. Washed the net thoroughly Prior to its usage in order to minimize the risk of clogging and to ensure maximum filtration.
3. Submerge the net deep in water and move it slowly.
4. Retrieve the net by pulling slowly out of water.
5. Sample was made upto 5 ml using the water from the same source.
6. If fixed organisms need to be identified, then fix the sample within five minutes of sampling using 4% formalin.
7. If live study has to be done then, dilute the sample with more 25 ml of water from same source.
8. Drop from the Sample can be placed on the slide for observation and if the movement is very swift then add 4% formalin to immobilize the organisms.

The common type of microscopic fauna can be studied under following major divisions: ***Protozoa*** Ciliates, Flagellates, Rhizopods, ***Rotifers, Crustacean-*** **Cladocera** such as *Daphnia*, B*osmina*, **Copepods** such as *Cyclops*, *Diaptomus*

Protozoan: Protozoa are unicellular, phagotrophic organisms, and 16 phyla of protists contain free-living freshwater protozoan species.



Few common forms are:

Vorticella

Vorticella is sessile organisms as adult forms are attached to substrates with contractile stalks.

This stalk is a filamentous organelle called the spasmoneme.

Although they can detach themselves if food supplies are scarce or they have to relocate.

Vorticella use the cilia to create a water current (vortex) to direct food towards its mouth.

Vorticella is heterotrophic organism.

Frontonia

Frontonia species vary in length from 50 to 600 micrometres.

Cell shape is typically ovoid or elongated and dorsoventrally flattened.

They are flexible, uniformly ciliated, and usually surrounded by trichocysts.

Frontonia are capable of ingesting large prey such as diatoms, filamentous algae,amoeba and also their own forms.

Paramecium

Paramoecia are elongated and slipper-shaped.

The anterior end of the animal is blunt but the posterior end is pointed.

The food of*Paramoecium* consists of bacteria, yeasts, algae, and small protozoa.,*Amoeba, Euglena.*

Rotifers

They are common microscopic organisms in fresh water.

They are mostly littoral, sessile, but some are completely planktonic.

Most rotifers are around 0.1–0.5 mm long. They are Filter-feeders.

Rotifers are preferred food of the larvae because of its small size that suits to the mouth size of the larvae compared to others. Hence, can be established as a vital link in the food chain.

Examples: *Philodena, Brachionus, keratella*

Philodenaflaviceps

Broad and Small body with 320micro meter size

Trunk is yellow in colour and the head with neck is brownish)

Wheel organ is wider than collar region

Wheel bears sensitive setae

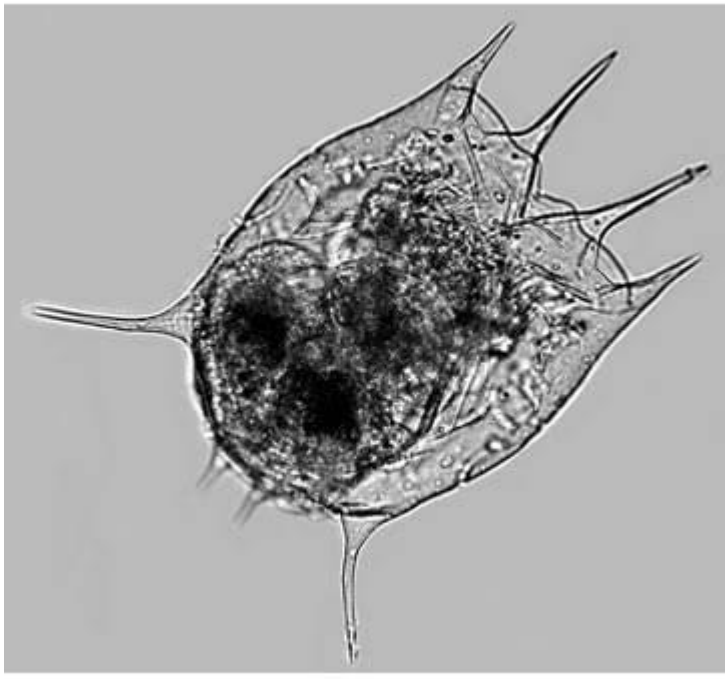
Short foot is also present.

***Keratella**:*

Bear one spine at posterior end and three at anterior end.

The lorica is broad and yellowish brown in colour.

Lorica bears two or three plaques on its surface.



Brachio-nuscalyciflorus

It bears postero-median and antero-median spines.

Lorica is rectangular in shape

Copepods

Copepods include the two groups:

Cyclopoids and calanoids are the two major groups of copepods which are frequently available in fresh water.

Adult copepods are 1mm to 5 mm in size.

Copepods are cylindriconical in shape, with wide anterior end.

The trunk region consists of cephalothorax and the abdomen.

The head has a central eye and a long unirameous antennae.

Cyclops*:*

They are 0.5 – 5 mm in length.

Body is divided into two sections cephalothorax and abdomen.

Cephalothorax bears a paired antenna and a single median eye.

Pair of caudal fork is located at the end of abdomen.

In female a pair of ovary and ootheca are attached at the end of thoracic segments.

Cyclops is also a frequently found freshwater organism which serves as a preferred food item for the larvae.

Helio-diaptomuscinctus

Body is stock and wide middle part which narrows anteriorly.
Anterior end is rounded
Body bears a head which separated from thorax by a constriction Head

Cladocera

These are small aquatic crustaceans (0.2-3.0 mm) commonly called as water fleas. The body is covered by bivalve carapace and divided into head and body. They swim by using large antennae. These are filter feeders.

Daphnia

Body is segmented and is around 1–5 millimeters in size.
Head is fused and is tilted towards the body. Head bears compound eyes and antennae. Body bears five or six pairs of legs and abdominal setae.

Daphnia is used as a live feed for fishes and tadpole. It can also be used as an experimental model to study heart beat and effect of toxins on it.
It may be used as a pollution indicator species as well as model organism to test various toxins

Application

As food in aquaculture: these are preferred as a natural food for larval stage of fish and prawn. E.g. rotifer *Brachionus species* dried Cladocerans

Potential Bio-indicator: Variations in water quality such as changes in nutrient levels, conductivity, temperature or pH, can lead to changes in species composition and abundance. Hence, they can be used for water quality assessment.

Practical No. 6:

Estimation of water holding capacity of given soil sample.

Theory: Water holding capacity of soil refers to the maximum amount of water that can be held in a saturated soil. Water holding capacity is beneficial for the plants/ crops to grow.

The key components that determine soil water holding capacity are

1. Soil texture
2. Organic matter

Soil texture: The soil with smaller particle sizes (silt and clay) has larger surface area. The larger the surface area facilitates the water holding capacity of soil whereas, soil with large particle sizes (sand) has smaller surface area and low water holding capacity.

Soil organic matter (SOM): Soil organic matter (manure/humus) has a natural adhesion to water which results in increased water holding capacity of soil.

Requirements: Soil samples (garden soil, road side soil, sand, clay) tin/brass box with perforated bottom (metallic sieve), weighing balance, Whatman filter paper, petri plates, glass bowls, water.

Procedure:

1. Take a soil sample crush it and allow it to dry in air.
2. Place a filter paper layer in the bottom of brass box covering the entire base.
3. Weigh the brass box along with filter paper.
4. Transfer the soil into the brass box by tapping it gently.
5. Now place this soil filled brass box in a petridish containing water, if all water has been absorbed adds some more after some time and then wait for almost 6 hours.
6. Remove the box wipe it dry from outside and weigh it.
7. Now dry the soil in oven for 12 hrs at 105^0C.
8. Cool it off and weigh again.

9. Also find out the weight of wet filter paper and dry filter paper, to know the amount of water absorbed by filter papers.

Observations:

W_1=Weight of brass box+ filter papers=

W_2=Weight of brass box+ filter paper + saturated soil=

W_3=Weight of brass box+ filter papers+ oven dried soil=

W_4=amount of water retained by the filter paper=

% water holding capacity= Amount of water present in soil/Weight of oven dried soil× 100

$$\textit{Percent water holding capacity} = \frac{\textbf{Amount of water present in soil}}{\textbf{Weight of oven dried soil}} \textit{X}\ \mathbf{100}$$

$$= \frac{W2-W3-W4}{W3-W1} \mathbf{X\ 100}$$

Practical No. 7:

Estimation of dissolved carbon dioxide from water sample.

Theory: Carbon dioxide reacts readily with water to form carbonic acid. Water bodies like oceans, river etc serve as a sink for carbon dioxide. The solubility of carbon dioxide in water decreases with the increase in temperature. The global warming is results in the increased the temperature of water bodies which gradually forces these water bodies to release more carbon dioxide in return causing further increase in temperature.

Dissolved carbon dioxide level in water affects both plants and animals. Aquatic plants right from tiny phytoplanktons to large plants depend on carbon dioxide and bicarbonates in water for their growth and photosynthesis. The increase in organic matter in a water body results in eutrophication, which decreases the levels of dissolve oxygen in water. This causes a rise in the levels of carbon dioxide, which makes it more difficult for fish to use the limited amount of oxygen present in water. Fish diffuse out the carbon dioxide from the blood streams of gills surface into the water by simple diffusion from higher concentration to lower. This diffusion rate is slowed down with the increase in the levels of carbon dioxide in the water.

Principle: CO2 reacts with sodium carbonate or sodium hydroxide to form sodium bi carbonate. Completion of this reaction can be visualized by appearance of pink colour of phenolphthalein indicator at the equivalence pH of 8.3.

Requirement: Burettes, conical flask, 250 ml beakers,

1. Phenolphthalein indicator solution:

Dissolve 0.5g phenolphthalein in 50 ml of ethyl alcohol and add 50 ml of distilled water. Add 0.02N NaOH drop wise until a faint pink color appears.

2. Standard Sodium Carbonate:

Dissolve 0.02g anhydrous, Na2CO3 in freshly boiled and cooled distilled water. Dilute it to 250ml stored in rubber stopper bottle. (Solution not to be kept for more than 2 weeks)

Procedure:

1. Take 100ml of sample in Nessler's tube and add 10 drops of phenolphthalein indicator. If sample turns pink in colour then carbon dioxide are absent in water.

2. If the sample doesn't changes its color even after addition of phenolphthalein then titrate it with sodium carbonate while stirring until faint color appears permanently.

3. Note down the used volume of titrant.

$$\text{Carbon dioxide mg/L} = \text{Volume of titrant used X } 1000$$

Practical No. 8:

Study of Eutrophication in lake/river.

"*Eutrophication is an enrichment of water bodies by nutrient that causes structural changes to the ecosystem such as: increased production of algae and aquatic plants, depletion of fish species, general deterioration of water quality and other effects that makes the water unfit for further usage.*" (OECD-Organization for Economic Cooperation and Development).

Major culprits in eutrophication are excess nitrogen and phosphorus present in the water body.

Eutrophication is the outcome of 3 factors:

- Extensive use of fertilizers: Agricultural runoff caused by the rains or flood bring all the extra fertilizers to the nearby water bodies. Even some amount of fertilizers leaches into the ground water.
- Waste water discharge into water bodies: In a developing country, like India, waste water is discharged directly into water bodies such as rivers, lakes and seas. This result in the increased load of organic matter into the water bodies. This leads to algal or some aquatic plant bloom in water bodies

- Reduction of self-purification capacity: Over the years, lakes accumulate large quantities of solid material transported by the water (sediments). These sediments are such as to able to absorb large amounts of nutrients and pollutants. Consequently, the accumulation of sediments starts to fill the basin and, increasing the interactions between water and sediment, the resuspension of nutrients present at the bottom of the basin is facilitated. This phenomenon could in fact lead to a further deterioration of water quality, accentuating the processes connected with eutrophication.

ANIMAL DIVERSITY II

Practical 1

MUSEUM STUDY OF PHYLUM ASCHELMINTHES: *ASCARIS LUMBRICOIDES*,

Aschelminthes

The Phylum name Aschelminthes refers to the cavity between body wall and digestive tract. "Askos" means "bag" and "helminthes" means "worms"

I. **Habit and habitat:** Organisms classified in Phylum Aschelminthes includes smooth, elongated, cylindrical, round worms which are mostly parasitic in nature.
II. **Germ layers:** These are triploblastic in nature i.e body is made up of three germ layers. Outer germ layer is ectoderm, middle is mesoderm and inner is endoderm.
III. **Coelom:** Body cavity exists between body wall and digestive tract**.** As it is not formed by the splitting of mesoderm hence named as pseudocoel.
IV. **Body size and shape:** Organisms vary in size and have cylindrical unsegmented body with bilateral symmetry.
V. **Body Covering**: body is covered by thick tough resistant cuticle which is resistant to the digestive enzymes of host.

VI. **Organization**: They show an **organ grade** of organization.

VII. **Digestive system**: Digestive system is complete, starting with mouth and finishing at anus.
VIII. It has non muscular wall.

IX. **Respiratory system**: respiration in parasitic forms **are anaerobic** in nature.

X. **Circulatory System:** Circulatory system is absent, pseudocoelomic fluid transports materials.

XI. **Excretory System:** it consists of two intra cellular tubes running in the lateral lines.

XII. **Nervous system:** nervous system comprises of a circumpharyngeal ring which extends nerves forward as well as backward.

XIII. **Reproductive system:** sexes are separate with sexual dimorphism.

XIV. **Fertilization:** Fertilization is internal.

XV. **Development:** Development is direct or indirect. Larval form exist during indirect development (microfilaria larvae of*Wuchereria*).

Ascarislumbricoids

Systematic position:

Kingdom: Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum:Aschelminthes: Triploblastic, pseudocoelomates

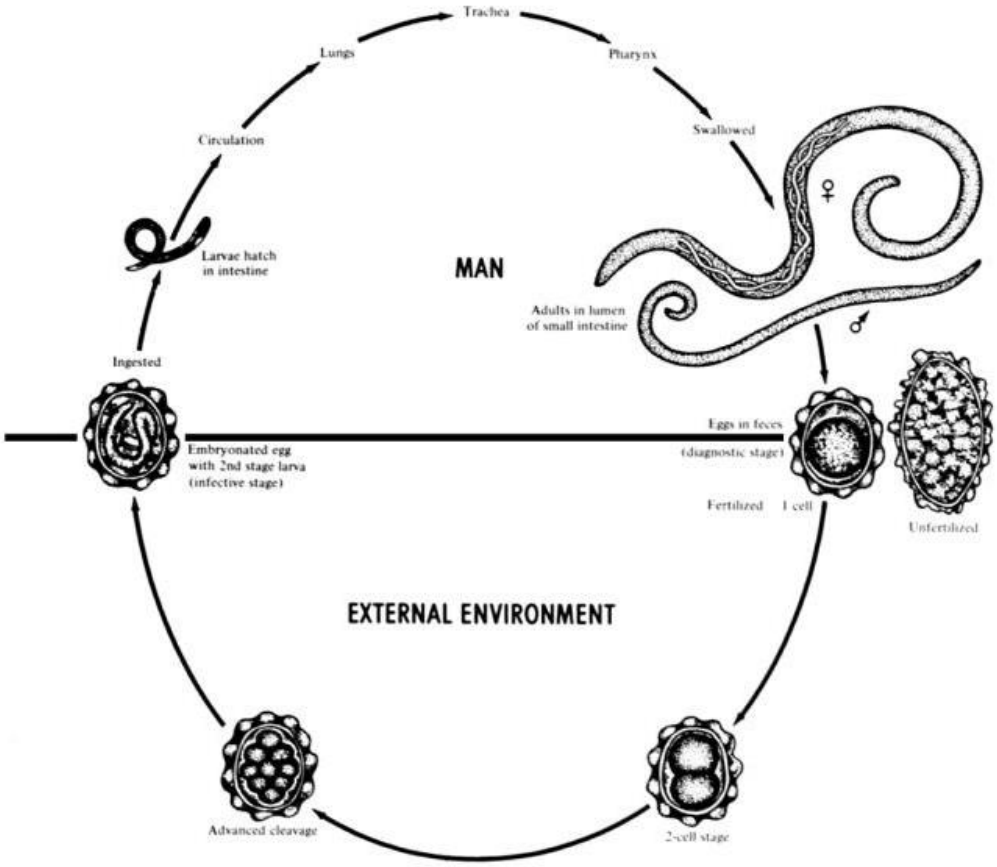
Class: Nematoda: Unsegmented cylindrical body (round worms)

Genus: *Ascaris*

Species: *lumbricoids*

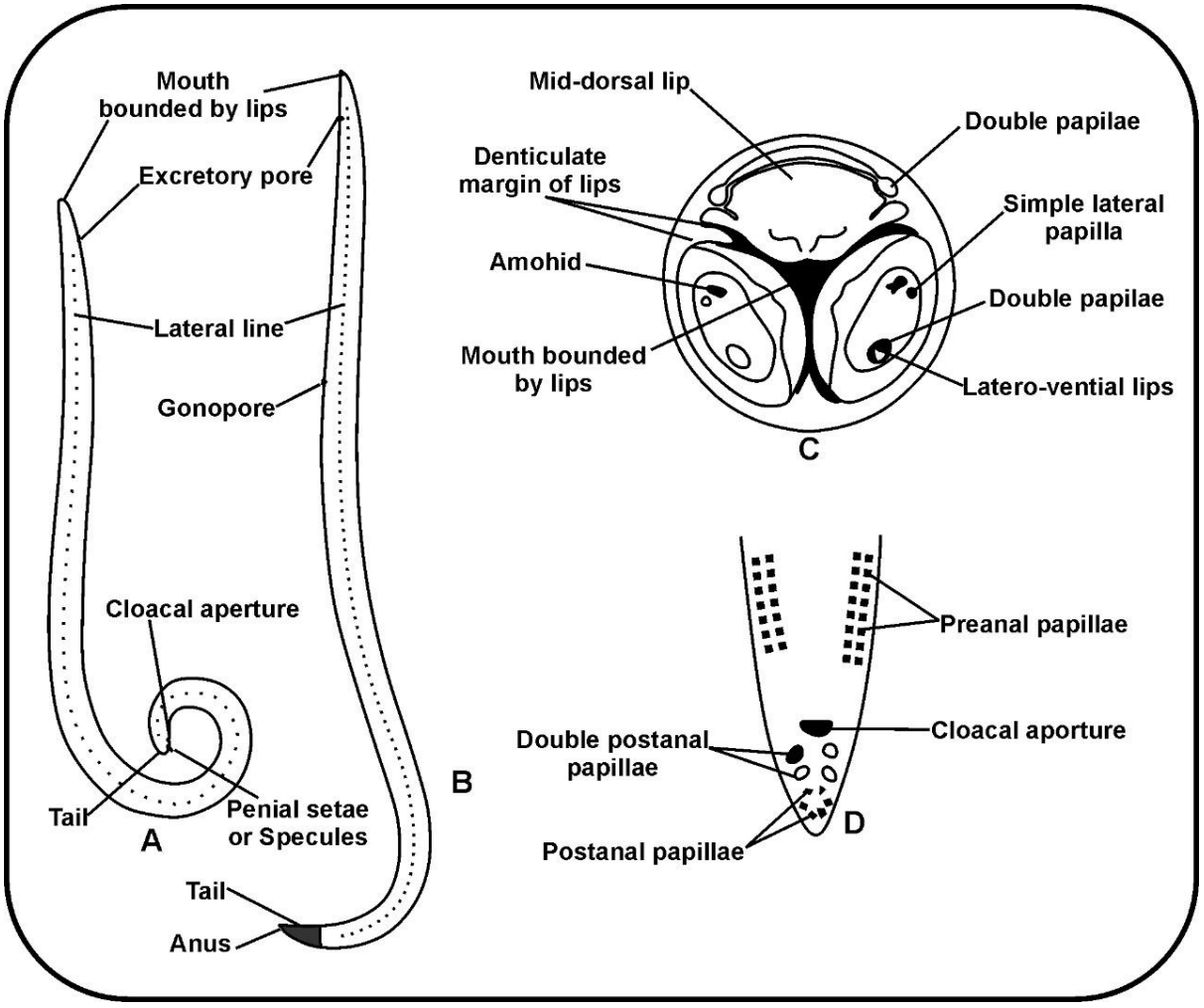
LIFE CYCLE of—

Ascaris lumbricoides



Comments:

1. It is commonly called as round worm.
2. Body is unsegmented, elongated, and cylindrical and with tapering ends.
3. Sexes are separate with a distinct sexual dimorphism.
4. Male measures 15-30 cm in length with a curved posterior end whereas female measures 20-35 cm with a straight posterior end.
5. Mouth is guarded by three lips and situated at anterior end.


Mouth bounded by lips
Excretory pore
Lateral line
Gonopore
Cloacal aperture
Tail
Penial setae or Specules
A
Tail
Anus
Mid-dorsal lip
Double papilae
Denticulate margin of lips
Simple lateral papilla
Amohid
Double papilae
Mouth bounded by lips
Latero-vential lips
C
B
Preanal papillae
Cloacal aporture
Double postanal papillae
D
Postanal papillae

Practical No. 2

MUSEUM STUDY OF PHYLUM ANNELIDA: *NERIES*, EARTHWORM, LEECH.

Annelida

The phylum name Annelida refers to metamerically segmented worms. The word "Annelus" means "rings"

I. **Habit and habitat:** These are soft bodied elongated metamerically segmented vermiform organisms. They prefer moist environment and are found in moist soil, freshwater and marine water.

II. **Germ layers:** These are triploblastic in nature i.e body is made up of three germ layers. Outer germ layer is ectoderm, middle is mesoderm and inner is endoderm.

III. **Coelom:** body cavity is present between gut and body wall. It is formed by the splitting of mesoderm hence called as true coelom.

IV. **Body size and shape:** the size ranges from 1mm (eg. Neotenotrocha) to 3m (Eunice). Giant gippsland earthworms can be 1 m long. They Mostly have cylindrical and elongated vermiform segmented body

V. **Body Covering:** body is covered by thin cuticle, single layered epidermis and well developed musculature. Epidermis bears glands and sensory cells. In some forms body wall has segmental extensions called as parapodia. These parapodia bears chaetae (bristles) for locomotion and gills for respiration.

