स्वाध्याय स्वमन्थन स्वावलम्बन

UTTAR PRADESH RAJARSHI TANDON OPEN UNIVERSITY

(Established vide U.P. Govt. Act No. 10, of 1999)

Indira Gandhi National Open University

UP Rajarshi Tandon Open University

UGZY-03
ANIMAL DIVERSITY LAB

FIRST BLOCK
NON-CHORDATES

Shantipuram (Sector-F), Phaphamau, Allahabad - 211013

Uttar Pradesh
Rajarshi Tandon Open University

UGZY -03
ANIMAL DIVERSITY LAB

Block

1

NON-CHORDATES

List of Exercises

LABORATORY COURSE ON ANIMAL DIVERSITY

The Animal Diversity Lab course LSE-11 (L) is an integral component of the Animal Diversity package (16credit). This 4 credits course is based on the courses Animal Diversity – I (LSE-09) dealing with Non-chordate and Animal Diversity II (LSE-10) dealing with Chordate Diversity.

The course comprises two blocks. The first block deals with the diversity of nonchordates whereas block two deals with chordates. In block 1 there are 22 exercises some of which deal with the different aspects of type studies of animals with their classification, salient feature visible externally, habit and habitat and geographical distribution etc. Each example has been illustrated with diagrams and coloured illustrations wherever possible. Besides type studies, you will learn skills involved in dissection and preparation of temporary mounts of some of the nonchordates. You will also be able to identify and comment on the social insects, observe inter- and intraspecific relationships like commensalism, mutualism, and parasitism in different groups of non-chordates.

In Block 2, there are 16 exercises. The focus of this block is similar to Block 1 and it deals with different aspects of type studies of various groups of chordates, their identification and classification upto level of order, general and salient features, habit and habitat, and geographical distribution. All examples have been illustrated with diagrams. You will also get an opportunity for developing your skill of dissecting and preparing temporary mounts of certain parts of different chordates. This will familiarise you with the general anatomy, digestive system, circulatory system, urinogenital systems etc. of the various chordate groups. You will also be able to identify, mount certain organs/tissue and make temporary/permanent slides of the same. You will also be expected to undertake a field trip so as to study animals in a museum/zoo or in their natural habitat and submit a report.

Like all other IGNOU laboratory courses this is an intensive residential exercise requiring 2 weeks to complete it. Everyday there will be two laboratory sessions of 4 hours each. So there will be a total of 28 sessions. The first session will be introductory and the remaining 2nd to 26th session will be based on the exercises given in the course. Sessions 1 to 26 will have guided exercises under the supervision of the academic counsellor. The last two sessions i.e. 27 and 28 will be the unguided sessions that is, the term end examination. In each session you will perform exercises for three hours and in the remaining 1 hour you will complete your practical note book. A schedule for laboratory exercises will be given to you in the first session.

You are aware that there is a time constraint as you will have limited access to laboratory work, therefore, you are required not to miss any of the laboratory sessions.

You will be assessed for your performance each day and on the last day you will have the term end examination. This examination will be compulsory for you to pass.

Study Guide

1. Before you enter your laboratory for performing laboratory exercises you should read the theory components of Animal Diversity I and Animal Diversity II, because the practical component is an integral part of the package based on LSE-09 and LSE-10.
2. You should also go through the laboratory manual and underline the important steps given in it.
3. Do not forget to carry a dissection kit consisting of a pair of scissors, needles, brush, forceps etc. to the laboratory. You should also carry the laboratory manual and a practical record book for making and recording your observation.

Dissections

1. Always ensure that the animal to be dissected should be kept submerged under water in the dissecting tray.
2. The water in the dissecting tray should be kept clean. Keep changing the water whenever its becomes stained with blood or other matter so that the dissected animal is clearly visible.
3. Dissect along and not across blood vessels and nerves.
4. Put every waste of the dissection in a petri dish so that it can be properly disposed off later.
5. While doing the dissection, ensure that the parts to be dissected are properly displayed by clearing the extra tissues.
6. You should remember that invertebrates are always dissected from the **dorsal** side.
7. A well-labelled diagram of the dissection should be drawn.
8. When you are asked to dissect some organs and flag-label them, keep the following instructions in mind:

   Prepare small pieces of white paper (2.5 x 0.7 cms) as flag-labels. The name of each organ to be flag-labelled is to be written by pencil on the flag-label. The flag-label is to be pierced by a pin or needle and inserted in the dissecting tray close to the organ to be flag-labelled.

Mounting of Specimens

1. Always use a brush and never forceps for holding the mounting material.

2. While preparing the temporary mounts ensure that they do not dry up. Keep them in water or saline or glycerine as instructed.

3. Temporary mounts should be quickly viewed, as they tend to dry up or become distorted in a short period of time.

Study of Specimens

1. Study the characteristics of the specimen.
2. Draw only that view (like dorsal, ventral or lateral) which show maximum details. Diagrams should be drawn from original specimen, though you should take the help of the laboratory manual for comparing details and labelling of various parts.
3. Draw only line diagrams.
4. Note those features which you can observe in the specimen. Also state their habit and habitat and geographical distribution.
5. Always write down the entire classification of the specimen.

Study of Slides

1. While studying permanent slides under the microscope, first focus under low power and then once you have focused on the structure you want to study then change the focus to high power. You can ask your counsellor to help you focus the slide in the beginning or whenever you have difficulty in focusing the slide. This will prevent damage of the slides.
2. Draw from the slide. You can take the help of your laboratory manual for their details of the structures and labelling.
3. Whenever there is a mount of an entire animal always write its classification.

Spotting

Spotting is the term used for identifying, describing and writing the classification of a specimen or writing details of a slide in a time period of 2 minutes during the practical examination. Keep the following instructions in mind during spotting.

1. First write the spot number.

2. Draw a rough but well labelled diagram of the spot.
3. Write down the classification of the specimen.
4. Write the important features, habit and habitat and geographical distribution of the specimen.

Hope you enjoy your practical exercises.

Acknowledgements

The following persons are acknowledged for providing Museum specimens and slides which have been photographed for this course.

Mr. Ganga Singh, Curator of Zoology Museum, Gargi College, New Delhi.

Mrs. Meena Malhotra, Curator of Zoology Museum, Maitryi College, New Delhi.

BLOCK 1 NON-CHORDATES

In this block you will do 22 practical exercises relating to non-chordates. These exercises focus on the following aspects of practical work.

	Exercise No.
Study of museum specimens and permanent slide	1,3,5,6,8,10,11,12,13,14,15, 16,18,19,21,22
Culture and permanent mounting of Protozoa (Protista)	2
Dissection and mounting of specimen	4,7,9,17,20

A study of preserved specimens and slides, representative of various non-chordate phyla include the general characters of the concerned phylum, distinguishing features of each class and order, and the special feature of the specimen under study. You will learn to classify each specimen along with the justification for its classification. While preparing protozoan cultures and performing dissections of other animals you will be expected to make temporary or permanent mounts of some of the organs and tissues.

In such a course it is not possible to examine even a part of the known invertebrate species so we have chosen the most common and familiar forms. Through examination of living and preserved materials, it is hoped that you will see how structural organisation relates to function in non-chordates.

EXERCISE 1 PROTOZOA-I: OBSERVATION AND CLASSIFICATION OF SPECIMENS

Structure

1.1 INTRODUCTION

In Unit 2 of Block 1 of LSE-9 you have already learnt that animal protists or the protozoans constitute a large assemblage of microscopic, unicellular organisms. These organisms exhibit all sorts of symmetry; show varied modes of nutrition and have diverse life histories. Some are autotrophic (chlorophyll bearing flagellates); others are heterotrophic including the saprozoic, phagotrophic or holozoic protozoa. They may be free-living or mutualistic or commensals or parasites. They do not have tissues or organs, rather they have specialised organelles, and possess one or many nuclei.

In this exercise you will observe prepared slides of some representative protozoans. You will learn to classify these protozoans giving justification for placing them within their various groups and classes. You will also draw diagrams of the specimens displayed in the prepared slides as you observe them and compare them with figures given in this manual.

Objectives

After performing this exercise you should be able to:

- identify the protozoan specimens belonging to the genera – *Amoeba, Paramecium, Trypanosoma, Giardia, Euglena,* and *Vorticella* and specimens of radiolarians giving their scientific and common names,
- draw labelled diagrams of the identified genera,
- classify the identified protozoans up to the level of class,
- list characters justifying their classification and mention special features, if any,
- mention the habitat and geographical distribution of the identified genera, and
- mention the economic importance, if any, of the identified specimens.

1.2 MATERIAL REQUIRED

1. Compound microscope.
2. Prepared slides of *Amoeba, Paramecium, Trypanosoma, Giardia, Euglena, Vorticella* and radiolarians.
3. Drawing sheets/note book, an HB pencil and eraser.

1.3 OBSERVATION OF PROTOZOAN SLIDES

Protozoans are a group of animal protists of more than 50,000 species and are found under almost all natural conditions where there is moisture. A protozoan is not as simple an organism as one would think it to be. It is so designed that even though it is a single cell, it still functions as a complete organism.

The slides that you will get for observation will all be permanent, stained whole mounts. While observing them you should sketch them as accurately as you can. You will note that as you sketch the specimen under observation you are more likely to look for details you would not see otherwise, and if you put those details in the right places in the sketch and in the right dimensions, you will recognise the specimen when you see it again.

Some times you may not be able to see all the details in a single specimen but by observing several specimens and drawing a composite picture from your observations you will be able to recognise the specimen in any given slide. Colour coding also helps. You can devise a colour coding system for your self, for example blue for the nucleus, green for the chloroplast, etc.

1.3.1 *Amoeba*

Place a slide of *Amoeba* (common species is *A. proteus*) under the microscope and focus it under low power (5x × 5x), and observe it carefully. *Amoeba* looks like an irregular colourless drop of gelatinous protoplasm.

Now focus it under high power (10x × 10x) and note the following features:

i) The body is covered by a thin elastic, semi-permeable membrane called **plasmalemma**
ii) Under the plasmalemma, the protoplasm is clearly distinguished into an outer clear **ectoplasm** and an inner granular fluid-like **endoplasm.**
iii) Try to identify the anterior and the posterior ends of *Amoeba.* The anterior end is characterised by a thick layer of ectoplasm (the **hyaline cap**), while the posterior end is modified in the form of a tail like region the **uroid** (The anterior end of amoeba is the one in which direction a pseudopodium is given out for progression).
iv) You will see some blunt, finger-like projections. These are the **pseudopodia** and are the extensions of the protoplasm. Pseudopodia help the *Amoeba* to move in the medium and also in capturing food.
v) You can also see the single, clearly stained nucleus, a large single contractile vacuole and large number of food vacuoles in the endoplasm. Compare your slide with Figure 1.1 given in the text.

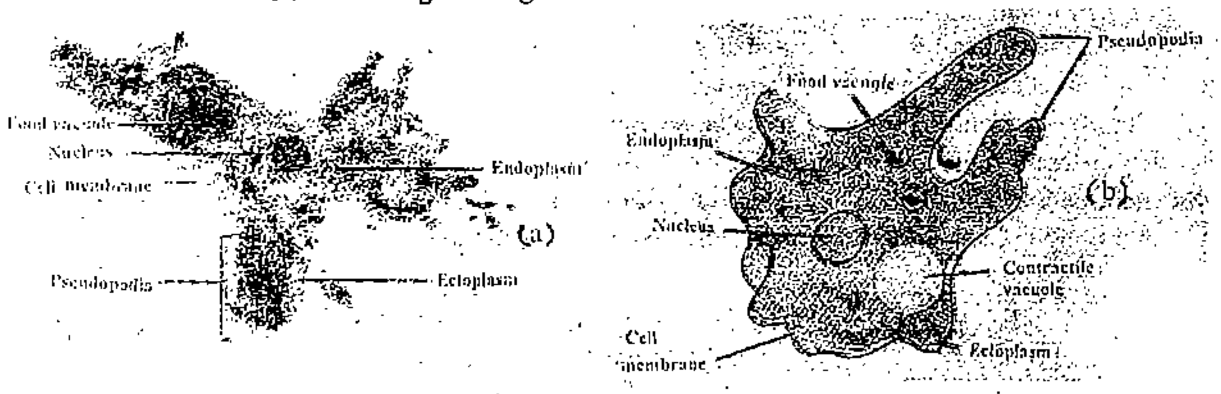


Fig.1.1: *Amoeba proteus.* **a) light micrograph (160 x). b) diagrammatic view.**

Habit and Habitat

Amoeba is commonly found in the mud, in fresh water ponds and ditches, and slow running streams. It is abundantly found in the water with lots of decaying vegetation and bacteria.

Geographical Distribution

All over the world.

Classification and its Justification

Kingdom	**Protista**	because *Amoeba* is unicellular
Phylum	**Sarcomastigophora**	because its locomotory organs may be pseudopodia or flagella; only one type of nucleus present; cilia are absent
Subphylum	**Sarcodina**	because pseudopodia are present and flagella are present in the development stages of some species
Superclass	**Rizopoda**	because locomotory organelles are lobopodia, filopodia or reticulopodia (pseudopodia)
Class	**Lobosia**	pseudopodia lobose may be of indefinite length, usually uninucleate
Genus	*Amoeba*	

1.3.2 Radiolarians

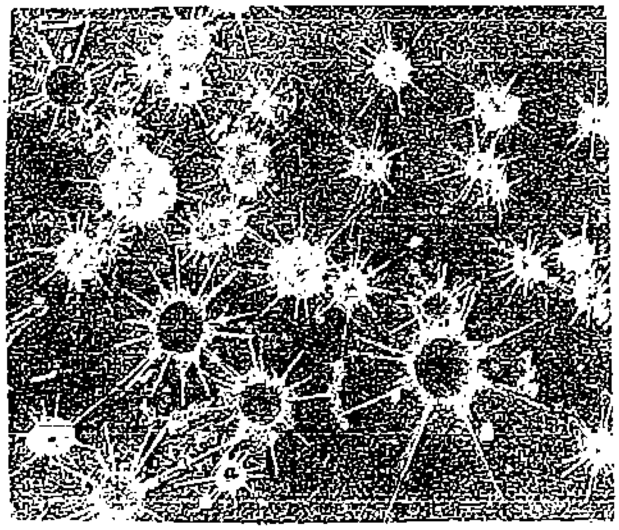
In the living condition (found in sea) you would be able to observe the following features in radiolarians:

The cytoplasm is divided by a perforated and chitinous membrane into an inner medulla or intracapsular region containing one or more nuclei and oil globules, and an outer cortex or extracapsular region which sometimes contains yellow symbiotic algae (Fig. 1.2 a).

Each example represents a zooid of a colony, having a single nucleus. When these organisms die their skeletons sink to the bottom of the sea and form **radiolarian ooze.**

Place a permanent slide of radiolarian ooze under the microscope and observe it:

i) In many radiolarians a hard, transparent, symmetrical skeleton is present (Fig. 1.2 b).
ii) The skeleton may be consisting of silicon or strontium sulphate, and imparts different shapes to these organisms.
iii) The opening of the skeleton is extended in the form of fine, stiff ray-like pseudopodia.



a

Fig.1.2: All radiolarian have photosynthetic endosymbiotic organisms that provide them with food. Living radiolarian shown in the figure (a) have glossy skeleton and a pigmentation derived from the endosymbiotic algae. (b) Skeleton of a radiolarian as you can see in the slide.

Habit and Habitat

Radiolarians are marine protozoans commonly occurring as bottom ooze. *Collozoum* is one of the common radiolarian found in deep sea.

Geographical Distribution

Most warm water seas.

Classification and its Justification

Kingdom	**Protista**	because radiolarians are single celled
Phylum	**Sarcomastigophora**	because locomotory organs may be pseudopodia or flagella; only one type of nucleus present; cilia are absent
Subphylum	**Sarcodina**	because pseudopodia are present and flagella are present in the development stages of some species
Superclass	**Rizopoda**	because locomotory organelles are lobopodia, filopodia or reticulopodia (pseudopodia)
Class	**Radiolaria**	Locomotory organelles are filopodia or axopodia
Genus	**Unspecified**	

1.3.3 *Euglena*

Take the prepared slide of *Euglena* and focus it first under low power and next under the high power of the microscope. Observe the following characteristics:

i) *Euglena* is an oval spindle shaped organism with a blunt anterior end and a pointed posterior end.
ii) Body is externally covered with a **pellicle.**
iii) Underneath the pellicle the cytoplasm is clearly differentiated into an outer **ectoplasm** and an inner **endoplasm.**
iv) Anterior end of the body bears an opening **cytostome,** which continues internally as a tubular **cytopharynx.** The cytopharynx leads into a large spherical reservoir.
v) From the base of the reservoir a single **whip-like flagellum** arises.
vi) A single large spherical **nucleus** is located towards the posterior region of the body.
vii) Cytoplasm also contains chlorophyll – containing bodies known as **chloroplasts.**

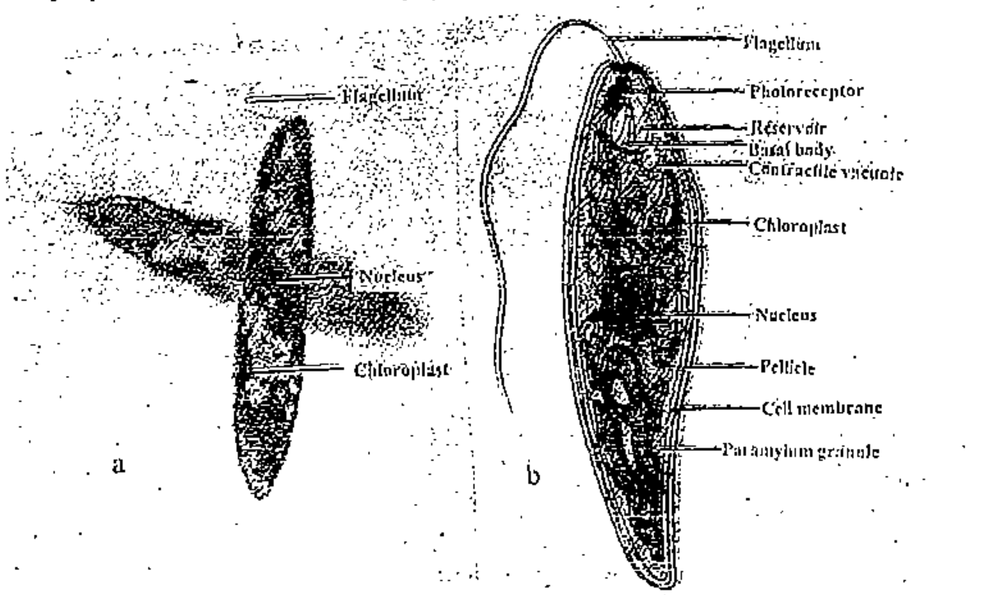


Fig. 1.3: a) Photomicrograph showing *Euglena* (200 x). b) Diagrammatic view.

viii) You can also see a brightly coloured spot – **stigma**, closely adhered to the cytopharynx (hence the name *Euglena*, which means **Eu=true+glena=eye ball)**

ix) A large **contractile vacuole** is also seen in the cytoplasm.

x) Compare your slide with Figure 1.3.

Habit and Habitat

Euglena is a solitary protozoan found in fresh water ponds, ditches, lakes and slow running streams with a lot of vegetation. It is abundantly found in those ponds, which contain decaying nitrogenous organic matter such as animal faeces leaves, etc.

Geographical Distribution

Abundant in warm waters throughout the world.

Classification and its Justification

Kingdom	**Protista**	because *Euglena* is single-celled
Phylum	**Sarcomastigophora**	because locomotion may be by pseudopodia or flagella; only one type of nucleus is present
Subphylum	**Mastigophora**	because one or more flagella present
Class	**Phytomastigophorea**	because it contains chloroplasts
Genus	***Euglena***	

1.3.4 *Trypanosoma*

Place a prepared slide of *Trypanosoma* under the microscope and focus it under low power. You will observe large number of tiny spindle-shaped trypanosomes lying in the plasma amidst red blood cells (Fig.1.4). Now focus the slide under high power and observe the following structures while comparing with Figure 1.4 given below.

i) The body is elongated and tapering at both ends. The anterior end is more tapering while the posterior end is somewhat bluntly rounded.

ii) A single flagellum is seen to come out from the anterior end; the flagellum is attached with the outer surface of the **undulating membrane**, which runs all along the entire length of the protozoan ending in the posterior end in the flagellum.

iii) The flagellum actually arises from a basal body or the **kinetoplast** situated near the anterior end of the body lying close to another structure the **parabasal body**.

iv) A rounded nucleus can be seen somewhere in the middle of the body.

v) Contractile vacuole is absent (this is true about any other parasitic protozoan).

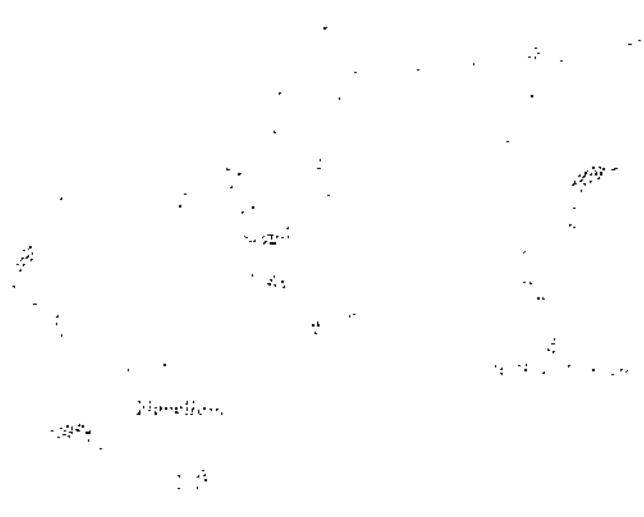


Fig.1.4: A photomicrograph of *Trypanosoma brucci* in vertebrate blood showing the undulating membrane and the trailing flagellum

Habit and Habitat

Trypanosoma is an endoparasite of vertebrates found in the plasma among the blood cells of their hosts. It is transmitted by blood sucking flies.

Geographical Distribution

Some species *T. gambiense* and *T. brucei* are largely found in Africa.

Economic Importance

Trypanosoma is an important blood parasite of human beings. One of its various species cause the lethal sleeping sickness.

i) *T. gambiense* causes West African sleeping sickness, and is transmitted by the tsetse fly (*Glossina palpalis*).
ii) *T. cruzi* causes Chagas disease, and is transmitted by a bug *Triatoma.*

Classification and its Justification

Kingdom	**Protista**	because *Trypanosoma* is single-celled
Phylum	**Sarcomastigophora**	because locomotion may be by pseudopodia or flagella; only one type of nucleus is present
Subphylum	**Mastigophora**	because locomotion is by one or more flagella
Class	**Zoomastigophora**	because it has a flagellum without chloroplasts
Genus	***Trypanosoma***	

1.3.5 *Giardia*

Place a prepared slide of *Giardia* first under the low power and then under the high power of the microscope and observe the following characters. Compare what you see in your slide with the diagram shown in Fig.1.5.

i) Bilaterally symmetrical pear shaped body, with the anterior end rounded and the posterior end tapering. Its one surface is convex and the other surface is concave with a sucking disc.
ii) The protoplasm contains two axostyles, two nuclei and four pairs of flagella arising from basal granules. (Can you simulate a cartoonist's impression of a human face in this figure?)

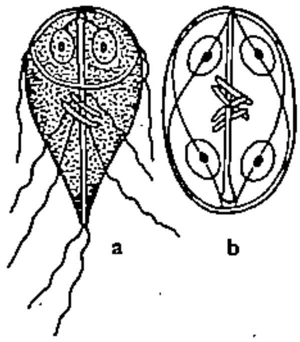


Fig.1.5: *Giardia intestinalis.*

Habit and Habitat

Parasitic form in human intestine.

Geographical Distribution

Giardia occurs world-wide.

Economic Importance

One species of *Giardia* namely *G. intestinalis* is a common human intestinal parasite causing a disease known as Giardiasis. The symptoms of the disease include persistent looseness of the stool and mild steatorrhea (passage of yellowish and green stools with excess of fats). The parasite can cause allergy and traumatic effects.

Classification and its Justification

Kingdom	**Protista**	because *Giardia* is single-celled
Phylum	**Sarcomastigophora**	because locomotion may be by pseudopodia or flagella; only one type of nucleus is present
Subphylum	**Mastigophora**	because locomotion is by one or more flagella
Class	**Zoomastigophora**	because it has a flagellum without chloroplasts
Genus	*Giardia*	

1.3.6 *Paramecium*

Place a prepared slide of *Paramecium* under the microscope and focus it under low power (5x × 5x) and observe the following:

i) It has a cigar-shaped or slipper-shaped body, hence commonly called **slipper animalcule** (=little animal).

ii) Now focus it under high power (10x × 40x):The entire body is covered with pellicle, which shows rows of tiny depressions.

iii) Look carefully at these depressions. From each such depression arises a **cilium**.

iv) These cilia cover the entire body and are uniform in size except at the posterior end of the body where they are larger and form a **caudal tuft.** These cilia help the *Paramecium* in locomotion.

v) The anterior end is bluntly rounded and the posterior end is slightly pointed.

vi) One side of the organism has a depression, which leads into an oral groove. This groove ends in the mouth or cytostome.

vii) Now observe the protoplasm, which is clearly divisible into an outer **ectoplasm** and an inner fluid-like **endoplasm.** You can see series of rod like trichocysts under the pellicle embedded in the endoplasm.

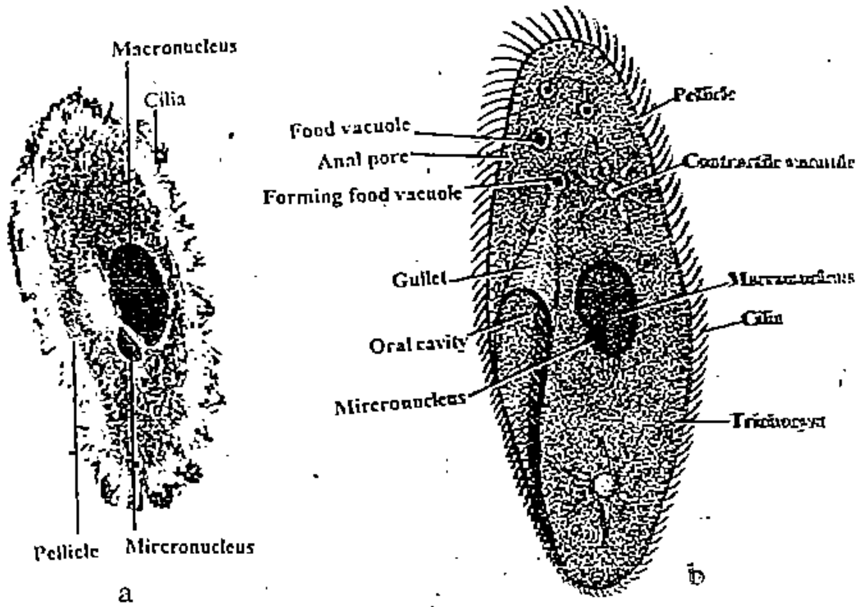


Fig.1.6: *Paramecium bursaria.* a) photomicrograph (430 x). b) diagrammatic representation

viii) The endoplasm contains two nuclei – one large kidney-shaped **macronucleus** and the other small dot-like **micronucleus.**

ix) You can also see two **contractile vacuoles** – one towards the anterior end and the other towards the posterior end.

x) Apart from these structures, many **spherical food vacuoles** can be seen in the endoplasm.

xi) Compare your slide with Figure 1.6.

Habit and Habitat

Paramecium is found in fresh water ponds and ditches rich in dead and decaying vegetation.

Geographical Distribution

World wide.

Classification and its Justification

Kingdom	**Protista**	because *Paramecium* is single-celled
Phylum	**Ciliophora**	because of the presence of at least one macronucleus one micronucleus and cilia
Genus	***Paramecium caudatum/P. bursaria***	

1.3.7 *Vorticella*

Vorticella can first be seen by the naked eye, but to study it place a prepared slide under the microscope. Focus it under low power, and observe it. You can see a large number of specimens attached to aquatic plants or some object by thread-like contractile stalks. They appear like tiny balloons attached by strings.

Now focus the slide under the high power of the microscope, and study the following characters carefully:

i) *Vorticella* has bell-shaped body with a long slender and contractile stalk for attachment.

ii) The free broad end of the body is the oral end, while the opposite narrow end is the aboral end.

iii) The entire body is covered by a thin **pellicle** and the protoplasm is clearly distinguishable into an outer **ectoplasm** and an inner **endoplasm.**

iv) The bell margin is fringed with a circle of cilia, while the central mass forms the **peristomial disc**, which is separated from the margin by a shallow circular depression called oral groove or **peristome.**

v) On one side of the groove the peristomial groove is extended into the interior of the bell forming a vestibule or the **buccal cavity**. At the inner end, the vestibule opens through the **cytostome** into the **cytopharynx.**

vi) Cilia unlike in *Paramecium* are not distributed uniformly all over the body, but are confined in the oral region. These cilia are arranged in two circles – one outer circle on the rim and an inner circle on the edge of the disc.

vii) The endoplasm contains a horse-shoe shaped **macronucleus**, a small **micronucleus**, a single **contractile vacuole** and a few **food vacuoles** (Fig.1.7).

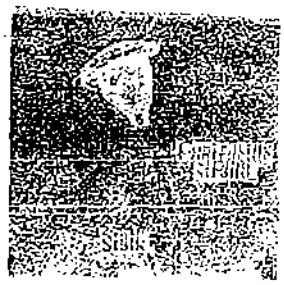


Fig. 1.7: *Vorticella*.

Habit and Habitat

Vorticella is normally found in freshwater ponds attached to some objects like weeds and leaves.

Geographical Distribution

Found in warm waters worldwide.

Classification and its Justification

Kingdom	**Protista**	because *Vorticella* is unicellular.
Phylum	**Ciliophora**	because of the presence of at least one macronucleus one micronucleus and cilia.
Genus	***Vorticella***	

1.4 TERMINAL QUESTIONS

1. How do you distinguish ectoplasm from endoplasm?

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2. What are the functions of contractile vacuole, cytoplasm, pseudopodia and food vacuoles respectively?

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3. At what level of organisation are the protozoans placed?

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4. Fill in the blanks:

   a) Phylum Sarcomastigophora is divided into .... and .... on the basis of ....

   b) Phylum Ciliophora is characterised by the presence of .... and ....

EXERCISE 2 PROTOZOA-II: PREPARATION OF SOME PROTOZOAN CULTURES AND MAKING PERMANENT SLIDES

Structure

2.1 INTRODUCTION

In the earlier exercise you observed permanent slides of some representative protozoans and learnt to identify and place them in different protozoan groups according to their characteristic features. In this exercise you will learn to prepare suitable cultures of *Amoeba, Paramecium, Vorticella* and *Euglena*. You will also take out parasitic protozoans from the rectum of frog and observe these protozoans alive as well as prepare their permanent mounts.

Objectives

After performing this exercise you should be able to:

- describe how a culture is prepared for the genera *Amoeba, Paramecium, Vorticella* and *Euglena*,
- prepare temporary slides of protozoans to study them alive,
- prepare permanent mounts of above mentioned protozoans,
- make cultures of any two of the above listed protozoans,
- prepare permanent mounts of rectal ciliates from frog to study parasitic protozoans,
- compare the structures of free living and parasitic protozoans.

2.2 MATERIAL REQUIRED

1. A glass trough and some petri dishes
2. Dry hay and some wheat grains
3. 2-3 living frogs
4. A few eggs
5. Glass slides and cover slips
6. Glass dropper and normal saline
7. Ascending grades of ethanol (ethyl alcohol)
8. Albumen glycerin
9. Absolute alcohol
10. Xylene
11. DPX mountant
12. Aceto-carmine and acetic acid

13. Watch glass
14. Dissection box

2.3 CULTURE METHODS

Free living protozoans can be best collected in the scum on ponds or among plants and debris at the edge of shallow ponds, marshes, or backwaters of streams or among tide pools along the seashores. However, it is also easy to culture these organisms in the laboratory for a regular supply of live samples. You will find it easier to start your culture during the summer months of the year.

In order to maintain a successful culture it is important that:

1. there be an abundant supply of food
2. adequate inorganic nutrients be present
3. suitable temperature and chemical conditions be maintained and
4. the environment is without any enemies.

2.3.1 Preparation of *Amoeba* Culture

Using the following method you can culture *Amoeba*:

- Take about 500 ml of water in a flask and add 25 –30 grains of wheat and some hay.
- Boil this to get the starch extracted.
- Allow the water to cool down. This provides the most satisfactory culture medium.
- Collect some pond water along with some decaying weeds; filter it through a muslin cloth.
- Now mix the residue with the starch solution in a petri dish (the residue contains a large number of *Amoeba*).
- Cover the petri dish and leave it for a week or so.
- *Amoebae* will multiply rapidly, and can be obtained as and when required.