VI. **Organization**: They show an **organ grade** of organization.

VII. **Locomotion**: some forms use chitinous setae for locomotion and some uses parapodia.

VIII. **Digestive system**: digestive tract is complete and muscular. Digestion is extracellular.

IX. **Respiratory system**: respiration occurs through general body surface by simple diffusion. Some forms have gills.

X. **Circulatory System: closed c**irculatory system is present. Blood is red in color due to presence of a respiratory pigment, hemoglobin in plasma and amoeboid cells.

XI. **Excretory System:** excretion is done via nephridia. Some are enteronephric (opening into gut) and some are exonephric (opening outside body wall)

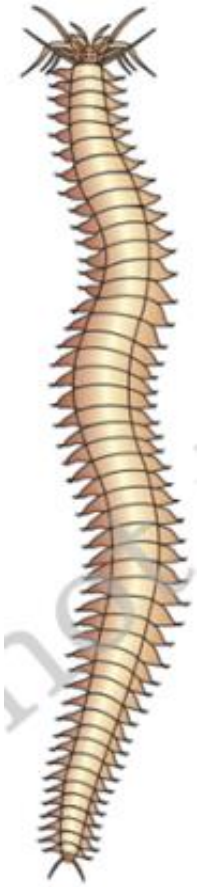
XII. **Nervous system:** nervous system comprises of brain (nerve ring) formed by ganglions connected by connectives and a ventral nerve cord formed by a pair of cords which shows ganglion in each segment.

XIII. **Reproductive system:** Sexes can be separated (*Neris*) or united (*Pheretimaposthuma*- earth worm). Some embers reproduce by budding

XIV. **Fertilization:** Fertilization is internal.

XV. **Development:** Development is direct or indirect (may include a larval stage-trochophore larvae).

Nereis



Systematic position

Kingdom: Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum: Annelida: cylindrical body with metameric segmentations, coelomates

Class: Polychaeta: numerous setae, parapodia present, no clitellum

Genus:*Nereis*

Species:

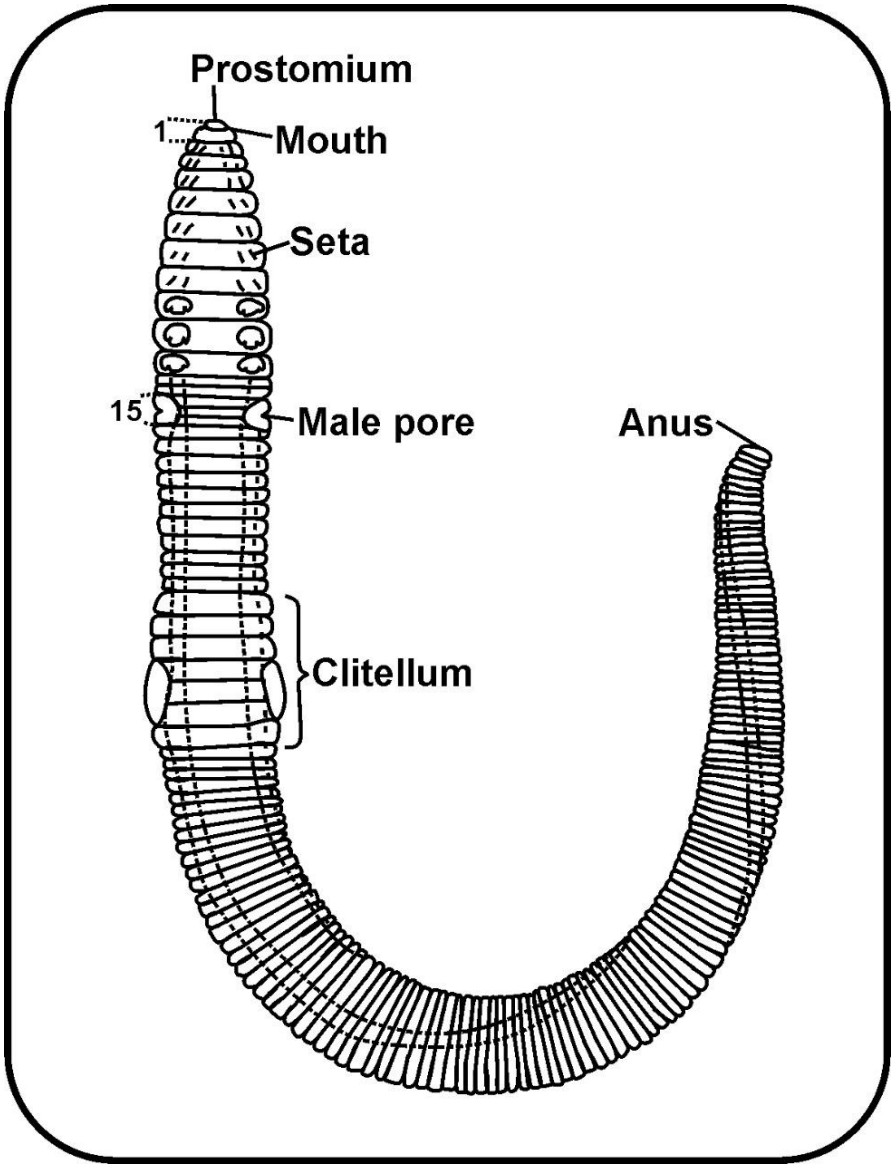
Comments:

1. They are marine nocturnal worms, which often cling to the sea weeds in swallow waters or sandy areas.
2. Commonly called as rag worms.
3. Body is alongated, vermiform and segmented.
4. Segments are called as metamere and each of it bears a pair of parapodia.
5. Parapodia are the locomotory organs plus

respiratory organs which bears chitinous setae.

6. Cephalization is there at the anterior end. Head consist of pairs of eyes, tentacles, palps and mouth.
7. Terminal segment is anal segment which bears anal cirri.

Pheretimaposthuma



Systematic position

Kingdom: Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum: Annelida: Cylindrical body with metameric segmentations, coelomates

Class: Oligochaeta: few setae, no parapodia,clitellum present

Genus: *Pheretima*

Species:*posthuma*

Comment:

1. *Pheretima* is a fossorial organism staying in moist regions.
2. It measures 150mm in length and 3-5 mm in width.
3. Body is elongated, vermiform and segmented.
4. Anterior end is slightly tapered and bears a cresentric slit as mouth whereas posterior end is blunt with anus at the terminal segment.
5. It is dark brown in colour.
6. Dorsal surface can be marked by the presence of dorsal blood vessel which is visible through integument.
7. A prominent circular and glandular band, called clitellum is present around 14^{th} , 15^{th} and 16^{th} segments.
8. Locomotion is done by chitinous S shaped setae present in all segments except first, last and clitellum segments.
9. Hermaphrodite organism showing cross fertilization.

Hirudinaria

Systematic position

Kingdom: Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum: Annelida: Cylindrical body with metameric segmentations, coelomates

Class:Hirudinea: Instead of setae and parapodia suckers are there to facilitates the locomotion.

Genus:*Hirudinaria*

Species: *granulose*

Comments:

1. It is commonly called as Indian cattle leech.
2. It is found in fresh water bodies like lakes or ponds.
3. Body is soft, elongated, vermiform, and dorsoventrally flattened with 33 metameric segments.
4. Body has olive green colored dorsal surface and yellowish ventral surface.
5. Body bears two suckers at both ends. Anterior sucker is oval in shape and consist of mouth where as posterior sucker is circular which is meant for attachment and locomotion.
6. Anterior end bears eyes on dorsal side and a mouth with triradiate aperture equipped with sharp teeth.

7. Feeding mode is sanguivorous, that is blood sucking.
8. They are hermaphrodite.

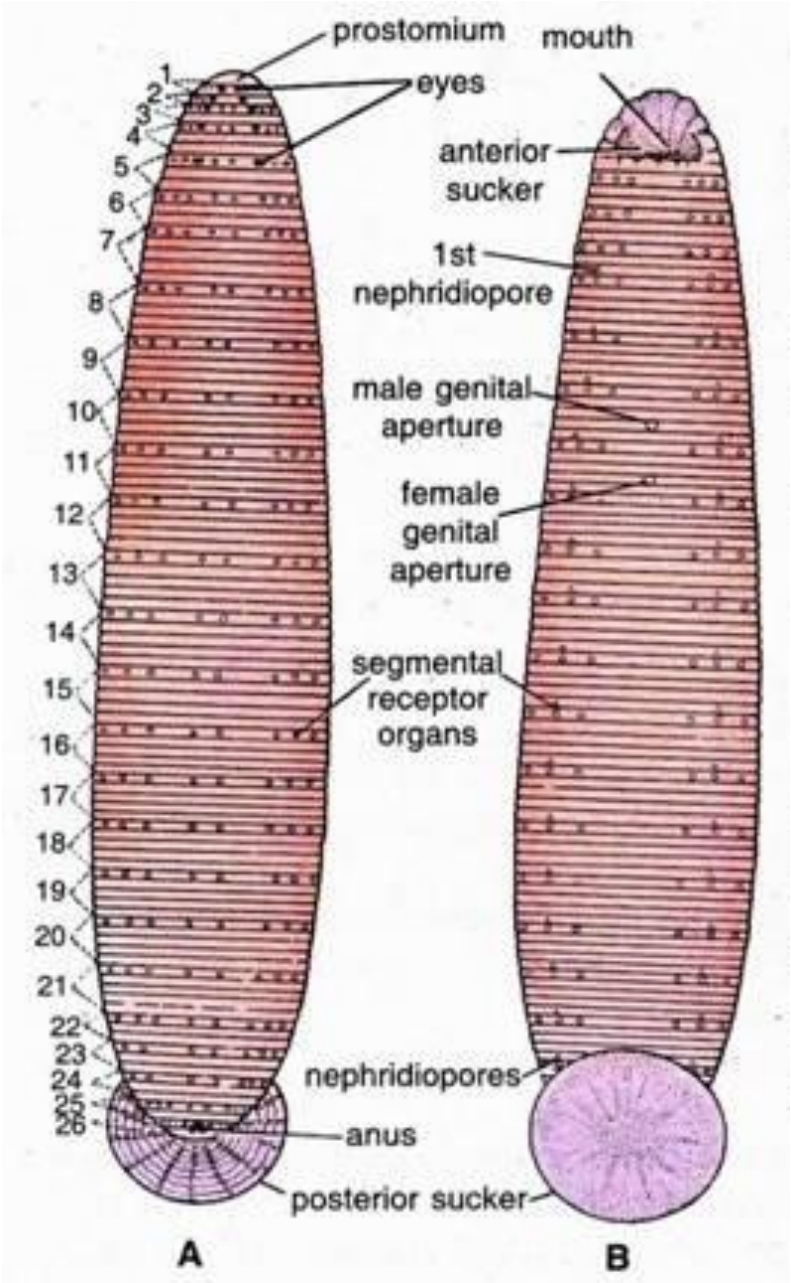


Fig: *Hirudinaria granulosa*, External features,
A Dorsal view, B. Ventral View.

Practical No. 3

MUSEUM STUDY OF PHYLUM ARTHROPODA: PRAWN, COCKROACH, CENTIPEDE, MILLIPEDE, CRAB

Arthropoda

The phylum Arthropoda refers to the organisms with joint appendages. The word "Arthro" means "joint" and "Poda" means "legs"

I. **Habit and habitat:**

II. **Germ layers:** These are triploblastic in nature i.e body is made up of three germ layers. Outer germ layer is ectoderm, middle is mesoderm and inner is endoderm.

III. **Coelom:** True coelom is reduced to the cavities around gonads and visceral mass.

IV. **Body size and shape:** size varies from 1 mm to 13 feet. Body is segmented and have various shapes.

V. **Body Covering:** bodyhas thick chitinous cuticle, which form exoskeleton.

VI. **Organization**: They show an **organ grade** of organization.

VII. **Locomotion**: variety of joint appendages are there for locomotion

VIII. **Digestive system**: digestive tract is complete. Mouth has modified parts as Alimentary canal shows three different regions stomodaeum, mesenteron and proctodaeum.

IX. **Respiratory system**: respiration is through general body surface, or by gills in aquatic forms and by lungs or book lung in terrestrial forms.

X. **Circulatory System:** It is open type with heart and arteries with organs directly bathed in blood

XI. **Excretory System:** in aquatic forms excretion of ammonia directly takes place by diffusion through gills but in terrestrial forms excretion is done by malpighian tubules

XII. **Nervous system:** nervous system consists of primitive dorsal brain and ganglionated nerve chord.

XIII. **Reproductive system:** Sexes are separate with sexual dimorphism.

XIV. **Fertilization:** Fertilization is internal.

XV. **Development:** Development is direct or indirect

Palaemon (Prawn)

Systematic position

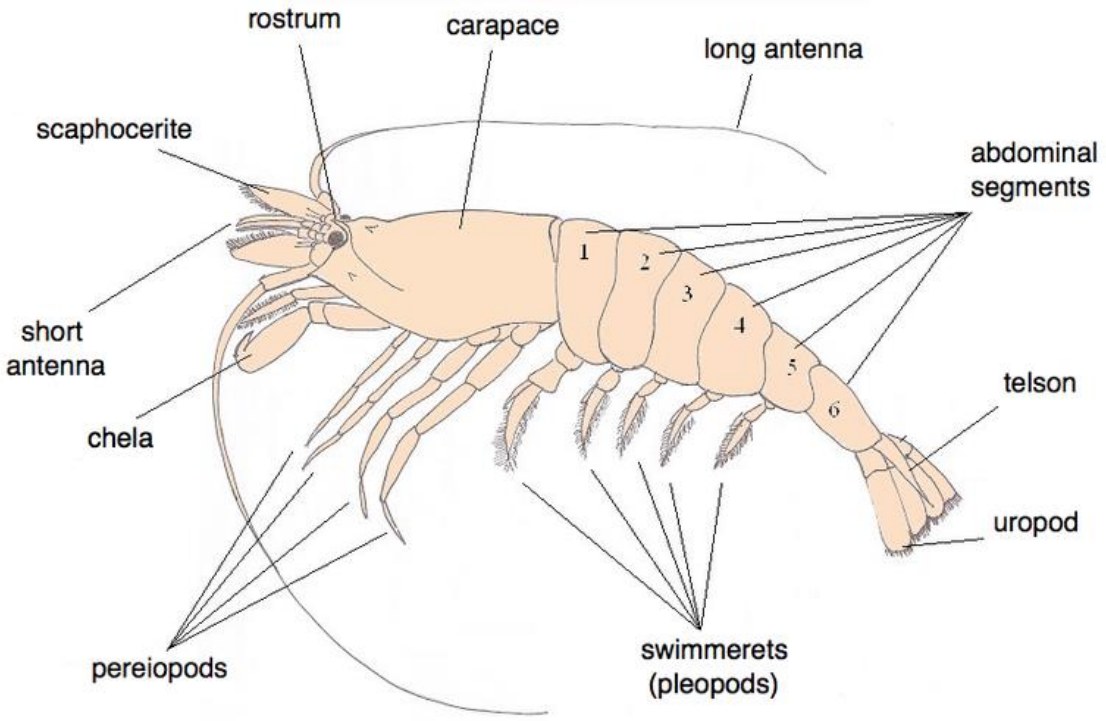
Kingdom: Animalia : Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum: Arthropoda: Triploblastic; jointed appendages; body divided into head thorax and abdomen

Class: Crustacea: head and thorax fused to form cephalothorax, thick exoskeleton

Order: Decapoda: ten pairs of appendages

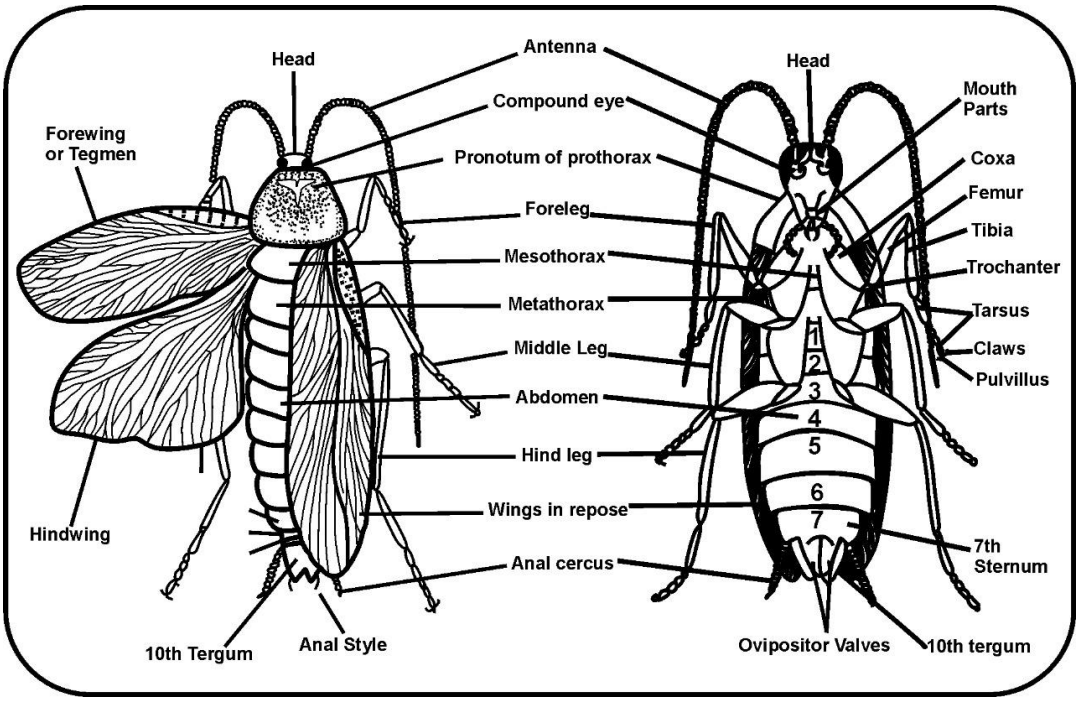
Genus: *Palaemon*



Comments:

1. It is commonly called as prawn. It is nocturnal and found in fresh waters of ponds, ditches, lakes etc.

2. Body is elongated and spindle shaped.
3. Body is divided into cephalothorax and abdomen.
4. Cephalothorax is formed by the fusion of five segments of head and eight segments of thorax.
5. Cephalothorax is rigid, without joints and is covered with a carapace.
6. Abdomen region is flexible and has six segments with movable joints.
7. Each segment of body bears a pair of appendages making all together 19 pairs.
8. These appendages are modified for various purposes like feeding, walking and swimming.



Male (Dorsal view) **Female (Ventral view)**

Periplaneta americana

Systematic position

Kingdom: Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum: Arthropoda: Triploblastic; jointed appendages; body divided into head thorax and abdomen

Class: Insect: three pairs of legs

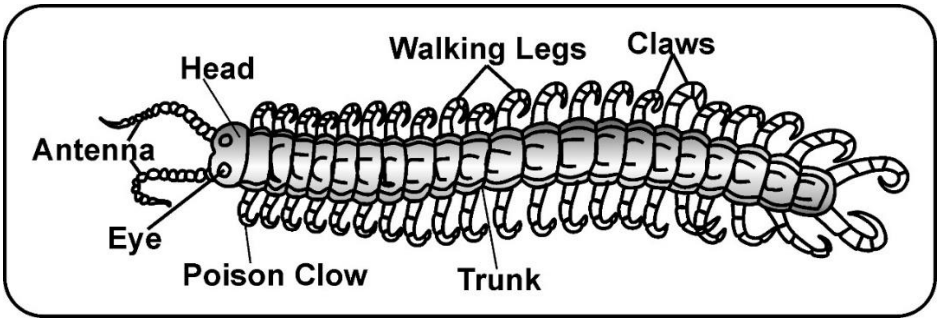
Genus: *Periplaneta*

Species: americana

Comments:

1. Its habitat is dark, warm and humid
2. Body is divided into head thorax and abdomen
3. Body is flattened with a perpendicular head.
4. Mouth is chewing and biting type.
5. Thorax is further divided into prothorax, mesothorax and metathorax. Each with a pair of legs
6. Two pairs of wings are there, fore wing (strong and mesothorasic) and hind wings (thin membranous and metathorasic).
7. Abdomen consists of 10 segments.

Scolopendra (Centipede)



Systematic position

Kingdom : Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum: Arthropoda: Triploblastic; jointed appendages; body divided into head thorax and abdomen

Class:Myriapoda

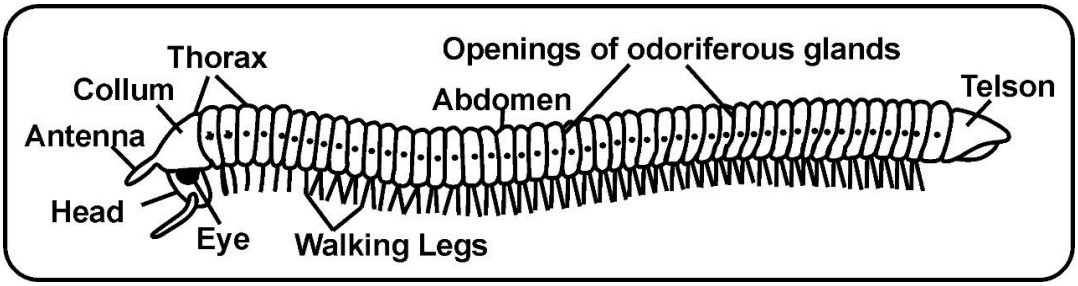
Genus:*Scolopendra*

Comments:

1. It is commonly called as centipede.
2. It is found in damp places like under the rock or logs and even in houses some times.
3. Body is elongated, segmented and dorsoventrally flattened.
4. Body is divided into head and trunk.
5. Head bears antennae, mandible and maxillae.
6. Many forms lack eyes but some forms possess clustered ocelli working as a compound eye.

7. There are 22 segments and each bears a pair of walking legs.
8. First pair of legs bears a sharp poisonous claw.
9. Poisonous and carnivorous form.

Julus (Millipede)



Systematic position

Kingdom: Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum: Arthropoda: Triploblastic; jointed appendages; body divided into head thorax and abdomen

Class: Diplopoda: trunk is segmented and each segment bears

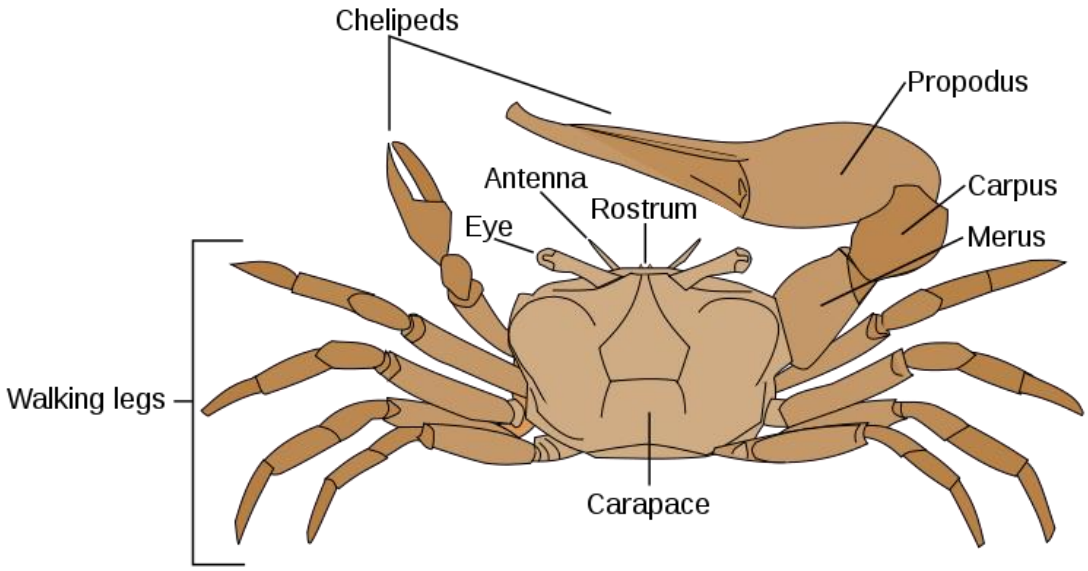
Genus: *Julus*

Comments:

1. It is commonly called as millipede.
2. Body is elongated, segmented and cylindrical.
3. Body is divided into head thorax and abdomen.
4. Head bears antennae, mandibles and maxillae.
5. Thorax bears four segments with a pair of walking legs in each segment.
6. Abdomen has 25-100 segments and each segment bears 2 pairs of walking legs.
7. Non poisonous herbivorous form.

Cancer (Crab)

Systematic position



Kingdom: Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum: Arthropoda: Triploblastic; jointed appendages; body divided into head thorax and abdomen

Class:Crustacean : Thick exoskeleton and cephalothorax (head fused with thorax)

Order:Decapoda: Ten pair of appendages and cephalo-thorax is covered by hard carapace.

Genus: *Cancer*

Comments:

1. It is commonly called as rock crab.
2. They are found beneath the rocks or buried in sand.
3. Body is dorsoventrally flattened and oval shaped.
4. Cephalothorax region is broad and large where as abdomen is highly reduced.
5. Body is covered by a carapace.
6. Eye stalk and antennae are present in the sockets in carapace.
7. Five pairs of thoracic legs are well developed and other pairs are reduced.

Practical No. 4

MUSEUM STUDY OF PHYLUM MOLLUSCA: PILA, CHITON, BIVALVE, OCTOPUS.

Mollusca

The phylum mollusca refer to the organisms with soft body. The word "Mollis" means "soft".

I. **Habitat:** They are mostly marine with few freshwater and moist soil living forms.

II. **Germ layers:** These are triploblastic in nature i.e body is made up of three germ layers. Outer germ layer is ectoderm, middle is mesoderm and inner is endoderm.

III. **Coelom:** Body cavity is true coelom though greatly reduced.

IV. **Body size and shape:** body is soft and divided into head visceral mass and foot. Body has bilateral symmetry.

V. **Body Covering:** A thin fleshy fold of dorsal body wall is called mantle which generally secretes the shell. Shell may be internal, external or completely absent. Some forms exhibit torsion of body along with shell.

VI. **Organization**: Organ system level organization can be seen.

VII. **Locomotion**: Muscular ventral foot helps in locomotion.

VIII. **Digestive system**: Digestive tract is complete. Buccal cavity has a specialized rasping organ called radula with transverse rows of teeth. Large digestive gland called hepato-pancreas is also present which helps in digestion and assimilation.

IX. **Respiratory system**: respiration in aquatic forms is by gills (ctinidia) in the mantle cavity and by lungs in terrestrial forms

X. **Circulatory System:** Open circulatory is present although 2-3 chambered heart is there with few arteries that drain into sinuses. Respiratory pigment, haemocyanin is also present.

XI. **Excretory System:** A pair of kidneys performs the task of excretion.

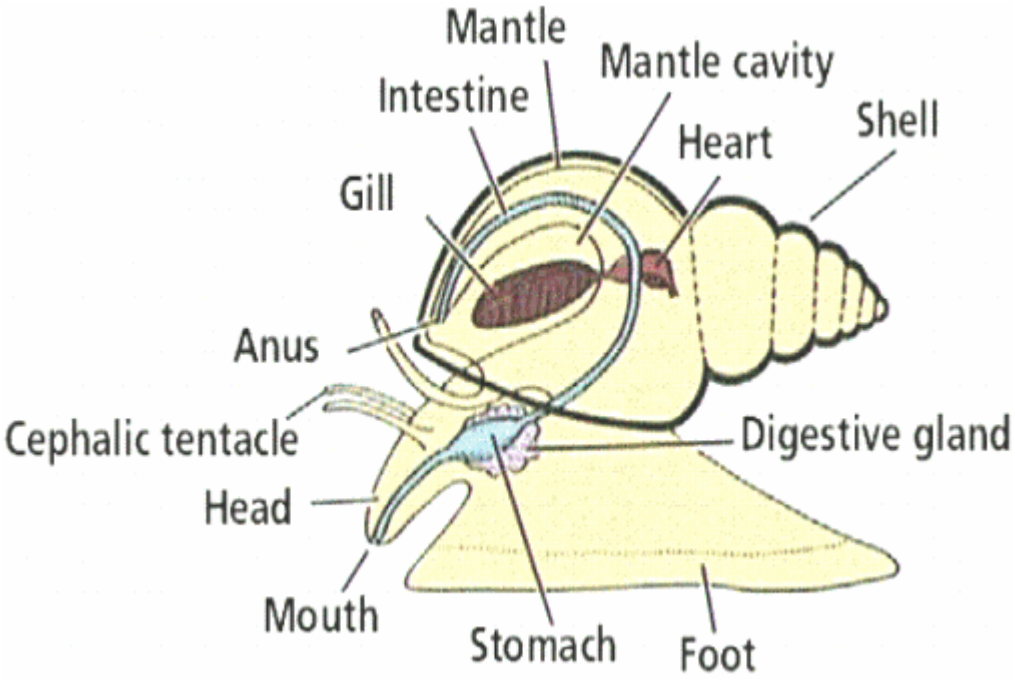
XII. **Nervous system:** Nervous system comprises of three paired ganglia (cerebral, pedal and visceral), connectives and nerves. Sense organ consists of statocyst, osphradium and eyes.

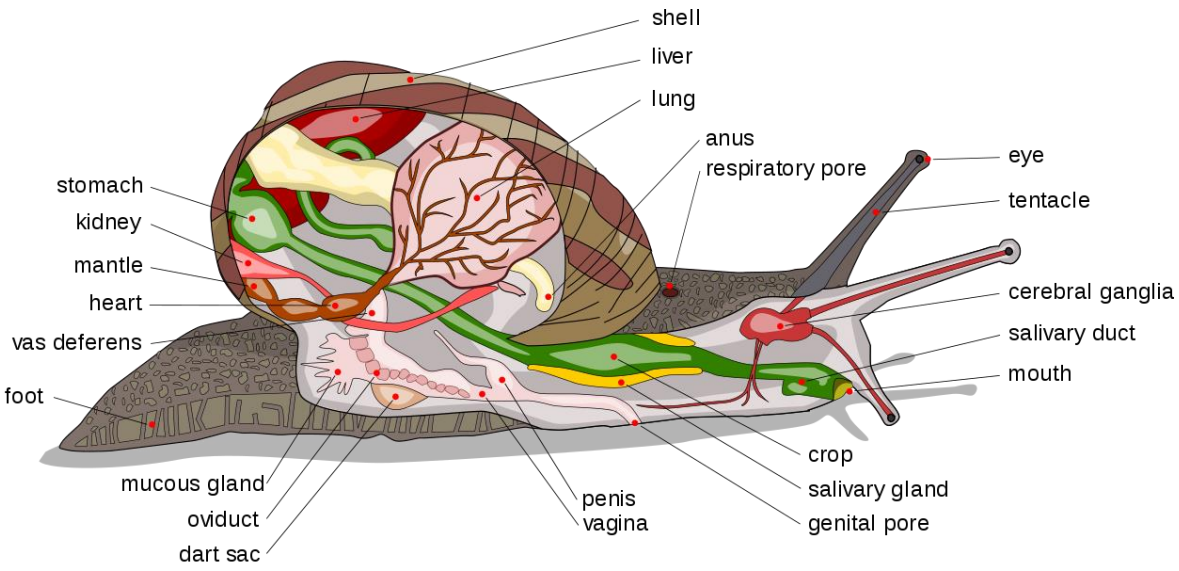
XIII. **Reproductive system:** Reproduction mode is sexual only. Sexes are generally separate

XIV. **Fertilization:** Fertilization is internal.

XV. **Development:** Development is direct or indirect. Indirect development include a glochidium or velinger larva.

Pila globose





Systematic position

Kingdom: Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum: Mollusca: Soft bodied; unsegmented; body consist of head, visceral mass, mantle and foot

Class: Gastropoda:spirally coiled shell; distinct head with eyes and tentacles

Genus: Pila

Species: globosa

Comments:

1. It is commonly named as apple snail.
2. One of the largest fresh water snail.
3. It is found in rivers, ponds, lakes and even in paddy fields.
4. Body is enclosed in a univalve spirally coiled shell.
5. Top portion of the shell is called as apex.
6. Lines of growth can be seen on the shell as whorls.
7. Body comprises of head, foot and visceral mass.
8. A distinct head bears eyes and two pairs of tentacles.
9. A large muscular foot assists in creeping.
10. Visceral mass is spirally coiled exhibiting torsion and bears all the main organs.
11. Mantle covers the visceral mass, forms respiratory siphon, and has shell glands which secrete the shell.

Chiton

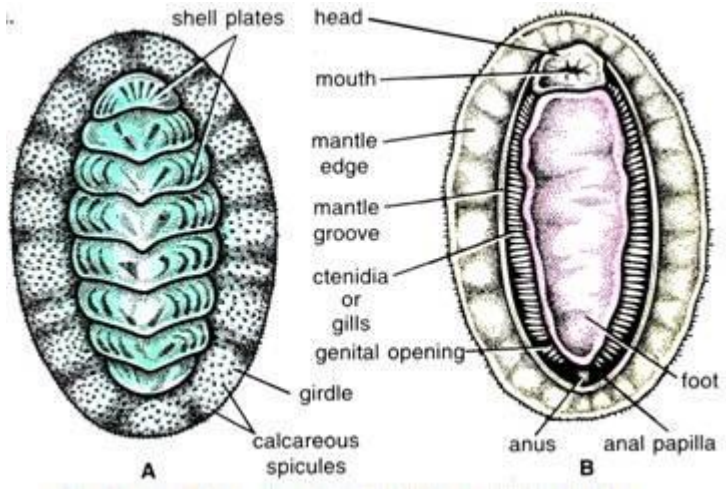


Fig. Chiton, Dorsal and ventral view

Systematic position

Kingdom: Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum: Mollusca: Soft bodied; unsegmented; body consist of head, visceral mass, mantle and foot

Class: Polyplacophora: shell comprises of eight calcareous plates; foot is flat and ventrally located.

Genus: *Chiton*

Comments:

1. It is commonly named as sea mice.
2. It is found in marine shallow waters attached to rocks or empty shells.
3. It is a dorsoventrally flattened mollusk with eight distinct overlapping calcareous shell plates on dorsal side.
4. Stiff mantle of *Chiton* helps in respiration and is termed as girdle.
5. Head is without eyes and tentacles.
6. Muscular foot is present on ventral side and helps in creeping.
7. Mouth and anus are present at the opposite ends.

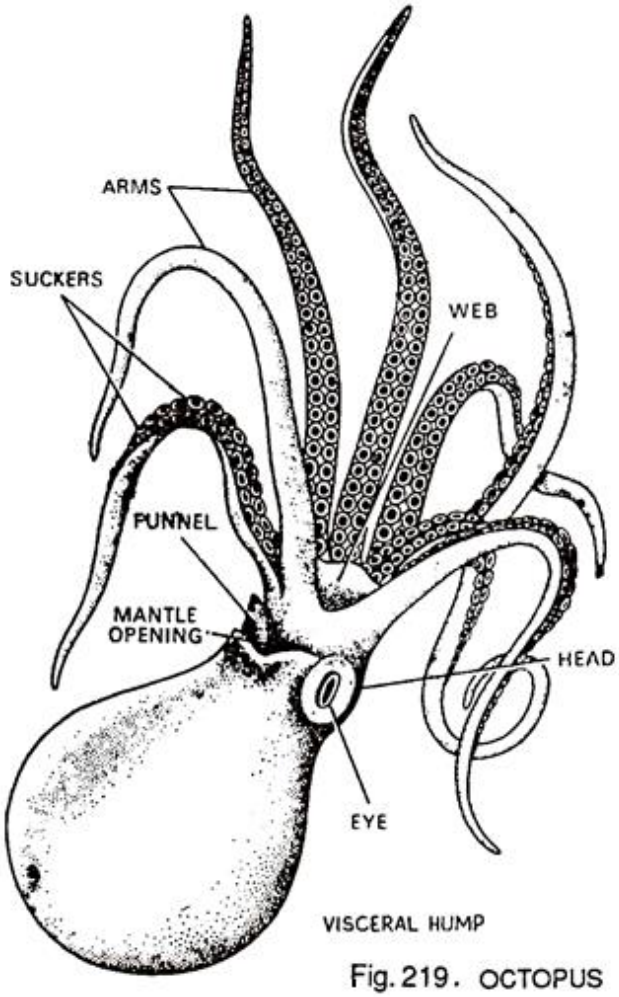


Fig. 219. OCTOPUS

Octopus

Systematic position

Kingdom: Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum: Mollusca: Soft bodied; unsegmented; body consist of head, visceral mass, mantle and foot

Class: Cephalopoda: body is divided into head and foot. Foot is modified into arms.

Order: Octapoda: eight arms

Genus: *Octopus*

Comments:

1. It is commonly called as devil fish.
2. It is found at sea bottom under rocks and crevices.
3. The soft body of octopus is divided into head and eight arms.
4. The head bears pair of eyes and appears enormous because of visceral hump.
5. Each arm has two rows of suckers.

6. Siphon expels the water and helps in swimming.
7. Mouth bears a sharp beak.
8. Ink gland ejects out a fluid which helps the octopus to escape when in danger.

***Unio* (Bivalve)**

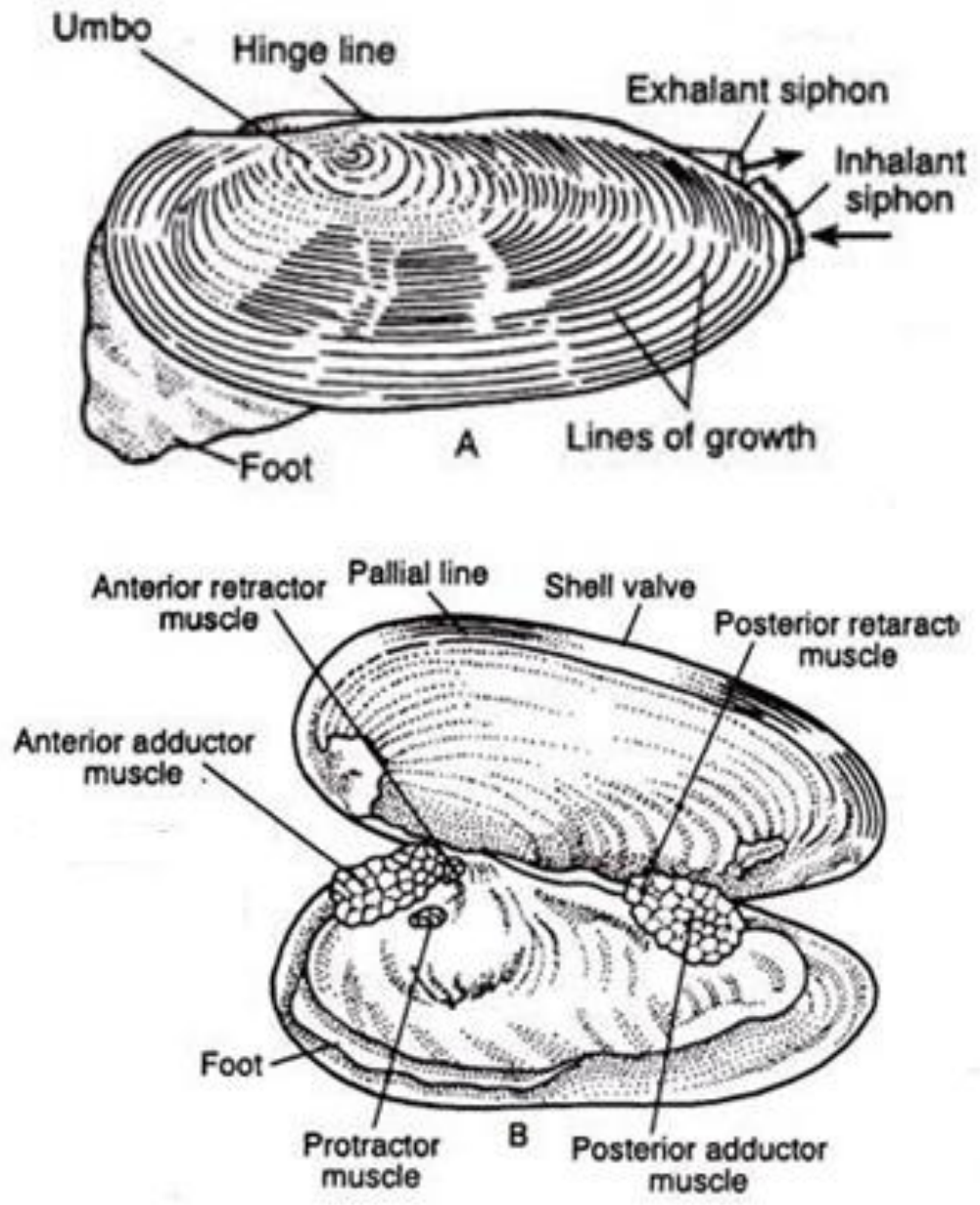


Fig. External features of Uno. A. Side view, B. Internal structure

Systematic position

Kingdom: Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum: Mollusca: Soft bodied; unsegmented; body consist of head, visceral mass, mantle and foot

Class: Pelecypoda: bivalve shell

Genus: Unio

Comments:

1. It is commonly called as fresh water mussel
2. Body is flattened and enclosed by a bivalve shell.
3. The two halves of the shell are joined together by a hinge ligament.
4. Mantle flaps form siphons.
5. Posterior and anterior abductor muscles regulate the opening and closing of shell.
6. A large muscular foot helps in burrowing.

PRACTICAL NO.5

MUSEUM STUDY OF PHYLUM ECHINODERMATA: SEA STAR, SEA URCHIN, BRITTLE STAR, SEA CUCUMBER.

Echinodermata

The phylum echinodermata refer to the organisms with spiny skin. The word "echino" means "spines" and "derma" means "skin".

I. **Habitat:** They are found in marine waters and can be seen in depths of oceans as well as in shallow inter tidal zones.

II. **Germ layers:** These are triploblastic in nature i.e body is made up of three germ layers. Outer germ layer is ectoderm, middle is mesoderm and inner is endoderm.

III. **Coelom:** Body cavity is true, spacious and has a peculiar water vascular system.

IV. **Body size and shape**: Body is unsegmented, radially symmetrical and lack head. Echinoderms exhibits various shapes like star shape, discoidal, flower shape, spherical, hemispherical or cylindrical.

V. **Body Covering:** Single layered epidermis is present which overlies a thick dermis.

VI. **Organization**: Organ level organization can be seen.

VII. **Locomotion**: Locomotion is done by tube feet powered by water vascular system.

VIII. **Skeleton system:** Endoskeleton is made up of calcareous plates with spines

IX. **Digestive system**: Digestive tract is complete

X. **Respiratory system**: Respiration takes place with tube feet and gills called, dermal papulae.

XI. **Circulatory System:** Circulatory system is open type and highly reduced

XII. **Excretory System:** Nitrogenous waste is eliminated by simple diffusion through papulae as there are no specialized excretory organs.

XIII. **Nervous system:** Nervous system is simple with a nerve ring and a radial nerve cord. No brain development is there.

XIV. **Reproductive system:** Reproduction is asexual (autotomy & regeneration) and sexual both. Sexes are separate without sexual dimorphism**.**

XV. **Fertilization:** Fertilization is internal.

XVI. **Development:** Development is indirect including minute ciliated transparent larvae.

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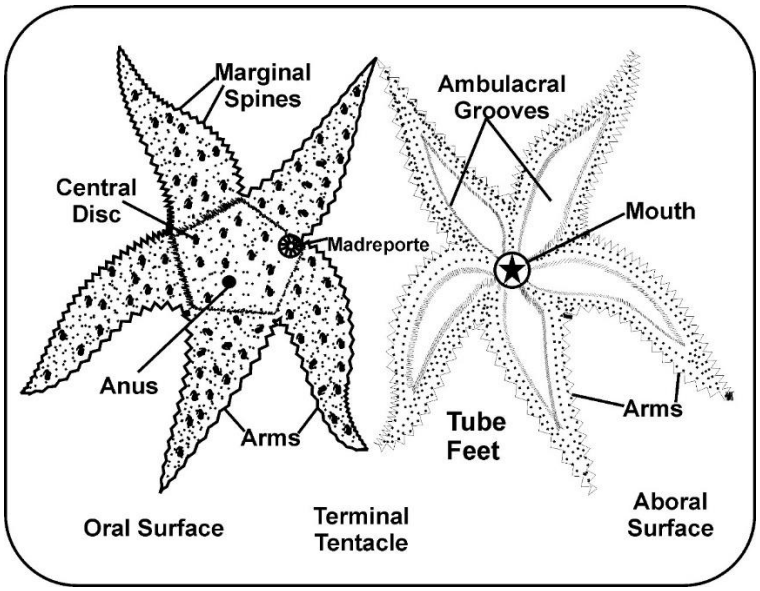
***Asterias (*Sea star)**



Systematic position

Kingdom: Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum: Echinodermata: Pentaradiate forms with spiny skin

Class:Asteroidea: Star shaped body without any distinct demarcation of arms from the disc.