2.3.2 Preparation of *Paramecium* Culture

Paramecium can be cultured by the following method:

- Boil in a flask 500 ml water with 20-25 grains of wheat and some hay. Allow it to cool down. This is your culture medium.
- Collect some water from a pond which has submerged leaves and some *Paramecia* (ascertain the presence of the protozoans by examining under the microscope).
- Mix this pond water with the culture solution prepared as above in a petri dish, cover and leave for about a week.
- In a few days paramecia will appear along with some bacteria in the petri dish.
- It is best to culture paramecia at 22-25° C.

2.3.3 Preparation of *Euglena* Culture

Euglena can be cultured by the following method:

- Take a glass trough and fill it about three-fourth with water. Add about 70-80 gms of wheat grains and some hay.
- Keep this trough at the base of a window so that the sun rays do not fall directly on it. Leave it for about seven days.
- Now add to it some pond water containing *Euglena*.
- Within 14-15 days the water will become greenish and the surface of the water will be covered with a scum.

- Examine this scum under the microscope for *Euglena.*

2.3.4 Preparation of *Vorticella* Culture

Vorticella culture can be prepared by the following method:

- Take about 1gm of mashed hard boiled egg yolk and add to it a liter of distilled water.
- Allow it to stand for two days and then filter it through cotton.
- Take about 100 ml of this filtrate in a petri dish and introduce into it a few *Vorticella* specimens along with some weeds.
- Within 14-15 days, *Vorticella* multiply and will be available in plenty in the culture.

2.4 OBSERVING LIVING PROTOZOA

Once you have learnt to prepare protozoan cultures, you should also be able to observe living specimens under the microscope.

- Using a glass pipette or a dropper put one or two drops of water from the culture on a clean slide.
- Disperse the water evenly with the help of a glass rod or tip of the dropper.
- Place a clean coverslip gently over the drop. Too much water will make the coverslip float and too little water will dry up fast and you will not be able to observe any thing for long. With a little practice you will learn to put the right amount.
- To observe protozoans for some time, scrape some petroleum jelly from a thin layer applied to the palm of your hand onto each edge of the coverslip (see Fig. 2.1).
- Place the coverslip side coated with jelly on the drop of water on the slide and press gently to seal it over the drop.
- Now you can observe the slide under the microscope.

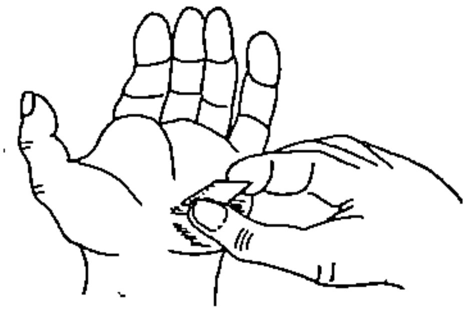

Fig. 2.1: Applying vaseline to the edges of a coverslip.

Many protozoans move very rapidly so that it becomes difficult to see them. A viscous solution of methyl cellulose slows them down without much distortion. Make a ring of methyl cellulose on the slide and put the drop of culture within the ring and cover with the coverslip (Fig. 2.2). As the organisms swim from the center into the mixing methyl cellulose and water, they slow down.

When you observe the live protozoans you will note that stained permanent slide of a protozoan usually looks much different from a live active, swimming specimen. Therefore, it is very important to make accurate drawings of live specimens and then compare them with the permanent mounts.

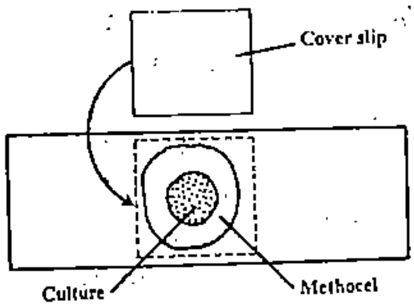

Fig.2.2: Methyl cellulose ring on a slide.

2.5 PREPARATION OF PEMANENT SLIDES OF SOME PROTOZOANS

In this part of the exercise you will learn to make a permanent mount of (i) *Paramecium* and (ii) rectal ciliates taken from a frog. Let us start with the method of mounting *Paramecium*.

2.5.1 Permanent Mounting of *Paramecium*

- Take a clear dry glass slide, put a very small drop of albumen glycerin in the center of the slide and with the tip of your fore finger, spread it to form a thin film.
- Using a dropper put 1-2 drops of *Paramecium* culture on the film and observe under the low power of the microscope. You will see a large number of paramecia moving rapidly in the medium.
- Let the culture become dry, you can put the slide under an electric lamp.
- Now open a bottle of acetic acid, and quickly pass the slide (dried culture side downwards) over the mouth of the bottle. This will fix the protozoans.
- Keep this slide in a larger petri dish (5" diameter) with the paramecia bearing side facing upwards. Put 3-4 drops of aceto-carmine so as to cover the culture fully.
- Stain the slide for 5-7 minutes.
- Drain off the extra stain from the slide with a sheet of blotting paper.
- Wash the slide with 30%, 50%, 70% and 90% alcohol in ascending order, keeping the petri dish covered with another petri dish so that no atmospheric moisture enters, at the same time moisture is gradually removed from the culture. This process is known as dehydration.
- Now cover the slide with absolute alcohol. Give two treatments with absolute alcohol, this will ensure complete dehydration.
- Remove the extra alcohol, put a few drops of xylene on the culture film. This will make the protozoans transparent (a process known as clearing) so that they are visible better under the microscope.
- Any turbidity with xylene indicates improper dehydration. If any turbidity is seen
- then repeat the treatment with absolute alcohol followed by treatment with xylene.
- Put a drop of DPX mountant over the culture film and lower the coverslip gradually and carefully over it. Ensure that no air bubbles are trapped in the preparation.
- Keep the slide inside the incubator overnight for drying. Your permanent mount is ready.

Fig. 2.3: *Opalina*.

2.5.2 Permanent Mounting of Rectal Protozoans from Frog

The rectal parasitic protozoans of frog are *Opalina*, (Fig. 2.3) *Balantidium* (Fig. 2.4) and *Nyctotherus* (Fig. 2.5). To obtain rectal ciliates the following procedure is used:

- Take a freshly chloroformed frog, cut it open and remove its rectum. Make a longitudinal cut in the rectum and empty its contents in a petri dish containing 0.75% sodium chloride.
- Take a few drops of this solution on a clean slide and observe under the microscope to ascertain whether the rectum is infected by protozoans.
- Spread a thin film of albumen glycerine on another clean slide and put a few drops of the solution containing rectal protozoans.
- Fix the protozoans by passing the side of the slide with the solution over the open mouth of an acetic acid bottle or by putting a drop of ethanol on the slide.
- Let the slide dry and then follow the procedure of dehydration with alcohol series, clearing with xylene and mounting in DPX or Canada balsam as given in subsection 2.5.1.
- Observe under the microscope. Note the characteristic features and identify the type of protozoans present with the help of your counsellor.
- You may be able to observe *Opalina, Nyctotherus, Balantidium*. Draw and label the important features as you observe them, in your note book.

Fig. 2.4: *Balantidium*

Fig. 2.5: *Nyctotherus*

2.6 TERMINAL QUESTIONS

1. Why do we have to empty the contents of the rectum in 0.75% NaCl before making a slide of rectal parasitic protozoans?

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2. Why is it recommended that a culture of protozoans be prepared in the summer months?

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3. What difference did you note between the structure of free living and parasitic ciliates?

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EXERCISE 3 PORIFERA-I: OBSERVATION AND CLASSIFICATION OF SPECIMENS

Structure

3.1 INTRODUCTION

If you are asked to identify a multicellular animal that has evolved for the first time in the geological time scale, you would look for members in the Poriferans. Since you are familiar with the unicellular animals from the earlier study, you would expect to see a many-celled animal in the next group of animals viz: the poriferans. As you observe the various examples, you will understand and appreciate the shape, size and modifications exhibited by the specimens. It is advisable that you go through unit 4 of LSE-09 and refresh your knowledge of sponges.

The initial advantage of becoming multicellular is the opportunity for increase in size. Larger organisms are less subject to attack, they have greater reserves within the body to withstand temporary unfavourable conditions and they are better able to determine their direction of movement against the flow of medium in which they live.

Sponges are sessile organisms with a low degree of individuality and organisation. They can be broken up and will grow into new sponges, or two individuals will grow together and apparently become one. Each is a hollow structure in which water is taken in through numerous minute pores scattered over the surface and passed out through one or several large apertures. Food particles and possibly dissolved organic matter are taken from the water. This type of feeding in which the major aperture is exhalent demands that the body of the sponge should be more or less rigid since collapse would preclude the intake of water. All sponges, therefore, have skeletons which may be either composed of spicules, calcareous or siliceous, or of an anastomosis of elastic fibres called sponging fibres, as in the familiar bath sponge. Spongin fibres are of two types. Spongin A fibres – composed of long unbranched fibrils of uniform width and Spongin B fibres made up of a halogenated scleroprotein. The form of skeleton is the major basis for sponge classification.

Sponges may be recognised by a single feature which is unique to them. They all have choanocytes, flagellate cells with a collar encircling the base of a single flagellum. In this practical exercise you will identify some specimen species of phylum Porifera and study the internal details of a poriferan.

Objectives

After performing this exercise you will be able to:

- identify the specimen and give its scientific and common name,
- classify up to order level and list the characters justifying the classification,
- describe its habit and habitat,
- draw a labelled diagram of the specimen, and
- distinguish a multicellular animal from an unicellular animalcule.

3.2 MATERIAL REQUIRED

1. The museum specimens of the following poriferans:
   Sycon or *Scypha*
   Hyalonema
   Euplectella
   Spongilla
2. Permanent slide of cross section of *Sycon*.
3. Compound microscope.
4. Hand lens

3.3 OBSERVATION OF PORIFERANS

The general characteristics belonging to this phylum are as follows:

1. The body is cellular.
2. The gametes are formed from specialised cells.
3. Choanocytes are always present.
4. The principal aperture of the body is exhalent.
5. During development (amphiblastula) the outer flagellate cells migrate inwards to form choanocytes and thus give rise to a reversal of each layer not found elsewhere in the animal kingdom.
6. The cells are comparatively independent of one another.
7. Sense organs and nervous system are absent.
8. There is no enteron lined by endodermal cells.

You will examine the listed specimens contained in museum jars or permanent slides for special structures wherever specified. If you feel the need, please use hand lens to observe certain details of the specimens.

3.3.1 *Sycon*

Look at the specimen contained in the jar by rotating it so as to get the view from all the sides. Note the following points/characters:

General Characters

i) Branching colonial sponge consisting of several hollow cylindrical branches.

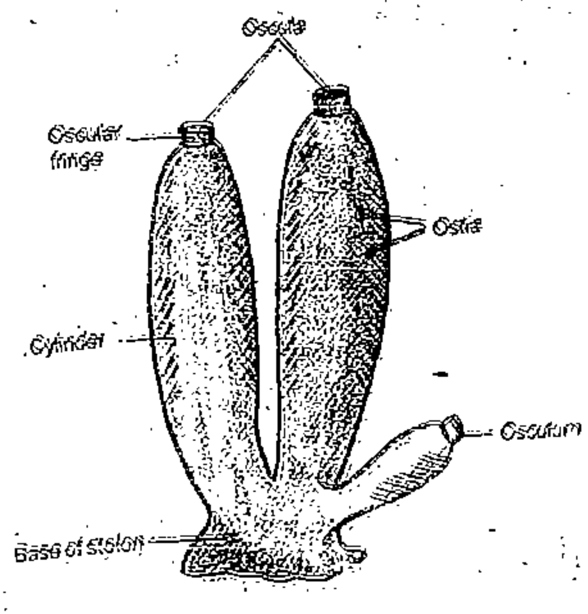

Fig. 3.1: *Sycon*.

ii) It has a central paragaster/spongocoel and a terminal osculum.
iii) Body wall is thick, perforated by ostia and permeated by an alternate system of incurrent canals and flagellated radial canals.
iv) Canal system syconoid and course of water current is Ostia – Incurrent canal – Prosopyle – Flagellated chambers – Apopyles – Paragaster – Osculum – outside (visible only in microscopic section).
v) The spicules are of various types like monaxon, triaxon or tetraxon.
vi) Hermaphrodite; reproduces sexually as well as asexually.

Habit and Habitat

Commonly found in shallow seas attached to rocks.

Geographical Distribution

Generally found in warm waters and widely distributed particularly near North Atlantic shores.

Classification and its Justification

The following are the reasons that justify the classification of *Sycon*.

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Porifera**	The body of the animal bears numerous pores. The body exhibits cellular grade of organisation.
Class	**Calcarea**	The spicules are made of calcium carbonate.
Genus	***Sycon* (*Scypha*)**	

3.3.2 *Hyalonema*

Observe the specimen from all directions and note the characters.

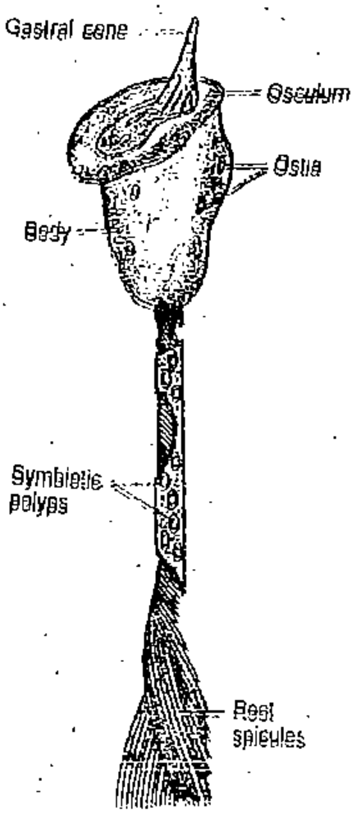

Fig. 3.2: *Hyalonema*.

General characters

i) The body of the sponge is ball shaped borne on a long twisted 'rope like root' of siliceous spicules, hence commonly known as glass rope sponge.
ii) The long siliceous spicules pass through the middle of the body as columella and often project as a gastral cone.
iii) Canal system is leuconoid type and a spongocoel is absent in forms with a gastral cone. Course of water current is Ostia–Incurrent canal–Prosopyle–Flagellated chambers–Apopyle–Excurrent canal–Osculum–outside.

Habit and Habitat

Attached to substratum by root specules in rather shallow deep waters of sea.

Geographical Distribution

Mostly found in the coastal regions of New England and America.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Porifera**	The body exhibits cellular grade of organisation. The body of the animal bears numerous pores.
Class	**Hexactinellida**	The spicules are made up of hydrated silica and are six rayed.
Genus	*Hyalonema*	
Common name	**Glass rope sponge**	

3.3.3 *Euplectella*

Study the detail features of the organism by studying it from all the sides.

General Characters

i) Body is curved, cylindrical and rigid about 12" long.
ii) Osculum is protected by a sieve plate, the oscular sieve.
iii) A tuft of siliceous root spicules are present posteriorly.
iv) The canal system is syconoid, but true ostia are absent; the body is perforated by parietal gaps.
v) Popularly known as Venus's flower basket. Dried skeleton of this sponge is used as a Wedding gift in Japan.

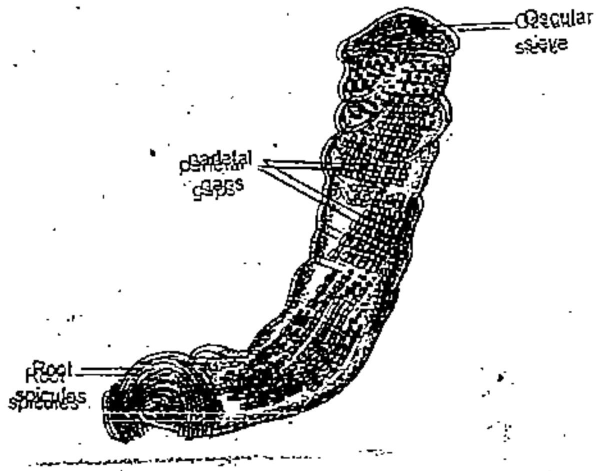

Fig. 3.3: *Euplectella*.

Habit and Habitat

It is a solitary animal, attached to substratum in deep sea.

Geographical Distribution

Found in abundance in Phillipines and West Indies.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Porifera**	The body exhibits cellular grade of organisation. The body of the animal bears numerous pores.
Class	**Hexactinellida**	The spicules are made up of hydrated silica and are six rayed.
Genus	***Euplectella***	
Common name	**Venus's flower basket**	

3.3.4 *Spongilla*

Study the details of the organism from all the directions and note the following characters.

General characters

i) Colonial, and highly branched.
ii) Yellowish brown in colour but may be green due to the presence of symbiotic algae.
iii) Body wall consists of a very thin dermal membrane perforated by ostia and oscula.
iv) Canal system is Rhagon type. Water current is as follows. Ostia–Flagellated chambers–Apopyle–Paragaster—Oscula–outside.
v) Siliceous spicules and spongin fibres are present.
vi) Regeneration and gemmule formation is common.
vii) Sexual and asexual reproduction are evident.

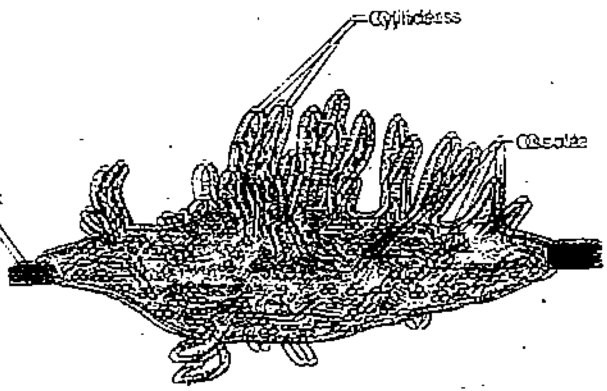

Fig. 3.4: *Spongilla*.

Habit and Habitat

It grows on substratum like submerged sticks and plants and found in ponds, lakes and slow flowing streams.

Geographical Distribution

Commonly found in warmer regions of India. At one time it was abundant in Delhi.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Porifera**	The body exhibits cellular grade of organisation. The body of the animal bears numerous pores.
Class	**Demospongia**	Skeleton made of siliceous spicules, spongin fibres or of both or of none.
Genus	***Spongilla***	
Common name	**Fresh water sponge**	

3.3.5 Cross Section of *Sycon*

You have already seen and studied the specimen of *Sycon*. Now examine and study its cross section under low power of light microscope. If not in complete view, rotate the slide to get an idea of the section in totality.

You will be able to observe the following details:

1. The body wall consists of an outer dermal epithelium formed of a single layer of flattened pinacocytes.
2. The inner gastrodermis is formed of a single layer of choanocytes.
3. In between the two cellular layers is the mesenchyme cementing them, formed of non-living gelatinous matrix containing Sclerocytes, Archaeocytes, Collencytes, and calciferous spicules.
4. The thick folded body wall consists of incurrent canals and radial canals arranged alternately.
5. The incurrent canals are lined by pinacocytes and communicate with exterior by ostia and with the flagellated chambers by prosopyles.
6. The flagellated canals are lined by choanocytes and open into the paragaster through apopyles.
7. The paragaster is the central space bound by the body wall and lined by the pinacocytes.

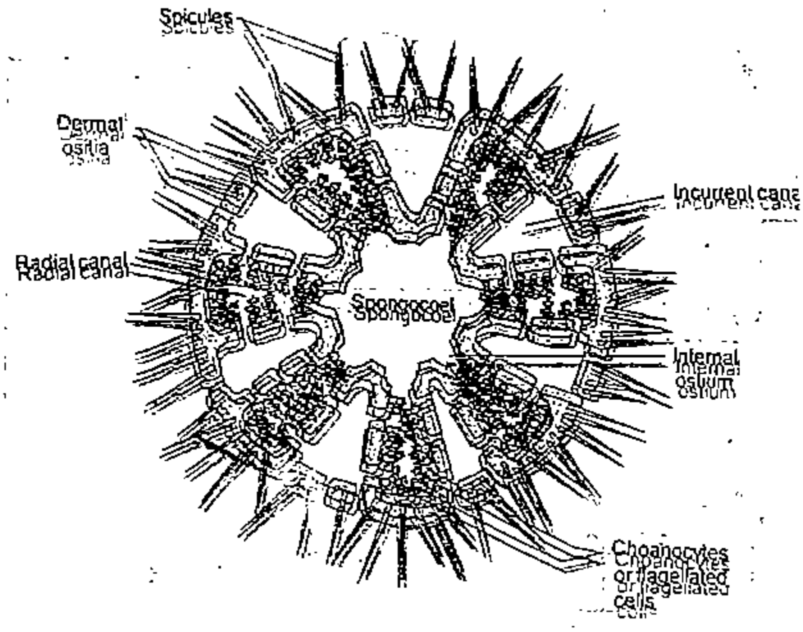

Fig. 3.5: Cross section of *Sycon*.

3.4 TERMINAL QUESTIONS

1. What are the characteristics of Sponges?

2. How is multicellularity advantageous to an organism.

3. Name a few examples of deep sea sponges? Mention their economic importance.

4. List five characters seen in the T.S. of *Sycon*?

EXERCISE 4 PORIFERA-II: MAKING OF TEMPORARY MOUNTS

Structure

4.1 INTRODUCTION

The mountings in porifera are used to study the hard and soft structures that form the skeleton in sponges. The spicules and the spongin fibres are present in the mesenchyme layer of the sponge body. The gemmules are asexual bodies and are formed in the sponge body under unfavourable condition chiefly with the advent of cold winter, when the surrounding water is unsuitable for a free existence. The gemmule is capable of forming a new sponge body at the return of favourable conditions prevailing in the water. Before performing the exercise you should observe the permanent slides of spicules, spongin fibres and gemmules under a compound microscope. Recall your knowledge of sponges about which you have studied in LSE-09.

Objectives

After doing this exercise you will be able to:

- locate and take out the gemmules, spicules and spongin fibres from their respective sponges,
- make a temporary mount of the material,
- make labelled diagrams of the mounts, and
- list the special features of the materials mounted.

4.2 MATERIAL REQUIRED

1. Sponge like *Sycon* for spicules, bath sponge for spongin fibres and fresh water sponge (*Spongilla*) for gemmules, preserved in 10% formalin.
2. Glycerine
3. Slides
4. Cover slips
5. Pasteur Pipettes/dropper
6. Spirit Lamp
7. Watch glass
8. Filter paper
9. Dissection kit
10. Compound microscope
11. 5% Potassium hydroxide solution (KOH)
12. 10% Potassium hydroxide solution (KOH)

4.3 GEMMULE

In this exercise you will learn to take out the gemmules from the given material, the fresh water sponge and make a temporary mount of it.

4.3.1 Procedure

Take a small portion of the freshwater sponge with gemmules (material provided – fresh water sponge, *Spongilla*) in a test tube. Add 5% or 10% KOH solution. Boil gently over a flame. The tissue (sponge body) will dissolve, and the gemmules will settle down in the test tube. Transfer the gemmules in a watch glass and wash well in water. For mounting in glycerine put the gemmules on the slide, add one to two drops of glycerine and cover with cover slip. Soak the extra glycerine on the sides of cover slip by filter paper. Observe under a compound microscope.

4.3.2 Observation

Each gemmule is a rounded body with a central mass of archaeocytes enclosed in a double layered cyst wall. The inner membrane is thick and is supported by monaxon spicules. Gemmules are asexual reproductive bodies formed by the freshwater sponges to tide over the unfavourable conditions (Fig. 4.1).

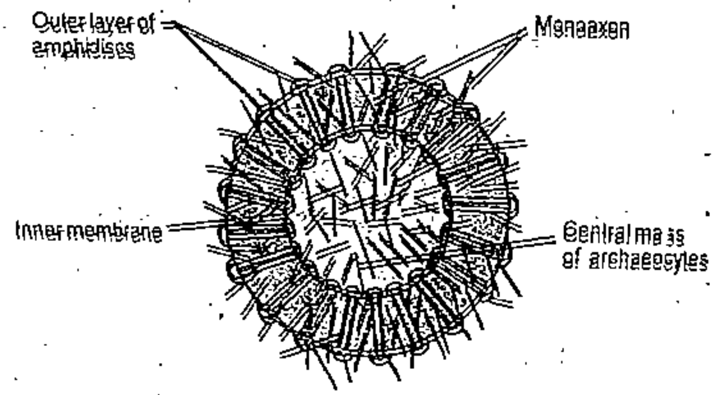

Fig. 4.1: Structure of gemmule of *spongilla* as seen under microscope.

4.4 SPICULE

Spicules are the skeleton of the sponges, that vary in shapes. In this exercise you will learn to take out monaxon spicules from the sponge body and make their temporary mount. The procedure for taking out the spicules from sponge body is same as used for gammules. As you have seen earlier monaxon spicules support the membrane of gemmule.

4.4.1 Procedure

Take a piece of sponge body in a test tube and add 5% or 10% KOH solution. Boil gently over a flame. The tissue (sponge body) will dissolve, and the spicules will settle down in the test tube. Wash well in water as done earlier. Mount in glycerine and observe under a Compound microscope.

4.4.2 Observation

You will be able to observe the different shapes of the monaxon spicules. Monaxon spicules are linear shaped in a single axis (Fig. 4.2).

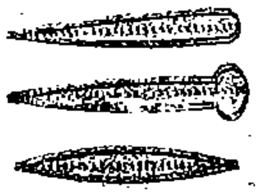

Fig. 4.2: Monaxon spicules.

4.5 SPONGIN FIBRE

Spongin fibres are proteinaceous in nature that form the skeleton of sponge body. In this exercise the procedure is again similar. However, treatment with concentrated KOH and boiling the solution will damage the sponging fibres.

4.5.1 Procedure

Take a piece of bath sponge in a test tube and add 5% KOH solution. Warm the solution. The sponge body will dissolve and the spongin fibres will be left behind in the test tube. Wash in water and transfer in a little glycerine on a slide as done earlier. Tease the material on the slide with needles to spread it evenly and put a cover slip. Observe under a microscope.

4.5.2 Observation

You will be able to observe a network of spongin fibres. It is a profuse network of fibres with cross links. It forms the supporting skeleton of the sponge body. Spongin fibres are somewhat elastic in nature and do not crack easily (Fig. 4.3).

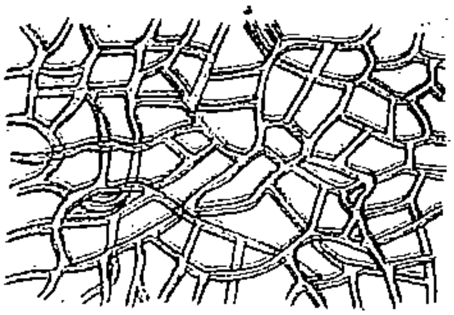

Fig. 4.3: Spongin fibres.

4.6 TERMINAL QUESTIONS

1. What is a gemmule?

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2. What are the different types of spicules?

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3. What is the function of spongin fibres?

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EXERCISE 5 CNIDARIA: OBSERVATION AND CLASSIFICATION OF SPECIMENS

Structure

5.1 INTRODUCTION

The phylum Cnidaria or Coelenterata, includes the familiar hydras, jelly fishes, sea anemones and corals. You have already studied about Cnidarians in Units 4 and 7 of LSE-09 course. These are often brilliantly coloured. They exhibit radial symmetry. The Cnidarians possess two basic metazoan structural features. One, there is an internal space for digestion, called in Cnidarians as gastrovascular cavity. This cavity lies along the polar axis of the animal and opens to the outside at one end to form a mouth. The presence of a mouth and digestive cavity permits the use of a much greater range of food sizes than is possible in the protozoans and sponges. Two, in Cnidarians a circle of tentacles, representing extensions of the body wall, surrounds the mouth to aid in the capture and ingestion of food.

The Cnidarian body wall consists of three basic layers: an outer layer of epidermis, an inner layer of endodermal cells lining the gastrovascular cavity, and between these two a layer called mesoglea. The mesoglea ranges from a thin, non-cellular membrane to a thick, fibrous, jelly-like, mucoid material with or without wandering amoebocytes. A considerable number of different cell types compose the epidermis and gastrodermis, but there is only a limited degree of organ development.

The different structural types are present within the phylum. One type, which is sessile, is known as the polyp. The other form is free swimming and is called the medusa. Typically, the body of a polyp is a tube or cylinder in which the oral end, bearing the mouth and tentacles, is directed upward, and the opposite, or aboral end is attached.

The medusoid body resembles a bell or an umbrella with the convex side upward and the mouth located in the centre of the concave undersurface. The tentacles hang down from the margin of the wall. In contrast to the polypoid mesoglea (middle layer) which is more or less thin, the medusoid mesoglea is extremely thick and constitutes the bulk of the animal. Because of this mass of jelly-like mesogleal material, these Cnidarian forms are commonly known as Jelly-fish. Some Cnidarians exhibit only the polyp form, some only the medusoid form, while others pass through both in their life cycle. Except for the hydras that are found in fresh water, cnidarians are marine and are found in shallow waters.

Objectives

This exercise will enable you to:

- identify the specimen and give its scientific and common name,
- classify up to class level, and give the reasons for the classification listed by you,

- draw a labelled diagram of the specimen, and
- monitor any special features in the life history.

5.2 MATERIAL REQUIRED

1. Museum specimens - *Physalia*, *Aurelia*, Sea Anemone, *Acropora*
2. Compound microscope
3. Binocular microscope
4. Permanent slides - *Obelia* colony, Medusa of *Obelia*, T.S. of Hydra through testis and ovary.

5.3 OBSERVATION OF CNIDARIANS

Cnidaria are Radiata in which:

1. Nematocysts are present.
2. Adult movement is by muscular activity.
3. The body is either a polyp or a medusa, and these alternate in the life-cycle of many species.
4. A planula larva is developed.

5.3.1 *Obelia* Colony

Examine the slide under low power of microscope/binocular. Note the details of the colony starting from its basal end to the terminal structure. On the branches note different types of zooids and their distinctions from each other.

General Characters

Obelia colony is a highly branched structure and consists of a horizontal hydrorrhiza attached to the substratum and several vertical branches or hydrocauli which bear zooids. The colony is dimorphic consisting of:

i) Polyps or hydranths that are nutritive zooids having vase-shaped body with mouth and tentacles. The polyp is enclosed by a perisarcal covering called hydrotheca.
ii) Blastostyles are club-shaped without tentacles. These are enclosed in gonotheca, the perisarcal covering. Buds arise from its axis, which develop into medusae.
iii) Life history exhibits regular alternation of asexual and sexual generation or metagenesis.

Habit and Habitat

Marine, colonial, sedentary, in shallow water region, attached to substratum.

Geographical Distribution

Widely distributed from Arctic region down to Gulf of Mexico and Pacific Coasts.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Cnidaria**	Nematocysts are present, adult movement is by muscular activity. The body is either a polyp or a medusa, and these alternate in the life cycle of many species. A planula larva is developed.

Class **Hydrozoa** The polyp typically alternate with the medusa.
The medusa possesses a velum and a nerve ring.
The enteron is not subdivided by vertical septa.
The gonads are ectodermal in origin.
There may or may not be a skeleton.
The tentacles of the polyp are generally solid.
The members almost always form colonies.

Genus ***Obelia***

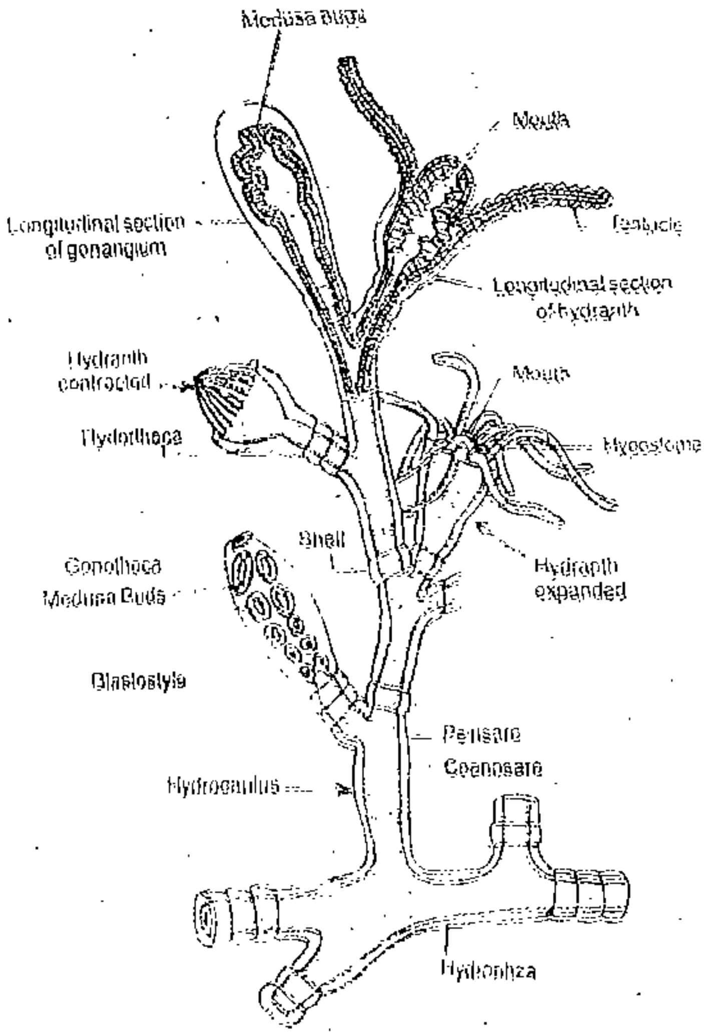

Fig. 5.1: *Obelia* colony.

5.3.2 Medusa of *Obelia*

Examine the slide of medusa of *Obelia* and note the following characters. It is a life-history stage of *Obelia*.

General characters

The following are the identification characters of the Medusa.

i) Medusae are saucer-shaped. These bear gonads and produce sperm or ova for sexual reproduction.
ii) Gonads are borne on radial canals.
iii) Medusa is a free swimming reproductive zooid of *Obelia* colony developing asexually on the blastostyles.

iv) Margin of the umbrella with a true velum and a circlet of tentacles. Medusae are craspedote i.e. with velum.
v) Four adradial tentacles carry statocysts at their base.
vi) Mouth rectangular borne on manubrium which is present in the centre of inner or sub-umbrellar surface.

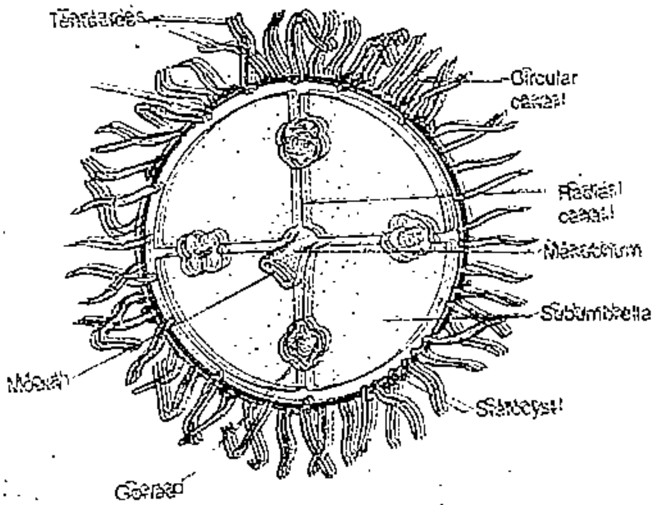

Fig. 5.2: Medusa of *Obelia*.

Habit and Habitat: It is a free living and swimming stage of *Obelia*.

Geographic Distribution: Widely distributed from Arctic region down to Gulf of Mexico and Pacific coasts.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Cnidaria**	Nematocysts are present. Adult movement is by muscular activity. The body is either a polyp or a medusa, and these alternate in the life cycle of many species. A planula larva is developed.
Class	**Hydrozoa**	The polyp typically alternate with the medusa. The medusa possesses a velum and a nerve ring. The enteron is not subdivided by vertical septa. The gonads are ectodermal in origin. There may or may not be a skeleton. The tentacles of the polyp are generally solid. The members almost always form colonies.
Genus	***Obelia***	

5.3.3 *Physalia*

Observe the specimen in the jar from all sides. You will be able to observe the following characters.

General characters

i) It is a colonial form, brightly coloured, blue or purple unichambered float – the pneumatophore, filled with gas having the composition of air.

ii) The gas is secreted by gas gland present in the underside of the pneumatophore. It is hydrostatic in function.

iii) Upper surface of the float is drawn into a sail or crest and has an opening called pneumatopore.

iv) *Physalia* exhibit the highest degree of polymorphism. The colony consists of:
   - Gastrozooids or nutritive zooids with mouth but without tentacles.
   - Blastostyles or gonophores or reproductive zooids bear clusters of medusae.
   - Dactylozooids or protective zooids with tentacles and nematocysts.
   - Tentacles are very long and coiled. Carry batteries of nematocysts.
   - Collection of all of the zooids forms cormidia.

v) It is popularly known as Portuguese man-of-war. ("Man-of-war" refers to a warship denoting its highly aggressive nature as a predator)

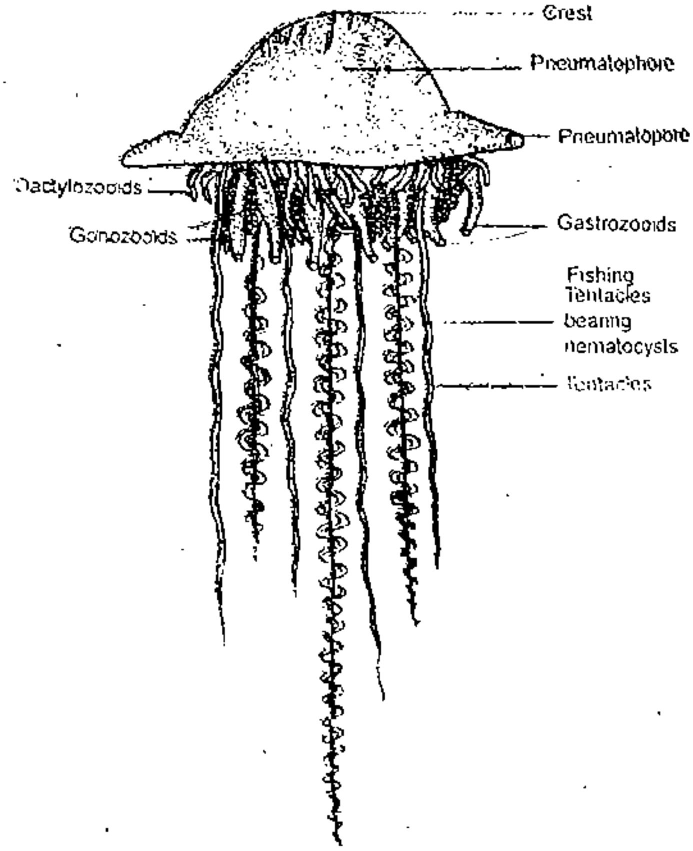

Fig. 5.3: *Physalia.*

Habit and Habitat

Marine, pelagic, colonial and floating form.

General Distribution

Found in tropical and subtropical seas.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Cnidaria**	Nematocysts are present. Adult movement is by muscular activity. The body is either a polyp or a medusa, and these alternate in the life cycle of many species. A planula larva is developed.

Class Hydrozoa The polyp typically alternate with the medusa.
The medusa possesses a velum and a nerve ring.
The enteron is not subdivided by vertical septa.
The gonads are ectodermal in origin.
There may or may not be a skeleton.
The tentacles of the polyp are generally solid.
The members almost always form colonies.

Genus *Physalia*
Common name **Portugese Man of War**

5.3.4 *Aurelia*

Observe the specimen in the jar from different sides and study the details.

General Characters

Aurelia is disc-shaped with a convex exumbrellar surface and a concave subumbrellar surface.

i) It is found in coastal waters of all seas.
ii) It has a gelatinous, transparent and coloured body.

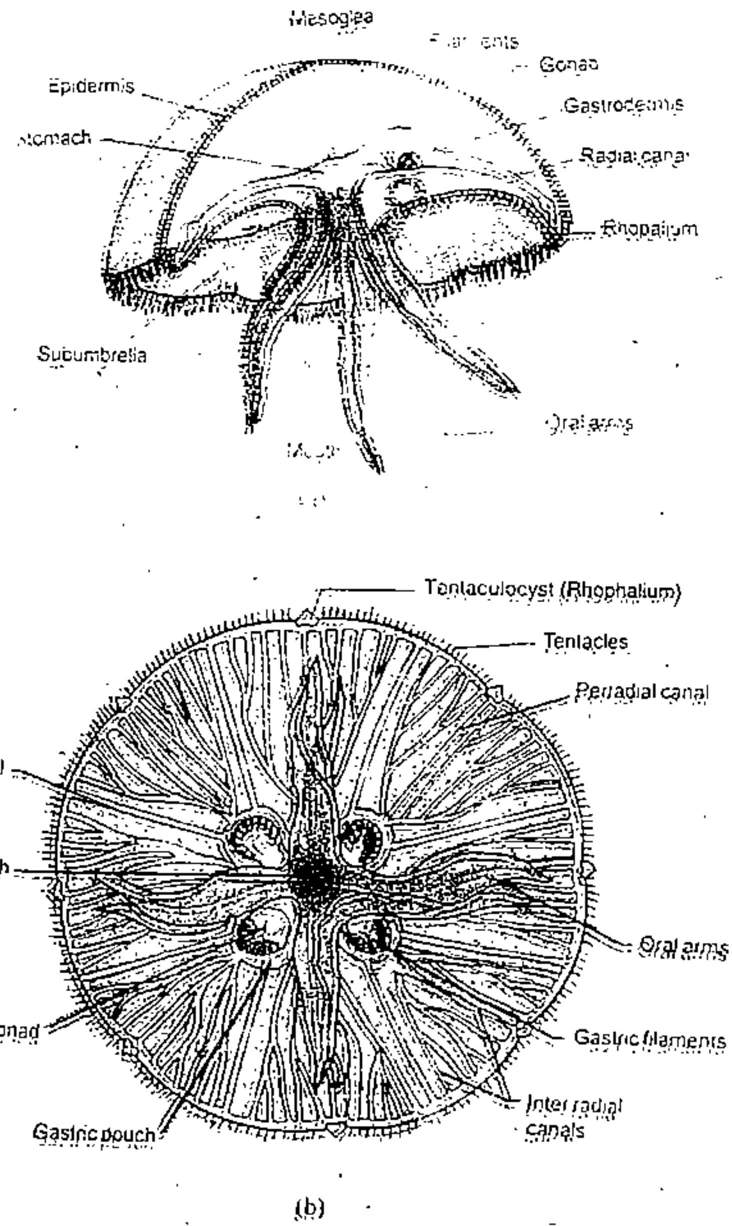

Fig. 5.4: *Aurelia*: (a) Side view (in section); (b) Oral view.

iii) The subumbrellar margin of the umbrella beset with tentacles and broken into 8 notches.
iv) Each notch has a tentaculocyst and a pair of marginal lappets.
v) The squarish mouth borne on a short manubrium, placed in the centre of subumbrellar surface.
vi) Angles of the mouth drawn into four long oral arms.
vii) Gonads two pairs, horse-shoe shaped and placed on the floor of the four gastric pouches.
viii) Sexes are separate and life cycle presents alternation of generations.

Habit and Habitat

It is a marine, solitary jelly fish.

Geographical Distribution

Found throughout the world in coastal waters.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Cnidaria**	Nematocysts are present. Adult movement is by muscular activity. The body is either a polyp or a medusa, and these alternate in the life cycle of many species. A planula larva is developed.
Class	**Scyphozoa**	The medusoid form is dominant and the polyp form is greatly reduced or absent. The medusa possesses neither a velum nor a nerve ring. The enteron of either the adult of the larva is subdivided by vertical septa. The gonads are endodermal in origin. The tentacles are solid. The members are solitary. Marine forms only.
Genus	***Aurelia***	

5.3.5 *Metridium*

Observe the specimen. This is one of the commonly known sea anemone (anemone is a kind of flower of the same group as sunflower).

General characters

i) Body short, cylindrical, differentiated into oral disc, column and pedal disc.
ii) Oral disc is flat with a slit-like mouth surrounded by numerous short and hollow tentacles.
iii) Column differentiated into thin walled distal portion Capitulum and thick walled proximal portion – Scapus.
iv) Wall of scapus is perforated by small openings called cinclides.
v) Basal disc broad and muscular meant for attachment.
vi) Gastrovascular cavity divided into compartments, usually by six pairs of mesenteries.
vii) Stomodaeum carries two siphonoglyphs.

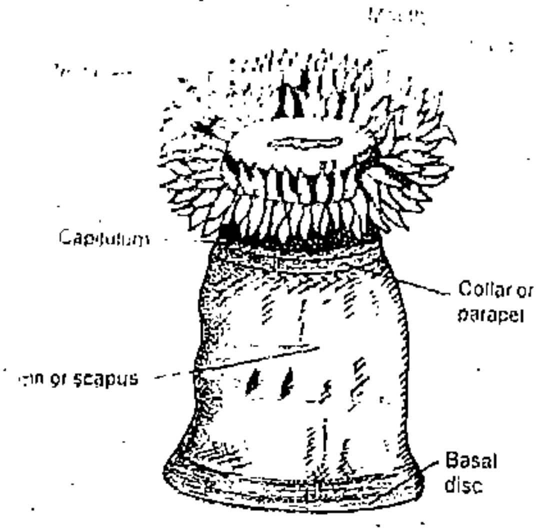

Fig. 5.5: *Metridium.*

Habit and Habitat

It is a sessile, bright coloured solitary flower like form. Attached to substratum like rocks, etc.

Geographical Distribution

Found in coastal waters of Atlantic, Pacific and Indian Oceans.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Cnidaria**	Nematocysts are present. Adult movement is by muscular activity. The body is either a polyp or a medusa, and these alternate in the life cycle of many species. A planula larva is developed.
Class	**Anthozoa**	The polyp form is dominant and the medusoid form is absent. The enteron is subdivided by vertical septa. The gonads are endodermal in origin. A skeleton may or may not be present. The tentacles are hollow. The members are colonial or solitary.
Genus	***Metridium***	
Common name	**Sea anemone**	

5.3.6 *Acropora*

Observe the specimen and look for the following characters (In the dried specimen you will not be able to see soft parts like polyps).

General characters

i) Colony tree-like with numerous terminal and the lateral polyps which are enclosed in cylindrical cups or corallites separated by perforated coenosteum. (In the dried specimen you will not be able to see soft parts like polyps).

ii) Terminal polyps contain 6 tentacles and lateral polyps possess 12 tentacles.
iii) Corallite is made up of calcium carbonate secreted by the polyps.

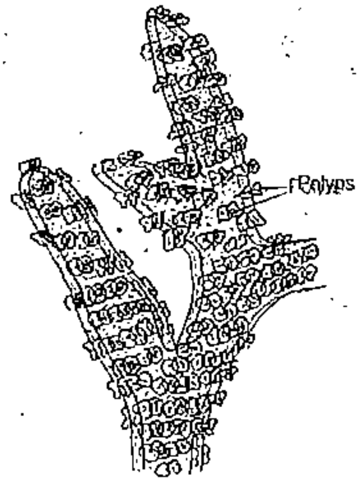

Fig. 5.6: *Acropora*.

Habit and Habitat

Major coral reef builders. These are marine, colonial forms.

Geographical Distribution

Found in tropical waters of Australian seas, West Indies and Florida.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Cnidaria**	Nematocysts are present. Adult movement is by muscular activity. The body is either a polyp or a medusa, and these alternate in the life cycle of many species. A planula larva is developed.
Class	**Anthozoa**	The polyp form is dominant and the medusoid form is absent. The enteron is subdivided by vertical septa. The gonads are endodermal in origin. A skeleton may or may not be present. The tentacles are hollow. The members are colonial or solitary.
Genus	***Acropora (Madrepora)***	

Common name **Stag horn coral**

5.3.7 T.S. of *Hydra* through testis

When you examine a slide of T.S. of *Hydra* through testis under low power, you will be able to observe the following structural details. If required, change to high power carefully so as not to break the slide. You have already studied about the organism in theory course LSE-09.

1. Body wall consists of an outer ectoderm and an inner endoderm with a cementing non-cellular mesoglea in between.
2. There is a single central cavity, the gastro-vascular cavity or coelenteron, lined by endoderm.

3. The ectoderm cells are columnar and are of various types namely – epithelio-muscular cells, interstitial cells, gland cells, nerve cells, sensory cells and nematocysts.
4. The endodermal cells are cylindrical and are of various types namely: Nutritive, muscular, secretory, sensory and nerve cells.
5. The testis arises on the upper region of the body of the animal as a conical surface from the interstitial cells of the ectoderm. It is bounded by a layer of ectodermal cells.
6. It contains numerous spermatogonia which give rise to spermatozoa.
7. A mature sperm has a swollen head, a narrow middle piece and a long slender tail.

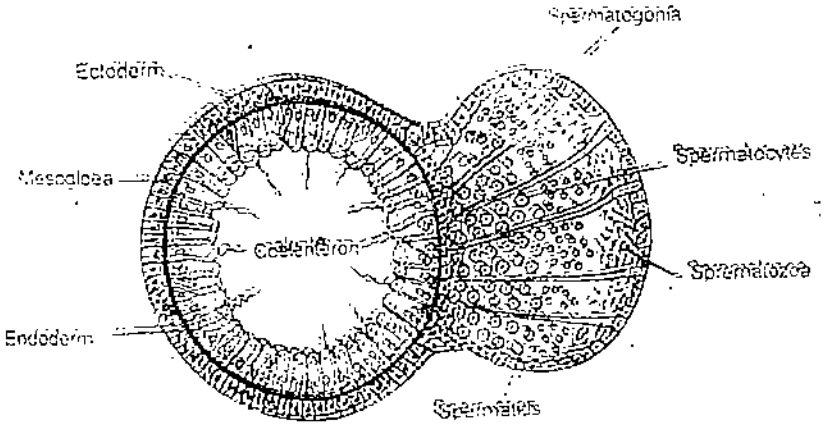

Fig. 5.7: T.S. of *Hydra* through testis.

5.3.8 T.S. of *Hydra* through ovary

You will observe the following details while examining the slide of T.S. of *Hydra* through ovary.

1. Body wall consists of an outer ectoderm and an inner endoderm with a cementing non-cellular mesoglea in between.
2. There is a single central cavity, the gastro-vascular cavity or coelenteron, lined by endoderm.
3. The ectoderm cells are columnar and are of various types namely – epithelio-muscular cells, interstitial cells, gland cells, nerve cells, sensory cells and nematocysts.
4. The endodermal cells are cylindrical and are of various types namely: Nutritive, muscular, secretory, sensory and nerve cells.
5. Ovary develops on the lower region of the body of *Hydra* from the interstitial cells of the ectoderm. It is surrounded by a layer of ectodermal cells.
6. The ovary consists of a large spherical ovum with a centrally situated nucleus and granules of reserve food in its cytoplasm.
7. The germ mother cell or oogonium located in the centre of the ovary enlarges, becomes amoeboid and undergoes reduction division to form the ovum.

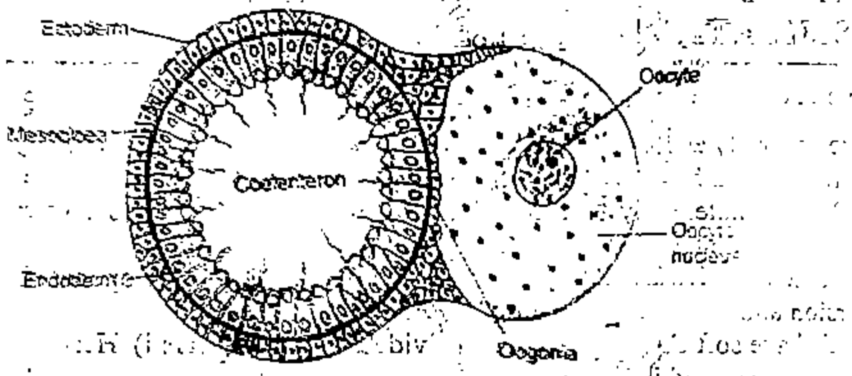

Fig. 5.8: T.S. of *Hydra* through ovary.

5.4 TERMINAL QUESTIONS

1. List the characters of Cnidaria.

2. Compare the body wall of a sponge and a Cnidarian.

3. What is polymorphism? Describe this phenomenon from the example studied by you.

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4. In what way do you feel that the study of a coral is important?

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EXERCISE 6 ANNELIDA: OBSERVATION AND CLASSIFICATION OF SPECIMENS

Structure

6.1 INTRODUCTION

In Latin Annelida means "little rings". If you happen to see a long, elongated, soft bodied, slimy worm with rings all over its body (on its anterio-posterior axis), it is an annelid (an animal belonging to phylum Annelida). These rings divide the animal's body into smaller compartments or segments or somites or meros. Annelids are different from flatworms (Platyhelminthes) and round worms (Nematoda) in having these rings. They also differ from arthropods (specially centipedes and millipedes) because of their slimy, soft outer skin. Phylum Annelida includes the most familiar and eco-friendly earthworms and also the feared blood-sucking leeches. *Nereis*, a marine worm, is also a good and typical textbook representative of this phylum but is not so commonly seen around us.

Annelids are distributed worldwide; they inhabit practically all parts of the temperate and tropical regions of the earth. In fact, this phylum has **8600 species**. Most of them prefer living in sea, but there are freshwater and terrestrial forms also. You will observe and learn to classify some typical representatives of phylum Annelida like the earthworms that make burrows in damp soil, *Nereis* and *Chaetopterus* that live in the sea, *Aphrodite* that creeps on the sea floor, and leeches that live both on land and in water. It would be helpful to study unit of LSE-09 before you come for this exercise.

Objectives

After performing this exercise you should be able to:

- identify the specimens of *Nereis, Chaetopterus, Aphrodite, Pheretima* and *Hirudinaria* and give their scientific and common names,
- draw labelled diagrams of the identified genera,
- classify each of the identified annelids up to the level of the class,
- list characters justifying their classification and mention special features, if any
- mention the habit and geographical distribution of each of the identified genera,
- mention economic importance, if any, of each of the identified genera.

6.2 MATERIAL REQUIRED

1. Preserved specimens of *Nereis, Chaetopteus, Aphrodite, Pheretima and Hirudinaria*
2. A hand lens
3. Note book, pencil, etc.

6.3 GENERAL CHARACTERS AND OUTLINE CLASSIFICATION

You would recall from Unit 5 of Block 4 Animal Diversity I course that annelids are segmented, triploblastic, coelomates, bilaterally symmetrical, protostomes, having well-developed organ systems.

Before we explain to you the specialities of the specimens in your course (*Nereis, Chaetopterus, Aphrodite, Pheretima* and *Hirudinaria*) it is essential to explain the general characters and classification of phylum Annelida.

General Characters of Phylum Annelida

1. Body long, elongated, worm-like, having **metameric segmentation,** with the exception of anterior and posteriormost sides of the body. A small part towards the head may also be without apparent segments. This part is called **clitellum** and is best seen in earthworms - refer to Fig. 6.8.
2. Body is **bilaterally** symmetrical.
3. **Triploblastic** and have true schizocoelous coelom. Coelomic fluid supplies turgidity to the soft body and the functions as hydrostatic skeleton.
4. Found on land and in water.
5. **Skin** is soft, slimy and moist because exchange of gases takes place through it.
6. Blood circulatory system is **closed** and **metamerically arranged**. Respiratory pigments like **haemoglobin**, **hemerythrin** or **chlorocruorin** may be present in different annelids.
7. Digestive system well **developed** and **complete**, may or may not be segmentally arranged.
8. Respiration takes place also through special structures (besides skin) like **gills**, and **parapodia** that are thin, vascular, flap like extensions of body wall, projecting on lateral side, also used for locomotion. **Chitinous setae** often present on the parapodia.
9. Excretion is by many segmentally arranged **nephridia** (singular nephridium). These are small coiled structures having a ciliated funnel (nephrostome) inside the coelom and a small pore (nephridiopore) opening on the body wall.
10. Nervous system with a **double ventral nerve cord** having a pair of ganglia - in each segment. Brain has two cerebral ganglia connected to nerve cord.
11. Sensory structures like tactile organs, taste buds, statocyst, photoreceptors and eyes with lenses may be present in some.
12. Some annelids are **hermaphrodite** (earthworm, leech) some have separate sexes (*Nereis*).
13. In some annelids development may be through a **trochophore** larva, some show asexual reproduction by **budding.** The development is **mosaic** (indeterminate) by **spiral cleavage.**

Animals of phylum Annelida have been divided into three classes – Polychaeta, Oligochaeta and Hirudinea. This classification is based mainly on following traits:

- presence or absence of distinct head and sense organs.
- presence or absence of clitellum.
- mode of locomotion.

Table 6.1: Distinguishing Characteristic Features of Annelid Classes.

Polychaeta e.g: *Nereis, Aphrodite, Chaetopterus, Glycera, Arenicola*	Oligochaeta e.g: Earthworm, *Aeolosoma, Tubifex*	Hirudinea Leech, *Placobdella, Pontobdella, Macrobdella*
1. Mostly marine, burrowing.	1. Mostly terrestrial, burrowing and fresh water.	1. Mostly terrestrial freshwater and marine.
2. Head distinct.	2. Head not distinct.	2. Head not distinct.
3. No suckers.	3. No suckers.	3. Anterior and posterior suckers present.
4. Head bears eyes, palps and tentacles.	4. Head does not bear any such sensory structures.	4. Head does not bear special sensory structures but has simple light sensitive eyespots.
5. Body has fixed number of segments.	5. Number of segments variable.	5. Body has fixed number of segment.
6. Locomotion by segmentally arranged flap-like parapodia.	6. Locomotion by chitinous setae	6. Locomotion by suckers.
7. Sexes separate.	7. Hermaphrodite.	7. Hermaphrodite.
8. Development through trochophore larva.	8. No larval stage.	8. No larval stage.
9. No clitellum.	9. Permanent clitellum.	9. Clitellum appears only during breeding season.
10. No cocoon formation.	10. Cocoon formation.	10. Cocoon formation.

6.4 OBSERVATION OF SPECIMENS

If you have understood the general characters and classification of phylum Annelida it will be much easier for you to identify and describe some of the typical specimens of each class. Besides general characters each animal has some or the other very special characters. We will now classify and describe the specimens in your course one by one.

6.4.1 *Nereis*

Special Characters

Examine the given preserved specimen with the aid of a hand lens and compare with the Fig. 6.1.

You will note the following features:

i) *Nereis virens* is generally 40 cm long, about 1.25 cm wide and shining blue in colour in nature.
ii) Examine the head and note the prostomium, which bears four dark eyes, a pair of small tentacles, and fleshy palps (Fig. 6.2 a).
iii) At the back of the prostomium is the peristomium bearing four pairs of peristomial tentacles.

iv) The pharynx, bearing pincer like jaws, is inverted into the head. While feeding the jaw is everted and used for capturing prey. After ingesting the prey the proboscis is retracted back to its original position (Fig.6.2 b).

v) Posteriorly each segment bears a pair of lateral parapodia. Each parapodium is divided into a dorsal lobe (notopodium) and a ventral lobe (neuropodium). Parapodia are strengthened by aciculum and acicular muscles. Notochaetae and neurochaetae project out to make locomotory stroke effective. Sensory dorsal and ventral cirri present (Fig.6.3).

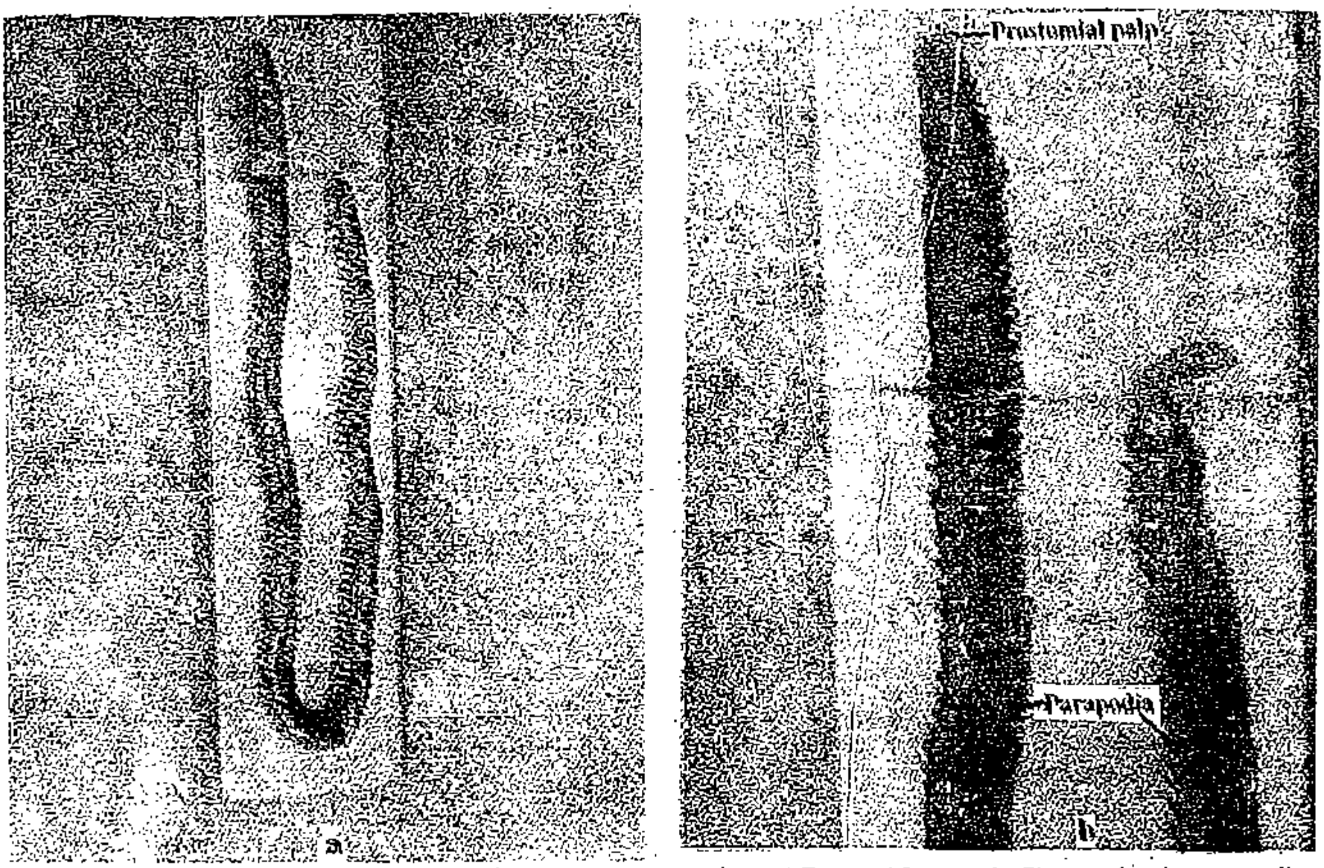

Fig.6.1: Preserved museum specimen of *Nereis*. a) External features. b) Closeup showing parapodia and palps.

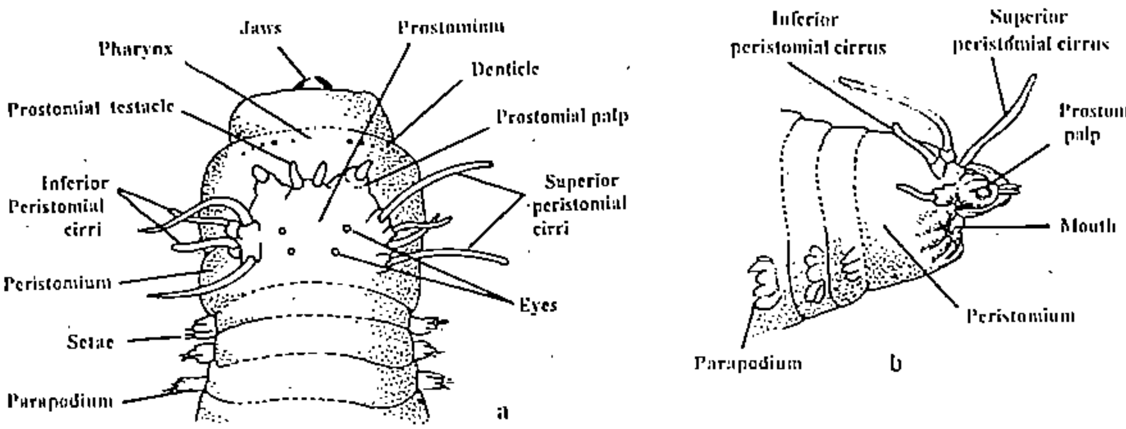

Fig. 6.2: *Nereis* Everted proboscis. (a) Top view with everted probosis. (b) Side view retracted proboscis.