Genus:*Asterias*

Comments:

1. It is commonly called a s star fish.

2. They can be found crawling on the rocky sea bottom.
3. Body comprises of a central disc with five radiating arms.
4. Mouth is present on the oral side.
5. Five ambulacral grooves radiate from the mouth towards the tip of the arms.
6. Each groove has two rows of tube feet, which helps in locomotion.
7. Aboral surface bears numerous spines and an anus at the center of the disc.

***Echinus* (Sea urchin)**

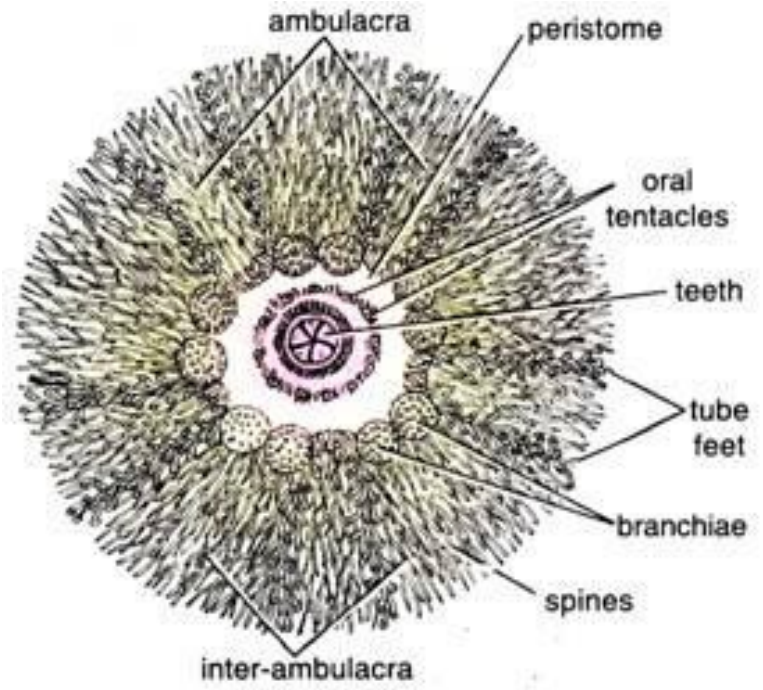


Fig. Echinus, oral view

Systematic position

Kingdom: Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum: Echinodermata:pentaradiate forms with spiny skin

Class: Echinoidea: body enclosed in a test and lack arms

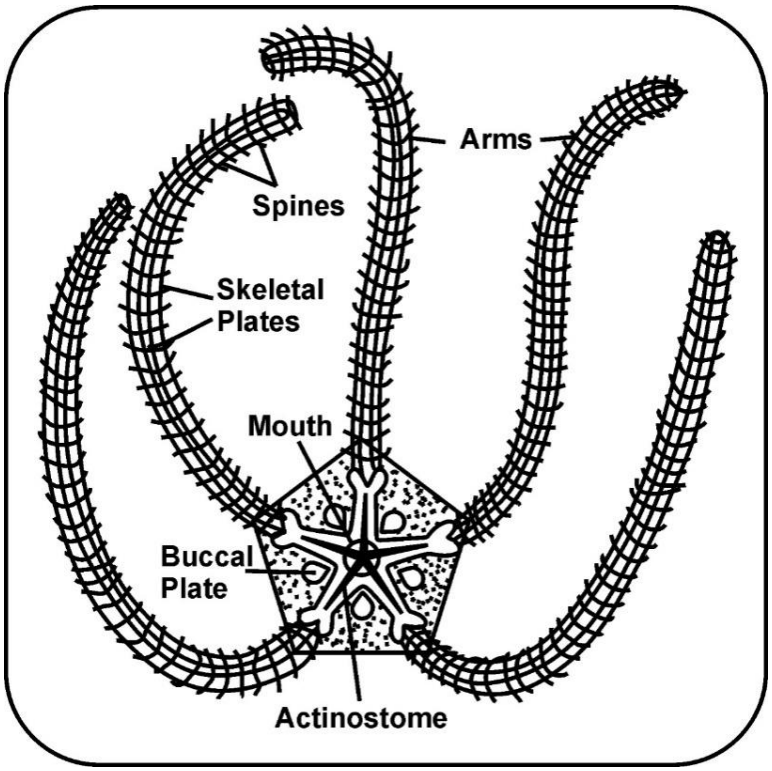
Genus: *Echinus*

Comments:

1. It is commonly called as Sea Urchin

2. It is found in marine waters with rocky base.
3. Bogy shape is globose as distinct arms were absent and is covered with movable spines.
4. Body is covered with a test of calcareous interlocking plates bearing five ambulacral grooves.
5. Tube feet are located in these ambulacral grooves.
6. Mouth is present at oral surface whereas anus is at aboral surface.

***Ophiothrix fragilis* (Brittle star)**



Systematic position

Kingdom: Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.

Phylum: Echinodermata: Pentaradiate forms with spiny skin

Class: Ophiuroidea: central disc with distinct arms; long sleek arms resembles serpents

Genus:Ophiothrix

Species: fragilis

Comments:

1. It is commonly called as brittle star due to the ease with which its arm fall when touched.
2. Body has a central disc with distinctly radiating slender arms.
3. Each arm is covered with plates fringed with spines.
4. Oral surface bears pentaradiate mouth with five movable plates and aboral surface bears anus.
5. At the base of each arm is a pair of grooves called bursal slit which releases the gametes in water.
6. Sexes are separate and fertilization is external.

***Holothuria* (Sea cucumber)**

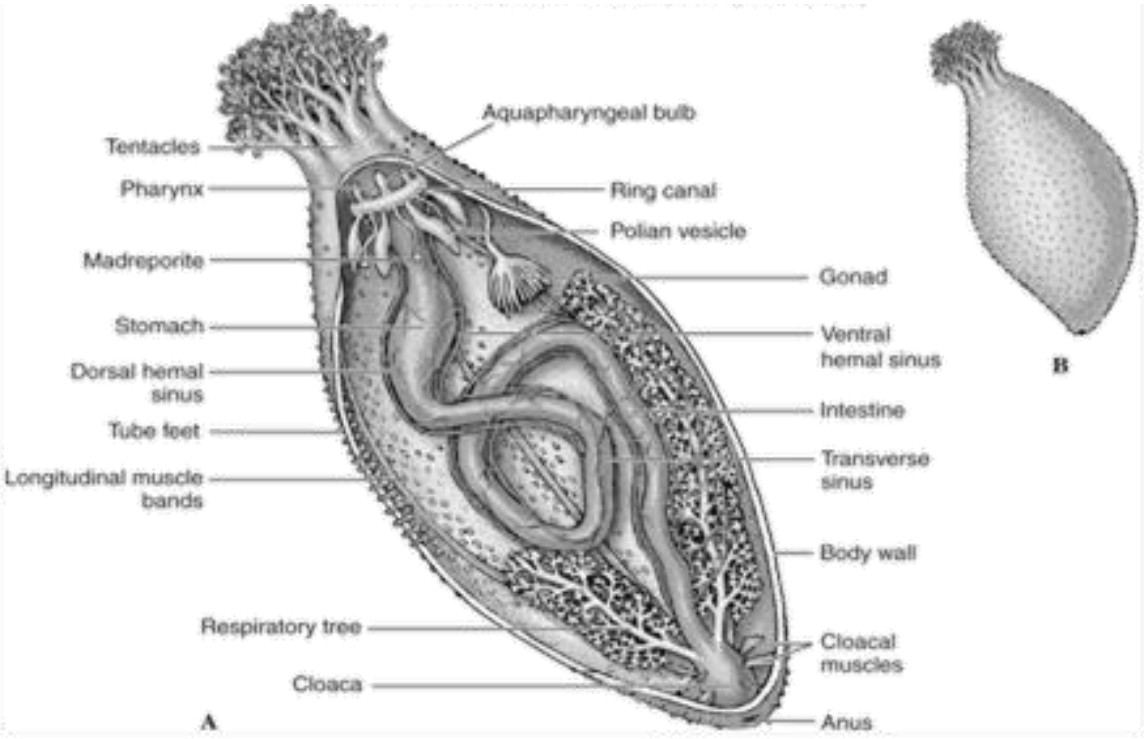


Fig. Sea cucumber A. Inside, B. External View**.**

Systematic Position

Kingdom: Animalia: Multicellular hetrotrophs with ingestion mode, nerve cell and muscle cells present.
Phylum: Echinodermata: Pentaradiate forms with spiny skin
Class:Holothuroidea: Cylindrical body without arms
Genus: *Holothuria*

Comments:

1. It is commonly called as sea cucumber.
2. Body is elongated and bears mouth and anus at opposite ends.
3. Mouth has circular lips and is surrounded by 15-30 tentacles.
4. Body covering has calcareous ossicles.
5. Arms are absent but retractile locomotory tube feet are present on all over ventral surface.

Practical No. 6:

Economic importance of honey bees, Lac insects silk worms, red cotton bug, Anopheles mosquito.

Importance of Honey bees:

Honey bees have the following importance.

(i) **Honey:** The honey is a neutral, natural valuable tonic for human body. Honey is a sweet, viscous edible fluid. Chemical composition of honey is (i) ash 1.00%, (ii) minerals (0.22 to 0.3 per cent), e.g., calcium, iron, phosphate and manganese, (iii) vitamins (0.2 to 0. 5 per cent), e.g., pantothenic acid, biotin, pyridoxine, choline, ascorbic acid, thiamine, riboflavin and niacin, (iv) Sugars (20 to 40 per cent), e.g., levulose (38.90%), dextose (21.28%), maltose (8.81 %) and sucrose (1.9%), (v) Water (60 – 80%), (vi) Amino acids, enzymes. Honey also contains pollen. The colour, flavour and smell of honey depend on the flowers from which nectar is collected. It is an energy rich food. One kilogram of honey contains 3200 calories. A number of Ayurvedic medicines are taken with honey.

(ii) **Bee wax:** Bee wax is made of secretion of worker bees' abdominal glands. It is a product of industrial importance. It is used in the manufacture of many items including cosmetics, shaving cream, face cream, ointments, plasters, carbon papers, pencils, electric goods, toothpaste, lotions, furniture-polishes, boot-polishes, protective coating, ink paints and candles. It is also used in model and mould making and in printing industry. It is also used in the laboratory for microtomy with the common wax for block preparation of the tissues.

Fig. yellow colored virgin bee wax.

(iii**) Pollination**: The honey bees are pollinators of many crop species such as sunflower, Brassica, apple and pear. The most important thing that bees do is pollinate. Pollination is needed for plants to reproduce, and so many plants depend on bees or other insects as pollinators. When a bee collects nectar and pollen from the flower of a plant, some pollen from the stamens—the male

reproductive organ of the flower—sticks to the hairs of her body. When she visits the next flower, some of this pollen is rubbed off onto the stigma, or tip of the pistil—the female reproductive organ of the flower. When this happens, fertilization is possible, and a fruit, carrying seeds, can develop.

Flowers that are visited more often by bees will produce larger and more uniform fruit than those visited less often. This beneficial effect of pollination is most obvious in tree fruit.

(iv) **Medicinal value:** A drug, prepared from the bodies of honey bees, is used in the treatment of Diphtheria and some other dangerous diseases. The venom of stings of honey bees has been used in the treatment of rheumatoid arthritis and snake bite.

Economic importance of LAC

1. Lac is a resinous exudation from the body of female scale insect. Since Vedic period, it has been in use in India.
2. Lac is the only known commercial resin of animal origin.
3. It is the hardened resin secreted by tiny lac insects belonging to a bug family.
4. To produce 1 kg of lac resin, around 300,000 insects lose their life. The lac insects yields - Resin, Lac dye, Lac wax.
5. Application of these products has been changing with time. Lac resin, dye etc. still find extensive use in Ayurveda and Siddha systems of medicine.
6. Since lac insects are cultured on host trees which are growing primarily in wasteland areas, promotion of lac and its culture can help in eco-system development as well as reasonably high economic returns.
7. It is a source of livelihood of tribal and poor inhabiting forest and sub-forest areas.
8. Lac is used in making toys, bracelets, sealing wax, gramophone records, bangles etc.
9. It is by the jewelers and goldsmiths as a filling material in the hollows of gold and silver ornaments.
10. It in the form of shellac is used as a furniture finish.
11. Waste materials produced during the process of stick lac are used for dying purpose.
12. Nail polish is a good example of the by-product of lac.

13. The fluid lac dye obtained by dissolving the crushed stick-lac in water is called Alakta or Alta. This dye is applied by Indian Hindu women on hands and sole of feet.
14. From the stick-lac (twigs encrusted with lac), shellac is obtained after purification. Shellac is used as coating for medicines.
15. In Ayurveda, Siddha and Unani system of medicine Lac is used for treatment of variety of diseases. In Ayurveda, Lac is considered astringent (Ras/taste), cool (Veerya/potency), and Pungent (Vipaka/post-digetsive effect). It balances pitta-kapha dosh and promotes strength. In Unani, Lac is considered tonic for liver, stomach and intestine.
16. India and Thailand are the two major producers of lac.
17. The main lac producing states in India are Chhattisgarh, Jharkhand , Madhya Pradesh, West Bengal, Uttar Pradesh, Orissa , Maharashtra and Gujarat.
18. The cultivation of lac is at present mainly confined to the conventional lac hosts trees of Palas ,Ber and Kusum.
19. At present total annual average production of stick lac in India is approximately 20-22 thousand tons which forms the raw material for lac industries.
20. Chhattisgarh ranks 1st among the states followed by Jharkhand , Madhya Pradesh Maharashtra and West Bengal.
21. These five states contribute around 95 % of the national lac production.
22. Nearly 75-80% of the finished product is exported and only a small portion nearly 20 to 25 % is consumed within the country.

Fig. Lac flex, harvested from lac stick.

Fig. Lac insect incrustation on plant twigs.

Fig. Kusumi lacincrestation (growth) on plant branches.

ECONOMIC IMPORTANCE OF RED COTTON BUG

Red cotton stainer, *Dysdercus cingulatus*

The cotton strainer are the most destructive cotton pest. The boll is the only part of the cotton plant that is attacked by *D. cingulatus*. Medium to large-sized nymphs and adults feed on seeds in developing cotton bolls. When the bolls are ripening and the carpels opening, the bug inserts the rostrum between the

carpels and sucks the juices from the soft and developed seeds, injuring the cotyledons and causing the seed to wither and the lint to be uniformly stained. In many cases the fiber does not mature and expand but remains adhered together causing the lint to become quite valueless.

Dysdercus species are thought to be the most serious pests of cotton. In piercing the boll they introduce microorganisms which cause the bolls to rot, or the lint to become discolored, hence the common name 'cotton stainers'; this greatly reduces yields in cotton-growing countries.

This insect has been a severe pest of oranges on occasions. In puncturing an orange, a cotton stainer often inserts its beak full length with no visible wound; nevertheless, a single puncture may cause the orange to drop in a few hours from the tree and to decay in one or two days.

Some other hosts of *Dysdercus suturellus* include tangerines, okra pods, ripe papaya fruit, pods and blossoms of oleander, seed pods of tree hibiscus (*Hibiscus syriacus*), rose buds and blossoms, eggplant, nightshade, and guava.

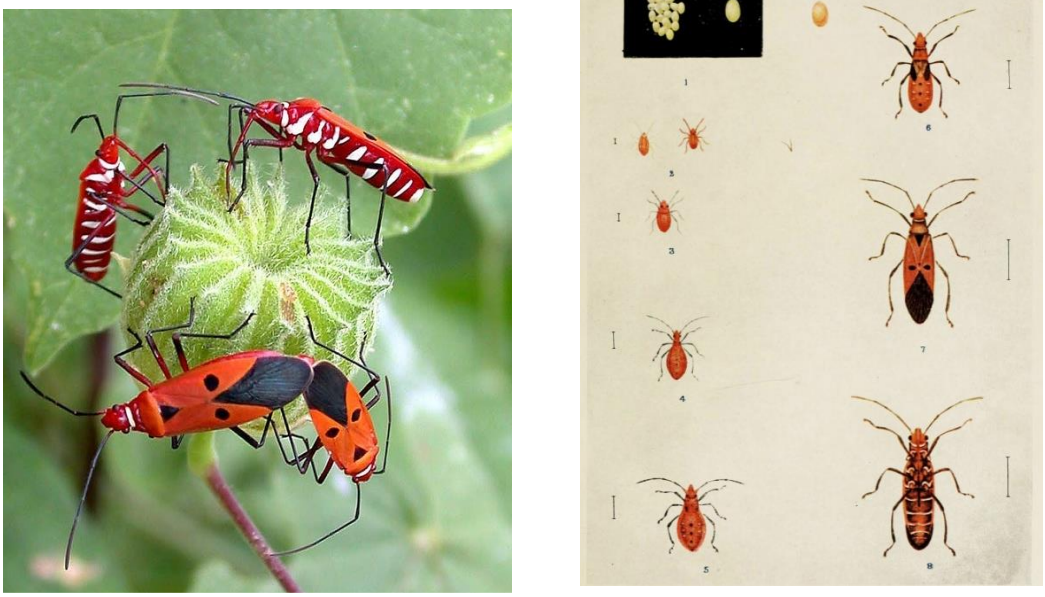


Fig. Red cotton bug feeding on ball, life stages of cotton bug.

ECONOMIC IMPORTANCE OF ANOPHELES MOSQUITO

Aside from the irritation and annoyance that mosquitoes inflict on humans and livestock alike, the threat of disease pathogen transmission is always present. Mosquitoes are potent vectors of three types of organisms pathogenic to man and animals. These are (1) the plasmodia, causal organisms of the malarias, belonging to the Protozoa; (2) filarial worms of the genera *Wuchereria*,

Brugiaand Dirofilaria, the causal organisms of human lymphatic filariasis and dog heartworm; (3) viruses, especially the arbo viruses causing such important diseases as yellow fever, dengue fever, and the encephalitides (Western Equine encephalitis, Eastern Equine encephalitis, St Louis Encephalitis).

Fig. Anopheles Mosquito (Female), Anopheles species feeding on human blood.

The largest and most studied negative effect of Anopheles on humans is its role as the primary vector of malaria. Anopheles is the primary vector of the most pathogenic agent of malaria, *Plasmodium falciparum*, along with the less pathogenic strains, *Plasmodium vivax* and *Plasmodium malariae*.

On a worldwide basis, malaria remains the most important human disease transmitted by mosquitoes. It is estimated that there are 400 million human cases of malaria in the world (mostly in Asia and Africa), with over two million human deaths annually. Most of the deaths are children under 10 years of age. In Africa, more than one in every 20 children dies from malaria. It is believed that malaria was introduced into the North American continent during colonial days. Tens of thousands of cases occurred in the U.S. before the 1930s, but there are no reliable statistics available for the period. In the 1930s, approximately 100,000 cases were reported annually; in the early 1940s, the number of cases was reduced dramatically due to the work of public health agencies using DDT during and after World War II and to the Tennessee Valley Authority (TVA) source reduction program.

Human malaria is caused by any of four species of Plasmodium, a protozoan parasite that causes fever, chills, sweating, and headache. Anemia results from destruction of red blood cells by malaria parasites in their various stages. If not treated, it may cause shock, renal failure, acute encephalitis, coma, and death. The four human malaria parasites are: Plasmodium falciparum; most severe form; circumtropical; resistant strains exist P. vivax; tropical and

temperate zones P. malariae; Africa and SE Asia; also in chimpanzees P. ovale; mildest, rarest form; West African coast. The disease is transmitted by several species of Anopheles mosquitoes. In the eastern U.S., some members of the An. quadrimaculatus species complex are important vectors. Another species, An. crucians, is also a vector but probably to a lesser degree. In the western U.S., the major vectors are An. hermsi and An. freeborni. These species are widespread and are most abundant from April through September. Worldwide, approximately 85 – 90 of the 370Anophelesspecies are vectors of malaria. In malaria, the mosquito is an obligatory vector, in which the parasite must complete part of its life cycle in the mosquito and part in the human host. An infected female Anopheles mosquito injects the asexual form of the parasite (sporozoites) into a person's blood stream as she feeds. The sporozoites travel through the blood stream to the liver, entering the liver cells. After 6 to 25 days, merozoites are formed and leave the liver to enter the bloodstream and attack the red blood cells. This developmental stage is called the trophozoite. As the trophozoite grows it destroys its red blood cell to release merozoites that invade more red blood cells. This produces the fevers and chills associated with malaria as these parasites and their toxins are released into the bloodstream periodically. Male and female gametocytes of the parasite are also released from the red blood cells and are then ingested by another female Anopheles mosquito when she bites a victim. In the mosquito, the gametocytes (the sexual forms of the malaria parasite) unite to form a zygote which then travels to the wall of the mosquito's gut, penetrates the lining cells, and comes to rest on the outer wall of the gut. The resulting oocyst begins producing sporozoites. The sporozoites invade the salivary glands of the mosquito where they are injected into the next host for the cycle to repeat. Eradication of malaria in most areas is made more difficult by vectors becoming resistant to pesticides, resistance to antimalarial drugs in some areas, lack of skilled vector control workers, and lack of drugs and resources. The spread of malaria parasites is facilitated by the ease of worldwide travel these days. Other factors influencing the spread of malaria include vector capability and longevity, anthropophilic tendencies, population density, education of the public, use of antimalarial chemoprophylaxis, chemical, physical, and cultural (i.e., screens on windows) vector control methods, and access to medical care.

Anopheles species are also a vector for other diseases, including Cache Valley virus. The disease rarely is diagnosed in humans; infections primarily afflict sheep, along with other livestock, such as cows, horses, and small ruminants.