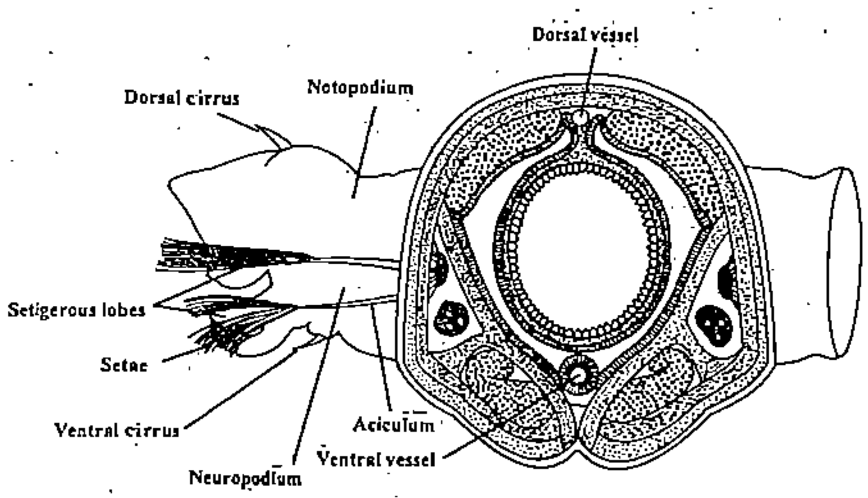

Fig. 6.3: *Nereis* cross section with parapodium.

Habit and Habitat

Clam worms are marine and widely distributed. Many species of *Nereis* are found in intertidal zones in shallow waters on sandy shores hidden below stones, logs, and rocks or among seaweeds. Some species live in burrows of sand, which are lined by their own body mucus. They are free living, predatory and nocturnal and feed on small crustaceans, molluscs and small annelids

Geographical Distribution

Nereis is cosmopolitan in distribution and found in coastal waters of Pacific and North Atlantic oceans, Europe and U.S.A.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Annelida**	Triploblastic, vermiform, coelomate, metamerically segmented; appendages unjointed.
Class	**Polychaeta**	Setae numerous; clitellum absent
Genus	***Nereis***	
Species	***virens***	
Common Name	**Clam worm**	

Heteronereis (if available in the study center)

Heteronereis is a sexually mature *Nereis* differing drastically from a non-breeding *Nereis*. The gonads develop in the posterior half of the body called the **epitoke** (Fig.6.4).

Sexual maturity brings about following changes.

i) The parapodia become larger and more vascular, oar-shaped chaetae become distinct. Extra foliaceous outgrowths can be seen too. Dorsal and ventral cirri get enlarged.
ii) Eyes and peristomial cirri become enlarged.
iii) The anterior region is non sexual and is called atoke.
iv) The animal leaves the burrow and comes to surface waters to swim actively and spawn.
v) Intestine is compressed, and the animal stops feeding.
vi) Male and female animals spawn and die.

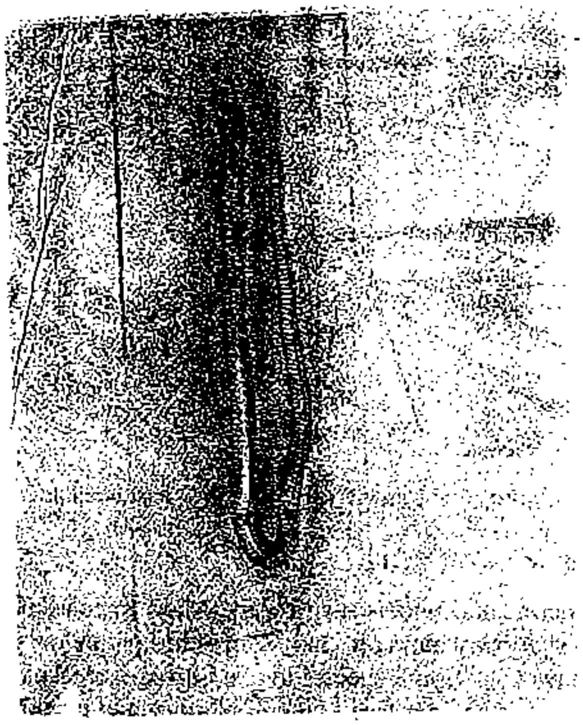

Fig. 6.4: Heteronereis phase.

6.4.2 *Aphrodite*

Special Characters

Examine the given preserved specimen of *Aphrodite* from all sides and compare it with Fig.6.5.Note the following characters:

i) Body is about 12 cm long, oval, broad, dorsally arched and ventrally flat.
ii) Flat ventral surface has segments, used for creeping.
iii) Locomotion by modified parapodia, bristles and chaetae.
iv) The dorsal side is covered by long, thin, thread-like iridescent bristles, which gives a feeling of hair (hence the name given sea mouse).
v) Head remains hidden and is well developed.
vi) In defense, animal stiffens the stiff chaetae, resembling a small porcupine.
vii) Alive, it is a beautiful animal which changes colour from gold to peacock blue. [The animals you see in the specimen jars are preserved in formaline which decolourises the animal]

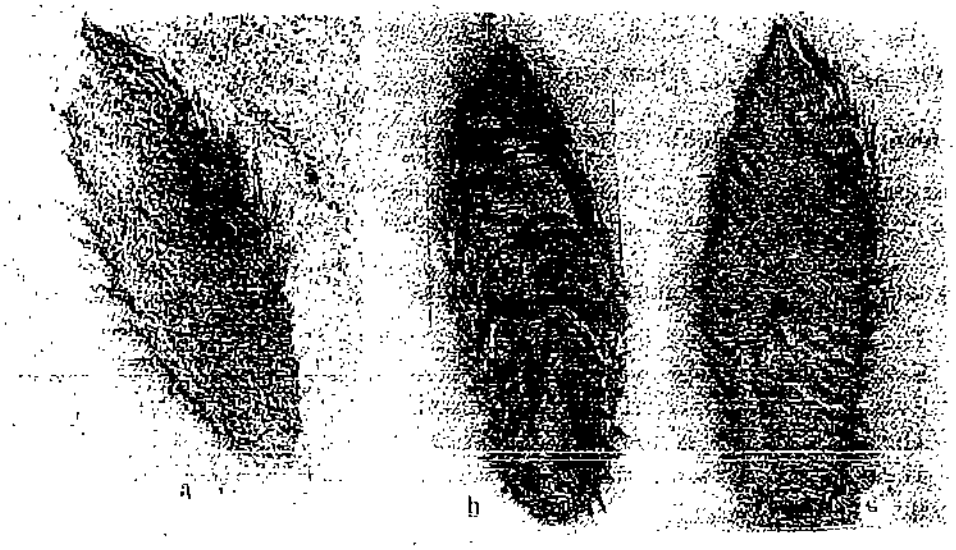

Fig.6.5: *Aphrodite*. a) In natural habitat. b) Preserved specimen dorsal side. c) Ventral view.

Habit and Habitat

Aphrodite lives at the bottom of deep sea buried in the sand.

Geographical Distribution

Aphrodite is found in U.S.A.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition
Phylum	**Annelida**	Triploblastic, vermiform, coelomate, metamerically segmented; appendages unjointed.
Class	**Polychaeta**	Setae numerous; clitellum absent
Genus	***Aphrodite***	
Common name	**Sea mouse**	

6.4.3 *Chaetopterus*

Special Characters

Observe the given specimen and note the following features:

i) Body can grow up to 30 cm and is divided into 3 distinct regions - anterior, middle and posterior (Fig.6.6 a).

ii) The anterior region includes head, mouth, a funnel, collar and a ciliated food groove. The parapodia modify to give rise to great wings, food cup and food scoop. Parapodia of this region are mainly used for food collection.

iii) The middle region has specially modified parapodia called fans (Fig.6.6) used for food collection, creating water current and for locomotion.

iv) The posterior region is the longest, where metameric segmentation is most evidently seen. Each segment bears biramous parapodia used chiefly for creating water current in tube and also for slight locomotion inside the tube.

v) The sexes are separate, the spawn is sent out of the burrow with water.

vi) The worm also possesses great power of regeneration, from one live segment the entire body can be developed.

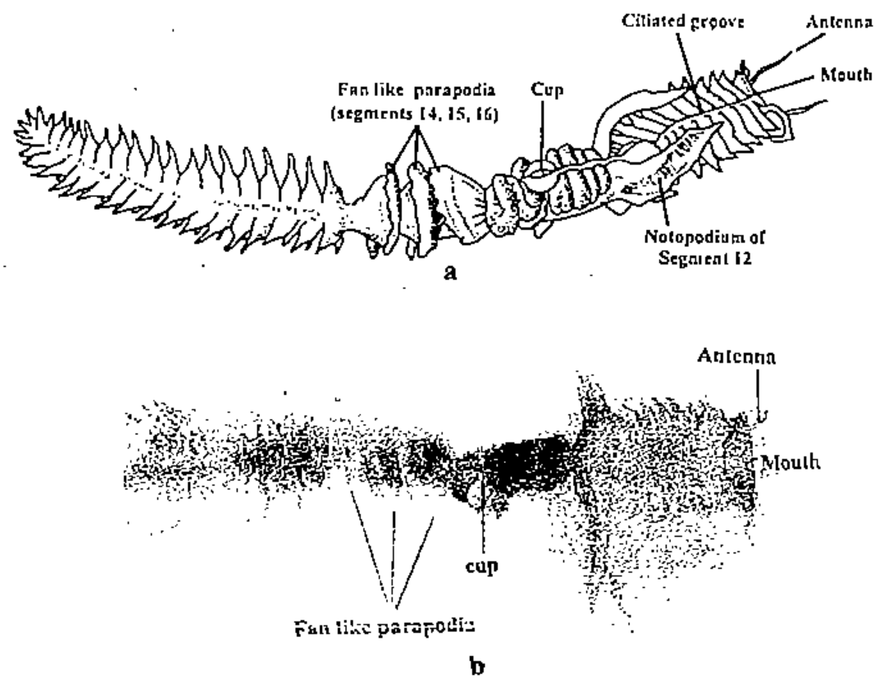

Fig. 6.6: *Chaetopterus*. a) Diagrammatic. b) Preserved specimen.

Habit and Habitat

Marine, tubicolous, lives in parchment like U shaped tubes, open at both end embedded in mud encrusted with sand and debris. Once they get into a burrow they rarely come out of it. It is a filter feeder. It is strongly luminescent, emits bluish-green light. The mucus secreted from the body when dispersed in water produces luminescence.

Geographical Distribution

It is distributed worldwide and commonly found in Europe, USA (North Carolina to Cape Cod).

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Annelida**	Triploblastic, vermiform, coelomate, metamerically segmented; appendages unjointed.
Class	**Polychaeta**	Setae numerous; clitellum absent.
Genus	***Chaetopterus***	
Common name	**Paddle worm**	

6.4.4 *Pheretima*

Special Characters

Observe the given specimen and note the following features:

i) Body is long, narrow and cylindrical measuring up to 150 mm in length; brown in colour.There is no head as such, and there are no special sensory structures projecting out from anterior region the way it does in *Nereis*. The body has 100 to 120 segments.
ii) In all adult earthworms clitellum (an area without outward segmentation) can be seen covering segments 14, 15 and 16.
iii) Hence, the body of earthworm is divided into preclitellar, clitellar and post-clitellar regions (Fig.6.7).

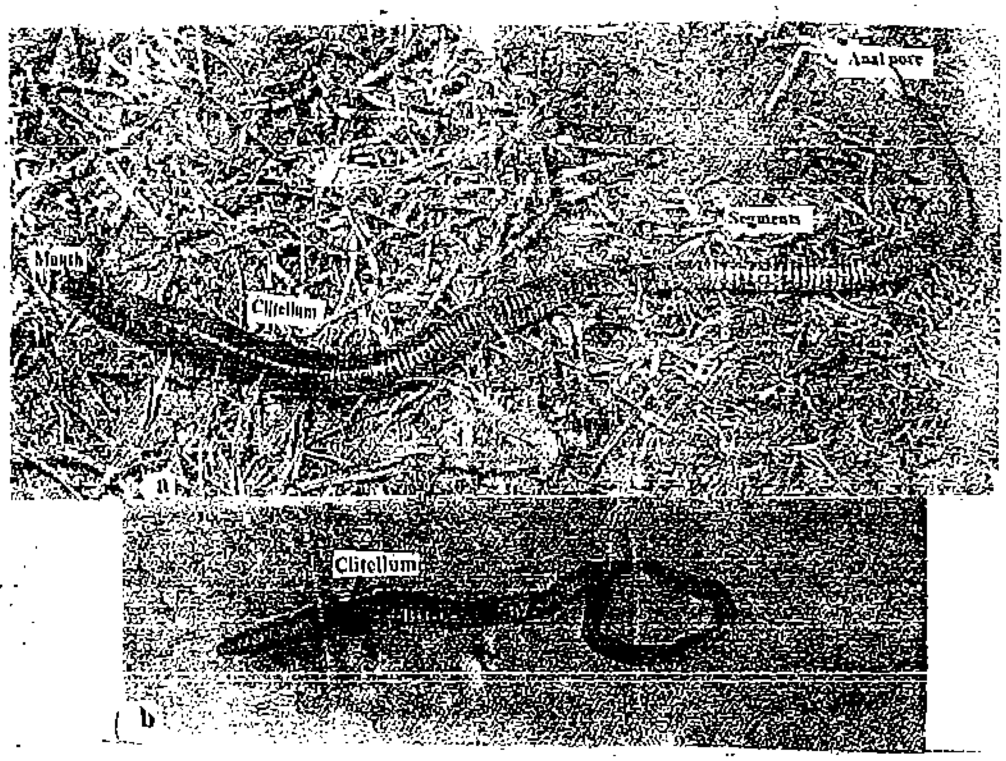

Fig.6.7: a) Earthworm. b) Preserved specimen of *Pheretima*.

iv) Each segment except the first and the last, bears small, chitinous setae which help in crawling.
v) Middle segments have small, microscopic openings called nephridiopores. Excretory material is thrown out of the body through these pores.
vi) These animals are hermaphrodites. Female genital pore opens on the ventral surface of the clitellum on segment 14^{th} and the male genital pores open on either side of ventral surface of 18^{th} segment.

Habit and Habitat

Earthworms are nocturnal, live in moist soil, rich in organic material. They are burrowing and make their burrow partly by boring with their anterior end and partly by swallowing the soft mud. They retain nutrients from this mud and remaining mud is thrown out through anus and can be seen as little mud piles on the openings of their burrows. During rainy season when their burrows are flooded they leave the burrows and can be seen crawling in the day time also. Though earthworms are hermaphrodite they always have cross-fertilisation. Copulation takes place at night, after mating earthworms separate and gelatinous, frothy, sticky substance is secreted from clitellum which hardens gradually and becomes a cocoon. The animal slowly wriggles out of it leaving sperms and ova into this box or cocoon.

Geographical Distribution

Widely distributed all over the world.

Economic Importance

a) Earthworms are beneficial in agriculture. A land rich with worms is rich in nutrition, because of the earthworms' ability to feed on decaying organic matter and passing out useful organic matter in their excreta.
b) Earthworms make burrows, which makes the soil porous and permits more penetration of air and moisture.
c) They are used as baits to catch fishes.
d) They are used in laboratories for research and teaching.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Annelida**	Triploblastic; vermiform, coelomate; metamerically segmented; appendages unjointed.
Class	**Oligochaeta**	Parapodia absent; clitellum usually present; pharynx not eversible and without jaw segment.
Genus	***Pheretima***	
Species	***posthuma***	
Common name	**Earthworm**	

6.4.5. *Hirudinaria*

Special Characters

Examine the given specimen and note the following features:

i) *Hirudinaria* has soft, vermiform dorso-ventrally compressed body.
ii) Has two suckers, anterior and posterior (Fig.6.8). Anterior sucker has jaws. The salivary gland produces anticoagulating saliva. Its pharynx is suctorial. Posterior sucker along with anterior sucker is used for locomotion.
iii) The body has 33 segments.
iv) The alimentary canal has crop chambers and lateral caecae to store and digest blood.

v) Respiration is through skin. Excretion is by nephridia.

vi) Though hermaphrodite but cross-fertilisation occurs. Leeches develop clitellum only for breeding. The male genital aperture is located in segment no. 10, and female genital aperture is found in the 11th segment.

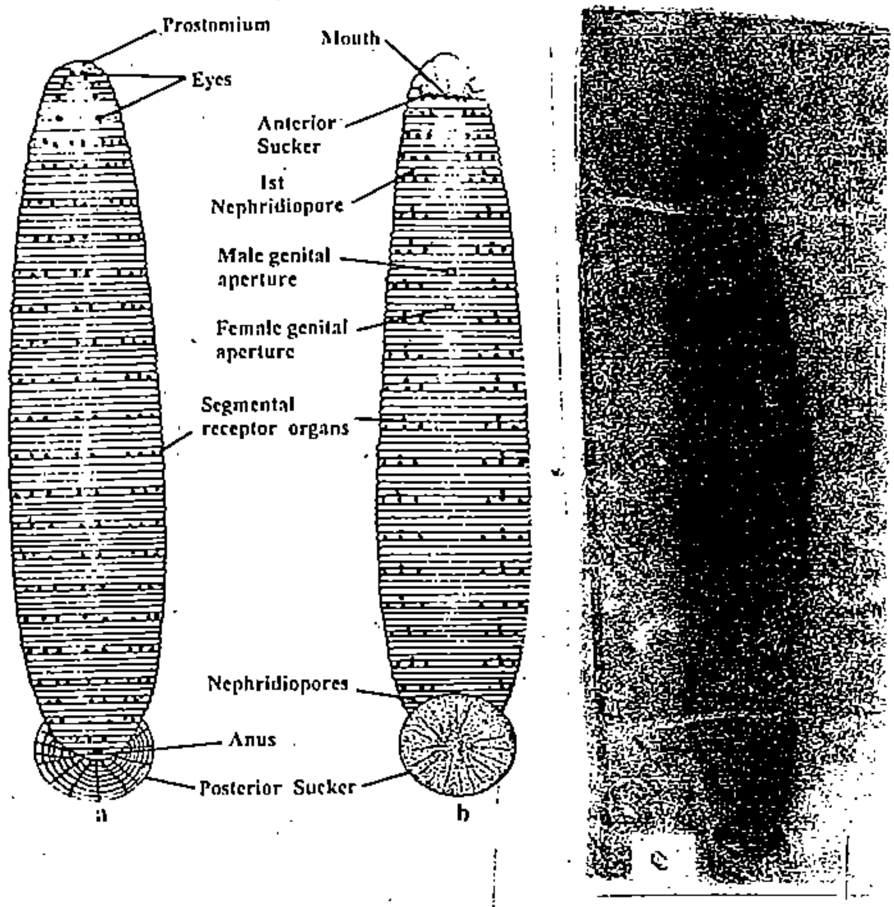

Fig.6.8: *Hirudinaria granulosa*. External features. a) Dorsal view. b) Ventral view. c) Preserved specimen.

Habit and Habitat

Found in ponds, lakes, tanks, swamps, streams, paddy fields. It is an ectoparasite and feeds on blood (sanguivorous) of fish, frog, cattle and humans who enter the water where leeches are found. Leeches make a painless incision on the skin and then suck blood (Fig. 6.9).

Fig. 6.9: Terrestrial leech. a) Feeding on human hand. b) After the meal.

After having exchanged the spermatozoa in the breeding season in March-April (in water or land) the leeches separate and each one forms a clitellum on segments 9, 10 and 11, this secretes frothy substance and forms a cocoon leaving sperms and ova in it. The leech wriggles out of the cocoon. Polar plugs close the two ends of the cocoon.

A cocoon is about 25 to 30 mm long and 12-15 mm wide and 1 to 24 young leeches can develop in a cocoon.

Geographical Distribution

Widely distributed, this particular species is found in India, Bangla Desh, Pakistan, Myanmar and Sri Lanka.

Economic Importance

a) Used as food for fish, ducks and turtles.
b) Bloodsucker of vertebrates.
c) Acts as vector for certain diseases.
d) In tribal societies leeches are used to suck out "bad blood".
e) Chemical nature of their saliva led to the invention of heparin, a chemical used in medicines as anticoagulant.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Annelida**	Triploblastic, vermiform, coelomate; metamerically segmented; appendages unjointed.
Class	**Hirudinea**	Body having definite number of segments; parapodia and setae are absent; presence of anterior and posterior suckers.
Genus	***Hirudinaria***	
Species	***granulosa***	
Common name	**Leech**	

6.5 TERMINAL QUESTIONS

1. On what basis are the annelids placed in different classes?

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2. What is clitellum? What purpose does it serve?

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3. What is the difference between *Nereis* and *Heteronereis*?

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EXERCISE 7 *PHERETIMA POSTHUMA:* EXTERNAL FEATURES, DISSECTIONS AND TEMPORARY MOUNTS

Structure

7.1 INTRODUCTION

In the previous lab exercise you have studied that *Pheretima posthuma* is an earthworm, which is metamerically segmented, coelomate and non-chordate metazoan belonging to Phylum Annelida, Class Oligochaeta (L. *Oligos*, few and *Chaetae*, spines). The earthworms are found in moisture-rich soil and are chiefly nocturnal. Earthworms are bisexual but self-fertilization never occurs. The development is direct, that is, there is no larval stage. Earthworms are favourable material for dissections in many laboratories all over the world and are also excellent organisms for the study of behaviour.

In the present exercise you will be dissecting more than one earthworm in order to study their digestive, reproductive and nervous systems. You will also be preparing temporary mounts of pharyngeal nephridium, septal nephridium and spermathecae. **The entire exercise depending upon the time available may be performed on the same day or split into two days: one day devoted to dissections and the other day for making temporary mounts.**

Objectives

After performing this exercise you should be able to:

- point out, describe and draw the external features of *Pheretima posthuma.*
- give reasons for usually dissecting earthworm (like most other invertebrates) from the dorsal side.
- dissect, display, flag-label as well as draw labelled diagrams of the digestive, nervous and reproductive systems of earthworm.
- demonstrate the hermaphroditic nature of earthworm.
- prepare temporary mounts of septal nephridia, pharyngeal nephridia and spermatheca of earthworm and draw their labelled diagrams.

7.2 MATERIAL REQUIRED

1. Dissecting microscope
2. Hand lens or eye glass
3. Compound microscope
4. Dissecting dish
5. Dissection kit
6. Preserved earthworms
7. Given material of pharyngeal nephridium, septal nephridium and spermathecae
8. Permanent slides of pharyngeal nephridia, septal nephridia and spermatheca
9. Brush
10. Common pins
11. Blackpaper
12. Needles for flags
13. Paper for flags
14. White sheets
15. 70% alcohol
16. Clean slides
17. Coverslips
18. Droppers
19. Watch glass
20. Aqueous eosin stain
21. Wet lens paper or small filter paper pieces

7.3 EXTERNAL FEATUES OF PRESERVED EARTHWORM

Obtain a preserved specimen of *Pheretima posthuma* and using Fig. 7.1 as a study guide observe its external anatomy. A hand lens or dissecting microscope will help you to identify finer features.

7.3.1 Gross External Features (Fig. 7.1 a & b)

Lay the specimen straight in the dissecting dish.

1. Notice an elongated, cylindrical, body in which the anterior end is pointed while the posterior end is more or less blunt.
2. **Size:** Body of earthworm is 12-15 cm long and 3-5 mm thick.
3. **Division of the body:** The whole surface of the body is divided by a distinct series of circular furrows into a series of ring-like 100-120 conspicuous segments which are evidently seen both externally and internally.
4. **Difference in body colouration:** Try to differentiate between dorsal and ventral sides of the body. Ventral surface is somewhat flattened and paler as compared to the dark, dorsal surface. Dorsal side is more evidently seen due to the presence of a **dark median line** marked by the inner dorsal blood vessel.

7.3.2 Finer External Features

1. Anterior and Posterior end

There is no head. If you mark the front end of the anteriormost complete segment, it surrounds the **mouth** (Fig. 7.2). The mouth is overhung dorsally by a spherical, fleshy lobe, the **prostomium.** This prostomium is not taken as segment number 1 but as a part of the body in front of the first segment. The mouth is surrounded by the first segment of the body, known as **peristomium.** The last segment of the body is known as the anal segment, since it bears an oval **anus.**

2. Clitellum

It can be easily distinguished as a circular, smooth band of glandular tissue lying at a distance of about 20 mm from anterior end. Clitellum extends over segments 14^{th} to 16^{th}. The **clitellum (or cingulum)** is a very important part of the body as it functions in reproduction. It secretes mucous, albumen and other exudates for forming a cocoon or egg-case. The clitellum is significant morphologically too, as, due to its presence, the body of an earthworm is distinguished into **pre-clitellar, clitellar** and **post-clitellar** regions.

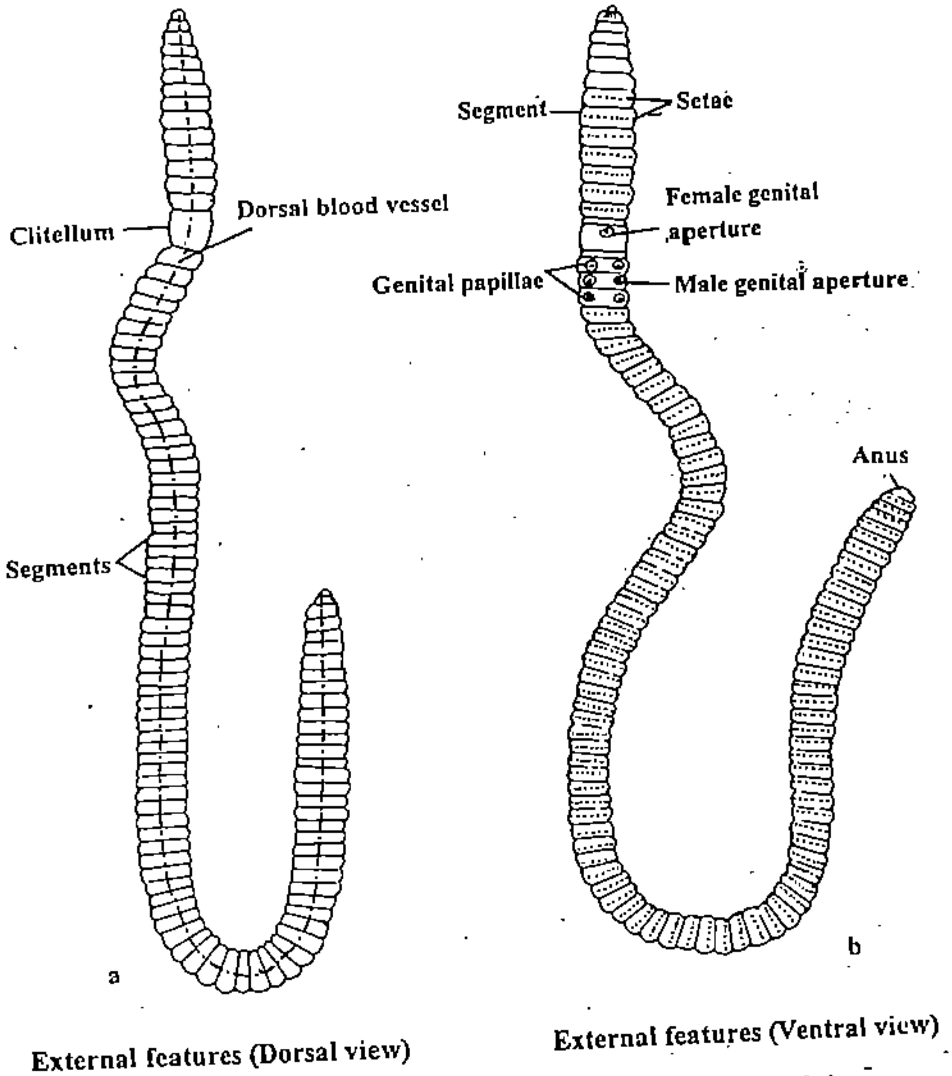

Fig. 7.1: External features of earthworm. a) Dorsal view. b) Ventral view.

3. The Pores

Before proceeding for dissection of the animal, you can observe many external pores in addition to the openings of mouth and anus.

A. Dorsal pores

i) Dorsal pores lie along the mid-dorsal line, one pore in each intersegmental groove behind the 12^{th} segment. These are not found in the last one.

B. Ventral pores

i) **The genital pores.** Now hold the animal from its ventral side to see the various pores on this surface. A median **female genital pore** is seen on 14^{th} segment lying on the ventral surface of clitellum. A pair of **male genital pores** is present on either side of 18^{th} segment behind the clitellum. Ventral surface of each of the

17th and 19th segments also have a pair of conspicuous raised, rounded copulatory **genital papillae.**

ii) Numerous minute **nephridiopores** are scattered all over the body, except in the first two segments on the ventral side. These small openings connect with nephridia which are primitive 'kidneys' of the earthworm.

iii) Paired **spermathecal pores** which open to the exterior on the ventral surface are present in the intersegmental groove at 5/6, 6/7, 7/8 and 8/9 segments.

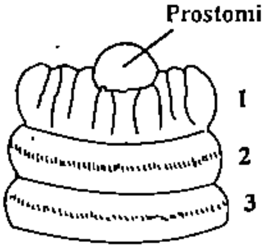

Fig. 7.2: Dorsal view of prostomium and first three segments.

4. **Setae**

Setae are present across the middle line of each segment. These form a ring of rod-like chitinous structures across the middle of the segments. The first and last segments do not bear any setae nor are setae present on the clitellum.

After studying the gross and fine morphology of earthworm you will now learn the procedure for dissecting it, especially for the digestive, reproductive and nervous systems.

7.4 DISSECTIONS OF EARTHWORM – *PHERETIMA POSTHUMA*

Earthworm has been a favourable material for dissection in most biological classrooms in the country. This is because earthworm is a simple and readily obtainable example of the Phylum Annelida.

7.4.1 Dissection, display, flag-labelling as well as drawing labelled diagram of the digestive system

Method of Dissection for digestive system

First stretch out one worm gently on the waxed dissecting tray with the dorsal side facing upward and pin it down in position through the first segment and the posterior end. Earthworm is always dissected from dorsal side because the nervous system in invertebrates is ventral. Secondly, the incision along the mid-dorsal line of the dorsal surface reveals all its organs conveniently. Look at Fig. 7.3 for dissecting and locating the various structures.

Make a longitudinal incision, above the clitellum right up to the anterior end. Cut through the skin and proceed forward, taking precaution to cut to one side of the mid-line only. Incise the partitions or septa that hold the body-wall. The flaps of the body wall should be released from the septa with needles and pinned back. After this, also cut longitudinally uptill the posterior end. If pins are inserted somewhere near segments 5,10,15 and 20 the internal organs can be readily located. A large body cavity between the body-wall and alimentary canal is seen which is the coelom. Now study the digestive system. After dissection, flag-label as well as draw the diagram of the digestive system.

For the dissection of the reproductive and nervous system you have to initially follow the same method that is used for the dissection of the reproductive system. However after this you have to proceed further, the method of which is given in the relevant exercise.

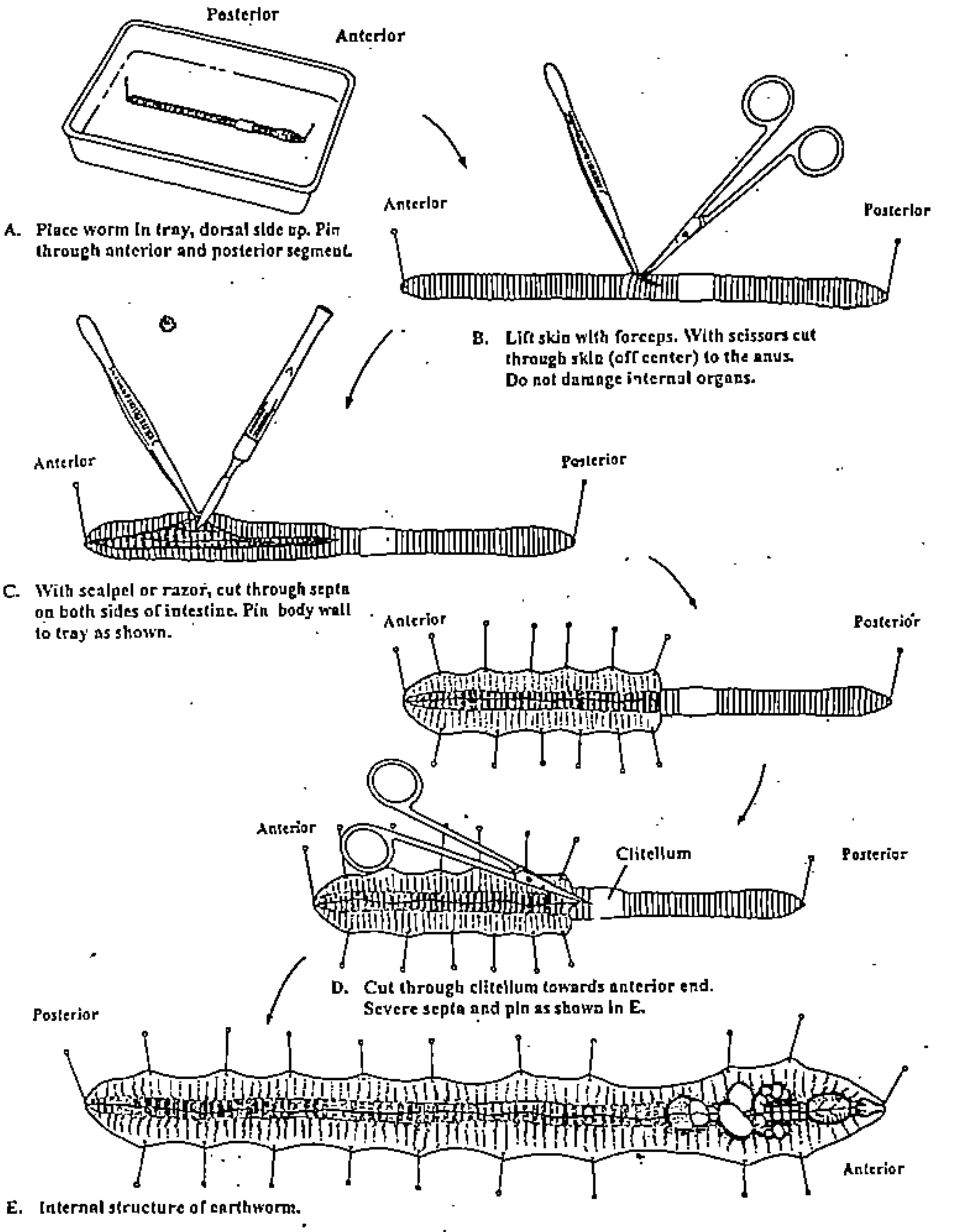

Fig. 7.3: Procedure for dissecting earthworm. (Steps A-E). The dissection is started from just above the clitellum and proceeds towards the anterior end. (Note: The position of the clitellum varies in different earthworm species)

Observations

After dissecting the earthworm observe the following features of the digestive system (Fig. 7.4 a & b):

1. Notice the straight alimentary canal running from mouth to the anus and observe the various features of the digestive system which are as follows:

   i) **Mouth and Buccal chamber:** Mouth is located at the anterior end, just below the overlapping prostomium. It leads to a short, thin-walled and protrusible buccal chamber. This is located from 1 to 3 segments. This is simply meant for ingesting the food.

ii) **Pharynx:** This is a stout, swollen, pear-shaped and thick-walled, muscular chamber with muscle fibers in its external walls and glands to lubricate food. Pharynx is marked off from the buccal chamber by a transverse groove on the dorsal surface. You will find the pharynx wall to be firm.

iii) **Oesophagus:** Behind the pharynx lies the slender, straight oesophagus or gullet. It is short, narrow, and thin-walled tube. It extends upto the 7th segment. It is not easy to mark it out as many other structures obscure it.

iv) **Crop:** At the end of the oesophgus, is the dilated crop. The crop receives the soil and food from the oesophagus and passes it intermittently backward to the gizzard.

v) **Gizzard:** It is a prominent, oval, hard, thick-walled and highly muscular organ. It lies in the 8th and 9th segments. The gizzard is red coloured due to its excellent blood supply. Its strong muscular wall crushes and thoroughly mixes the ingested food contents before filtering and passing them on to the intestine.

(**Note:** The crop and gizzard are so closely approximated and there is such a slight constriction between the two that they give the general appearance of a single chamber.)

vi) **Stomach:** Gizzard is followed by a short, narrow glandular and highly vascular tube, the stomach, which extends from segments 9-14.

vii) **Intestine:** Next to the stomach is the intestine which forms the remaining part of the digestive tract. It can be distinguished as a yellowish, long, wide tube from 15th to the last anal segment. It bulges laterally in each somite and its dorsal wall (from segments 26 to the end, leaving last 25 segments or so) carries an infolded typhlosole, which divides the intestine into pre-typhlosolar, typhlosolar and post-typhlosolar regions. The food already crushed to a fine consistency is completely digested here and is absorbed by the numerous blood vessels spreading over the surface of the intestine. You can see these vessels if you brush away yellow cells from the surface of the gut. The dorsal blood vessel is the main blood vessel which runs along the whole of alimentary canal in the mid-dorsal line and gives off subsidiary vessels at regular intervals.

(a) **Pre-typhlosolar region** – This is between segments 15 and 26. This region is thrown into extremely vascular, internal folds. In 26th segment, two short, conical outgrowths, one on either side, are given off from the intestine as *intestinal caeca.* They extend forward over 3 or 4 segments and have a special blood supply.

(b) **Typhlosolar region** – This region extends backwards from 26th segment, excluding the last 23-25 segments. It is the longest region of the intestine and is distinguished by a median fold of the internal epithelial lining of the dorsal wall, the *typhlosole*.

(c) **Post-typhlosolar region** – The last 23 to 25 segments, the region with no typhlosole is called the post-typhlosolar region, or the rectum. It contains small, rounded pellets, which are discharged to the exterior through the anus and form the characteristic castings of *Pheretima.*

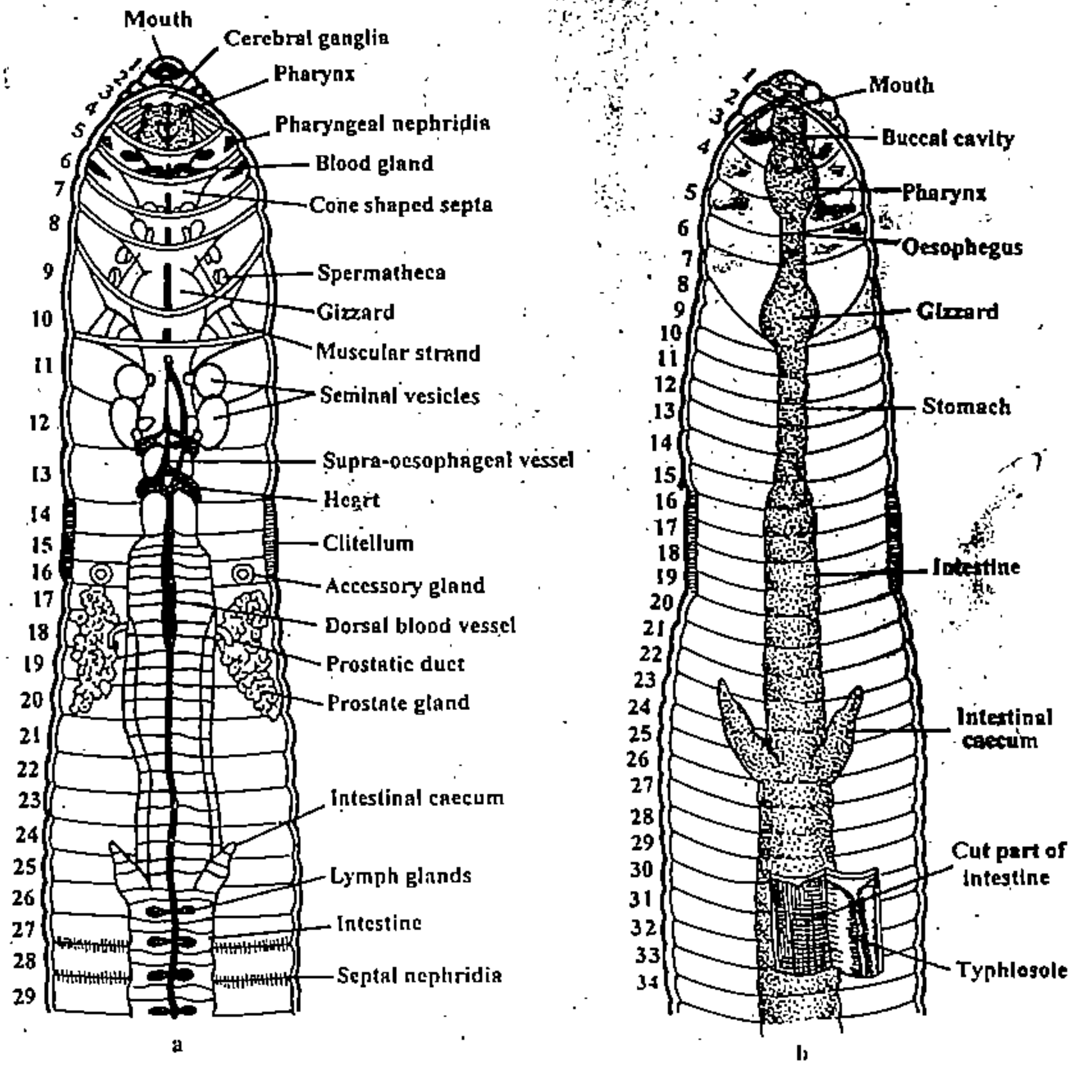

Fig. 7.4: Dissected earthworm showing: a) General anatomy of anterior region of body. b) View of digestive system.

Flag-Labelling & Drawing

1. **Flag-labelling:** Write the names of important parts of alimentary canal on small rectangular strips of clean white paper with pencil and stick them to the long pins meant especially for flag-labelling. Insert these pins near (not exactly on) the appropriate parts of the animal in the waxed tray.
2. Make notes in your record book on the observations you have made on the interior of the crop, gizzard and intestine.
3. Have you noticed the very rich blood supply of the gut? If so, make a note of it.
4. **Drawing:** Make a labelled drawing of the alimentary canal to show the various parts, which constitute it. It includes also the oesophageal glands and pouches, if observed. Indicate the segments and the number of segments throughout the drawing.

7.4.2 Dissection, display, flag labelling as well as drawing labelled diagram of the reproductive system of *Pheretima posthuma*

Hermaphroditic nature of *Pheretima posthuma*

Earthworms are monoecius or hermaphrodite, i.e. both ovaries and testes occur in the same individual; thus, each earthworm produces both ova and spermatozoa. However, self fertilization does not occur. As a rule, cross fertilization takes place accompanied by copulation after which eggs are laid in a cocoon.

To examine the reproductive system, it is necessary to remove the alimentary canal. With the removal of the alimentary canal, a general view of the reproductive organs is at once apparent.

Method of dissection for reproductive system

The dissection is similar to that which is done for the digestive system as given in subsection 7.4.1 and Figure 7.1 of this exercise. Once the dissection is complete, remove the anterior portion of alimentary canal so that a general impression of the reproductive organs is at one apparent. Now clear the reproductive organs, gently. You will observe the following structures (Fig. 7.5):

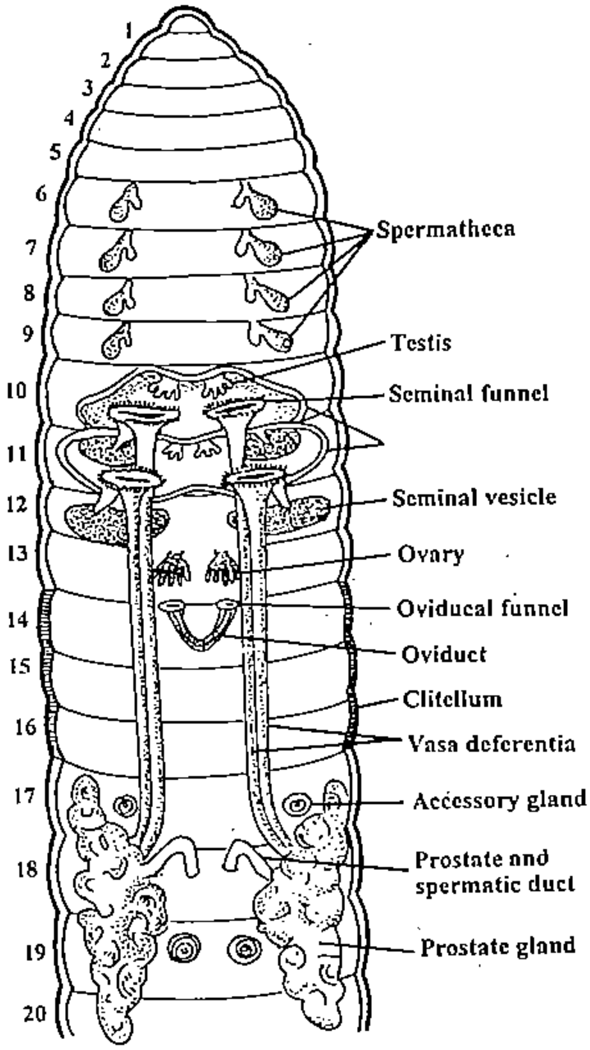

Fig. 7.5: Dissected earthworm showing reproductive system, especially position of spermatheca.

Observations

Male reproductive organs consist of testis sacs, testes, seminal vesicles, vasa deferentia, prostatic ducts and prostate glands.

i) Testis sacs lie ventrally beneath the oesophagus one behind the other in the 10^{th} and 11^{th} segments. Each testis sac is ventro-lateral in position but is bilobed in front. It encloses a pair to testes in front and a pair of ciliated seminal or spermaducal funnels behind, lying one on each side of the ventral vessel.

ii) Testes arise as a pair from the inner surface of the anterior wall of each testis sac. Each testis is a minute white body which lies close to the middle line.

iii) There are two pairs of seminal vesicles which extend laterally in the 11th and 12th segments.
iv) Vasa deferentia are observed as slender tubes that run along the inner surface of the body wall from the 12th – 18th segment.
v) Prostate glands are a pair of large, flat irregular shaped, solid white structures which lie on each side of the gut from the 17th to 20th segment.

In order to observe the female reproductive organs, it may be necessary to remove the seminal vesicles.

The female reproductive system consists a pair of ovaries, a pair of oviducts, and four pairs of spermathecae.

i) You can see the **ovaries** as minute, whitish masses attached to the posterior face of the septum between 13/14 segment beneath the gut, one on each side of the ventral nerve cord.
ii) **Oviducts** are two short tubes, each with a large oviduct funnel at its inner end.
iii) **Spermathecae** are in four pairs, that are situated in the 6th, 7th, 8th and 9th segments. Each spermatheca is a flask-shaped structure consisting of pear-shaped ampulla and a narrow duct.

Flag-labelling and drawing

1. **Flag-labelling:** Write on small rectangular strips of clean white paper with pencil the names of the important parts of the reproductive system which have been described and shown in the given drawing. Stick the paper strips to the long pins that are meant for flag-labelling. Insert these pins near (not exactly on) the appropriate parts of the animal in the dissecting tray.
2. **Drawing:** Make a labelled diagram of the dissection. Also do indicate the segments and number of segments at which the various organs are located.

7.4.3 Dissection, display, flag-labelling as well as drawing labelled diagram of the nervous system

Method of Dissection for nervous system

The nervous system in the earthworm is somewhat difficult to study. Its major component is the ventral nerve cord, which runs along the length of the worm on the inner ventral surface (Fig. 7.7).

Take a preserved earthworm and place it in the dissecting dish as described before and shown in Fig. 7.3 already. Make a longitudinal incision in the body in the mid-dorsal line from 10th segment right up to anterior end. Release the flaps of body wall from the septa with help of needles and pin down in the dish (Fig. 7.6).

The position of the ventral nerve cord can be seen if you seize the intestine with the broad forceps, lift it gently and cut through the attached septa for a short distance with fine scissors. This cut should be as close to the intestine as possible.

Observation

You can observe the white nerve cord after the removal of the intestine. The nerve cord is really a double structure bound together by connective tissue. In each segment, behind the fourth segment, the nerve cord shows a slight swelling that forms the ganglion. Successive pairs of ganglia are connected from segment to segment by fused double cords, the **commissure.**

The whole of the ventral nerve cord is thus a connected system of ganglia and commissures. In each segment, three pairs of segmental nerves are given off. These nerves seem to disappear at a short distance from the cord.

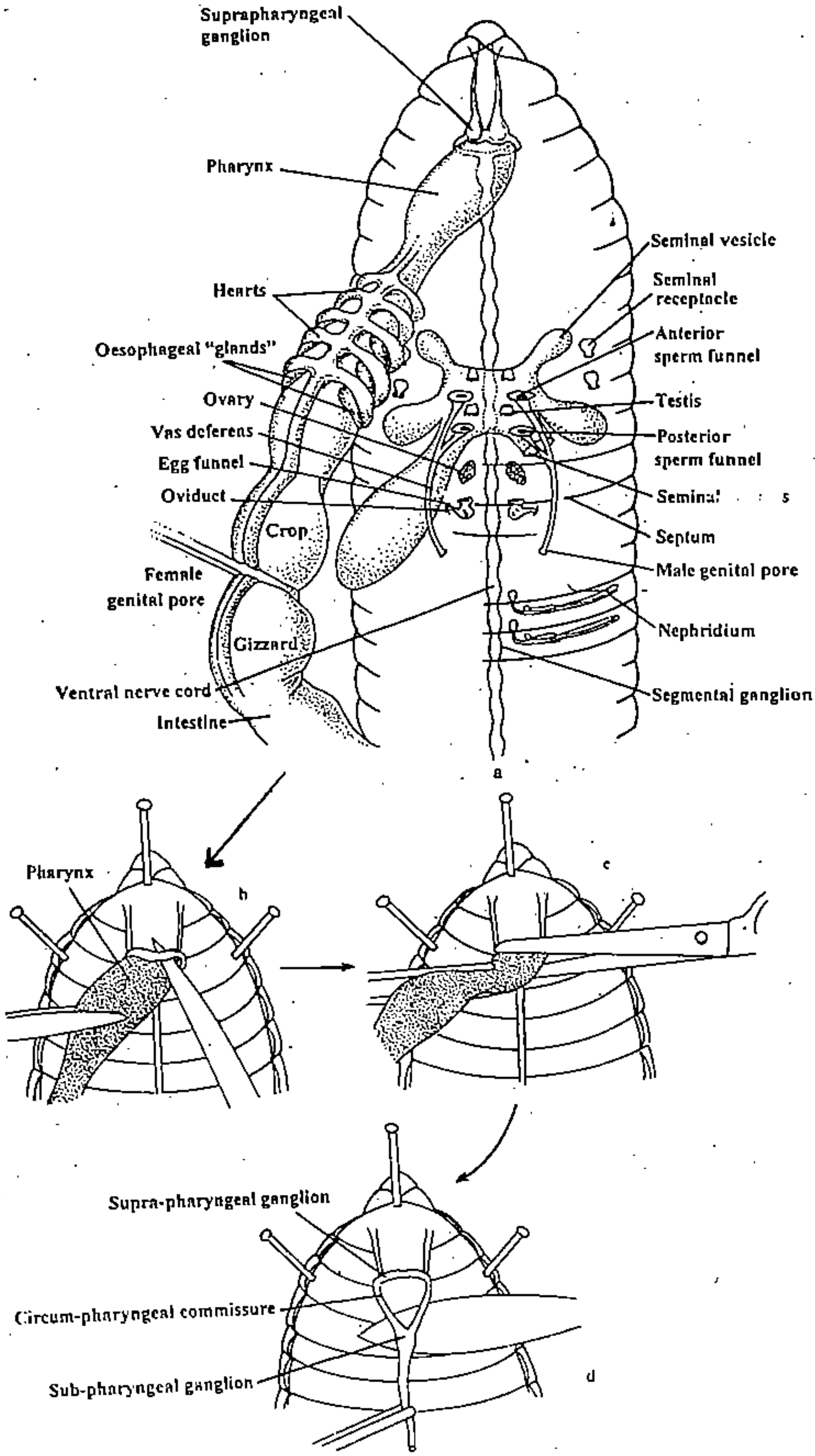

Fig. 7.6: Dissection of nervous system (steps a-d).

If you proceed anteriorly, you will find in segment number three, in front of the pharynx in the mid-dorsal line, two small yellowish-white, closely apposed and fused bodies. These are the **cerebral ganglia** or **supra-pharyngeal ganglia**. From each of these two ganglia, eight to ten nerves arise from the lateral side and divide into several branches.

In the posterior part of the third segment and anterior part of the fourth segment lies the sub-pharyngeal ganglia beneath the pharynx. A pair of **circum-pharyngeal connectives**, one on either side of the pharynx, join the supra-pharyngeal ganglia to sub-pharyngeal ganglia forming a ring. The mid-ventral line of sub-pharyngeal ganglia runs posteriorly to join the ventral nerve cord. All that remains to be done now is to clean up the dissection. Pour away water of the dissecting dish and wash the dissection under a very gentle flow of water from the tap.

When all the water is poured away, you may flood the dissection with 70% alcohol and leave it for a few minutes. The dissection may then be covered with water again. The effect of the alcohol is to whiten the nervous tissue and harden the other tissues, making their removal easier.

Using a eye-glass, carefully cut away any remaining tissue of the pharynx, so as to leave the cerebral ganglia and nerve collar quite clean. Similarly, remains of septa, blood vessels, etc. can be removed from above the nerve cord to show the segmental nerves quite clearly.

The prostomial nerves are usually clearly visible without further dissection and extreme care must be exercised in any attempt to clean them.

Flag-labelling and Drawing

1. **Flag-labelling:** Write the names of important parts of the nervous system on small strips of clean paper and stick them to the pins meant especially for flag-labelling. Insert these pins near the parts of the nervous system of the animal in the waxed tray.
2. **Drawing:** While drawing ensure that the visible structures are indicated by serial numbers of prominent segments, serving as land marks within the dissected outline of the body-wall.

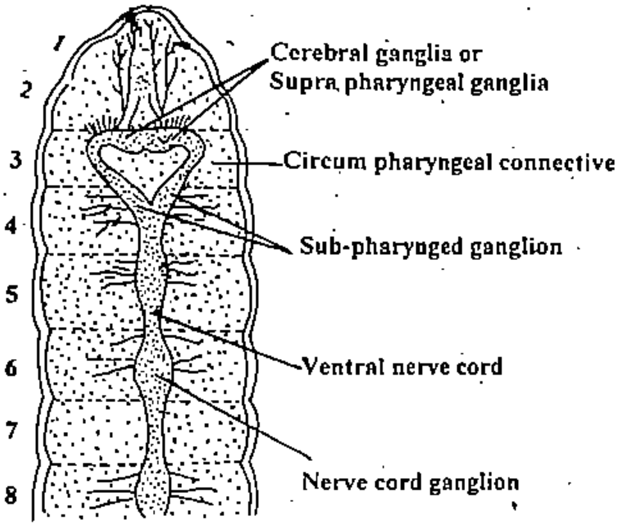

Fig. 7.7: Dissected earthworm showing nervous system.

7.5 MOUNTING OF NEPHRIDIA AND SPERMATHECAE OF *PHERETIMA POSTHUMA*

The minute organisms, organs or parts of body or sections of animals or tissues, which are to be studied under microscope, require either an extensive or a simple process of slide preparation, which is known as **mounting.** In this exercise, you are also expected to prepare temporary mounts of nephridia (excretory organs) and spermathecae and study them with the help of permanent slides provided to you. You should also consult figures 7.8, 7.9 for your observations and study.

There are two methods of preparation of mounts.

i) **Permanent mounting:** Most of the microscopic work involves the examination of permanent slides, which are mounted permanently in different media. This process needs complete dehydration and staining of the material. Permanent slides are prepared under special conditions and in bulk because, to prepare them individually is both tedious and time consuming. The slides prepared this way are more durable and can be kept for a long time. You will be provided with permanent slides of pharyngeal nephridia, septal nephridia and spermatheca which you will be expected to observe before preparing temporary mounts of these same structures. This will help you in your observation of the temporary mounts.

ii) **Temporary mounts:** This is a simple technique of mounting, which seems practical for the classroom. Temporary mounts are prepared in either water or normal saline or glycerine. These mounts are prepared for quick successive results in a short time. The slides prepared by temporary mounting cannot be kept for a long period of time. In this process the tissue to be mounted need not be dehydrated and may not be stained either.

7.5.1 Preparation of temporary mounts from ready given material of pharyngeal nephridium, septal nephridium and spermathecae

In your laboratory exercise you might either be provided with the previously taken out ready material from an already dissected earthworm or with a whole animal from which you would be required to take out the material after dissection. In both cases the material is to be mounted for temporary viewing. Let us first begin with the procedure in which you are provided with the ready material for mounting.

1. For preparation of any mounts, wash the material with water to free it from debris.
2. Transfer it to the aqueous eosin stain in a watch glass.
3. Put a drop of glycerine on a clean slide and with the help of a brush, transfer the material (only one kind at a time) on to it.
4. Take a clean glass coverslip and lower it down over the material on the slide, with the help of a needle at an angle of about 45°; let the coverslip sink gradually on the slide so that the object is nicely enclosed.
5. Clean the extra glycerine, which spreads outside the coverslip with the help of a clean, wet lens paper or filter paper piece.
6. Study the slide under the microscope.
7. Observe the detailed structure of septal nephridia (Fig. 7.8), pharyngeal nephridia and spermatheca (each type of material mounted on separate slide).
8. Make a labelled diagram.
9. Mention special feature, if any.

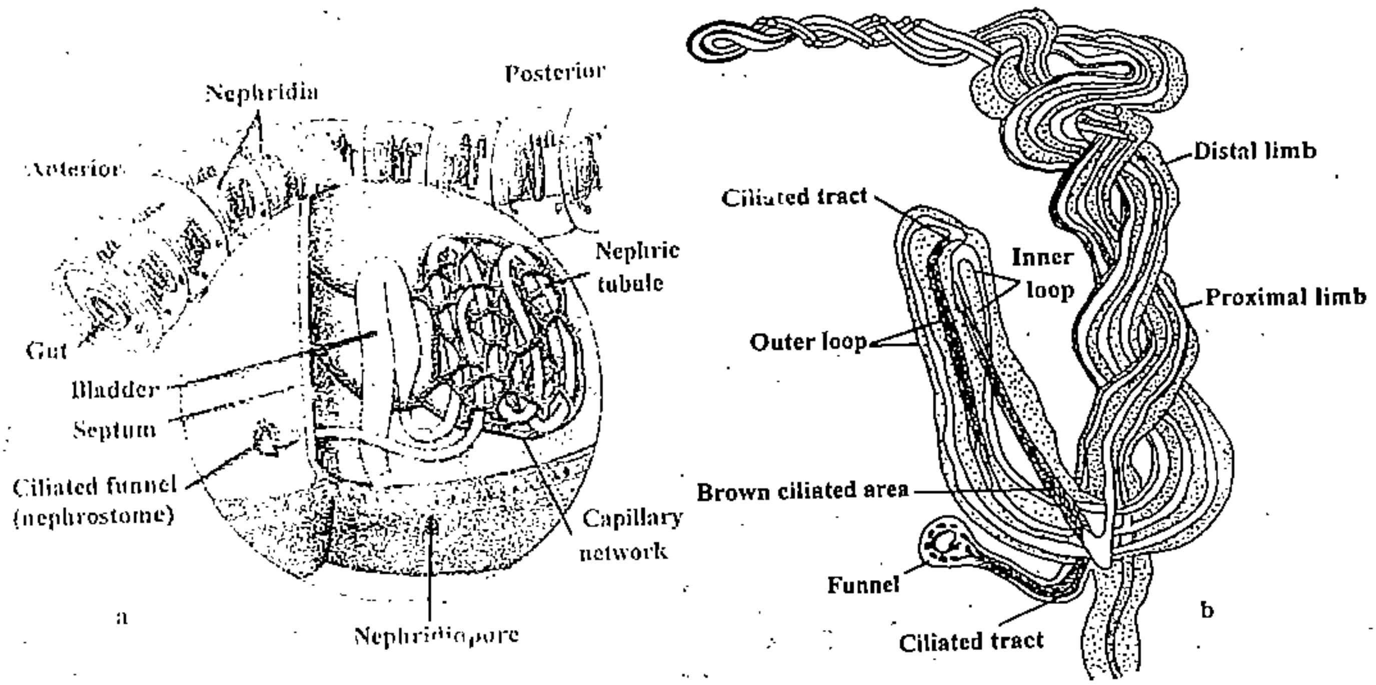

Fig. 7.8: Nephridium a) Structure of nephridium b) A septal nephridium showing entire course of nephridial tubule and ciliated tract.

7.5.2 Preparation of temporary mounts of nephridia and spermathecae obtained by dissecting an earthworm

In this procedure you will first have to dissect an earthworm as you did for the digestive system and then locate the structures that you have to mount. You will then have to take out the material from the earthworm and process it in the same way as in subsection 7.5.2. Let us first begin with preparing mount of nephridia.

The Nephridial system of *Pheretima posthuma* – pharyngeal and septal nephridia

The excretory organs of an earthworm occur in all the segments of the worm in the form of nephridia, except the first two. We can distinguish three sets of nephridia according to their position in the body of the worm (Fig. 7.9).

(a) The **Pharyngeal Nephridia**
(b) The **Septal Nephridia**
(c) The **Integumentary Nephridia**

Now you will learn the procedure for preparation of temporary mounts of pharyngeal and septal nephridia of earthworm.

a) Taking out, temporary mounting and observation of pharyngeal nephridia

Method of taking out and mounting of pharyngeal nephridia

1. Open the body of an earthworm as described earlier.
2. Pick up the mass from the 4^{th}, 5^{th} and 6^{th} segments.
3. Keep it on the side.
4. Observe under the microscope to confirm the presence of pharyngeal nephridia.
5. Prepare the temporary mount as described in subsection 7.5.2 of this lab exercise.
6. Study the features under microscope and draw a labelled diagram.

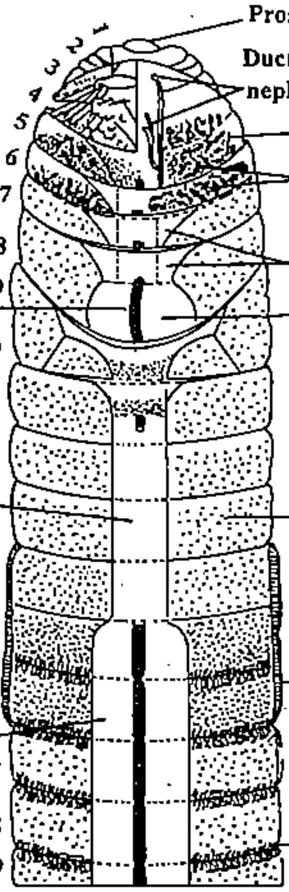

Fig. 7.9: Nephridial system of *Pheretima*.

Observation

1. The pharyngeal nephridia are confined only to the fourth, fifth and sixth segments in the inner segmental space between the septa.
2. These nephridia occur as paired tufts or bunches in each of the above segments, lying on either side of the pharynx and oesophagus.
3. Each tuft consists of a very large number of nephridia, the terminal ductules of which join together and form slender ducts, which unite with similar other ducts, ultimately forming three pairs of long thick walled ducts, a pair from each of the three segments.
4. These ducts run forward on each side of the ventral nerve cord, about 1 to 2 mm apart.
5. The pair of ducts from the nephridial bunches of the sixth segment open into the buccal cavity about the middle of the second segment.
6. The ducts from the nephridia of the fourth and fifth segments open into the pharynx.
7. Pharyngeal nephridia are as large as the septal nephridia but lack a coelomic funnel.

b) Taking out, Temporary mounting and Observation of Septal nephridia

Method of taking out and mounting of septal nephridia

1. After dissecting the earthworm take out any septum after the 15th segment alongwith the septal nephridia and place it in water.
2. Proceed further as directed for pharyngeal nephridia.

Observation

1. The **septal nephridia** (Fig. 7.8 b) are attached to each intersegmental septum behind the fifteenth segment (80-100 in number).
2. Each septal nephridium consists of:
   i) A ciliated funnel or nephrostome, neck, body of nephridium and terminal duct.
   ii) The ciliated nephrostome funnel is a rounded structure through which the nephridium opens into the coelom.
   iii) Neck is a short narrow ciliated tubule that leads from the funnel into the body of the nephridium in which it makes several loops and forms altogether a very long tubule.
   iv) The body of the nephridium consists of a short **straight lobe** and a **long spirally twisted** loop.
   v) The long spirally twisted loop is differentiated into proximal and distal limbs.
   vi) The terminal nephridial duct, which varies in length joins the septal excretory canal.
3. Of the two parts of the body of the nephridium, the twisted loop is more than twice the length of the straight lobe and consists of two limbs; a proximal and a distal limb which are spirally twisted around each other. The number of twists varies from 9 to 13.
4. At the base of the nephridium the straight lobe is continued into the distal limb of the twisted loop, while the proximal limb receives, the ciliated tubule from the funnel and gives off the terminal nephridial duct.