Whether this mosquito is the primary vector for Cache Valley virus. The mosquito also carries West Nile virus, which can cause death in humans and other animals, including dogs, cats, horses, and birds.

Anopheles quadrimaculatus also is a common vector of *Dirofilariaimmitis*, which is the agent that causes heartworm in dogs and cats. This disease can seriously harm household pets, and a great deal of money is spent on its prevention and treatment.Because *A. quadrimaculatus* and other mosquito species are vectors for several serious diseases, methods of reducing their populations have been implemented, such as minimizing breeding habitats (stagnant water) and applying insecticides.

Practical No. 7

Earthworm: Vermi-composting bin preparation and maintenance.

vermicomposting uses earthworms and other microorganisms to digest organic wastes, such as kitchen scraps. Vermicomposting is faster than traditional composting methods, requires less space, and creates little odor. Making a "worm bin" stocked with composting worms and feeding them plant scraps from the kitchen and garden is a convenient, low-maintenance waste-processing method usable almost anywhere people live, including urban environments. Vermicomposting is an easy way to make a positive environmental impact by reducing the amount of green-waste that finds its way into landfills, incinerators, and sometimes the ocean. The resulting nutrient-rich compost end product is an environmentally sound amendment to enrich soil for plant growth.

Composting with worms is practiced all over the world. Composting and soil-dwelling worms are not the same—they are related species, but they have different roles in nature. Any worms that are naturally attracted to fresh organic wastes can be used in a vermicomposting system.

Vermicomposting is a promising biotechnology for many waste management applications. The description here of a small-scale vermicomposting system is meant to introduce the basic principles of vermicomposting.

The most familiar worms are soil- dwelling worms, and their primary job is soil aeration. Commonly known as "earthworms," they live 2–8 inches down in the soil. If you dig a hole in your garden and found a large worm, it is most likely a soil-dweller.

Soil worms eat soil minerals and some organic matter in the soil or on its surface. They prefer the cooler temperatures found in the soil and often come to the surface to consume organic matter after a heavy rain. Soil worms require soil to survive—do not put them in a worm bin. It is difficult to duplicate their preferred environment in a worm bin, and they will not process food scraps as effectively as compost worms.

The primary job of compost worms is composting. *Perionyx excavatus* worms, for example, are small, red- purple worms that prefer an environment of decaying organic matter rather than soil. Compost worms reproduce quickly, consume large amounts of organic material, and tolerate the environment of a worm bin.

The worm bin

Some type of container is needed to house compost worms for vermicomposting. Systems can be as simple as a stack of plastic food-storage containers or as complex as an automated unit capable of processing hundreds of pounds of organic matter daily. Generally, each square foot of bin area can process 1 pound of food waste per week.

Preparing the bin

Worms need bedding in addition to food. Shredded paper or newspaper, coir (coconut husk fiber), and shredded cardboard are good bedding materials for worm composting. Soak the bedding well with clean water and then squeeze it to remove excess liquid. The bedding should be damp, like a wrung-out sponge. Here are basic directions for a stacked worm bin system with three bins:

- Spread a 1-2 inch layer of damp bedding on the bot¬tom of the top bin (the middle bin is empty).
- Add compost worms to the bedding; you do not need to spread them out.
- Add a small amount of food scraps to the bin, about 1-2 cups.
- Cover the scraps with another layer of damp bedding. Do not block the side air vents. Make sure all food scraps are covered with bedding material.
- Replace the lid. Excess moisture will drain to the lower bin. Remove any excess liquid from the lower bin as it accumulates (use it in your garden or outdoor compost pile).
- Make note of the date you started the worm bin.
- If you purchased the worm bin, follow the directions that came with it.

Bin maintenance

The worms will get settled in their new home, your worm bin. Worm eggs (cocoons) in the worm "starter" (inoculant) will hatch. Feed the worms a small amount (1-2 cups of kitchen fruit and vegetable scraps) when you start a bin and then nothing for two weeks. This helps the worm population to begin to grow without initially overwhelming the system. As the mature worms eat and grow, they will begin to lay eggs. Juvenile worms will appear, and the population will increase. In about 6 weeks, the immature worms will be mature and lay eggs of their own. Observing this population explosion can be an exciting and fascinating biology lesson.

You will notice worm castings (rich, gray-brown, soil-like material) in the bin. The worms produce castings as they eat, filling the bin as they go. Continue feeding the worms. If you purchased a worm bin system, follow the directions, because feeding schedules and amounts vary from model to model. When the worms have worked through the green waste, you will be left with rich, organic worm compost, ready to enrich your garden soil.

Over time, you may wish to buy another set of bins or share worms with your friends to start bins of their own. Compost worms will never "outgrow" your bin. If the population gets too large, the worms will stop reproducing and their numbers will decrease naturally according to the bin size and the food supply.

Worms like the "3 Ds"

Damp, Dark, and Dinner! First, worm bin bedding should be damp, like a wrung-out sponge, but not soggy. Worms will die or try to escape if the bin is too wet or dry. Check the drainage holes and clear any clogs with a toothpick.

Second, worms are sensitive to light and should be kept in a dark environment. In commercial stacking bin sys¬tems, the two bins that hold worms are dark-tinted. If worms are trying to escape, it is a signal that conditions are not ideal inside the bin (see the troubleshooting table on page 3 for help).

And finally, dinner—worms love to eat! Check the bin contents. Spread the feedings around to encourage worm population growth. Watch food disappear: some things will go faster than others, and useful worm castings and compost will be left. Worms eat best when the bin system is well maintained. A pound of worms can eat up to 2 pounds of food scraps each day. As the worm population grows, the amount of food that you can give them increases.

Temperature and ventilation

Compost worms can tolerate a wide range of temperatures, but most work best at temperatures between 70 and 80°F. The worms available locally are suited to our warm climate. Keep the bins out of direct sunlight (a covered porch or carport is a good location). Temperatures inside the bin are generally lower than the surrounding air because the bedding is moist and evaporation creates a cooling effect, creating a mini weather system in the bin. Ventilation, in the form of air vents, keeps oxygen in the bin. Worms

need oxygen and produce carbon dioxide, just like we do. Each time you open the bin to feed the worms you also refresh the air in the bin.

Acidity

Compost worms tolerate a wide range of acidity in their environment, but the ones found here prefer a just slightly acidic condition. It is possible for a bin to become too acidic, killing adult worms and preventing eggs from hatching. To be safe, limit amounts of acidic food scraps, such as pineapple, citrus, and tomatoes.

Other organisms associated with compost

Depending on where you keep your bin, you may notice other critters in with the worms. These worm "friends" are usually beneficial organisms in small numbers; they include springtails, mites, rove beetles, and millipedes, as well as microscopic bacteria and fungi, and these associated organisms enhance the composting process. Centipedes, however, are predators and should not be in your worm bin—if you find one, remove it carefully to avoid being bitten.

Using the compost

In a stacking bin system with bins that are rotated, the worms will feed on organic material in the middle bin. After the conversion to compost is finished, the worms will be attracted to the new feeding bin above them by the food added to it. A few worms may remain in the old bin to finish consuming all the available food before it becomes finished compost. Eventually, all the worms will leave, moving to the new feeding bin above, and you will be left with finished worm compost.

A good potting soil recipe is 1 part vermicompost and 3 parts soil. Vermicompost is best used moist, as it loses nutrients as it dries. In the garden, use it at root level, digging it into the soil. The liquid that drains into the lowest bin is called leachate. It is not uncommon for it to have a slight odor. It can be used full-strength or mixed with water. Use it to water plants or dispose of it on your compost pile. Worm compost "tea" is made from finished compost and involves a separate process.

Worm bin troubleshooting

Problems	Causes	Solutions
Bin smells bad	Overfeeding	Stop feeding for two weeks.
	Food scraps exposed	Bury food completely.
	Bin too wet	Mix in dry bedding; leave lid off.
	Not enough air	Fluff bedding; clear drainage

		holes.
Bin attracts flies	Food scraps exposed	Bury food completely.
	Rotten food	Cover with clean bedding.
	Too much food; esp. citrus	Don't overfeed worms.
	Black soldier fly larvae*	Pick out larvae, add them to backyard compost pile; bury food completely;
	Black soldier fly adults*	reduce acidic foods. Release from bin.
Bin attracts ants, centipedes		Remove centipedes; change bin location.
Worms are dying or crawling away	Bin too wet	Mix in dry bedding; leave lid off.
	Bin too dry	Thoroughly dampen bedding.
	Extreme temperatures	Move bin to 70–80˚F location.
	Not enough air	Fluff bedding, check for blocked vents.
	Not enough food	Add more bedding and more food scraps.
	Bin conditions not right	See above; leave lid off (worms will burrow into bedding).
Excess mold	Conditions too acidic	Cut back on acidic foods.
Bedding drying out	Too much ventilation	Dampen bedding; keep lid on.
	Extreme temperatures	Move bin to 70–80˚F location.
Excess drainage	Poor ventilation	Fluff bedding; add dry bedding.
	Too much water in food	Cut back on coffee grounds and watery scraps

Note: Flies are naturally occurring pests that can be avoided if food is buried. Black soldier flies can be beneficial insects that assist in rapid decomposition of organic materials, but they compete with worms for food in a vermicomposting bin. The adults look like black wasps but are harmless. Remove the larvae and add them to your backyard compost pile, where they will assist in the composting process.

	
Vermicomposter with three nesting bins. Bottom bin collects drainage. Initially, bedding, food, and starter worms are placed in the top bin, while the centre bin remains empty.	Top bin prepared with bedding and food scraps. Bins shown are approximately 17 x 12 inches.
	
Bottom of bin, with drainage holes. The top and center bins have holes; they also have holes in the sides for ventilation.	Finished compost, a uniform, loamy material in which no food scraps are identifiable.

	**Worm composting** is easy, fun, and educational. If done correctly, the composting system will have a pleasant, earthy smell. Infact, the worms eat the bacteria that cause bad odors. If there is a smell, conditions are not right in the bin (see the troubleshooting table on page4).Check the drainage bin regularly. Worm leachate should be discarded and never allowed to back up into the center bin. Always bury the food scraps in the bedding, and spread the food around. Should fruit fly maggots or adults appear, stop adding feed for a week. Harvest the bin when most of the bedding material has been converted to vermicompost and looks like soil. ***Be sanitary—wash your hands after working with a worm bin.***
Bottom bin has no holes, so drainage water is contained and can be added to compost or used for irrigating plants.	Ref: Piper Selden et al (2005), Small-Scale Vermicomposting. *Home Garden*, Aug.2005

Practical no. 8

Vermicomposting Unit Visit sites.

There are many vermicomposting unit commercially operating in Maharashtra. With little efforts and internet research you can find nearby vermicomposting production facility. Here given details of some nearby vermicomposting units.

Rushabh Dairy & Agro Farm Tech

Amar Shah
Village Japada, Near Paradise Resort, Padgha, Tal. Bhiwandi
Padgha.
Thane - 421101, Maharashtra, India

Product Specification

Grade Standard	Feed Grade
Product Type	Vermicompost
Purity	100 %
Speciality	Enriched nutrients, Optimum freshness

Product Description

Enriched by our vast industrial experience in this business, we are involved in offering an enormous quality range of **Vermi Culture.**

About the Company

Year of Establishment2012
Legal Status of FirmSole Proprietorship (Individual)
Nature of BusinessManufacturer
Number of Employees11 to 25 People
Annual TurnoverUptoRs. 50 Lakh
IndiaMART Member SinceAug 2012

Established in the year **2012** at **Near Paradise Resort, Maharashtra,** we **"Rushabh Dairy & Agro Farm Tech"** are a **Sole Proprietorship** based firm, engaged as the foremost **manufacturer** of **Vermi Culture, Organic Manure, Phosphate Fertilizer, Vermi Bed, Vermicompost Fertilizer, Organic Fertilizer, Animal Fodder,** etc. Our products are high in demand due to their affordable prices. Furthermore, we ensure to timely deliver these products to our clients, through this we have gained a huge clients base in the market.

Green Rise Agro Industries
Hadapsar, Pune, Maharashtra

Established in **2010, Green Rise Agro Industries** is the leading **Manufacturer, and, Wholesaler** of **Organic Fertilizer and Manure, Fulvic Acid, Potassium Humate etc.** These products are immensely demanded in the market owing to the features like environment friendliness, longer shelf life, effectiveness, precise pH value, accurate composition and non-hazardous nature.
Under the proficient management of our mentor, **Mr. ChandrakantJadhav**, we have become a renowned organization in this domain.
About Company
Nature of BusinessManufacturer
Total Number of EmployeesUpto 10 People
Year of Establishment2010
Legal Status of FirmPartnership
Annual TurnoverRs. 50 Lakh - 1 Crore
GST No.27AARFG7173R1ZA
Green Rise Agro Industries is the leading **Manufacturer** of **Organic Fertilizer And Wholesaler of Potassium Humate,Fulvic Acid, etc.**

Reach Us
ChandrakantJadhav (Partner)
Survey No. 13, Office No. 6, Shivanand Complex, Satavwadi Hadapsar, Pune- 411028, Maharashtra, IndiaCall Us 08048732744

Practical No. 9.

Field visit for Insect pest collection and identification

There is an increasing trend to discourage collection and preservation of biological organisms including insects and their relatives. Although insects can be studied and enjoyed without killing them using observation and photographic methods, there are a number of reasons or benefits from procuring specimens

COLLECTING EQUIPMENT

1. **Insect Boxes**
2. **Insect Pins** size 2 insect pins
3. **Forceps** 2 pairs of fine (jeweller's style) forceps.
4. **Insect Nets two nets, one** 12" diameter nets, one with a medium sweep bag, another with an aerial bag (7612NA @ $11.50). With wooden handles, or light-weight nets with aluminum handles.
5. **Kill Jars** one large 32 oz. jar, one 16 oz. jars, three or four pocket collecting jars with ethyl acetate (held in absorbent cotton) as killing agent.
6. **Other equipment needs**

Other supplies that you are responsible for procuring include:

1 pair of scissors (for cutting labels)

1 collecting bag (a shoulder bag is preferable so that you have easy access to vials, kill jars, etc.)

1 Marker pen (for writing labels; 0.25 mm or finer; indelible ink)

1 hardcover field notebook

Collecting insects

There are many methods of collectiong insects but only important methods and the necessary equipments are given here.

Hand picking: in this method insects are directly hand picked up by hands and placed in container. This method is used for collecting large insects such as beetles, bugs and grasshoopers.

Insect net: it is a light cloth bag hang in round or tranguler loop that attached to stick as handle. It is used for collecting flying insects such as butteflyies, moths dragonflies, wasps and otherlarged flying insects.

Swapping: here sweep net is used to collect insects from the bushes and plants. This net is swaped through herbage and after few stocks grasshoopers, bugs and other hopping insects are collected in the net.

Trapping: In this method different types of traps are designed to collect nectsspecially at night. Light trap is used to collect nocturnal insects like moths, midges, some beetles and delicate lacewings. It consist of light source, net and collecting container. Sticky traps are useful for collecting both diurnal and nocturnal insects. When insect Crawl on this sticky surface they stick up and can be collected in jars. Water traps consist of shallow tray containing water. Few drops of detergent is added in water to break the surface tension and insect sink to the bottom. Pitfall traps are designed for crawling and running insects like ground beetles. It consists of rectangular tough which either open or has a lid with large central hole. The trap is buried so that the top is at the ground level. Baits and bait-traps are special traps in which an attractive substance is placed which will lure insect into the trap. Sweet and fermenting, baits, decaying and over-ripe fruits, honey, syrup, etc. may be used in such traps and will attract any of the insects that normally visit flowers. A suitable bait for houseflies is decaying meat or fish. Some baited traps are made in the form of wire cages. The general principle is that the insects are attracted to the bait in a shallow container, and then when they rise up after feeding they enter a wire enclosure from which escape is difficult.

Pond net. Aquatic species of insects may be collected with a pond net. A pond net is made of tine nylon netting, usually smaller than a butterfly net but having a long handle, The loop should not be circular, but either square or semi-circular. The net is put into the water at various depths and then pulled quickly to the surface. When the water drains off, the insects left behind in the net are collected.

Collecting insects from debris. A very large number of small insects live in debris of leaf-mould, decaying vegetation, rotten wood, etc., and to capture them a sifter is used. Any container with a wire-mesh bottom Neill serve as a sifter. The ground litter is put in the sifter and shaken gently over a piece of with cloth. As the insects fall onto the cloth they may he easily captured with an aspirator or forceps. A modification of this is a separator, usually called a Berlese funnel. This consists of a funnel over which a sieve containing the litter may he placed. Immediately over the sieve an electric lamp is fitted. The funnel leads into a receiver containing liquid preservative. As the debris dries the

insects gradually move downwards to the conditions that they prefer and fall down the funnel into the preservative. The heat must be applied gradually, so that the insects are not harmed.

Pest Insect Identification

An important part of dealing with the insect is identification. Identification to group level is some time adequate but usually it is necessary to be more precise than this. Many features of body form and structure are used in identifying insects. Considering the great diversity in body parts, initial insect morphology knowledge is desirable.

A pest can be identified only with the help of key. This key given here to identify a number of nine or ten different insect specimens to their orders commonly found around. Read the instruction given in introduction to the key carefully before you start. To reach the correct answer it is essential to work slowly and carefully and only to move on to the next step when you are certain that you have the correct interpretation of the previous one. Begin with number one and decide which of the two options **a** or**b**, fits the insect in question. Whichever one you choose will either reveal the order or direct you to another part of the key, and so on, until the order is disclosed. Some orders have members that are both Winged and wingless, hence are listed twice in the key.

1. Does the insect have wings?

(a) Yes Go to # 2

(b) No Go to # 17

2. How many pairs of wings does the insect have?

(a) One Diptera

(b) Two Go to # 3

3. Do the two pairs of wings differ greatly in structure, the first pair being thick and hard or leathery?

(a) Yes Go to # 4

(b) No Go to # 7

4. Is the first pair of wings rigid, and do they meet in a straight line down the middle of the back?

(a) Yes Go to #5

(b) No Go to # 6

5. Is there a pair of prominent pincerlike cerci at the tip of the abdomen?

(a) Yes Dermaptera

(b) No Coleoptera

6. Does the insect have:

(a) chewing mouth parts, front wings leathery and heavily veined, and hind wings folded like a fan? Orthoptera

(b) sucking mouth parts and front wings leathery at the base, membranous and overlapping at the tip? Hemiptera

7. Are the mouth parts a coiled tube and the wings covered with scales?

(a) Yes Lepidoptera

(b) No Go to # 8

8. Are the wings roof like, sloping downward and outward from the middle of the back?

(a) Yes Homoptera

(b) No Go to # 9

9. Is the insect slender and moth like, with long, slender antennae and wings that are widest past the middle?

(a) Yes Trichoptera

(b) No Go to # 10

10. Do the wings have few or no cross veins?

(a) Yes Go to # 11

(b) No Go to # 12

11. Does the insect have chewing mouth parts and hind wings somewhat smaller than the front wings?

(a) Yes Hymenoptera

(b) No Thysanoptera

12. Are there two or three long, slender, tail-like appendages on the tip of the abdomen?

(a) Yes Ephemeroptera

(b) No Go to # 13

13. Does the head have an elongated trunk like beak with chewing mouth parts at its tip?

(a) Yes Mecoptera

(b) No Go to # 14

14. Does the insect have inconspicuous antennae, long narrow wings, and a long slender abdomen?

(a) Yes Odonata

(b) No Go to # 15

15. Does the insect have two short cerci on the tip of its abdomen and front wings narrower than the rear wings?

(a) Yes Plecoptera

(b) No Go to #16

16. Do the tarsi each have 5 segments?

(a) Yes Neuroptera

(b) No Isoptera

17. Is the insect antlike, with a narrow waist?

(a) Yes Hymenoptera

(b) No Go to # 18

18. Is the insect antlike, but with a wide waist?

(a) Yes Isoptera

(b) No Go to # 19

19. Is the insect small and flattened, with chewing mouthparts and a head about as wide as its body?

(a) Yes Go to # 20

(b) No Go to # 21

20. Are the antennae long, and composed of many segments?

(a) Yes Psocoptera

(b) No Mallophaga

21. Is the insect's body soft and rounded, with two short tubes protruding from the abdomen, and with a small head?

(a) Yes Homoptera

(b) No Go to # 22

22. Is the insect very small, with a vertically flattened body, a hook like claw on each leg, and sucking mouth parts?

(a) Yes Anoplura

(b) No Go to # 23

23. Is the insect very small and narrow (flattened laterally) with sucking mouth parts?

(a) Yes Siphonaptera

(b) No Go to # 24

24. Is the insect:

(a) Delicate with chewing mouth parts and threadlike "tails" and antennae?

Thysanura

(b) Very small with a spring like lever folded under its abdomen which it uses for leaping? Collembola

Practical No. 10

Study of permanent slides: Mouthparts of Insects -Mandibulate, Piercing and sucking, Chewing and Lapping.

Permanent slide of Mouthparts

Dissect out the mouthparts from different insects and make a permanent slide and study the different structures and sub structures.

— Biting and chewing types (Cockroach, Locust, Grasshopper and Beetles)

— Piercing and sucking type (Mosquito and Bugs)

BITING AND CHEWING TYPES (Cockroach, Locust, Grasshopper and Beetles)

1. Represent the simplest type of mouth parts

2 Consist of Labrum, mandibles, First maxillae, Second maxillae, Hypopharynx, labium and Jointed palps are present.

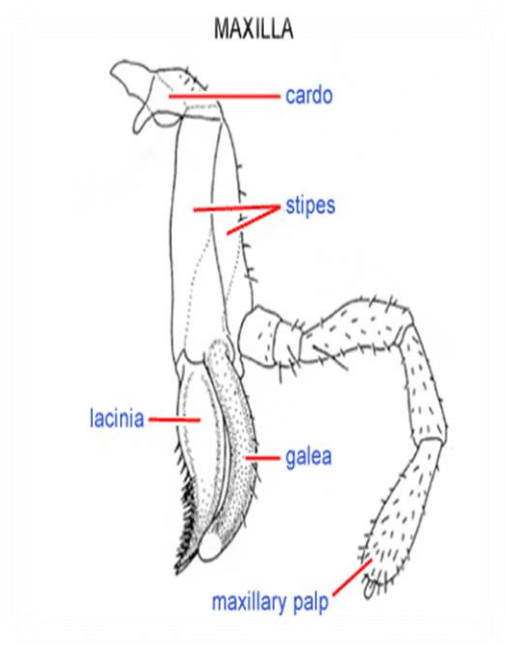
4. Mandibles cut off and grind the food.They are heavily sclerotized triangular structure lying just behind the labrum on the side of preoral cavity. They bear strong pointed teeth. Work horizontally to cut and chew the food.