The terminal ducts of these nephridia open into a pair of septal excretory canals running on each septum parallel and internal to the commissural vessel of each side.

c) Taking out, temporary mounting and observation of spermathecae

Method of taking out and mounting of spermathecae

1. In *Pheretima posthuma* there are four pairs of spermathecae or sacs which are situated in the sixth, seventh, eight and ninth segments.
2. Carefully remove the alimentary canal from the region of gizzard up to the middle of the body.
3. Trim away the oblique septa in the anterior region in order to expose the spermathecae.
4. Take the spermatheca and keep it on the slide.
5. Observe under the microscope to confirm the presence of spermatheca.
6. Prepare the temporary mount as described in subsection 9.5.2 of this exercise.
7. Study under the microscope and draw a well labelled diagram.

Observation

Each spermatheca shows a pear-shaped **ampulla** and a narrow duct which gives off an elongated **diverticulum.**

Unlike other earthworms, in *Pheretima* the sperms are stored in the diverticula and not in the ampullae. The spermathecae open to exterior through the four pairs of spermathecal pores.

Sometimes you may experience difficulty in locating the spermathecea, as they are very variable in size especially towards the end of phase of cocoon production, when they may contract, due to the expulsion of their contents, to the size of barely a pin's head or less.

7.6 PRECAUTIONS

1. Never allow your material to get dry at any stage.
2. Always use a fine brush but never forceps for holding the mounting material.
3. Put only the required amount of glycerine (1-2 drops) on the slide for mounting.
4. Examine under the microscope with reduced light intensity.
5. If during mounting, you get an air bubble, it must be removed with a clean needle.
6. Make it sure that all the required material is clean and dry, i.e. free of any contamination.

7.7 TERMINAL QUESTIONS

1. Why are earthworms dissected from the dorsal side?

 ....

 ....

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 ....

 ....

2. Give the location of the following organs in terms of number of body segments.

 i) Gizzard :..

 ii) Stomach..

 iii) Pre typhlosolar region ....

 iv) Testis..

 v) Ovaries ....

 vi) Pharyngeal nephridia ....

3. List the parts of the septal nephridia.

 ....

 ....

 ....

EXERCISE 8 MOLLUSCA-I: OBSERVATION AND CLASSIFICATION OF SPECIMENS

Structure

8.1 INTRODUCTION

Mollusca is one of the largest phylum after Arthropoda. It has more than 80,000 living species. In Latin "Mollis" means soft. The bodies of molluscs are soft but covered by hard, protective shells. This increased the chances of their preservation, which resulted in a rich fossil record; there are more than 35,000 known fossil species of phylum Mollusca. The study of Mollusca is termed as **malacology** and that of their shells **conchology**.

Molluscs are widely distributed. The phylum includes slugs, snails, chitons, oysters, clams, squids and octopuses and they greatly vary in form, structure, habits and habitats. They are highly adaptive and are found in all possible habitats, aquatic and terrestrial , except aerial. They generally inhabit shallow waters, but some are also found deep inside the sea (12,000 meters).In this exercise you will study some preserved representative molluscs and learn to classify them. Before you begin your study it would be helpful to read Unit 6 of Block 2, LSE-09 again.

Objectives

After performing this exercise you should be able to:

- identify the specimens of *Chiton, Pila, Dentalium, Octopus* and *Nautilus* and also two larval forms namely glochidium and veliger belonging to phylum Mollusca and give their scientific and common names.
- draw labelled diagrams of the identified genera.
- identify, describe and draw the larval stages glochidium and veliger.
- classify each of the identified mollusc up to the level of class
- list characters justifying their classification and mention special features, if any.
- mention the habit and geographical location of each of the identified genera.
- mention economic importance, if any, of each of the identified genera.

8.2 MATERIAL REQUIRED

1. Preserved specimens of *Chiton, Pila, Dentalium, Octopus* and *Nautilus*.
2. Prepared slides of glochidium and veliger larvae.
3. Note book and pencil, eraser, etc.

8.3 GENERAL CHARACTERS AND OUTLINE CLASSIFICATION

General Characters

1. Molluscs are generally aquatic animals, found mostly in [illegible], some are freshwater forms and a few are terrestrial.
2. Triploblastic, coelomate, body not metamerically segmented (these terms have already been well explained to you in Unit 5 Block 2, LSE-09).
3. Body is fundamentally bilaterally symmetrical; members of class Gastropoda undergo **torsion** and hence become asymmetrical (see Fig. 8.1).
4. These animals have soft body, which can be divided into three parts : i) Head – foot. ii) Visceral mass and iii) Mantle.
5. The **mantle or pallium** is a membrane (not very thin) that covers the soft body.
6. The space between mantle and body is called **mantle cavity,** into which lie the gills and openings of the digestive, excretory, and reproductive systems.
7. The outer side of the mantle secretes a hard calcareous shell forming a protective covering all around the body.
8. The shells may be bivalved (two pieces) or univalve (single piece) spiral [illegible] one like, internal or reduced or even absent in some.
9. The alimentary canal is simple, coiled and complete. In some buccal cavity [illegible] a cutting organ **radula** bearing rows of teeth.
10. Respiration is generally by gills or body wall and in some, also by pulmonar[illegible]c.
11. The circulatory system is open except in cephalopods where it is closed and the blood is confined to vessels. Respiratory pigments are carried in solution in the blood rather than confined to blood cells.
12. Excretion is by kidneys that open in the pericardial cavity.
13. Nervous system consists of paired cerebral, pleural, pedal and visceral ganglia, joined by commissures and connectives.
14. Sense organs are simple eyes, tentacles and **osphradia.**
15. The sexes are separate; fertilisation may be internal or external. Asexual reproduction not found.
16. During the embryonic development cleavage is spiral, determinate and unequal.
17. The development may be direct or indirect through larval stages like trochophore, glochidium, veliger, etc.

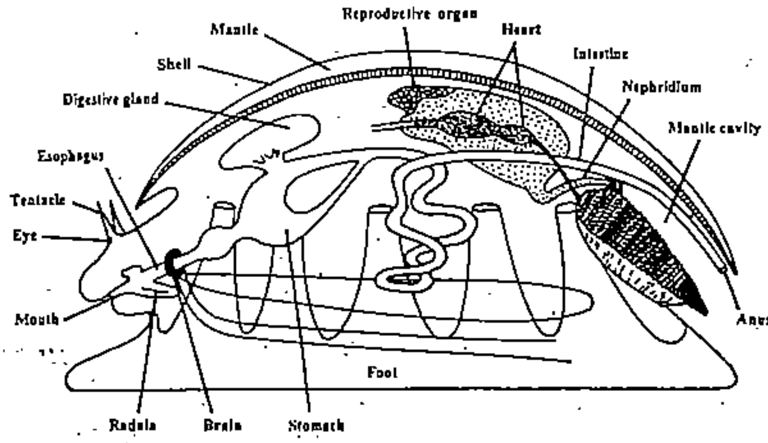

Fig.8.1: Generalised mollusc. Though this is a hypothetical plan none the less, it is useful in visualing a general body plan.

Classification

Phylum Mollusca has been divided into seven classes, the distinction is based largely on what kind of foot and shell the animal has. In this exercise you will study examples from only four classes namely, Polyplacophora (Chiton), Scaphopda (*Dentalium*), Gastropoda (*Pila*) and Cephalopoda (*Nautilus* and *Octopus*) out of the total seven. But it is useful to know about all other classes too. Table 8.1 gives a comparative account of the seven classes.

Table 8.1: Classes of Phylum Mollusca.

Aplacophora e.g. *Neomania*	**Aplacophora** e.g. *Neomania*	**Polyplacophora** e.g. *Chiton* (in your course)	**Scaphopoda** e.g. *Dentalium* (in your course)	**Gastropoda** e.g. *Pila* (in your course)	**Bivalvia** e.g. *Unio*	**Cephalopoda** e.g. Octopus and *Nautilus* (in your course)
1. Worm like	1. Elongated with broad foot	1. Elongated, dorsoventrally flattened	1. Conical, elongated body	1. Body twisted	1. Elongated bilaterally compressed	1. Body elongated
2. Shell absent, calcareous scales present	2. Univalve, limpet like shell present	2. Shell made up of eight dorsal plates	2. One piece tubular shell present	2. Coiled shell present	2. Bivalve (two pieces) shell present	2. Shell reduced and internal in octopus and well developed only in *Nautilus*
3. Bilaterally symmetrical	3. Bilaterally symmetrical	3. Bilaterally symmetrical	3. Bilaterally symmetrical	3. Asymmetrical due to torsion	3. Bilaterally symmetrical	3. Bilaterally symmetrical
4. Head absent, radula present or absent	4. Head absent, radula present	4. Reduced head, radula present	4. Head absent, radula present	4. Distinct head present, radula present	4. Head absent, radula absent	4. Very well developed head present, radula present
5. Foot not very developed	5. Foot small muscular	5. Foot, broad sole-like	5. Foot elongated tongue-like	5. Foot broad sole like	5. Foot elongated tongue like	5. Foot modified into oral arms
6. Gills absent respiration by secondary respiratory structures	6. Respiration by six pairs of gills	6. Respiration by many gills	6. Gills absent exchange of gases through mantle	6. Aquatic respiration by gills and aerial respiration by pulmonary sac	6. Respiration by pairs of gills	6. Respiration by two elongated gills
7. Poorly developed nervous system	7. Poorly developed nervous system	7. Moderately developed nervous system	7. Moderately developed nervous system	7. Well developed nervous system	7. Well developed nervous system	7. Very highly developed nervous system
8. No larval stage	8. No larval stage	8. Development through larva trochophore	8. Developed through trochophore larva	8. Developed through veligar larva	8. Developed through glochidium larva	8. No larval stage

8.4 OBSERVATION OF SPECIMENS

You will be given preserved specimen of molluscs. Observe them carefully and note their distinctive features and classify them accordingly.

8.4.1 *Chiton*

Special Characters

i) They are commonly known as "coat-of-nail shells".
ii) They have flat, sole-like foot, they remain attached to surface and move very slowly.
iii) They are about 2-8 cm long and 3 to 5 cm wide and have a dull turquoise or blue coloured appearance.
iv) The shell covers dorsal side and is made up of **eight transverse movable, overlapping plates**. The mantle forms a girdle around the plates (Fig.8.2 a).
v) Head, flattened with a slit-like mouth, on both sides of the body are gills (Fig.8.2 b).
vi) Genital, excretory openings and anus are on ventral side towards the posterior end (Fig.8.2 b).
vii) The alimentary canal is simple. The radula bears many rows of teeth, and each row has about 17 teeth.
viii) Open circulatory system with a respiratory pigment called haemocyanin.
ix) Specialised sensory organs absent. They have light and touch sensitive points called **aesthetes.**
x) Sexes are separate, no sexual dimorphism.

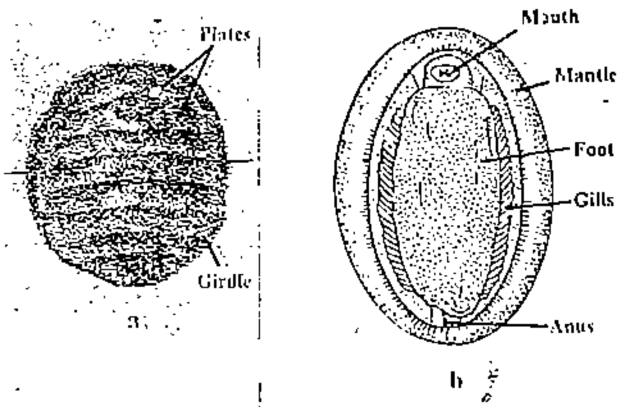

Fig.8.2: *Chiton*. (a) Dorsal view; (b) Ventral view.

Habit and Habitat

Marine. Mostly littoral or sub-littoral, occurring in shallow tidal areas. In India they are most commonly seen on the sea side rocks in Bombay and Rameshwaram. They are nocturnal and herbivorous and feed on diatoms and seaweeds.

Geographical Distribution

Chitons are found in all seas except polar seas.

Economic Importance

Chitons are eaten by Red Indians in USA therefore, sometimes also called as "Sea beef".

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Mollusca**	triploblastic, coelomate body divided into head-foot, visceral mass, and the mantle which secretes the shell; radula present in most.
Class	**Polyplacophora**	elongated dorsoventrally flattened body with reduced head; bilaterally symmetrical; radula present; shell of eight dorsal plates; foot broad and flat; gills multiple.
Genus	***Chaetoplura/Chiton***	
Common name	**Chiton**	

8.4.2 *Dentalium*

Special Characters

i) Commonly known as "Elephant tooth" or "The tooth" or "Tusk shell" because it looks like a miniature elephant tusk.
ii) *Dentalium* is about 25 cm long and 2-5 cm in diameter.
iii) The body is completely enveloped in a tubular mantle and shell.
iv) From the broader end of shell (which remains in the deeper side of burrow) projects out foot, mouth and small tentacles called **captacula** (Fig.8.3).
v) Captacula are sensory, prehensile and tactile, their tips are sticky so they also help in food collection.
vi) Gills are absent; exchange of gases takes place through the thin, vascular mantle.
vii) Sexes are separate. Development includes veliger larva .

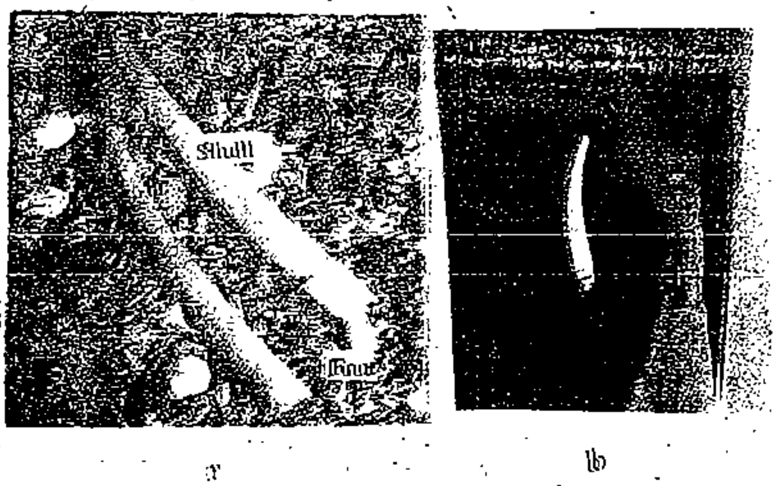

Fig. 8.3: ***Dentalium*. a) In its natural habitat. b) Preserved specimen.**

Habit and Habitat

Dentalium is burrowing and marine and it lives in single tubular shell open at both ends. Feeds on protozoa and detritus from the substrate.

Geographical Distribution

Widely distributed except for the cold polar waters. The common species found in Indian seas is *Dentalium octogonum*.

Economic Importance

Red Indians of USA use the empty shells to make ornaments.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Mollusca**	triploblastic coelomate unsegmented body divided in to head-foot,visceral mass,and the mantle which secretes the shell; radula present in most.
Class	**Scaphopoda**	body enclosed in a one piece shell open at both ends; conical foot; mouth with radula and tentacles; head absent; mantle for respiration
Genus	***Dentalium***	
Species	***octogonum***	
Common Name	**Elephant tusk shell**	

8.4.3 *Pila*

Special Characters

i) The body undergoes **torsion** and is protected by a spiral univalved shell (Fig.8.4).
ii) The largest part of shell is called **body whorl.** The shell is coiled clockwise around an imaginary column and is thus called **dextral.**
iii) The soft visceral hump remains projected inside the shell, whereas head, foot are exposed. At the time of danger these two are also withdrawn in the safe environs of shell.
iv) The head bears tentacles, eyes and mouth, bordered with left and right nuchal lobes (siphons to draw and drive water).
v) Alimentary canal very well developed with radula.
vi) A large well-developed digestive gland present. Respiration by one pair of gills for aquatic condition and by pulmonary sac when on land.
vii) Excretion by kidneys, circulatory system open, nervous system well developed and forms the figure of 8 due to torsion.
viii) Sense organs are osphradium, eyes, statocyst and tentacles.
ix) Males and females separate, breed in rainy season. Development through veliger larva.

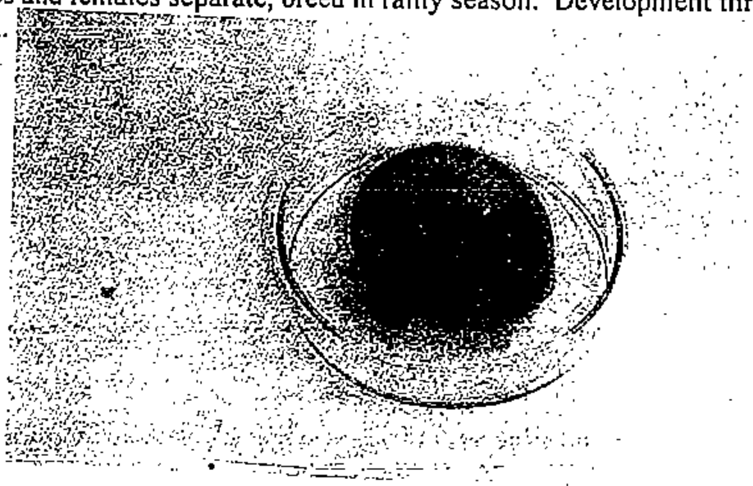

Fig.8.4: *Pila globosa.*

Habit and Habitat

Pila undergone extensive adaptive radiation and has invaded two habitats water and land. Food consists chiefly of succulent aquatic vegetation.

Geographical Distribution

Very widely distributed in fresh water and moist land around the oriental (in India, Myanmar, Sri Lanka, Vietnam, Phillipines) and Ethopian (in Africa, Arabia and Madagascar) regions.

Economic Importance

Used as food, shell used for decoration. It is a favorite item for dissection in biology laboratories

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Mollusca**	triploblastic coelomate unsegmented body divided in to head-foot, visceral mass, and the mantle which secretes the shell; radula present in most.
Class	**Gastropoda**	body asymmetrical; usually in univalve coiled Shell; head well developed with radula; foot large and flat; shows torsion
Subclass	**Prosobranchia**	gills present; operculum present; mostly marine only a few freshwater species
Genus	***Pila***	
Species	***globosa***	
Common Name	**apple snail**	

8.4.4 *Octopus*

Special Characters

i) The body (Fig.8.5) contains visceral mass but to a lay person it looks like a head, though the head is present but it is small.

ii) The muscular foot modifies and gives rise to 8 long arms (Fig. 8.5).

iii) Each arm has double rows of suckers.

iv) Arms are used for locomotion, food capturing and ingestion also in offense and defense.

v) In males tip of 3rd right arm is broad spoon like called **hectocotyl**, it is used to transfer spermatophores into the mantle cavity of female.

vi) The typical molluscan shell is absent; it is actually reduced and found embedded into the body wall, therefore, not visible.

vii) Octopus has a very well developed "**ink gland**", it releases a dark coloured fluid from it at the time of danger blinding the predator and making a fast escape from that area.

viii) This animal makes its movements using undulating arms but in emergency situations, it squirts out a lot of water through the funnel (Fig. 8.5 a) with a force and dashes away in the opposite direction (based on the law of equal and opposite reaction) through "**jet propulsion**".

ix) The food is captured by arms, the mouth has powerful beak-like jaws to ingest it into small pieces and then further grinding is done by radula.

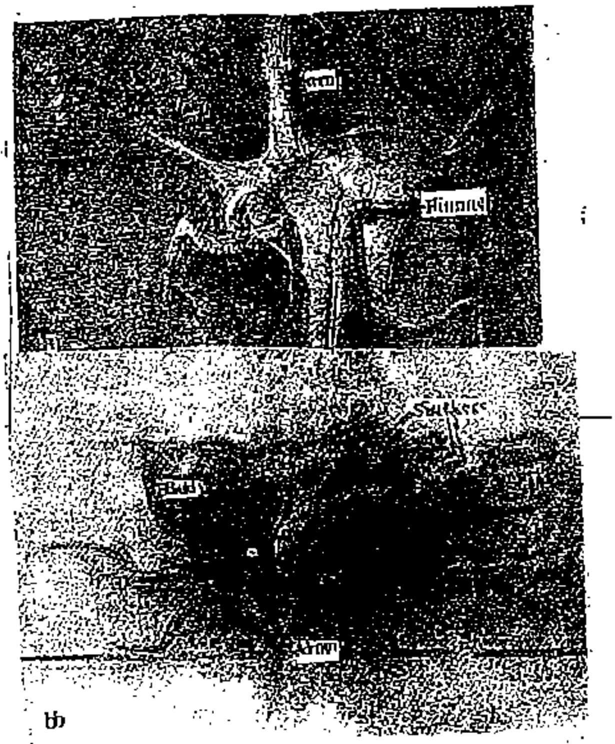

Fig.8.5: Octopus. a) In its natural habitat. b) Preserved specimen.

Habit and Habitat and Distribution

Octopuses are marine, bottom dwelling, nocturnal animals. Their food is crab, bivalves, snails, fish, etc. Experiments in labs have identified them as intelligent learners.

Geographical Distribution

Octopuses are very widely distributed; found in Europe, India, and Atlantic and Pacific coasts – Alaska to lower California and Cape Cod.

Economic Importance

In many countries its meat is considered a delicacy.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Mollusca**	triploblastic coelomate unsegmented body divided in to head-foot,visceral mass, and the mantle which secretes the shell; radula present in most.
Class	**Cephalopoda**	shell often reduced or absent; head well developed with radula;head with arms or tentacles; foot modified in the form of a funnel; nervous system of well developed ganglia, centralised to form a brain; sexes separate; development direct.

Genus Octopus
Species punctatus
Common Name Devil- fish

8.4.5 *Nautilus*

Special Characters

i) *Nautilus* is the only living cephalopod which has a well developed beautiful slightly spiral shell (Fig. 8.6 c). The shell is divided internally by simple partitions (Fig. 8.6 b).
ii) The large part of body remains enclosed inside the shell in the body chamber, the rest empty chambers are filled with air to give buoyancy to animal.
iii) 60-90 prehensile tentacles without suckers surround the mouth and project out of the shell (Fig. 8.6 a). Two thick tentacles form protective hood.
iv) Mouth has strong beak and radula.
v) Ink gland is absent.
vi) It can swim by "jet propulsion" like octopus.

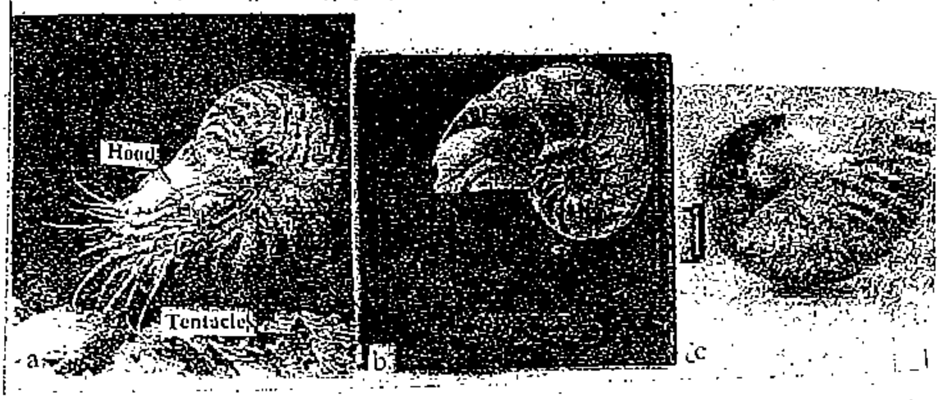

Fig. 8.6: a) *Nautilus* showing tentacles. b) Internal chambers in the shell. c) Shell of *Nautilus*.

Habit and Habitat

Marine, prefers deep tropical waters, gregarious, nocturnal, crawls at the bottom; feeds on crabs and shellfish.

Geographical Distribution

Nautilus is found in tropical waters of Indian and Pacific Oceans.

Economic Importance

1. The animal is eaten in many European, Far Eastern countries.
2. The shells are used in making ornaments and also as decorative pieces.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Mollusca**	triploblastic coelomate unsegmented body divided into head-foot,visceral mass, and the mantle which secretes the shell; radula present in most.
Class	**Cephalopoda**	shell often reduced or absent; head well developed with radula; head with arms or tentacles; foot modified in the form of a funnel; nervous system of well developed ganglia, centralized to form a brain.

Genus *Nautilus*
Species *pompillus*
Common Name **"Pearly Nautilus".**

8.5 LARVAL STAGES OF MOLLUSCA

You would recall from Unit 6 of Block2, LSE 09, that many aquatic molluscs pass through free swimming larval stages like the trochophore, and veliger. Fresh water bivalves, however, have another larval stage, the glochidium which develops internally and is discharged with the excurrent flow. We will study the glochidium and the veliger in this exercise.

8.5.1 Glochidium Larva

Glochidium is the larva of freshwater bivalves,for example, *Unio.*

i) Glochidium means "Point of an arrow".
ii) A glochidium measures 0.2 mm in length and is 0.5 mm wide.
iii) In *Unio,* fertilisation is internal. The male releases the sperms near the female. With the water current sperms enter the female's body (due to chemo attraction) through inhalant siphon. From there they reach the infrabranchial chamber, then they swim up to gills, where ova are already present in water tubes, and fertilisation takes place.
iv) The early development takes place inside the gill (in such females gills are called brood pouch or marsupiums), when the glochidium larvae are ready they move to the suprabranchial chamber, and then out of their mother's body through the exhalant siphon.
v) Glochidium has a bivalve shell, mantle, sensory bristles, hooks, teeth and a byssus thread (Fig.8.7),
vi) They keep lying in this position until a fish passes by; getting in contact with fish they snap close their shells and get a firm grip on the gills of the fish with the help of hooks and teeth.
vii) The byssus bores through the tough skin of the fish, this makes the attachment stronger and allows the developing mouth to ingest food through that hole.
viii) The glochidium gets good quality protein from fish and grows faster.
ix) After a few days, the byssus disappears, so do hooks and teeth. Mouth and gills develop. The larva leaves the fish and settles to the bottom and starts feeding on aquatic micro food particles and grows into a young *Unio.*

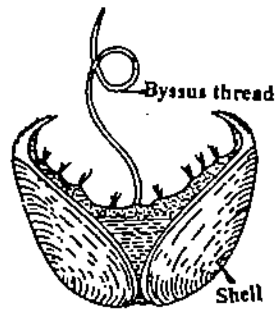

Fig. 8.7: A glochidium larva of *Unio.*

8.5.2 Veliger Larva

After the eggs are laid, the gastrula first changes to trochophre (not in *Pila*) and then to free-swimming veliger larva(not in pila).Place the permanent mount of the larva under the low power of the microscope and observe the following features:

i) Veliger is the larval stage in the development of most aquatic molluscs, especially in gastropods and bivalves.
ii) The larva looks like a face with turban on the head (fig.8.8).

iii) Almost in the center is the mouth. The narrow end has anus followed by mantle folds.
iv) Just above the mouth there are 3 ciliated rings called **velum**, followed by **cephalic tuft**.
v) These cilia help in locomotion, food collection and also as sensory structures.
vi) After feeding on small creatures, as it grows it sinks to the bottom to change into a young mollusc.

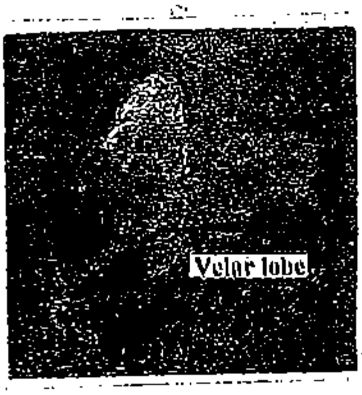

Fig. 8. 8: Veliger larva.

8.6 TERMINAL QUESTIONS

1. What are the three regions of the body of a mollusc?

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2. How would you characterise members of class Gastropoda?

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3. What is the function of osphradia?

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EXERCISE 9 MOLLUSCA-II – *PILA*: EXTERNAL FEATURES, DISSECTION AND PREPARATION OF TEMPORARY MOUNT OF RADULA

Structure

9.1 INTRODUCTION

Pila is a **Mollusc** belonging to the class **Gastropoda**. Pila is found in India, Myanmar, Sri Lanka, Thailand, Malaysia, Indonesia, Vietnam, Philippines and Africa. It is commonly called as **apple snail**. There are many species found in Indian subcontinent and the one, which is commonly used for studies, is *P. globosa*. It is found in fresh water ponds, pools, lakes and sometimes in rivers. *Pila* is an amphibious animal and seeks a habitat with plenty of aquatic vegetation. You should recall your knowledge about mollusca which you have studied in Units 6 and 7 of LSE-09.

Objectives

After doing this exercise, you should be able to:

- point out, describe and draw the external features of shell of *Pila*,
- break open the shell of *Pila* in order to observe the external features of the body,
- to identify the parts and display them, and draw their diagram,
- describe the location of various organs in the mantle cavity,
- dissect, expose, display, flag label as well as draw the nervous system of *Pila*,
- locate the buccal mass, take out and prepare a temporary mount of radula, and
- draw a labelled diagram of radula.

9.2 MATERIAL REQUIRED

1. Dissecting tray
2. Dissecting instruments
3. *Pila* (preserved specimens)
4. Table lamp
5. Watch glass
6. Dropper
7. Glass slides
8. Cover slips

. Dissecting microscope
0. Glycerin
1. Water
12. Blotting paper
13. Common pins
14. Black paper
15. White paper

9.3 EXTERNAL FEATURES OF *PILA* (ENTIRE)

You will get a preserved *Pila*. You wash it thoroughly to remove the formalin and then put it in the dissecting tray.

As you have already read, *Pila globosa* is a Mollusc belonging to class Gastropoda. The animal has a tough outer shell and the soft parts of body are protected inside this shell. Let us now identify the following features of *Pila*.

9.3.1 Shell

The shell of *Pila* is moderately thick, has globose shape and is unilocular i.e. it has one single continuous cavity but coiled around a central axis in a right handed (dextral) spiral. The structure of the shell is as follows:

1. The top of the shell is called **apex** which is the point of origin of shell.
2. The coils of shell are called **whorls** and the apex has the smallest and oldest whorl, the **protoconch**. Below the apex is a spire of successively larger whorls, 6½ in number, called the **teloconch**. The last whorl is the largest and is called the **body whorl**. The whorl just before the body whorl is called the **penultimate whorl**.
3. The whorls are separated externally from each other by lines, which are called the **sutures**. The whorls are connected to each other internally.
4. The central axis around which the whorls coil is called the **columella**. This is a hollow structure and its opening to the exterior is called the **umbilicus**.
5. The body whorl has a very large opening, the mouth or aperture. The outer margin of this opening is called the outer lip and the inner margin lying next to columella is called the **columellar lip**.
6. The shell is covered by lines of growth, which may appear ridge like and are called **varices** (singular; **varix**). The colour of shell varies from yellowish to brown to black. The shell shows a conical form with the smallest whorl on top and largest at the bottom (Fig. 9.1 a & b).

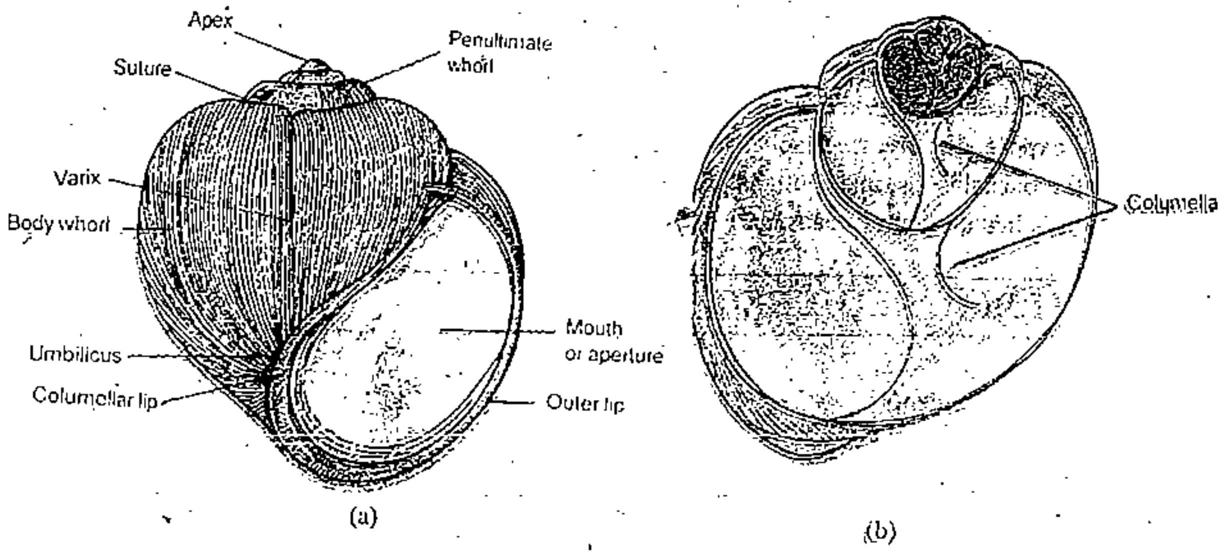

Fig. 9.1: Shell of *Pila*, (a) ventral view; (b) dorsal cut view.