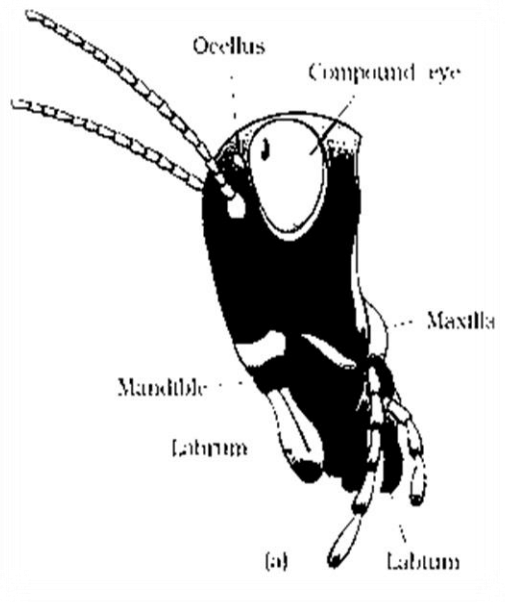
5. Maxillae and labrum push it into the oesophagus.

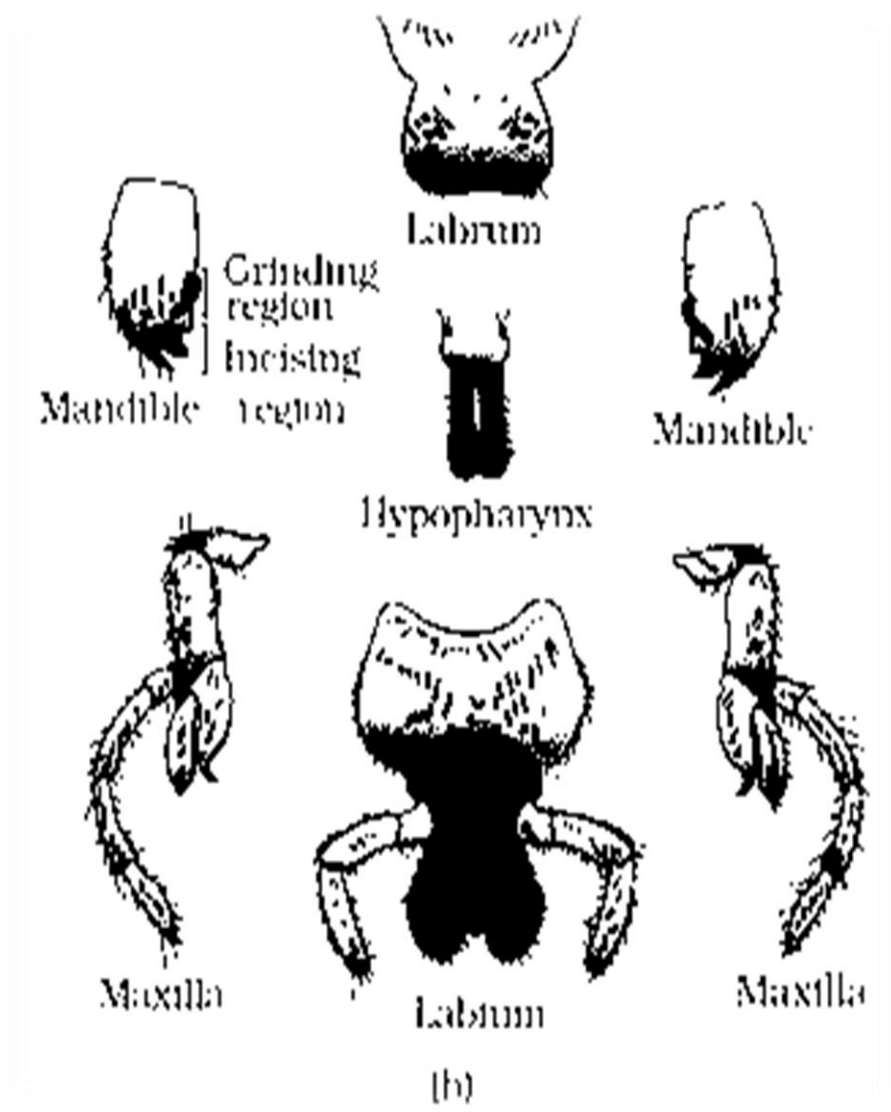
6. Labrum and Labium present. Larum is Broad rectangular, vertical plate. It forms anterior wall of the preoral cavity Called upper lip. Labium is lower supporting sturcture called as lower lip.

7. Locust, Crickets, Earwigs, Weevils, Lepidopteran larvae possess such types of mouthparts.

Note: Grasping present in soldier ants and stag beetles and grinding present in caterpillars, beetles and orthoptera are modifications of chewing type.


MAXILLA
cardo
stipes
lacinia
galea
maxillary palp


Ocellus
Compound eye
Maxilla
Mandible
Labrum
(a)
Labium

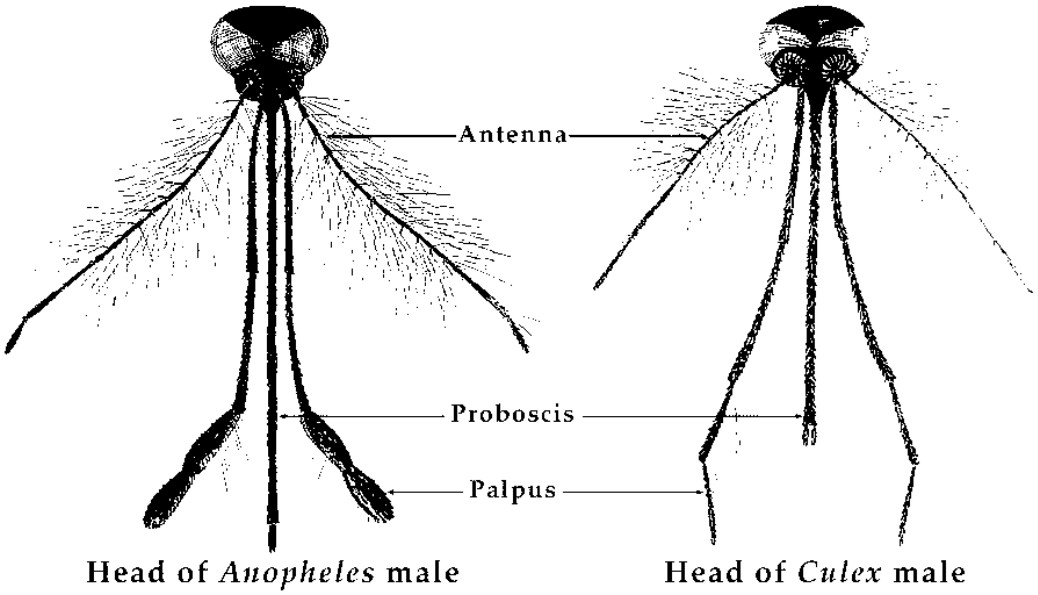


Head region of cockroach: a) part of head region b) mouth parts

First Maxillae:

Mandibles: Work horizontally to cut and chew the food.

PIERCING AND SUCKING TYPE (Mosquito and Bugs)



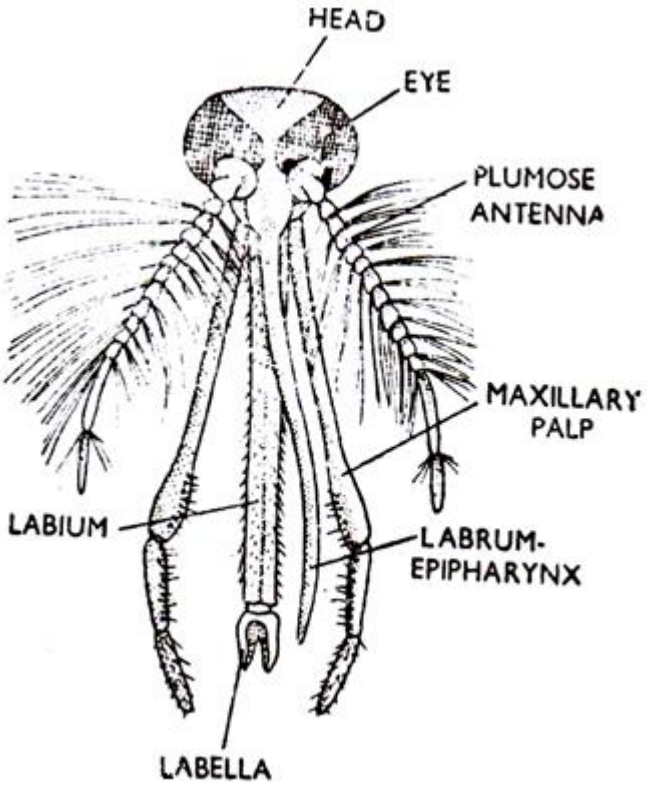


Fig. Mouthparts: piercing and sucking type

1. Mouthparts are elongated and slender to form a beak like structure.
2. Needle like styles are enclosed and protected with lower lip.
3. Maxillae and mandibles are slender and elongated.
4. Upper lip is short and flat.
5. Hypopharynx is elongated.
6. Palps are either absent or poorly developed.
7. All these stylets are joined to form a food channel and salivary duct.
8. Stylets are forced into the food source or tissue, it is sucked up by pump formed by the wells of mouth cavity.
9. Bugs (Heteroptera) Lice (Anoplura), fleas (Siphonaptera) and Mosquitoes (Diptera) posses such type of mouth parts.

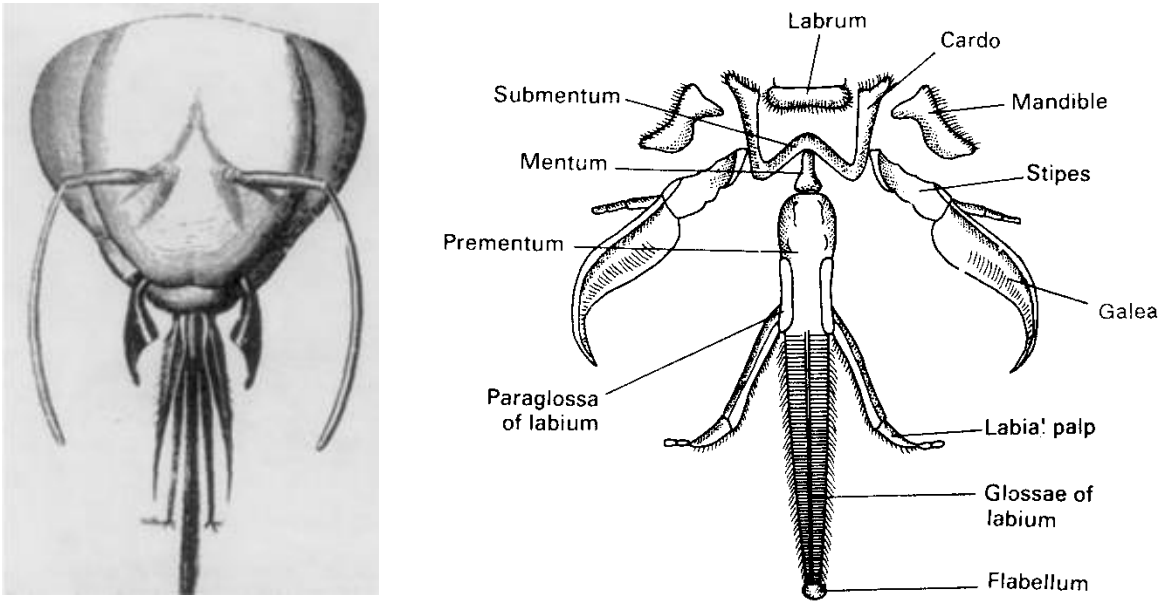


Fig: Chewing laping mouth parts of a honeybee. Photograph of Honey bee head.

CHEWING AND LAPPING TYPE Example: Honey bee

1. Upper lip and mandibles are of chewing type and helps grasping the food. Maxilla and labium are elongated.
2. Palps are small.
3. Galea with its concave inner surface forms a roof over glossa and fits length wise against the labial palps forming a food channel.

4. Mandibles and upper lip helps in grasping the prey.
5. Glossae are fused to form a channeled organ called alagossae.
6. The nectar is sucked up by the capillary action of glossa. Shortening of glossa takes place due to pull by muscles as a result the nectar is squeezed and deposited at the base of paraglossa.
7. Bees, wasps ants and other Hymenopteran insects possess such mouthparts.

CELL BIOLOGY

Practical No. 1

Study of Microscope: Simple and Compound

Micro means “small” Scope means “opportunity”, so it is an opportunity to view the microscopic world. Variety of microscopes is available to examine objects that are not visible to the naked eye. Study of different kinds of microscope is termed as microscopy.

Anton Van Leeuwenhoek was the first person to use microscope for biological studies. Robert hook designed a compound microscope.

Simple Microscope:

The two points which are less than 0.1 mm apart can’t be distinguished as two with naked eyes but simple microscope can do this. Eye can’t resolve an image that is less than 5microm as the distance between rods and cones on retina is 5 micron.

A simple microscope uses a convex lens to magnify images though only 3X magnification could be achieved by a single convex lens. However, the combination of lenses can used to magnify the image further like, double concave lens fitted between two convex lenses. This helps us to achieve the maximum magnification of 100X.

Principles of microscopy:

Power of a microscope to distinguish very closely placed two pointed objects is termed as resolving power. Human eyes can distinguish two pointed objects if they are lying at a distance of 0.1mm in between, whereas a simple microscope can distinguish the same objects as two if they are lying at a distance of more than 0.2pm. This increase in the power of resolution with microscope aided eyes can help us explore a whole new world although this resolution has a limit. Hence, the minimum distance between the two objects which the microscope can distinguish as two is called its limit of resolution. Limit of resolution is inversely proportional to the resolution power of a microscope.

Working of Simple Microscope

Light from the light source (mirror) is allowed to pass through a thin and almost transparent object to get an enlarged virtual image. A biconvex lens is used for this magnification. More the lens is close to the object higher the resolution and magnification. Adjustment of light intensity will create more contrast which can be increased further by using stained sample

Uses of simple microscope:

1. It can be used by biologists to perform dissections of smaller organisms and plants.
2. It can be used to identify smaller organisms like insects.
3. It can be used to study algae and fungi
4. It can be used to study skin by dermatologist.
5. It can be used for jewelry making

Compound Microscope

It is an upright *microscope* which utilizes two sets of lenses in order to get higher magnification and resolving power which provides a two-dimensional image.

Illumination system:

Light source light is a either a mirror placed below the stage or a built in illumination source coming from a bulb.

A ***condenser*** is placed between the mirror/light source and stage, which condenses the light rays to a common focus on the object on slide to be examined. Condenser is fitted with a ***diaphragm*** which is located below the condenser and is used to control the amount of light entering into the system. More of light provides more resolution however some samples like *Amoeba* can be seen well in low light.

Mechanical stage:

It is used to hold the sample slide on place for viewing. Stage is equipped with two movable vernier scales which facilitates the controlled and measurable movement of slide on the stage. This gives us an exact location of the part /sample viewed which can be used for subsequent viewing of same part /sample on that slide.

Body tube:

It is a hollow tube through which light passes from objective to ocular and then is receives by our eyes. The curved arm is attached to the tube for facilitating its handling. Tube comes with little variations like monocular, binocular or photo binocular (with camera attachment)

Lens system:

The magnification is obtained by using two sets of lenses, one at each end of a long metallic tube. The set of lenses located at bottom of tube, near the stage and above the sample slide is called as an ***objective lens***. The set of lenses located at the top of the tube where the observer places his eye is called as ***eyepiece lens*** **or** ***ocular.***

Objective lenses:

There are three to four objective lenses of different magnifications (10X, 40X and100X) mounted on a revolving nose piece. 100X lens can be used only by placing an oil drop between the cover slip and objective lens. Oil has a specific gravity similar to glass which reduces the refraction of light and improves the quality of image. At any point of time only one objective lens can be used for observation. Greater the magnification power of a lens smaller is the working distance (distance between the sample and the lens).

Eyepiece/ocular:

Monocular microscope has only one eyepiece whereas binocular microscope has two eyepieces attached. Generally the ocular come with 5X, 10X, 12.5X or 15X magnifications. Oculars also consist of elements. Some eyepiece also come equipped with a pointer to pin point the exact structure/part. Pointer is attached a flexible hinge and a handle which provides it a rotational flexibility.

Adjustment knobs:

Coarse adjustment is done by larger knob which does the initial focusing

Fine adjustment is done by a smaller knob which does the perfect focusing after the initial focusing is done.

Working of compound microscope:

In compound microscope, image formation takes place in two steps and so does the magnification. First real, inverted and magnified image is formed by the objective lens. Second image is virtual, inverted and more magnified. This image is received by the retina of eye. The combined magnification is calculated by multiplying the power of objective lens used with the power of eyepiece.

Uses of compound microscope:

It has a wide spread usage because of its higher magnification.

1. It can be used for morphological analysis.
2. Understanding Ultrastructure
3. It can be used to study cytochemistry of cells
4. It can be used for histochemistry analysis
5. It can be used to study the membrane dynamics.

Practical No. 2

MEASUREMENTS: OCULAR AND STAGE MICROMETERS

To measure an object seen in a microscope, an ocular micrometer serves as a scale or rule. This is simply a disc of glass upon which equally spaced divisions are etched. The rule may be divided into 50 subdivisions, or more rarely 100 subdivisions. To use the ocular micrometer, calibrate it against a fixed and known ruler, the stage micrometer. Stage micrometers also come in varying lengths, but most are 2 mm long and subdivided into 0.01 mm (10 micrometer) lengths. Each objective will need to be calibrated independently. To use, simply superimpose the ocular micrometer onto the stage micrometer and note the relationship of the length of the ocular to the stage micrometer (see figure). Note that at different magnifications, the stage micrometer changes, but the ocular micrometer is fixed in dimension. In reality, the stage micrometer is also fixed, and what is changing is the power of the magnification of the objective.

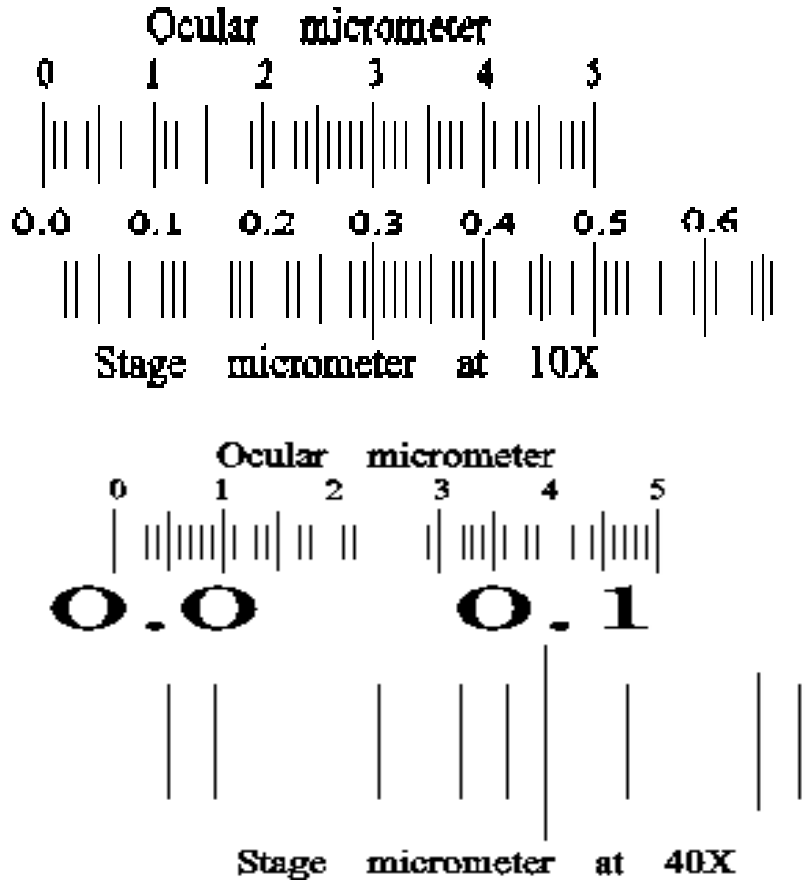


Fig. : Superimposed ocular and stage micrometers

Hemacytometer (for cell counting, volume and area measurements)

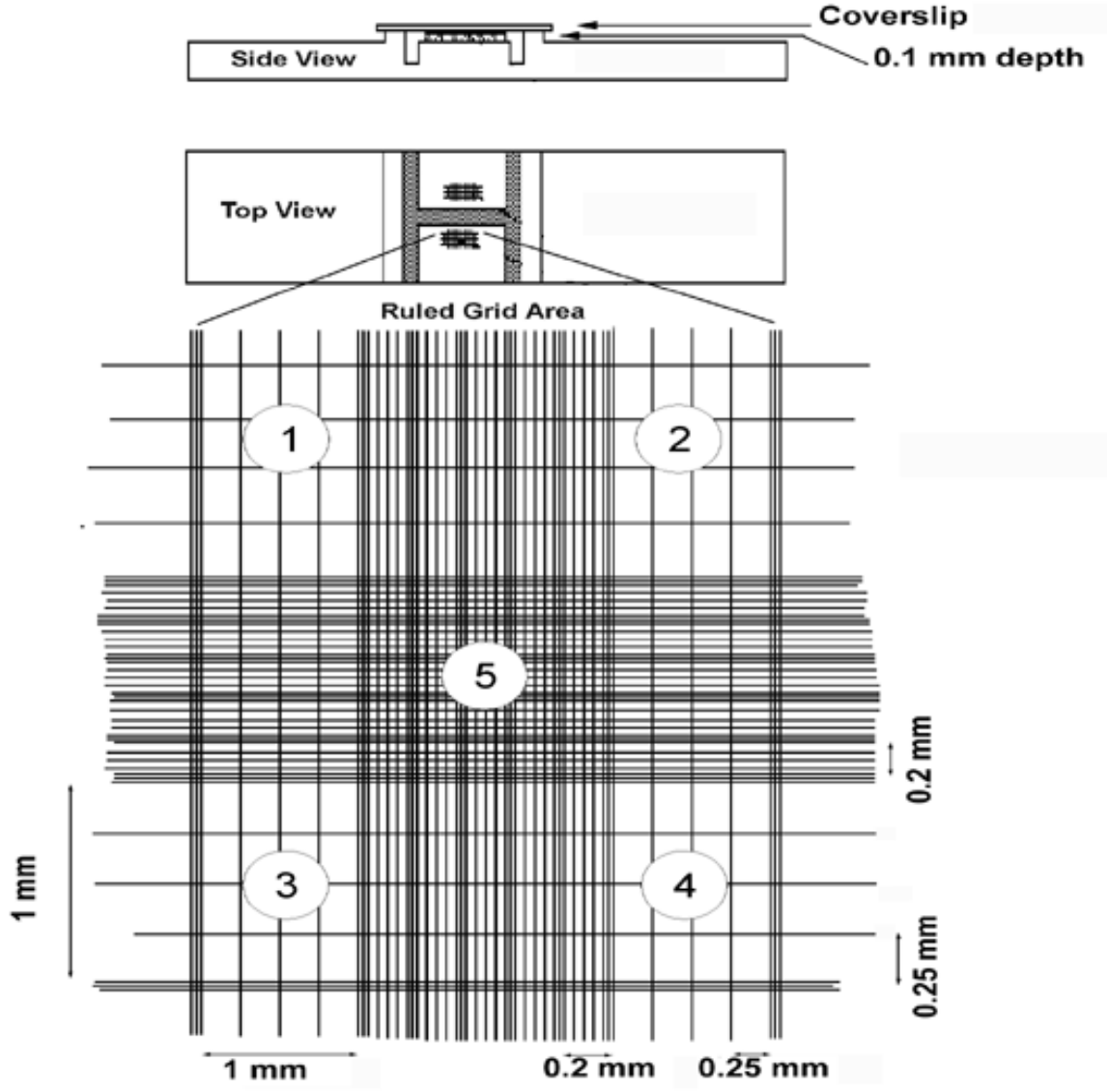


Fig. : Improved Newberg's chamber

1. The cover slip is 0.1 mm above the grid, and the lines etched on the grid are at preset dimensions.
2. The four outer squares marked 1-4, each cover a volume of 10^{-4} ml.
3. The inner square, marked as 5, also covers a volume of 10^{-4} ml, but is further subdivided into 25 smaller squares. The volume over each of the 25 smaller squares is 4.0 X 10-6 ml.

4. Each of the 25 smaller squares is further divided into 16 squares, which are the smallest gradations on the hemacytometer. The volume over these smallest squares is 0.25 X 10-6 ml.
5. For the squares marked 1^{-4}, the area of each is 1 mm^2, and the volume is 0.1 mm. Since 0.1 mm^3 equals 10^{-4} ml, the number of cells / ml = Average number of cells per one mm^2 times 10^4 times any sample dilution.
6. For the 25 smaller squares in the center of the grid marked five, each small square is 0.2 x 0.2 mm^2, and the volume is thus 0.004 mm^3. For small cells, or organelles, the particles / ml equals the Average number of particles per Small Square times 25 X 10^4 times any sample dilution.
7. Grids 1-5 are all one mm^2. Grids 1^{-4} are divided into 16 smaller squares (0.25 mm on each side); grid 5 is divided into 25 smaller squares (0.2 mm on each side). Grid 5 is further subdivided into 16 of the smallest squares found on the hemacytometer.

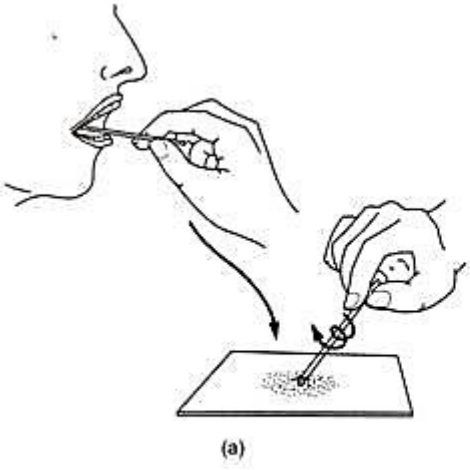
Practical No. 3

Study of cell: Preparation of temporary mount of human buccal epithelial cells.

All living organisms are made up of cells. The shape, size and the number of these units vary in organisms. The three major components of a eukaryotic cell are the cell membrane, cytoplasm and nucleus. Animal cells are usually irregular in shape. They do not have a cell wall. They are surrounded by a cell membrane and contain cytoplasm and nucleus. The epithelium or epithelial tissue provides a covering or lining for some parts of the body. It may be single or multi-layered. The lower most layer normally rests upon a non-cellular basement membrane. It is protective/sensory/absorptive/and secretory in nature and also helps in exchange and movement of materials inside the body.

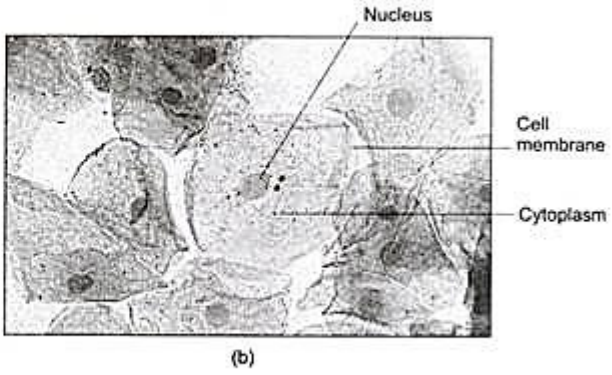
Requirement:

Live material/concerned tissue, beakers, glass slides, coverslips, watch glasses, dropping bottle, dropper, methylene blue stain, glycerine, NaCl solution (0.9% w/v), needle, forceps, brush, toothpick, water, wash-bottle, dissecting tray, microscope.



(a)

(a) Removing epithelial cells from the buccal cavity using a toothpick



(b)

(b) Cheek cells as seen under a microscope

Procedure

• Rinse your mouth well with water.

• Gently scrap the inside of your cheek with the broad end of a clean toothpick. Discard this material.

• Scrap again, and spread these cells gently on a clean slide. Add a drop of 0.9% NaCl solution or physiological saline and a drop of methylene blue with the help of a dropper.
• After two minutes, remove the excess stain and saline using the edge of a filter paper. Now, put a drop of glycerine on the cells.
• Place a coverslip over the tissue and gently press it with the back of a pencil to spread the cells.
• Examine the slide under the low power of microscope.
• Draw a labelled diagram of your preparation.

Precautions:

1. The cheeks should be scraped gently avoiding any injury.
2. Over-staining and under-staining of the cells should be avoided.
3. Coverslip should be placed carefully avoiding the entry of air bubbles.
4. A dry and clean glass slide and coverslip should be used.
5. The cheek cells should be spread properly to avoid their folding and overlapping.

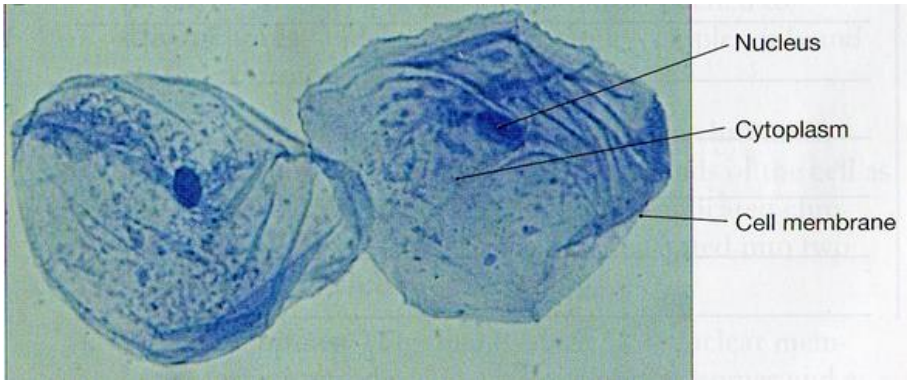


Fig. Stained Temporary preparation of Cheek epithelial cells.

Observation

Many flat, oval or irregular cells are seen. The cell membrane encloses hyaline cytoplasm and an oval, dense nucleus. The cell wall is absent as in all animal cells.

Record your observations as given below:

Features	**Observations**
1. No. of cells in a focus	
2. Shape of cells	
3. Nature of cell boundary	
4. Nucleus: Present/absent	
Shape / location-	

Practical No. 4

Preparation of blood smears to observe the blood cells

In this experiment, we make a human blood smear, to examine and identify different types of cells in the blood smear using leishman's stain, we were required to prepare a blood smear where a drop of blood was obtained by piercing the skin of the finger using a sterile lancet and used to prepare the smear. The smear was then stained using leishman's stain and then observed under both low and high power of a light microscope.

The human blood consists of a liquid extracellular matrix called plasma. In the plasma is suspended different types of blood cells such as erythrocytes (red blood cells), leukocytes (white blood cells) and thrombocytes (platelets).

These cells are described below

Red blood cells (erythrocytes)

These are the most numerous. After decent staining, the red blood cells are orange-red, about 7.5 microns in diameter (useful comparison for measurement), and may show a lighter-staining area in the middle.. Red blood cells are not real cells since they lack nuclei, they are highly specialized end product of a cell line.

White blood cells. these are in an area of the smear where the red blood cells touch each other, but are not on top of each other. They are divided into:

Neutrophils

These make up about 55-60% of all blood leukocytes, 10-12 microns in diameter. Dark-staining (dark blue to purple) nucleus is lobulated; young (about 3%) neutrophils have a stab or horseshoe shaped nucleus. There are plenty of grey and purple colored granules in the cytoplasm.

Eosinophils

They are (12-15 microns in diameter) usually have a bilobed nucleus. The cytoplasm is filled with orange-red granules, so that you cannot "see through."

Basophils

They are so few (less than 1% of leukocytes), that most likely you do not find one in your own blood smear. Therefore, go see an example in the demo microscopes in the interlab. Note that the dark blue or purple granules are large, numerous, and often mask the nucleus. Basophils and their connective tissue equivalents mast cells also play an important role in defense against foreign. They are much smaller than red blood cells (about 2_3 microns) and have a mixture of blue and orange-red staining. They have no nuclei, since they are really pieces of a megakaryocytic cytoplasm.

Lymphocytes. These consist about 30% of all leukocytes, they all look alike in ordinary blood smear. They have a very darkly staining, dense, round nucleus. Most lymphocytes are not much larger than the red blood cells, though their diameter may vary as much as 8 μm to 12 μm. The narrow cytoplasmic rim (in a well-stained smear) appears clear, sky-blue. Lymphocytes perform most of our immunological defense.

Monocyte,

These consist about 3 to 8% of all blood leukocytes), precursor of macrophages is a large cell (12_19 μm), usually much larger than the lymphocytes. Cytoplasm is especially abundant and lacks the sky-blue color; instead, it is often muddy grey looking. The nucleus is much less dense than in lymphocytes, it looks spongy, you can almost see through it. Often the nucleus is horseshoe shaped, or bent over itself (and resembles brain).

Remember that the red blood cells and platelets are not true cells (no nuclei), however, they are the ones who perform their functions within the blood vessels, whereas the leukocytes perform in the other.

Platelets play a critical role in normal hemostasis by stopping blood loss after vascular injury.

By adhering to sites of injury, recruiting other platelets and blood cells to the developing clot, and activating the plasma coagulation cascade, primary hemostasis is effected. In synchrony with the end products of the coagulation cascade.

Materials/ apparatus

Sterile lancets
Microscope slides
cover slips
Microscope
70% Alcohol
Distilled water
Leishmans stain
Cotton wool
Filter paper
D.P.X / Canada Balsan

Procedure

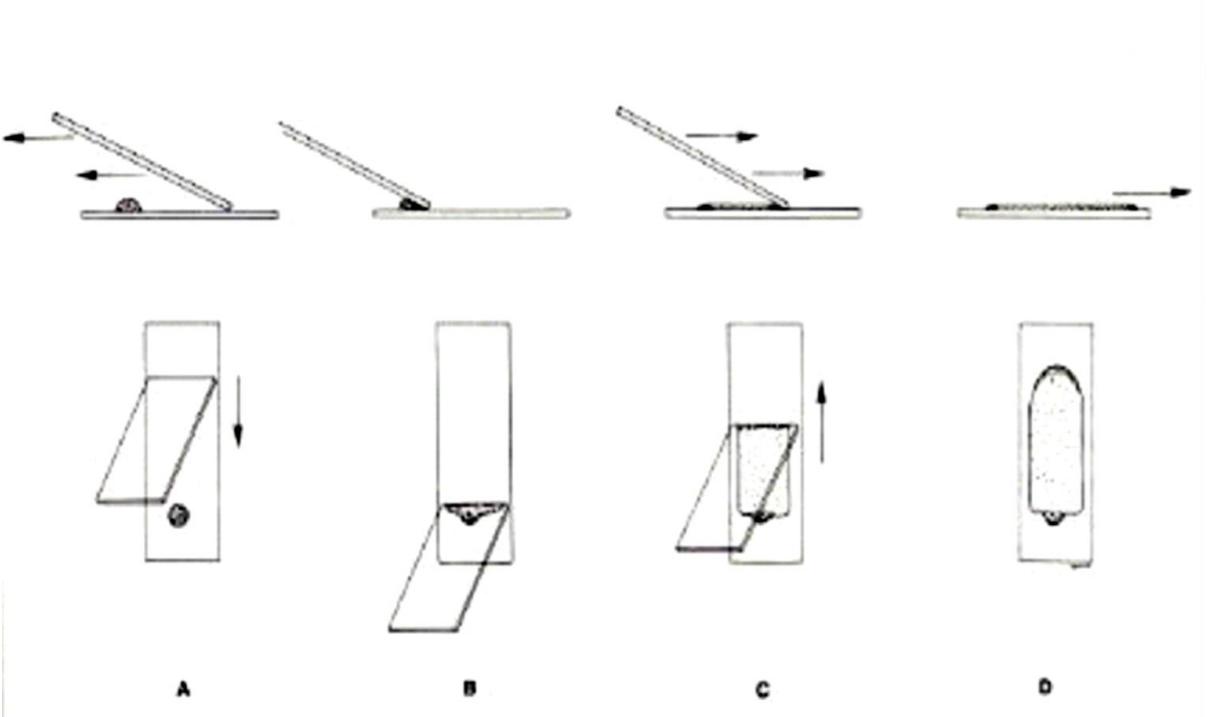
A drop of blood was obtained by piercing the skin at the tip of the finger using a clean sterile lancet after it had been cleaned using ethanol. The blood drop was placed on a clean microscope slide near the center. A second microscope slide

was held inclined at a position 45° with the short edge touching the other slide just behind the drop of blood. The second slide was pulled firmly and evenly on the opposite side of the blood drop there by making a thin blood smear. The slide was then waved in air for drying. The smear was then covered with two drops of leishman's stain and left to stand for one minute. Three drops of distilled water were then gently added to the slide from side to side to mix the water with the stain. The mixture was allowed to stand for 10 minutes. The stain was then drawn off the slide using a filter paper held at the side of the slide.

The surface of the slide was then rinsed using distilled water. The blood smear was then dried and then examined under low and High power of the microscope.

Common causes of a poor blood smear

1. Drop of blood too large or too small.
2. Spreader slide pushed across the slide in a jerky manner.
3. Failure to keep the entire edge of the spreader slide against the slide while making the smear.
4. Failure to keep the spreader slide at a 30° angle with the slide.
5. Failure to push the spreader slide completely across the slide.



This picture illustrates the proper procedure for making blood smears. Notice the angle and direction that the spreader slide is pulled, first BACK towardsthe drop of blood, then quickly FORWARD to the end of the slide. ***The spreaderslide is held in the dominant hand*****.**

Results

As Observed under low power

The stain appeared pale and some stain precipitates were present in the smear.

The red blood cells appear dark-pink in colour and spherical in shape.

The monocytes had lighter purple nuclei with cytoplasm.

Platelets were observed clumped together and smaller than red blood cells

More cells appeared clearer at the edge of the smear than in the middle the blood smear was thickest, and cells overlapped each other.

As observed Under high power.

The red blood cells were separated from each other and had a graduated central pillar.

A drawing of the red blood cells in the human blood smear as observed under high power of a light microscope.

A drawing of the monocytes in the human blood smear as observed under high power of a light microscope.

A drawing of blood plates in the blood smear as observed under high power of a microscope.

Discussion

Not many cells were observed under the microscope and this was due to use of much stain but also due to the thickness of the blood smear at certain points of the slide more so at the spot where the blood drop was introduced onto the slide.

Not all blood cells were observed because of their small size and also because the stain used could only isolate more clearly the cells reported above.

Recommendations.

To ensure that the blood smear is thin and that blood cells are evenly distributed on the slide, the smear should be made immediately after the drop blood is introduced onto the slide.

To be able to observe or view smaller cell more clearly, immersion oil should be applied on to the slide so as to increase the refractive index of the cells observed under the light microscope.

Applications

A blood smear is a blood test used to look for abnormalities in blood cells. The three main blood cells that the test focuses on are:

- red cells, which carry oxygen throughout your body
- white cells, which help your body fight infections and other inflammatory diseases
- platelets, which are important for blood clotting

The test provides information on the number and shape of these cells, which can help doctors diagnose certain blood disorders or other medical conditions.

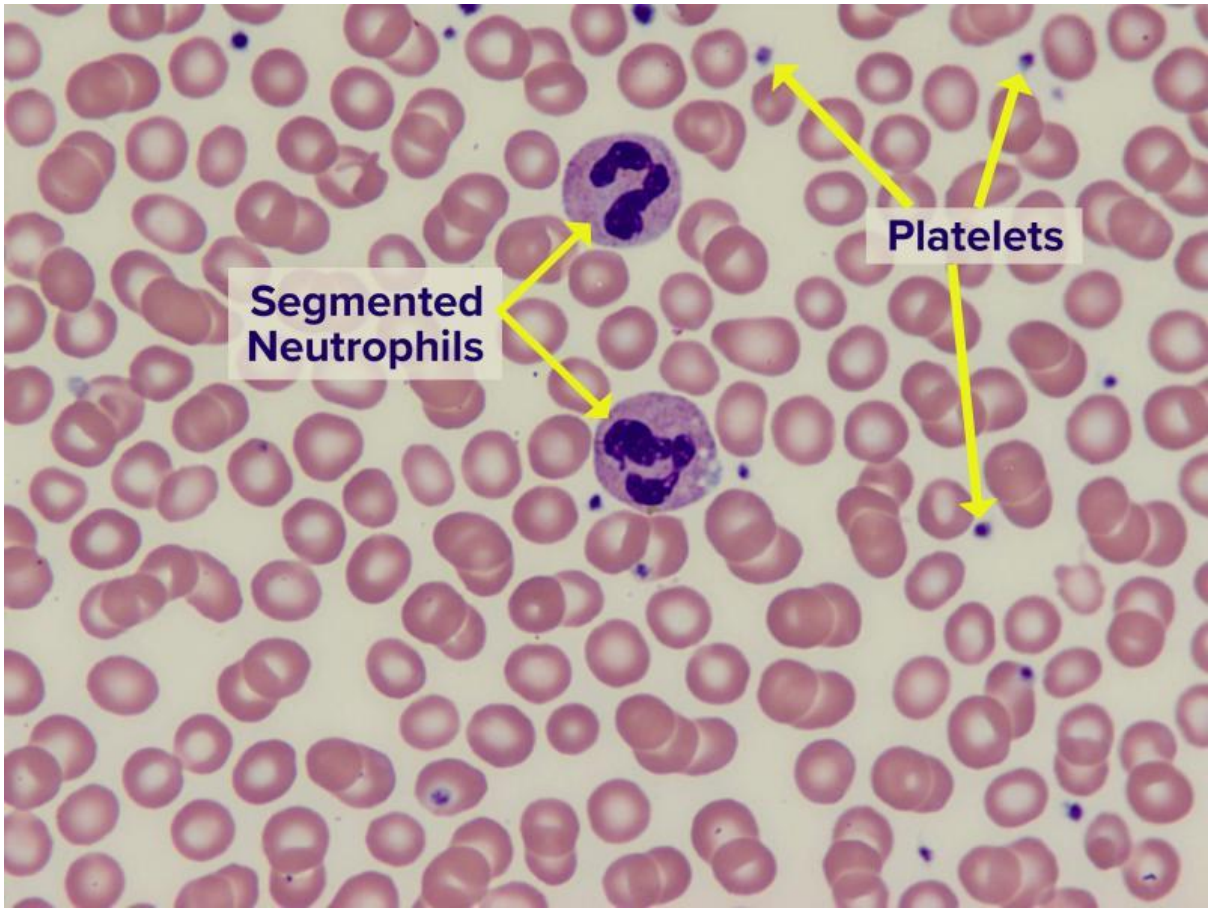


Fig. Normal blood smear with red blood cells (majority of cells shown), white blood cells (segmented neutrophils) and platelets (small purple dots). Image credit: Bette Jamieson, MEd

REFERNCE

Brown, Barbara, Hematology: Principles and Procedures, Fifth edition (P. 96-97)

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Practical No. 5

Temporary preparation of mitosis in onion root tips

Introduction : Onion root-tip is an ideal material to demonstrate mitosis. Old dried onions when set on jars containing water give out roots within 24 hours. If the onions do not give out roots, pods of garlic may be used.

Material : Old dried onions (with orange coloured peel),Cornoy's fixative – (Acetic acid : Alcohol 1:3),aceto-orcein or aceto-carmine stain, glass jars (coupling jar or small beaker), spirit lamp, razor blade, fine forceps, needles, etc.

Stain preparation:

Aceto-orcein preparation (1% solution)

Orcein is extracted from two species of lichens, *Rocellatinctoria* and *Lecanoraparella*. Orcein also is available in a synthetic form, but the natural form is preferred for chromosome analysis, because it gives better contrast. Orcein is used in form of a 1% solution in 45% acetic acid. This solution is prepared by pouring 55 mL boiling glacial acetic acid over 1 g orcein powder. The solution is cooled, 45 mL of distilled water added, and filtered. This solution is unstable and should be prepared fresh before use.