9.3.2 Operculum

The mouth of *Pila* is closed by a calcareous lid, the **operculum**, which fits strongly over the mouth. The outer surface of operculum is marked by a number of growth rings and a nucleus. The inner surface of operculum has an elliptical boss where muscles are attached and it is surrounded by a groove. The operculum is secreted by the glandular cells of the foot (Fig. 9.2 a & b).

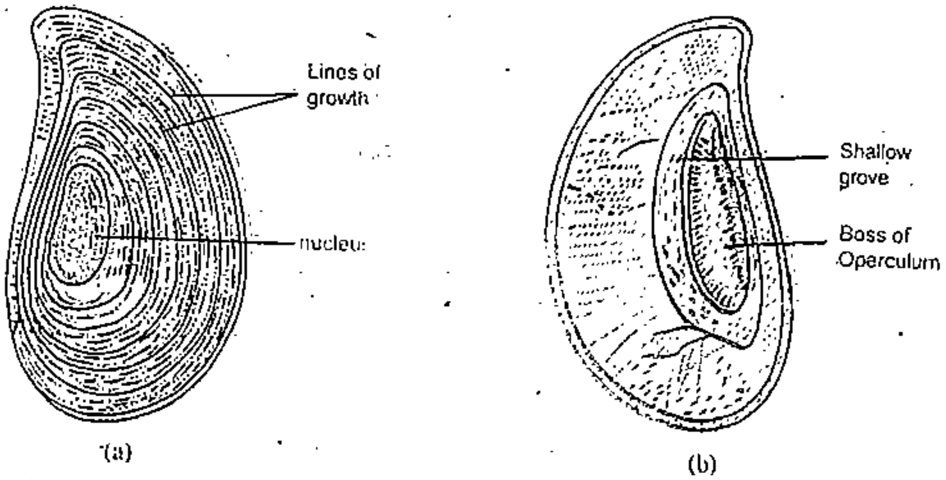

Fig. 9.2: Operculum, (a) outer view; (b) inner view.

9.4 EXTERNAL FEATURES OF *PILA* (SOFT PARTS)

To study the external features (soft parts) that is the external anatomy you have to remove the shell by following procedure so as to expose the body.

9.4.1 Procedure

1. Hold the intact animal in your left hand with its aperture/mouth facing your palm.
2. Break the top of the body whorl by repeatedly striking it with the back of the scalpel handle or some such object.
3. Using your fingers break away shell in small portions so that the underlying membrane like mantle is seen.

9.4.2 External Features

Now you will be able to see the external body parts of *Pila* as shown in Fig. 9.3 a & b.

1. The anteriormost part of the body is over the foot and is called the **head**. There are two pairs of **tentacles** arising from the head. The tentacles are capable of being extended. Ventrally and between the tentacles lies a slit-like mouth.
2. At the base of outer pair of tentacles lies a pair of small bead-like **eyes** situated on eye stalks or **ommatophores.**
3. The **foot** of *Pila* is a large, fleshy and muscular organ, which forms the ventral part of the body. It is triangular in shape and its pointed end is directed backwards. The ventral surface of the foot is called the **sole**. It is this sole which makes contact with the ground or substratum while the animal is moving.
4. The operculum is connected to the dorsal part of the foot and is posterior in position. When the foot is withdrawn the operculum covers the aperture like a tight fitting lid. The foot is the only locomotry organ of *Pila*. By the action of muscles of foot, *Pila* is able to creep over the ground. There is a mucous gland inside the foot, which leaves a trail of mucus during locomotion.
5. The rest of the body is in the shape of a mass called the **visceral mass**. It is a coiled structure, which extends into the penultimate whorl. In contains all the main organs of the body.

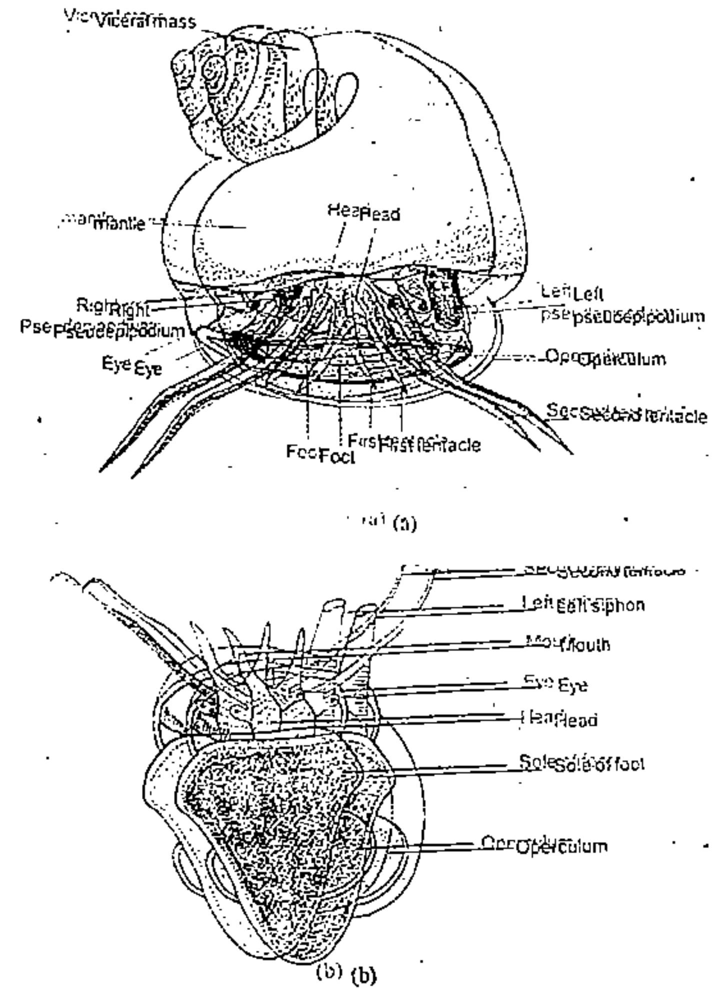

Fig. 9.3: External features of *Pila* as seen without the shell, (a) frontal view; (b) ventral view.

9.5 INTERNAL ANATOMY OF *PILA*

To study the internal parts of the *pila* follow the procedure given below.

9.5.1 Procedure

Give a longitudinal incision starting from the edge of the mantle to the posterior limit of the mantle cavity along the left edge to expose the mantle cavity. Pin down the mantle flap in the tray. You can look into the figure 9.4 for the organs of mantle cavity of the female *Pila*. [Male and female *Pila* are not sharply distinguishable externally in the intact animal. Female's shell is usually larger, the male has a well developed copulatory organ, penis, lodged in a penis sheath jointed to the mantle in the right hand side of the mantle cavity].

9.5.2 General Features

1. Mantle is the covering of the visceral mass. The edge of the mantle contains gland cells, which are responsible for secreting the shell. The mantle forms two contractile structures at the side of head, the left and right **nuchal lobes or pseudepipodia** (singular; pseudepipodium), that work as respiratory siphons.
2. Anteriorly, the covering of mantle over the body forms a cavity called the mantle or **pallial cavity**. The organs present within this cavity are known together as **pallial complex.**
3. A ridge is seen extending from right nuchal lobe to the posterior end of mantle cavity dividing the cavity into two chambers the **branchial** and **pulmonary**

chamber. These chambers play an important part during respiration. The respiratory organ in *Pila* is the **gill** or **ctenidium**, which is attached to the right side of branchial chamber.

4. The anus is situated near the right nuchal lobe. The aperture of genital duct is also situated close to the **anus**. The male has a penis in front of the genital opening.
5. Other structures that you can see in the cavity are a large **pulmonary** sac or **lung** attached to the roof of the pulmonary chamber. A comb-like **osphradium**, which is a sensory organ is situated near the left nuchal lobe.

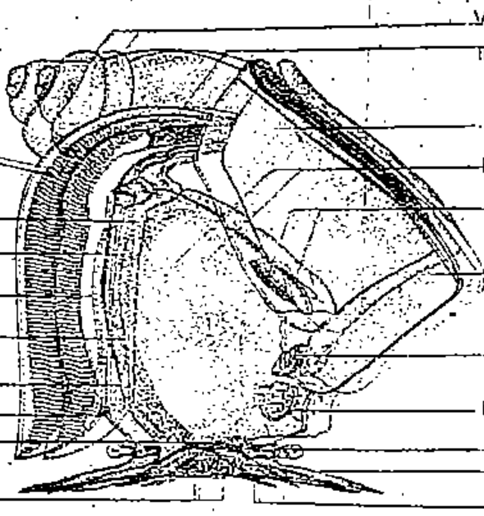

Fig. 9.4: *Pila*: organs of pallial complex (mantle cavity) in female animal.

9.6 NERVOUS SYSTEM OF PILA

Nervous system of *Pila* is dissected by the procedure given below. Study the diagram carefully so as to recognize the parts easily.

9.6.1 Procedure and Exposition

1. To expose the nervous system of *Pila*, carefully cut and remove the skin over the rounded head. A flat pale yellow or white **cerebral commissure** will be visible to you which joins the left and right **cerebral ganglia** (singular; ganglion). Incidentally the nerve connecting two similar ganglia is called a commissure whereas one connecting two dissimilar ganglia is called a connective.
2. Slowly and gently expose all the nerves and ganglia as shown in the diagram 9.5. You should be very careful as the nerves are very delicate and will break very easily.
3. While clearing the nerves always remove the other tissue in very small pieces. Keep your work wet by frequently dipping it in water.
4. After completely exposing the nervous system you should then try to insert small pieces of black paper under the nerves so that they are visible instantly.
5. Flag-label various parts of nervous system. You should insert the flag pins obliquely in the dissecting tray.

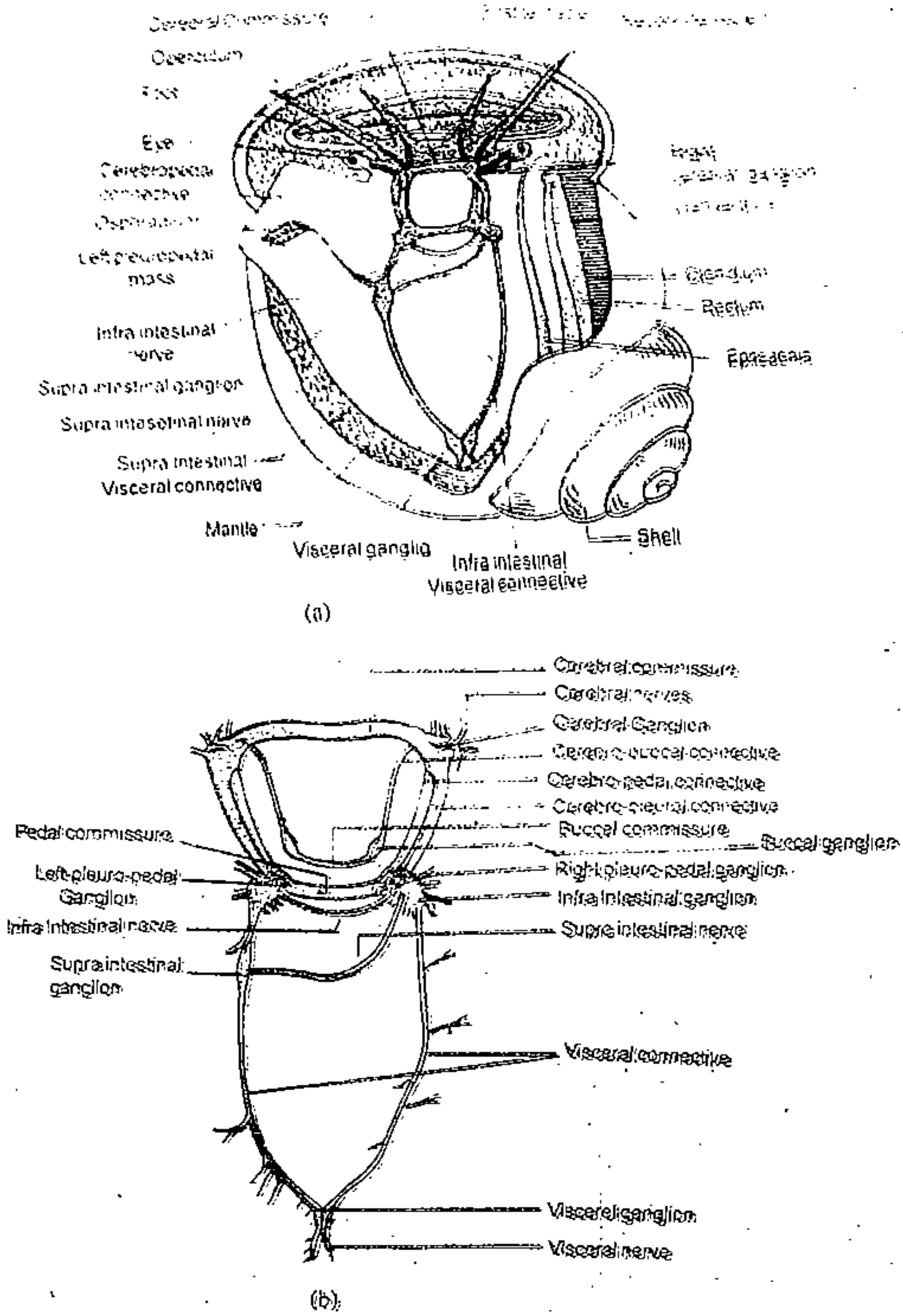

Fig. 9.5: *Pila*, (a) nervous system *in situ*; (b) nervous system.

9.7 TAKING OUT THE RADULA AND PREPARING ITS TEMPORARY MOUNT

The Radula is the organ of *Pila*, which is used to cut the food in small pieces. The radula is a flat ribbon-like structure found inside the buccal cavity of *Pila*. Radula is brownish in colour and quite hard. In this exercise follow the procedure given below to take out the radula from the *Pila*.

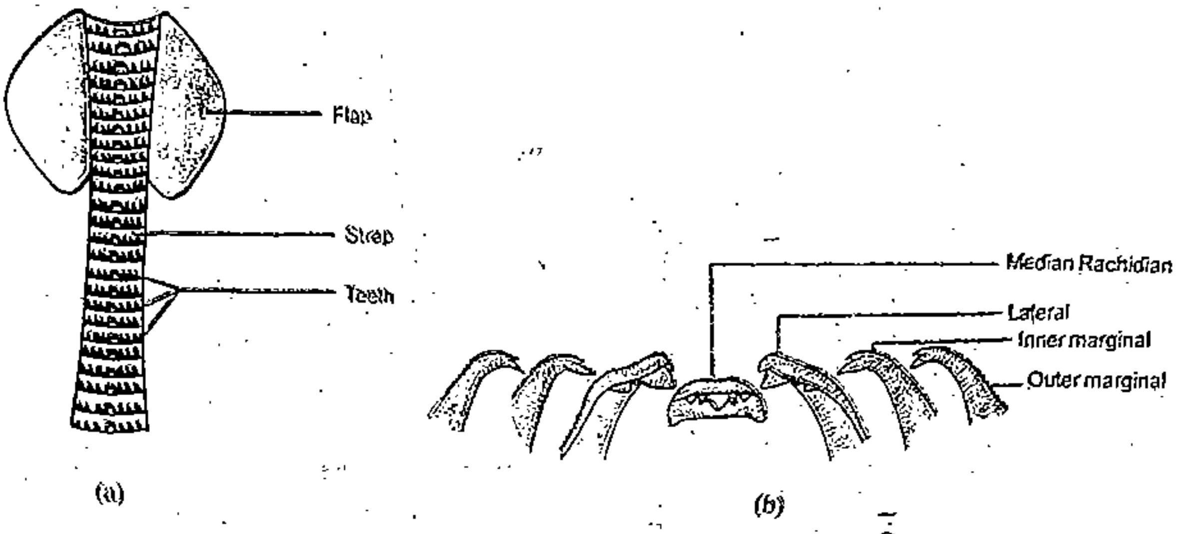

Fig. 9.6: (a) Radula of *Pila*; (b) radular teeth of *Pila*.

9.7.1 Taking out Radula

Radula is characterized by having transverse rows of minute horny teeth (Fig. 9.6a). Each row has seven curving teeth (Fig. 9.6 b). The one in the center is large and is called the **median rachidian tooth** as you can see in Fig. 9.6 b. This is followed by one **lateral** and two **marginals** on each side. The posterior end of radula lies in a **radular** sac which constantly secretes the teeth as they are being worn out on the anterior end. The cells, which secrete the teeth, are called **odontoblasts.**

Procedure

1. To take out the radula, remove the skin over the head region and you will see a rounded structure, the **buccal mass.** This is highly muscular structure, which encloses the buccal cavity.
2. If you now cut away the top layers of this buccal mass, you will see the radula in the buccal cavity.
3. Pick up the radula with a forceps and then cut it at its points of attachment.
4. Place it in a watch glass and cover it with water.

9.7.2 Mounting of Radula (Temporary mount)

Now, after taking out the radula you have to prepare a temporary mount of it for further examination. To do this,

1. Cut the radula in a piece of about 5 mm square.
2. Put it over a clean glass side with its tooth-bearing side facing upward.
3. Put a few drops of glycerin over it and gently lower a cover slip on it. You must take care to put only that much glycerin which should flow neither out of the coverslip nor should it be less to leave air spaces under it.
4. Now observe the fine details of teeth under a dissecting microscope as shown in Fig. 9.6 b.

Precautions

For carrying out the dissection a few points must always be kept in mind:

- Before cutting or separating any part, identify all the visible structures without dissecting them.
- Find out what structures will be visible after dissection and what may be damaged if dissection is not done carefully.
- Do not cut anything unless you know what it is and why it should be cut.
- Unless instructed, do not remove a part completely.

- For making an incision, insert one point of scissors so that it does not go in deeply then cut in short lifting strokes holding the lower blade almost parallel to the layer that is being cut.
- Use closed points of forceps, probe, needle or fingers for separating, loosening and lifting of parts to expose underlying structure.
- Carry out all operations in a dissecting tray filled with water. Change the water frequently.

9.8 TERMINAL QUESTIONS

1. Explain the following terms in short.
   i) Unilocular shell

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   ii) Operculum

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2. i) List the steps involved in exposing the external anatomy of *Pila*.

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   ii) Differentiate between:
   (a) Pallial cavity and pallial complex

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(b) Ctenidium and Osphradium

3. i) How many ganglia are found in the nervous system of *Pila*? Name them.

ii) What is a commissure? Name two commissures you have observed in the dissection.

4. i) Where is radula situated in the body of *Pila*?

ii) How many teeth are present in each row of radula? Name these.

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EXERCISE 10 PLATYHELMINTHES: OBSERVATION AND CLASSIFICATION OF SPECIMENS AND MICROSCOPIC STUDY OF THEIR SECTIONS

Structure

10.1 INTRODUCTION

The present laboratory exercise is based on Unit 4 (Section 4.6) of LSE-09 course which deals with Phylum Platyhelminthes. You will recall from that unit, that members of Phylum Platyhelminthes are also called flatworms since they are dorsoventrally flattened. Flatworms may be free living or parasitic. This phylum has four classes: **Monogenea, Turbellaria, Trematoda** and **Cestoda.**

In this laboratory exercise you will study with the help of permanent slides one representative each of the three classes Turbellaria, Trematoda and Cestoda namely: *Dugesia, Fasciola* and *Taenia.* You will also study their microscopic details with the help of cut sections passing through their body regions. For this purpose you will study the transverse sections (T.S) of *Dugesia,* passing through the the pharynx and intestine, T.S. of *Fasciola hepatica* passing through testes, cirrus sac and uterus and whole mounts of mature and gravid segments of *Taenia solium* as well as its transverse section passing through the uterus and atrium region.

Objectives

After performing this exercise you should be able:

- identify the specimens of *Dugesia tigrina, Fasciola hepatica* and *Taenia solium* and give their scientific and common names,
- classify upto the level of order the identified platyhelminths *Dugesia, Fasciola hepatica* and *Taenia solium,* which are the type representatives of classes Turbelleria, Trematoda and Cestoda respectively and draw their labelled diagrams,
- list the features justifying the classification of *D. tigrina, F. hepatica* and *T. solium* upto level of order,
- give economic importance and significant features of the identified species, if any,
- give the habit, habitat and geographical distribution of the identified flatworms,
- identify, describe and draw labelled diagrams of transverse sections through pharynx and intestine of *Dugesia,*

13-B

- identify, describe and draw labelled diagrams of transverse sections through testis, cirrus sac and uterus of *Fasciola hepatica*,
- identify, describe and draw labelled diagrams of whole mounts of mature and gravid body segments and transverse sections of body segment passing through atrium and uterus of *Taenia solium*.

10.2 MATERIAL REQUIRED

1. Compound microscope
2. Permanent slides of *Dugesia tigrina, Fasciola hepatica, Taenia solium* and museum specimen of *Taenia solium*.
3. Permanent slides of T.S. of *Dugesia tigrina* passing through the pharynx and intestin
4. Permanent slides of T.S. of *Fasciola hepatica* passing through testis, cirrus and uteru
5. Permanent slides of mature and gravid proglottids of *Taenia solium* as well as T.S. passing through uterus and atrium.
6. Laboratory note book.
7. Pen, pencils and eraser.

10.3 Method

Examine permanent slides of *Dugesia tigrina, Fasciola hepatica* and *Taenia solium*. Note the various morphological characters that you can observe and draw their labelled diagrams. Also with the help of slides of transverse sections passing through bodies of *Dugesia tigrina, Fasciola hepatica* and *Taenia solium* observe and study their finer details and draw their labelled diagrams. The descriptions given in this exercise as well as the figures provided will also help you in making observations.

10.4 PHYLUM PLATYHELMINTHES – FEATUES AND CLASSIFICATION FROM KINGDOM TO PHYLUM

Let us briefly review the main Phylum characteristics before proceeding with our exercise. This will help you in studying the general aspects of the type specimens.

10.4.1 General Features

1. Phatyhelminthes are the most primitive of bilaterally symmetrical animals (Fig. 10.1), with definite polarity of anterior and posterior ends.
2. Flatworms are the first among invertebrates to be triploblastic with three germ layers – ectoderm, endoderm and mesoderm.
3. The flatworms are acoelomate since coelom or hoemocoel is absent and no body cavity occurs between or within any of the germ layers except for digestive tube. Spaces between organs is filled with parenchyma, a type of connective tissue or mesenchyme.
4. Body is dorsoventrally flattened and oral and genital apertures are present on ventral surface.
5. Epidermis of tegument may be cellular or syncytial (it may be ciliated in some). Rhabdites are found in epidermis of most Turbellarians.
6. Muscular system is primarily in the form of a sheath and of mesodermal origin; layers of circular, longitudinal and sometimes oblique muscle fibres lie beneath the epidermis.
7. Major sets of organs present are in the form of excretory, nervous and reproductive systems.
8. Digestive system may be absent. When present it is incomplete (gastro-vascular type) with a single opening which functions both for food ingestion and waste elimination.
9. Nervous system is more organized than in cnidarians with a simple brain consisting of a pair of two masses of nervous tissues called ganglia. This accumulation of nervous tissue makes flatworms, the first metazoans to exhibit cephalization or

distinct head. A pair of ventral nerve cords one from each anterior ganglia extend posteriorly through the length of the body. These ventral nerve cords are connected by means of transverse nerves which form a ladder-like structure.

10. Simple sense organs are present; eye spots occur in some examples.
11. Excretory system consists of two lateral canals with branches bearing flame cells (protonephridia); excretory system is absent in some primitive forms.
12. Respiratory, circulatory and skeletal systems are absent; lymph channels with free cells are found in some trematodes.
13. Most forms are monoecious; reproductive system is complex, usually with well developed gonads, ducts and accessory organs; fertilization is internal, development is direct in free-swimming forms and in those which have a single host in their life cycle; life cycle is usually indirect in internal parasites and is complicated, often involving several hosts.
14. Class Turbellaria has mostly free living forms; members belonging to classes Monogenea, Trematoda and Cestoda are entirely parasitic.

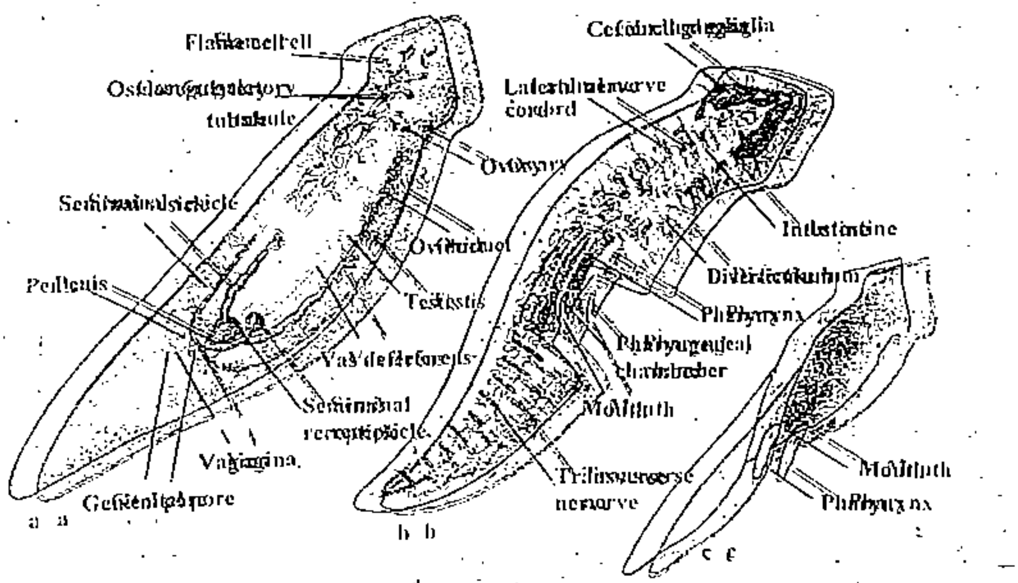


Fig. 10.1: Structure of a Platyhelminthes (Planaria). (a) Osmoregulatory and Reproductive Systems shown in part. (b) Ladder-like Nervous system and Digestive Tract in resting position. (c) Pharynx extended through Ventral Mouth.

10.4.2 Classification from kingdom up to Phylum Level

The classification from kingdom to phylum of Platyhelminthes is as follows:

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Sub-kingdom	**Eumetazoa**	Animals with tissues and organs.
Grade I	**Bilateria**	Bilateral animals.
Division	**Protostomia**	Cleavage is determinate and commonly spiral, mouth arising from blastopore.
Sub group	**Eutrochozoa**	Lack of a shed cuticle.
Phylum	**Platyhelminthes**	Acoelomate, triploblastic, bilaterally symmetrical animals with organ grade organization; epidermis ciliated at least in part, flatworms.

10.5 *DUGESIA TIGRINA* – TYPE SPECIMEN OF CLASS TURBELLARIA

You have thus learnt the main characters of Phylum Platyhelminthes and an outline classification of their position in the animal kingdom. In the following sections you will study one type specimen each of the Classes Turbellaria, Trematoda and Cestoda. For this purpose, you will identify the specimens upto the level of class and also give their distinguishing features, and draw diagrams. You will also study with the help of the permanent slides the histological details in the sections of *Dugesia, Fasciola* and *Taenia*

General Features of Class Turbellaria

Members of this class are fresh water, free-living, carnivorous forms. Body is covered by ciliated epidermis, mouth opening is ventral; Turbellerians are monoceious, and reproduction is by sexual, asexual and regeneration methods; asexual reproduction by fission is common – Example: *Dugesia* (Planaria).

10.5.1 Type Specimen – *Dugesia*

Study with the help of notes and drawing provided to you the permanent slide of the whole mount of Dugesia under the microscope. Draw its labelled diagram.

General Features of *Dugesia tigrina*

i) *Dugesia* is one of the commonly known planarians.
ii) It is free living.
iii) Body surface is ciliated. Epidermis contains secreting cell and rod-like bodies (rhabdites)
iv) It is a dark coloured flat worm ranging from 12 – 15 mm in length (Fig. 10.2).
v) The body is leaflike with triangular head and posteriorly tapering body.
vi) Triangular head contains two ear-like prominent auricles and two semicircular ocelli or eyes.
vii) Digestive system is present and consists of: mid-ventrally located mouth, protusible proboscis enclosed in proboscis sheath, pharynx (plicate = directed backwards) which extends through the mouth opening during feeding, branched intestine consisting of a single tube anteriorly which forks posteriorly.
viii) Digestion is both extra and intracellular.
ix) Respiratory System is absent and so respiration is by diffusion through body surface.
x) Nervous system consists of a bilobed, central ganglion nerve cord and peripheral nerves.
xi) Genital pore is situated a little posterior to the mouth.

[Reproduction is by sexual, asexual and regeneration method. During early summer, reproductive organs appear in breeding season and degenerate thereafter. New planarians multiply asexually through fission.]

Special Feature to Remember

Turbellarians possess great power of regenerating lost parts. Free cells from mesenchyme called neoblasts migrate to the cut surface, giving rise to a bud like structure called blastema, which forms to the lost part.

Due to the power of regeneration, the planarians are a favourite material for experiments on grafting.

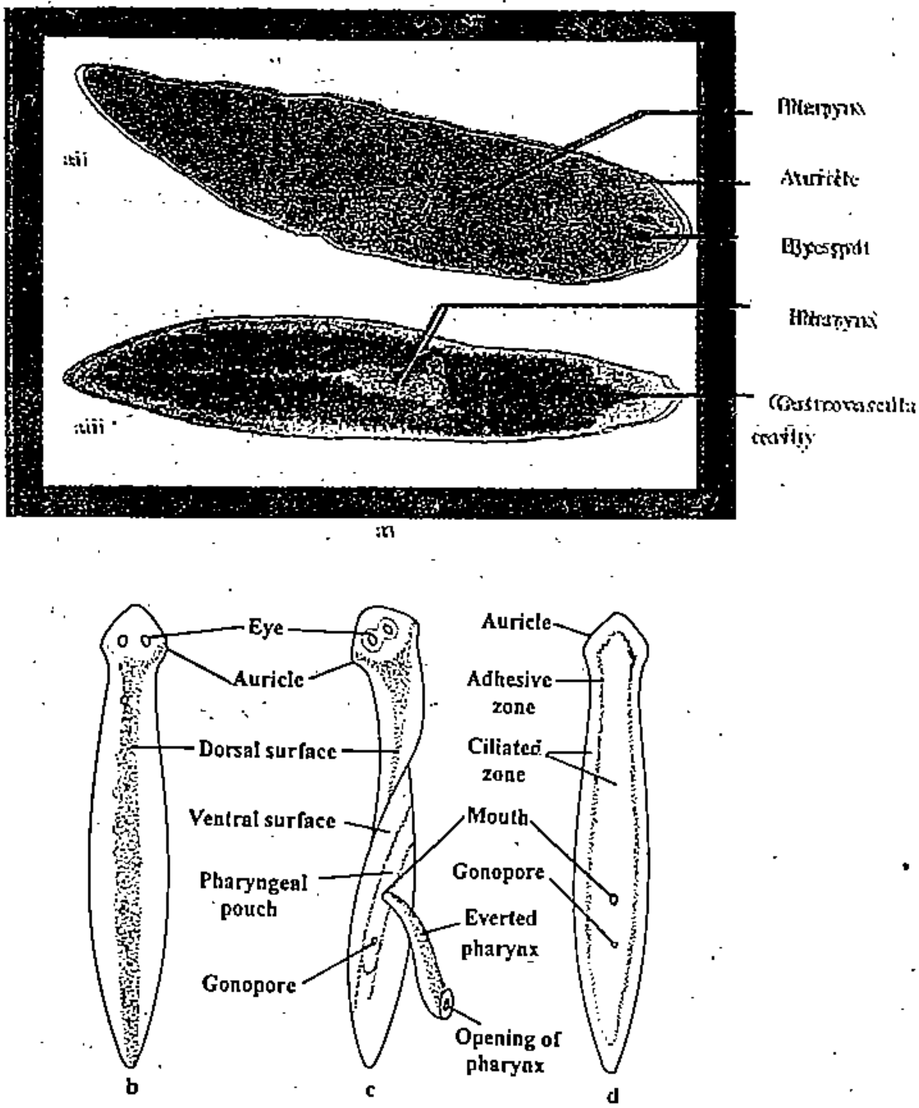


Fig. 10.2: Entire *Dugesia* (a) Stained specimens (a i) external view (a ii) internal view. (b) Dorsal view. (c) Body twisted to show part of ventral surface. (d) Ventral view.

Habit and Habitat

Planarians are free living, fresh water triclads. They are gregarious in habit and are found under logs, debris, rocks submerged in cool, clear and running water of stream. Planarians are carnivorous, their food consists of snails and crustaceans.