Aceto-orcein staining

Aceto-orcein staining does not require the addition of iron ions. The staining prodedure is similar to the aceto-carmine method. Fixed material is transferred for an approprioate time to 1% aceto-orcein and then analyzed by the squash technique.

Aceto-carmin staining

There are several versions of this stain. An iron containing stain is often used because of the darker bluish-red color produced

Non-iron version

1. Heat a solution of 45% acetic acid (45ml glacial acetic acid/55ml of distilled water) to boiling
2. Add 0.5g of Carmine and continue heating for 15-20 minutes while stirring

3. Cool resulting solution
4. Filter to remove any precipitate

Iron containing version

1. Heat a solution of 45% acetic acid (45ml glacial acetic acid/55ml distilled water) to boiling. ALWAYS use caution and wear personal protective equipment when in the laboratory with concentrated acids (or any other time)
2. Add 0.5g of Carmine and continue heating for 15-20 minutes while stirring
3. Cool resulting solution
4. Filter to remove any precipitate
5. Separately make a solution of 45ml glacial acetic acid/55ml distilled water/5g Ferric oxide)
6. Slowly (dropwise) add the Ferric oxide solution to 50ml of the Carmine solution until a precipitate starts to appear
7. Promptly add 50ml of Carmine solution to the titrate mixture
8. Filter to remove any precipitate

Cautions: ALWAYS use caution and wear personal protective equipment when in the laboratory with concentrated acids (or any other time)! Always add acid slowly into water and do not add water into acid!

Procedure :

1. Outer peels of the onion are removed and they are set over glass jars containing tap water. If suitable onions are not available, bulb of garlic may be used. The pods are separated and peeled. A pin is inserted across the middle part and the pod is made to stand along the edge of a petridish containing tap water. Roots appear within 24 hours.

2. In either case excise the roots one centimeter from the tip and transfer to the Cornoy'sfixative, made just before use. Let it fix for 1-3 h.

3. Treat the tips with 1.0 N HCl at 60°C over spirit lamp, for 5 minutes before transferring to the stain, it gives better results.

4. Transfer the tips to a cavity block containing stain. Let the tips stain for 10-30 minutes.

5. Take a tip and transfer it to a drop of stain on a clean slide. Cut the tip 3mm from the end and discard the rest. Place a coverslip over the tip so as not to include any air bubble.
6. Blot off excess stain around the coverslip and squash it.
7. Remove slide from the folds of blotting paper and seal with molten paraffin or nail polish.

Result : If the cells are well separated, various stages of mitosis with red stained chromosomes and nuclei are seen.

Exercise : Identify the various stages of mitosis viz., prophase, metaphase, anaphase and telophase, Make a sketch showing each stage. Count the total number of cells examined and the number of cells in each stage and determine the mitotic index.

Mitotic Index = $\frac{\text{Number of cell in mitosis X 100}}{\text{Total number of cells}}$

Precautions :

1. Avoid trapping air bubbles under the cover slip.
2. Avoid movement of cover slip while squashing.

Smear of onion root tip (Alternative method for group study).

As a group activity (in Practical class) instructor may want students to stain the dividing cells in the growing tip of onion roots so that chromosomes are visible. The method described here is modified from *Sharma and Mookerjea*

1. Germinate seedlings or place an onion bulb in water so that roots begin to grow.
2. With a razor blade cut off the root tips and place them in a saturated aqueous solution of *p*-dichlorobenzene for 3 hours (at 12° to 16° C).
3. Transfer the root tips to a Pyrex test tube containing a mixture of 2 per cent aceto-orcein solution and 1N hydrochloric acid in the ratio of 9:1.
4. Heat this for a few seconds until it just reaches the boiling point;
5. Pour into a Syracuse dish or watch glass and let it cool for 5 minutes.
6. Then transfer the root tips to a drop of 1 per cent aceto-orcein solution on a clean slide.

7. Carefully cut off the deeply colored region of the root tip; discard the rest of the material.
8. Apply a cover slip and press uniformly with a dissecting needle along the cover slip so that the material is squashed.
9. Place filter paper over the cover slip to squeeze out the excess stain.
10. Examine under high power for mitotic figures.
11. If these smear slides are sealed with a ring of paraffin they will last up to 15 days.
12. The slides can be made permanent if they are placed in 10 per cent acetic acid until the cover slips fall off.
13. Then pass the slides through this series: acetic acid and alcohol (half and half), absolute alcohol, then xylol, 2 to 3 minutes in each solution and mount in balsam.

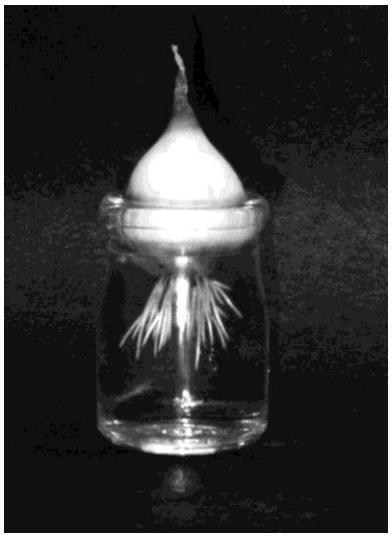

Fig.: Onion root tip growth.

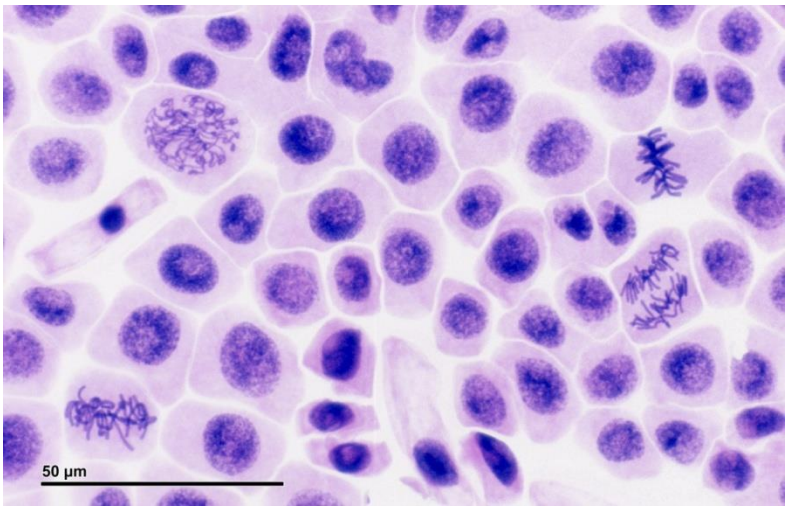

Fig.: Mitosis: Pressed; root meristem of onion (cells in prophase, metaphase, anaphase, telophase). Optical microscopy technique: Bright field. Magnification: 1600x (www.commons.wikimedia.org)

Practical No. 6:

ULTRA STRUCTURE OF A CELL ORGANELLS

Introduction:

Eukaryotic cell is highly complex structure with number of metabolic pathways, proteins synthesis and many other processes going on in it efficiently. To maintain these processes and to carry out these processes successfully the cell is compartmentalized in many membrane bound organelles like nucleus, mitochondria, etc. Hence, it is of utmost importance to study the ultra structure of the cell.

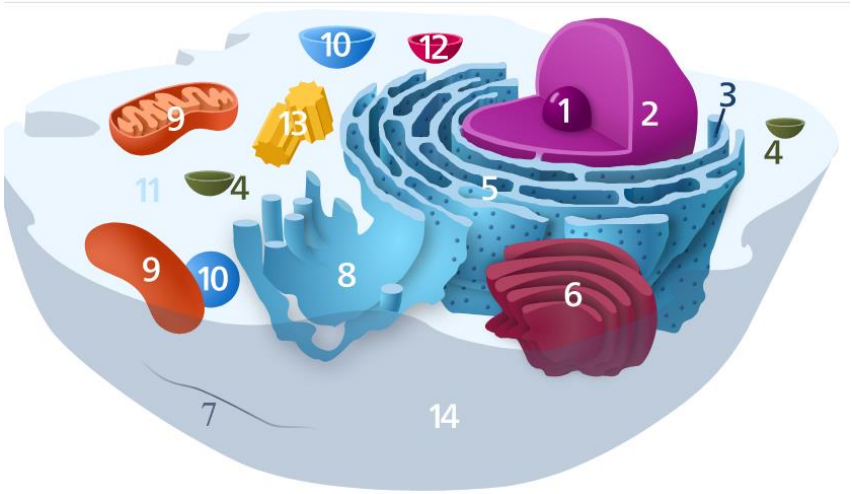

Fig. Components of a typical animal cell:

1. Nucleolus
2. Nucleus
3. Ribosome (little dots)
4. Vesicle
5. Rough endoplasmic reticulum
6. Golgi apparatus (or "Golgi body")
7. Cytoskeleton
8. Smooth endoplasmic reticulum
9. Mitochondrion
10. Vacuole
11. Cytosol (fluid that contains organelles, comprising the cytoplasm)
12. Lysosome
13. Centrosome
14. Cell membrane

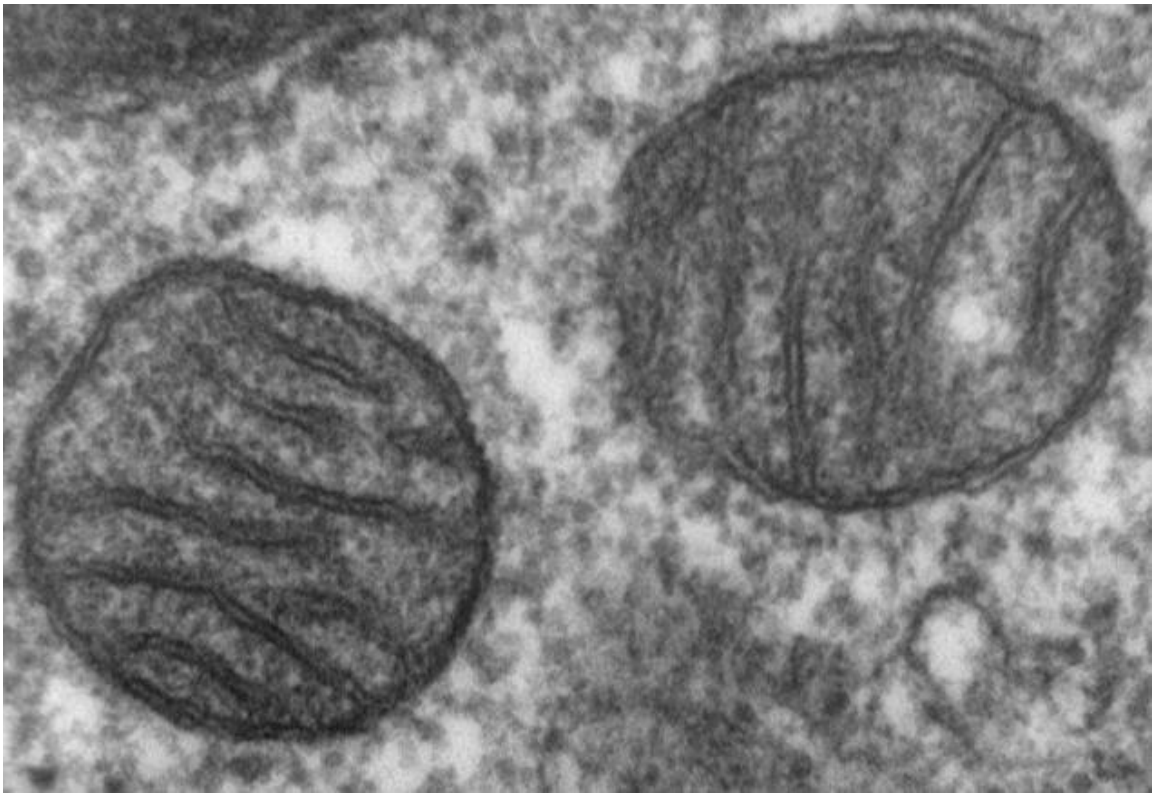

Fig.: Two mitochondria from mammalian lung tissue displaying their matrix and membranes as shown by electron microscopy. (en.wikipedia.org)

Mitochondria:

1. Mitochondria are a power house of a cell, as it is a site for cellular respiration.
2. Mitochondria are the specialized organelles bounded by double membranes, the outer and inner membranes.
3. The space between the two membranes is called as inter-membranous space.
4. The inner membrane has invaginations called cristae. Cristae have knobs containing F_1 proteins and ATPase responsible for ATP synthesis. Theses knobs are attached to the cristae by a stalk called F_o. Inner membrane is involved in electron transfer and oxidative phosphorylation.
5. Outer mitochondrial membrane is smooth and permeable to molecules such as salts, glucose, fatty acids, coenzymes, nucleotides and many more.
6. Interior space of the mitochondria is named as matrix. Matrix contain enzymes for various pathways like TCA cycle, beta oxidation and pyruvate dehydrogenase.

Nucleus:

1. Nucleus is termed as a control center of cell.
2. It is a spherical shaped double membranous organelle present in every eukaryotic cell. The membrane is termed as nuclear envelope.
3. Nuclear envelope helps in maintaining the shape of a nucleus and guards the entry and exit of molecules to and fro from nucleus through nuclear pores.
4. Nuclear pores are the channels through which larger molecules are transported by carrier proteins where as smaller particles can transport freely.
5. The outer layer of envelope is in continuation of endoplasmic reticulum (RER) and is studded with ribosomes.
6. The matrix inside the nucleus is called as nucleoplasm.
7. Nuclear lamina is a fibrillar network which provides support to the nucleus. It is composed of three types of lamins (protein type), lamin A, lamin B and lamin C. Nuclear lamina forms a network at both faces of nuclear memebrane, cytosolic as well as internal face and provide support for the nuclear membrane and offer a binding site for chromosomes and nuclear pores.
8. Nucleus contains genetic material that is DNA, which is arranged in the form of chromatin. This chromatin condenses to form chromosomes when the cell proceeds for division.
9. Nucleus contains a densely stained non-membranous structure called nucleolus. It is a site for rRNA synthesis and assembly of ribosomes.

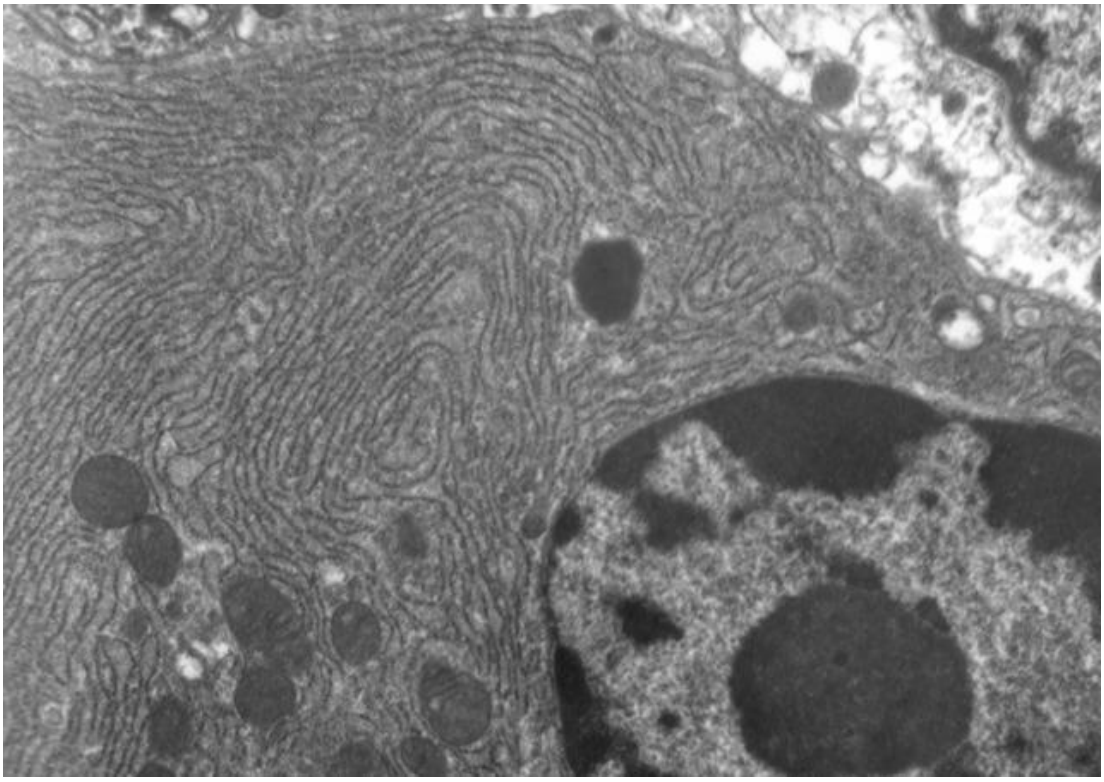

Fig.: Micrograph of rough endoplasmic reticulum network around the nucleus. (en.wikipedia.org)

Endoplasmic reticulum:

1. It is an organelle which comprises of a network of interconnected membrane enclosed tube/sac like structures. It is present in every cell except the red blood cell.
2. It is a dynamic structure involved in protein modification, carbohydrate metabolism, lipid synthesis, calcium storage etc.
3. On the basis of structure there are three kinds of endoplasmic reticulum structures:
   - Cisternae - long, flattened, sac-like tubules
   - Vesicles- rounded or ovoid structures
   - Tubules- come in diverse shapes and are irregularly branched.
4. There are two types of endoplasmic reticulum, Rough Endoplasmic Reticulum and Smooth Endoplasmic Reticulum.
5. Rough Endoplasmic Reticulum is studded with the protein synthesizing ribosomal units. It forms membranous sheets which are located near the nucleus and are in continuation with outer membrane of nuclear envelope. The other end of RER is in indirect contact with Golgi apparatus where the membrane bound small transport vesicles shuttles

protein between RER and Golgi apparatus. RER is abundantly seen in the hepatocytes. RER is engaged in the protein modification and trafficking.

6. Smooth endoplasmic reticulum (SER) is without ribosome so appears smooth. It is less in amount in a cell as compared to RER. Although specialized cells like gonadal cells (testes and ovary), hepatocytes and sebaceous glands shows abundance of SER. SER is engaged in important functions like synthesis of lipids, phospholipids and steroids. It is also involved in other functions like detoxification, regulation of calcium ions concentration and gluconeogenesis.

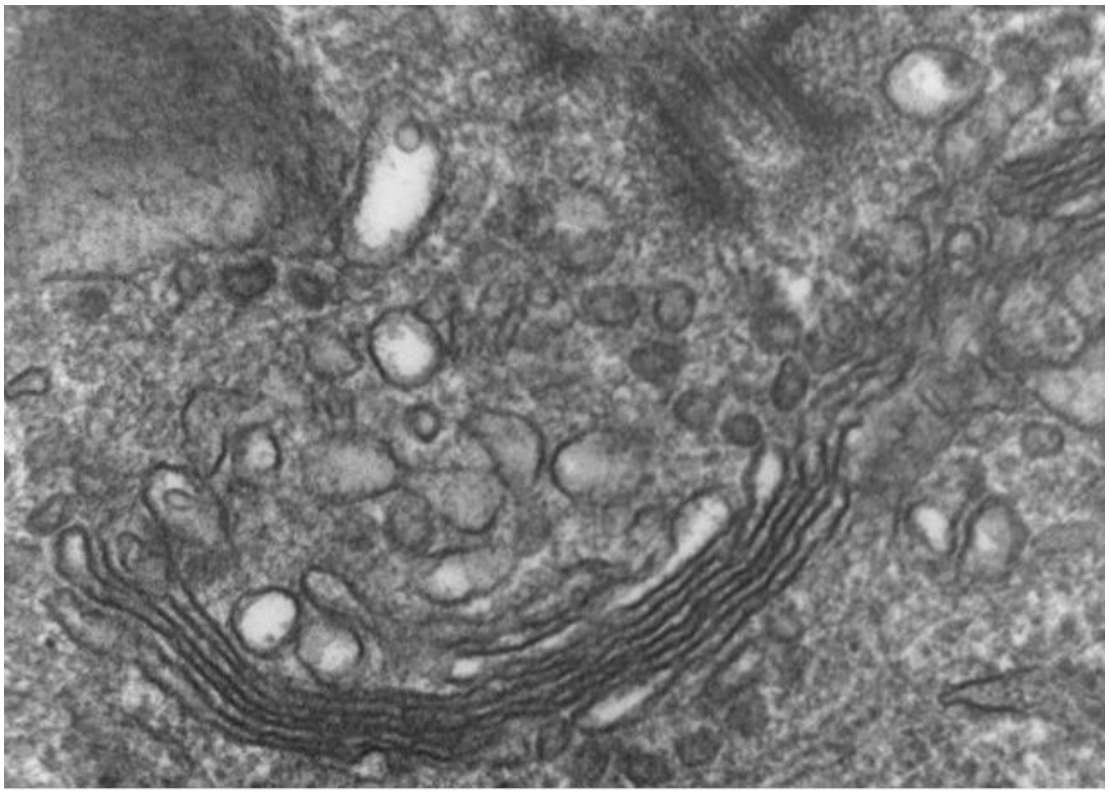

Fig. : Micrograph of Golgi apparatus, visible as a stack of semicircular black rings near the bottom. Numerous circular vesicles can be seen in proximity to the organelle. (en.wikipedia.org)

Golgi apparatus:

1. It is an organelle with an assemblage of fused flattened membrane enclosed cisternae budding from endoplasmic reticulum.
2. It is a stack of 4-8 cisternae with a "Cis" and "Trans" compartments.
3. Cis is an entry face and Trans is an exit face of Golgi apparatus.
4. The vesicles from RER are transported to Cis face of golgi apparatus where they fuse to deliver contents into the lumen. Molecules are modified inside and then trafficked to their destination locations accordingly.

5. Each stack has different set of enzymes, allowing the processing of cargo proteins while they travel from the Cis face to the Trans Golgi face.
6. Thus Golgi apparatus is referred as a post office of cell as it deals with packaging, labeling and shipment of molecules to different parts within the cell as well as outside the cell.

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