Geographical Distribution

Dugesia is world-wide in distribution.

Classification and its Justification

Kingdom	**Animalia**	Animalia, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at sometime of their life cycle, heterotrophic nutrition.
Phylum	**Platyhelminthes**	Acoelomate, triploblastic, bilaterally symmetrical animals with organ-grade organization, epidermis ciliated at least in part; flatworms.
Class	**Turbellaria**	Mostly free living, carnivorous, fresh water forms; epidermis at least in part, provided with rhabdoids (minute rod-like structures); adhesive organs present.

Order **Tricladida** Pharynx usually directed backwards (plicate), intestine with three branches, gonopore single.

Genus ***Dugesia* (*Planaria*)**

Species ***tigrina***

10.5.2 Transverse Sections of *Dugesia* passing through pharynx and intestinal region

The transverse section of *Dugesia* (Fig. 10.3) reveals the following histological features.

1. Body wall consists of:
   (i) an outer, single layer of ciliated, syncitial epidermis (epithelium) resting on a thin basement membrane and

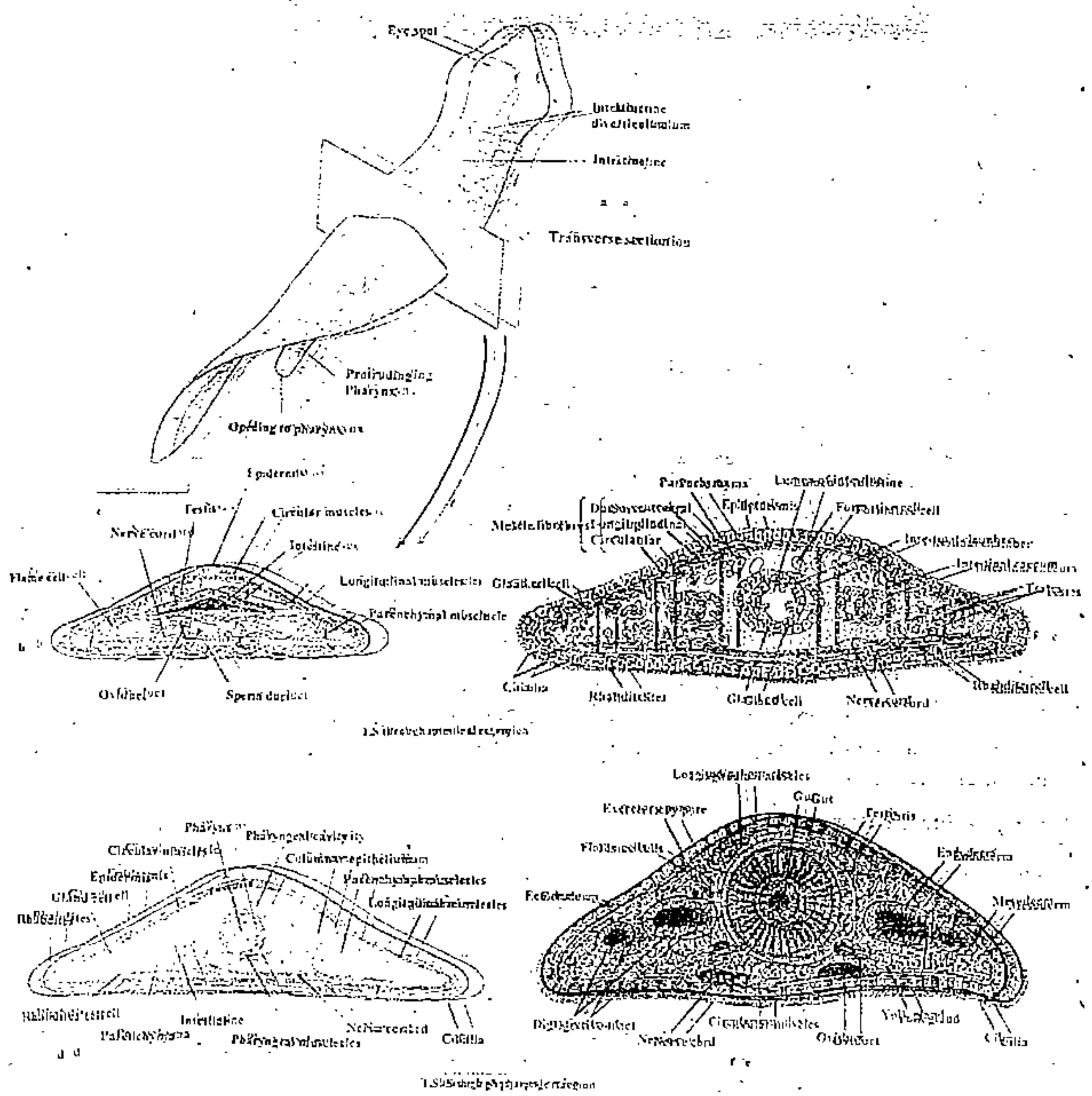


Fig. 10.3: Transverse sections (T.S.) of *Dugesia* (a) The type of cut for transverse section (b) Stained T.S. passing through intestine (c) Drawing of T.S. passing through intestine as interpreted from slide (d) Stained section of T.S. passing through pharynx (e) T.S. passing through pharynx as interpreted from slide.

(ii) inner muscle layer lying below the basement membrane.

2. Epidermis has sensory cells and mucous gland cells in certain areas, which secrete mucous. Epidermis also have characteristic hyaline rods called rhabdites which are more abundant on the dorsal side. Function of rhadites is unknown, but they probably have a protective discharge. They are thus associated with offensive or defensive function.
3. Muscle layer of body wall has three kinds of muscles (1) an outer layer of circular muscles, (2) an inner layer of longitudinal muscles, and (3) diagonal muscles, extending between body wall and inner space, that are called dorso-ventral muscles.
4. Body cavity is absent. The interior of the body between the muscle layer and internal organs is filled with a special type of tissue called parenchyma or mesenchyma. Thus these animals are acoelomate (coelom absent).
5. Cut section from pharynx region shows pharynx in the centre and intestinal caeca on its lateral sides as you can seen in Fig. 10.3 a. Also refer to fig. 10.3 b.
6. Cut section through intestinal region reveals cut section of gut in the centre and intestinal caecum on lateral side of the cut. Also visible, are section of testes, ovary, vas deferens and yolk gland on each side of the gut (Fig.10.3 b).
7. Nerve cord can be seen situated on the ventral side, just above the longitudinal muscles.

10.6 *FASCIOLA HEPATICA* – TYPE SPECIMEN OF CLASS TREMATODA

Features of class Trematoda

Members of this class are called flukes since they appear leaflike in shape; ciliated epidermis absent, body has non-ciliated syncytial (cells with multiple nuclei) tegument; oral and ventral suckers present and well developed; adults are ectoparasites or endoparasites of invertebrates and vertebrates; life-cycles generally complex with 2 or more hosts; example *Fasciola hepatica*.

10.6.1 Type Specimen – *Fasciola hepatica*

Fasciola hepatica (Fig. 10.4 a, b and c) is commonly known as liver fluke or sheep liver fluke and is found in the liver of sheep, ox, horse, dog, elephant, man, monkey etc.

Examine a permanent slide of *F. hepatica* under the compound microscope and observe some of the following features. Draw a well labelled diagram of *F. hepatica*.

General Features of *Fasciola hepatica*

i) *Fasciola hepatica* has a dorsoventrally, flattened body. It is oval and leaf-shaped and measures 25-30 mm in length and 4-5 mm in breadth. Body has pinkish appearance but may also look brown when it has ingested bile of the host.
ii) Anterior end of the body is distinguished into a triangular oral cone called, head lobe and bears a triangular mouth.
iii) There are two muscular suckers towards head end (i) an **oral sucker** at the anterior end, encircling the mouth and (ii) a large, highly muscular **ventral sucker** or **acetabulum** located segments 3-4 behind the oral sucker.
iv) Body wall lacks cellular layer i.e. epidermis. It has thick layered cuticle made of scleroproteins followed by a basement membrane. Underneath the basement membrane is a sub-cuticular muscular layer which consists of an outer layer of circular muscle fibres, middle layer of longitudinal muscle fibres and an inner layer of diagonal muscle fibres. Below the muscular layer is the parenchyma.
v) Alimentary canal is simple, consisting of mouth, muscular pharynx, short oesophagus, and branched, diverticulated, bifid intestine with many caeca.

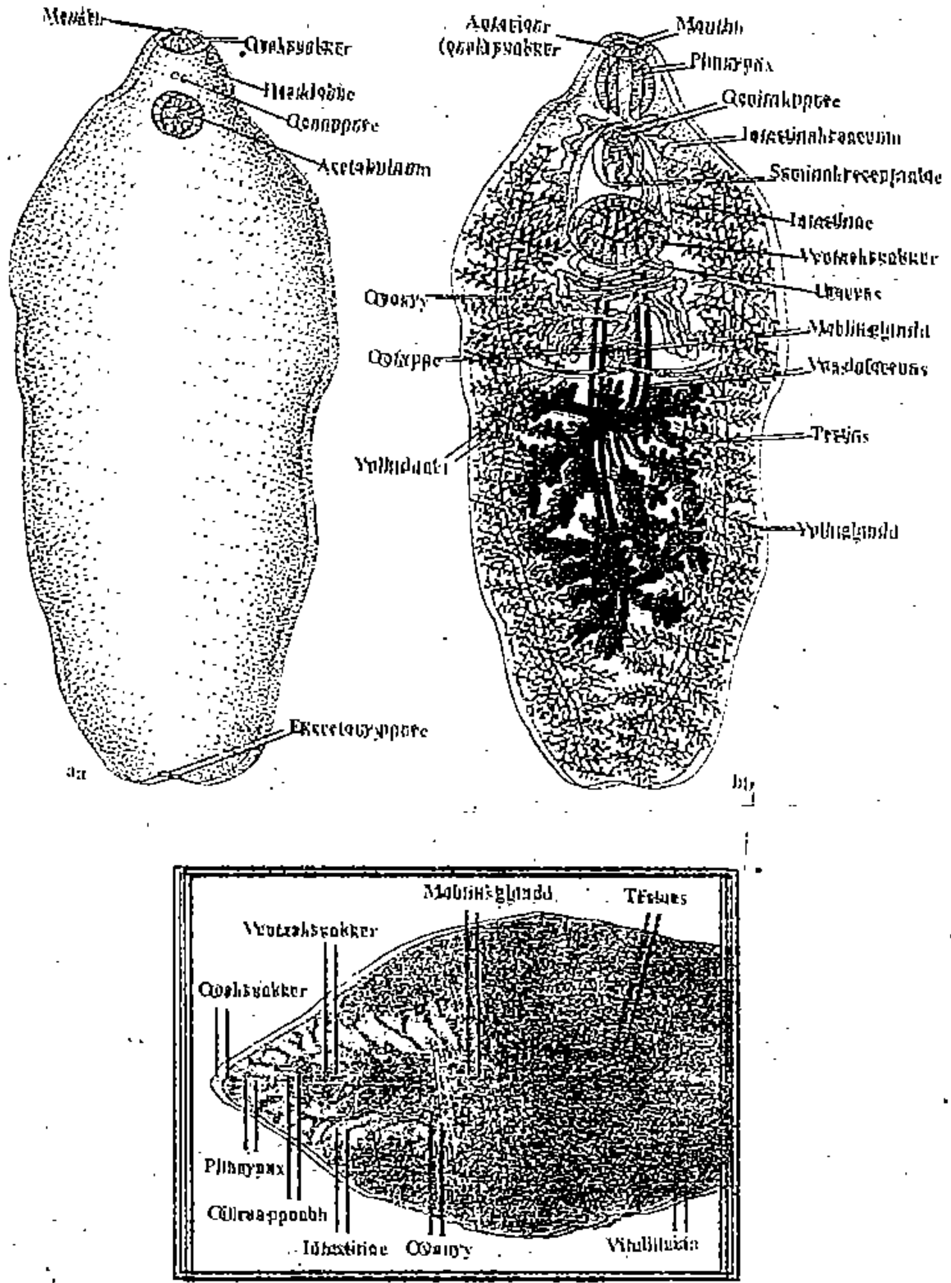
vi) Excretory pore lies at extreme posterior end of the body.

vii) Nervous system consists of a pair of cerebral ganglia, that form a nerve ring and dorsal, lateral and ventral pair of longitudinal nerve cords.

viii) Liver flukes are hermaphrodite with well developed reproductive systems.

ix) Male reproductive system consists of testes, vas deferens (vasa deferentia), seminal vesicle, cirrus or penis, ejaculatory duct, prostate gland and genital atrium while female reproductive system consists of ovary, oviduct, uterus, vitelline gland, Mehli's gland and Laurer's canal.

x) Genital pore is medially located between oral and ventral suckers. Eggs pass out to the exterior by the pore.



Anterior end of Fasciola hepatica. (Original image by Peter Darben)

Fig. 10.4: ***Faciola hepatica*** **a) ventral view of adult in low power. b) Ventral view of adult in high power. c) Stained anterior end.**

[Lifecycle is completed in two hosts, the main host being cattle or sheep and the intermediate host being snail of genus *Lymnae*. Life cycle has the followings stages: zygote, miracidium larva, sporocyst larva, redia larva, cercaria larva, metacercaria larva and adult parasite. Liver fluke causes a disease known as 'liver rot' in its main host namely sheep.]

Habit and Habitat

Fasciola hepatica is found as an endoparasite in the bile ducts of its main host usually sheep and cattle. It may however also occur in horses, rabbits, camels, pigs and even human beings. Human infestation is common in the Orient, where human faeces are used to fertilize ponds and fish from such ponds are eaten raw.

Geographical Distribution

Fasciola hepatica is cosmopolitan in distribution throughout sheep rearing areas in USA and also occurs in India.

Classification and its Justification

Kingdom	**Animalia**	Animal, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some their body parts or capable of movement at sometime of their life cycle; heterotrophic nutrition.
Phylum	**Platyhelminthes**	Acoelomate, triploblastic, bilaterally symmetrical animals with organ-grade organization, epidermis ciliated at least in part, flatworms.
Class	**Tremetoda**	Ecto or endoparasites, body wall lacks epidermis and cilia, well developed suckers present.
Order	**Digenea**	oral and ventral suckers present and generally well developed but without hooks, life cycle involves at least one intermediate host; usually endoparasites of vertebrates.
Genus	***Fasciola***	
Species	***hepatica***	
Common name	Liver fluke	

10.6.2 Transverse sections of *Fasciola hepatica* passing through testes, cirrus sac and uterus

Examine under the microscope the slides of transverse sections of testis, cirrus and uterus of *Fasciola hepatica* provided to you by your counsellor. Observe the various details with the help of notes and drawings provided to you. Draw labelled drawings of the sections showing the various important features.

A. T.S. of Fasciola hepatica passing through testes (Fig. 10.5)

Transverse section is cut through two-thirds of posterior region of body and reveals the following structures:

1. Body wall lacks an epidermis and is composed of:
   (i) Thick tegument of non-cellular cuticle which forms the outermost covering of body and bears numerous spinules or scales.
   (ii) Muscle layer – whose musculature is made up of an outer layer of circular muscle fibres; middle layer of longitudinal muscle fibres and an inner layer of diagonal muscle fibre layers. Longitudinal muscle fibers are predominantly abundant.
2. Coelom is absent and the space between body wall and internal organs in filled with parenchyma cells also called mesenchymal cells. Mesenchymal cells are irregularly shaped and filled with fluid.

3. T.S. of slide show irregularly shaped cut sections and dendrites of testes which contain spermatozoa at various stages of development.
4. Sections of intestinal diverticula with epithelial columnar cells can be seen.
5. In some transverse sections, cut sections of vitelline glands and uterus may also be observed.

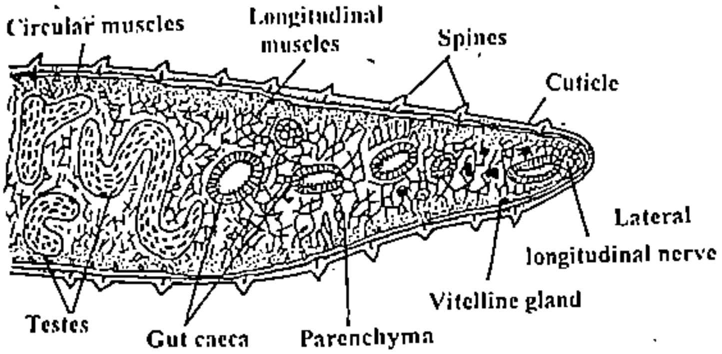


Fig. 10.5: Transverse section of *F. hepatica* passing through testis region.

B. Transverse Section of *F. hepatica* through Cirrus Sac (Fig. 10.6)

Section is cut from cephalic or anterior end of *F. hepatica* and shows the following important hiotological features.

1. Body wall lacks epidermis and is composed of:
   (i) Thick tegument of non-cellular cuticle, which forms the outermost covering of the body and bears numerous spinules or scales.
   (ii) Muscle layer – whose musculature is made up of an outer layer of circular muscle fibres; middle longitudinal muscle fibres and an inner layer of diagonal muscle fibre layers. Longitudinal muscle fibers are predominantly abundant.
2. Transverse section shows a large sac-like structure called cirrus sac that encloses seminal vesicle, prostrate gland, ejaculatory duct and cirrus.
3. Seminal vesicle appears like a large vesicle and is full of spermatozoa.
4. Body wall of cirrus sac has thick muscle : The lumen of the cirrus represents pre-cirral canal.
5. Cut sections of intestinal caeca can be observed on lateral sides of cirrus sac.
6. Some portions of ovary and vitellaria may also be seen.

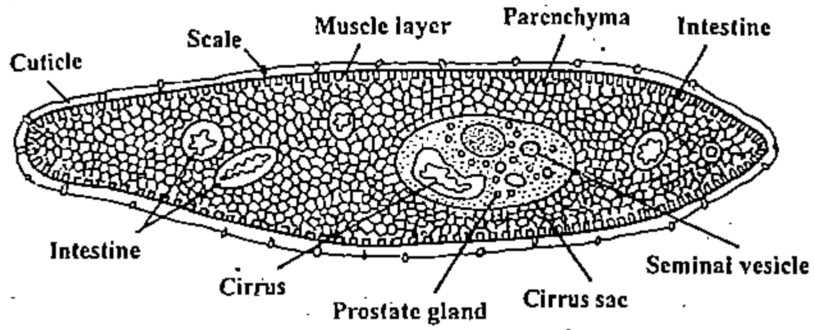


Fig. 10.6: T.S. of *F. hepatica* through cirrus sac.

C. Transverse Section of *F. hepatica* passing through uterus

Section is cut through anterior region of *F. hepatica* and reveals the following histological features (Fig. 10.7).

1. Body wall lacks an epidermis and is composed of:
   i) Thick tegument of non-cellular cuticle which forms the outermost covering of body and bears numerous spinules or scales.

ii) Muscle layer – whose musculature is made up of an outer layer of circular muscle fibres; middle layer of longitudinal muscle fibres and an inner layer of diagonal muscle fibre layers. Longitudinal muscle fibers are predominantly abundant.

2. Sections of uterus and ovary are seen near the central region.
3. Uterus is seen at various places packed with eggs. Fertilized eggs contained in the section of the uterus may also be seen.
4. Sections of vitelline glands and vitelline ducts are also visible on the lateral sides.
5. Few sections of intestinal caecae can also be seen.

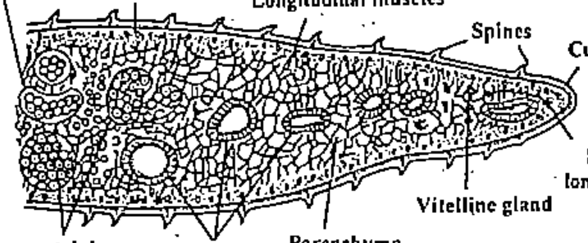


Fig. 10.7: T.S. of *F. hepatica* through uterus.

10.7 *TAENIA SOLIUM* – TYPE SPECIMEN OF CLASS CESTODA

Features of class Cestoda: Members of this phylum are called tapeworms; their body is covered with non-ciliated; syncitial tegument; body shape is tape-like and consists of anterior scolex bearing hooks and/or suckers and a long tape like-strobila which is divisible into few to many segments called proglottids; young segments occur just behind the scolex while mature segments occur towards the posterior end; mouth and digestive tract are totally absent; tapeworms are monoecious; each proglottid contains one or two sets of complete hermaphroditic reproductive systems; adult stages are almost entirely endoparasites of vertebrates; life cycle complex with one or more intermediate hosts. Example *Taenia solium*.

10.7.1 Type Specimen – *Taenia Solium*

Examine the slide of *Taenia solium* carefully under the microscope and the study the morphological features with the help of the given notes and labelled diagram given in this exercise. Draw a well labelled diagram of *Taenia solium*.

General Features

Taenia solium (Fig. 10.8) is commonly known as **pork tapeworm.** It is an endoparasite in humans and other animals.

i) Body of *Taenia solium* is long, dorsoventrally flattened, narrow ribbon like, more than 2 to 3 meters long.
ii) Body of *T. solium* consists of an anterior scolex, neck and strobila or body.
iii) Scolex is 1 mm in diameter with four cup like adhesive suckers and 22-32 curved, chitinous hooks in two circles (Fig. 10.8 a and b). Scolex remains embedded in the intestinal mucosa of host's intestine
iv) Scolex contains a spongy nerve ring and nephridial network.
v) Neck behind scolex is thin, small, narrow and unsegmented (Fig. 10.8 a and b). It proliferates into body segments or proglottids by transverse fission or asexual budding.
vi) Strobila or body consists of a large number of segments 800 or more in number.
vii) The proglottids behind the neck is devoid of reproductive organs and are broader than long. They are called immature proglottids. Mature proglottids are

pushed back and develop reproductive organs. Each mature proglottid contains a set of male and female reproductive organs, a part of excretory and nervous system and a lateral genital opening.

viii) Tapeworms are hermophrodite, female system consists of bilobed ovary, ovarian bridge or isthmus, oviduct, ootype, vitellaria, Mehlis gland, seminal receptacle and vagina which carry the sperms. Male system consists of follicular testes, vasa efferentia, vas deferens and cirrus.

ix) Gravid proglottids are the oldest and are towards the posterior end of the strobila. These segments are longer than wide and do not have reproductive organs in them, instead they contain only branched uterus packed with fertilized eggs.

[Life-cycle is complicated with man as final host and pig as intermediate host. The larval stage of *T. solium* is called cysticercus larva or bladder worms (Refer Lab. Exercise 11, Fig. 11.6 too). It gets encysted in the intermediate host pig, who gets the infection by eating human faeces. Man gets the infection by eating measly pork.]

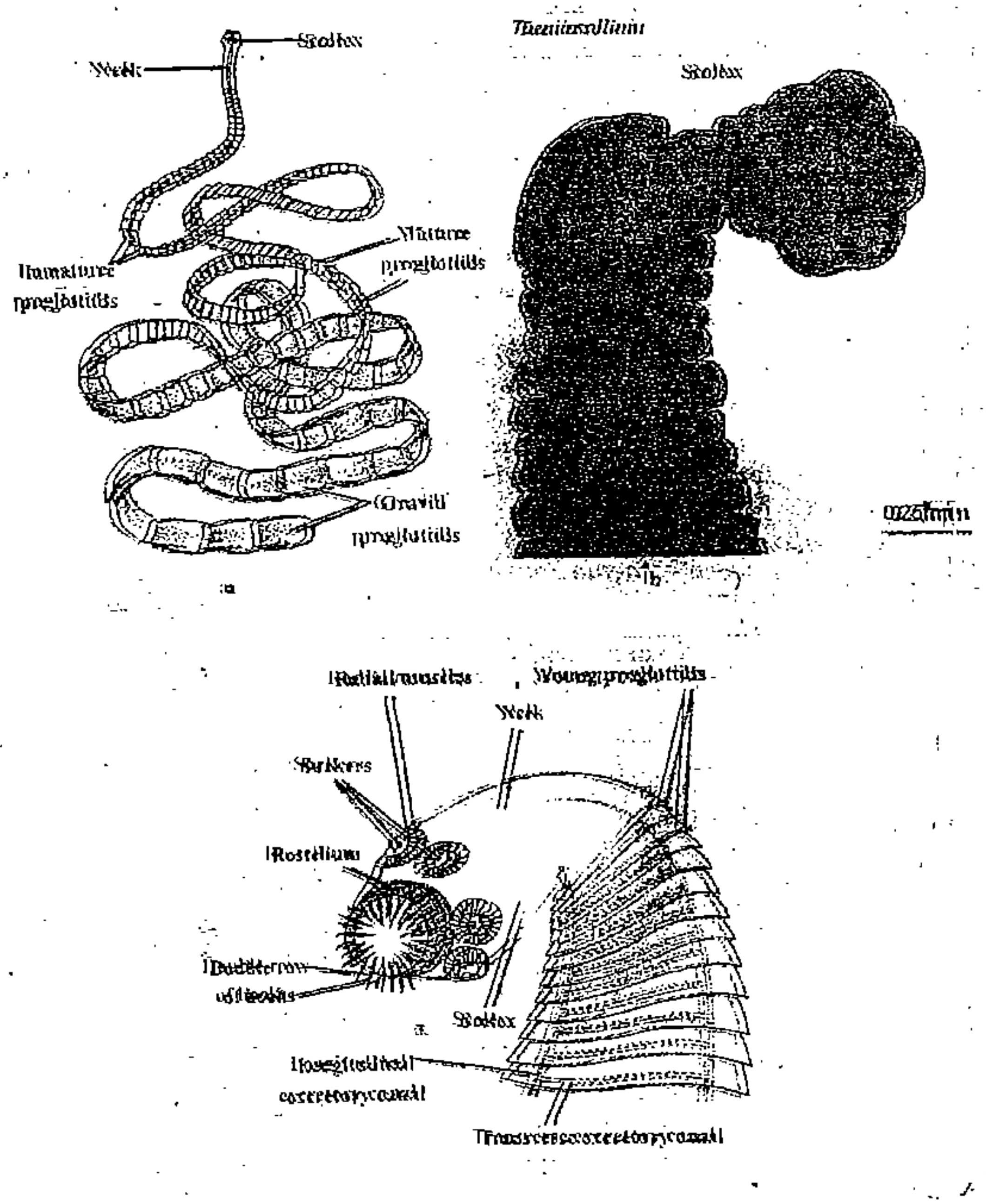


Fig. 10.8: *Taenia solium* (a) entire tapeworm (b) stained scolex (c) scolex showing hooks, suckers and young proglottids.

Habit and Habitat

The adult *Taenia solium* is commonly found in the intestine of humans, while their larval stages are found mostly in pigs. However, sometimes the larval stages get encysted in tissues and organs of humans, other mammals and birds. Cysts occurring in human brain cause headaches, convulsions and paralysis. In such cases, effect of the drug therapy is limited.

Geographical distribution

T. solium is cosmopolitan in distribution. It occurs in regions where pork is eaten. Infection is common in India, China and Germany. Other important species of *Taenia* are – *T. caninum* (dog tapeworm), *T. saginata* (beef tapeworm), *Diphyllobothrium latum* (broad fish tapeworm).

Classification and its Justification

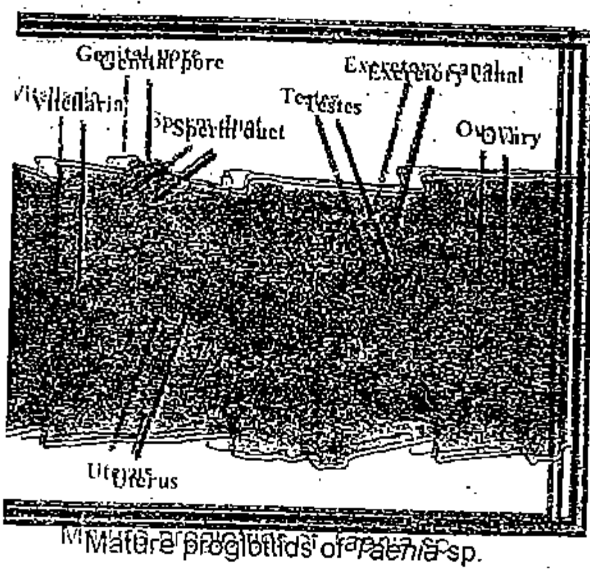
Kingdom	**Animalia**	Animal, multicellular organisms with cells that lack a cell wall many capable of movement or movement of some their body parts or capable of movement at sometime of their life cycle; heterotrophic nutrition.
Phylum	**Platyhelminthes**	Acoelomate, triploblastic, bilaterally symmetrical animals with organ grade organization, epidermis ciliated at least in part, flatworms.
Class	**Cestoda**	Endoparasitic in the intestine of vertebrates, anterior end with adhesive structures like hooks and suckers, body divided into few to many segments.
Sub-class	**Eucestoda**	Body elongated and ribbon like, anterior end has an expanded scolex, bearing suckers and hooks, each proglottid with more than one set of reproductive organs.
Order	**Cyclophyllidae**	Endoparasitic in intestine of birds and mammals; scolex with four suckers often with an apical rostellum armed with hooks; single and compact yolk gland.
Genus	*Taenia*	
Species	*solium*	

10.7.2 Mature and gravid segments of proglottids and T.S. of mature proglottid of *Taenia solium*

Examine slides of (A) a mature body segment (B) a gravid body segment and (C) T.S. of a mature proglottid of *T. solium*.

A. Mature proglottid of *T. Solium*.

1. Mature proglottid or segment is squarish in shape (Fig. 10.9).
2. Both the lateral sides of proglottid contain lateral longitudinal nerve cords and lateral excretory canals.
3. Mature proglottid has a complete set of male and female reproductive organs and so *T. solium* is hermaphrodite.
4. Male reproductive systems consist of testes, vasa efferentia, vasa deferentia and cirrus.
5. Testes appear as numerous spherical bodies, distributed throughout the proglottid.
6. Female reproductive system consists of bilobed ovary connected by isthmus, oviduct, ootype, vitellaria and Mehli's gland, vagina and uterus.
7. Oviduct divides into two ducts, one leading to vagina, opening into genital atrium by female genital opening and the other into uterus.
8. The compact vitelline gland lies behind the ovary.
9. Male and female genital organs open into the genital atrium by means of a common gonopore.
10. Genital atrium is situated on a swollen genital papilla.



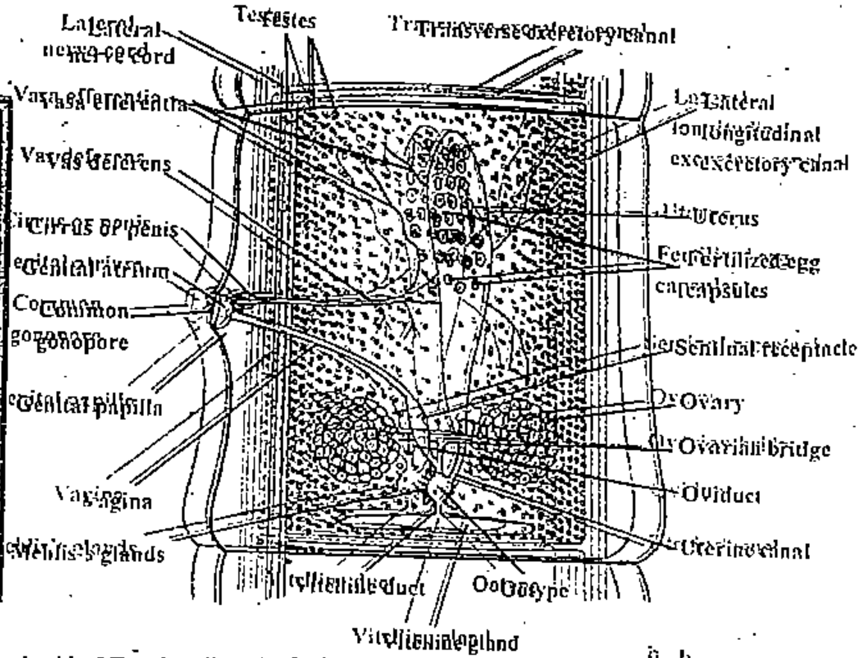


Fig. 10.9: Mature proglottid of *Taenia solium*. (a) Stained slide of mount of mature proglottid. (b) Drawing of mature proglottid as interpreted from slide.

B. Gravid proglottid of *Tanenia solium*

1. The body segments which are at the posterior most end of *T. solium* are the ripe or gravid proglottids.
2. Gravid proglottid (Fig. 10.10) is longer than broad and has a highly branched uterus with a minimum of 10-13 branches. Length of uterus is 10-12 mm and breadth may be 4-6 mm. Uterus is blind at both ends.
3. Uterus is filled with fertilized eggs or oncospheres.

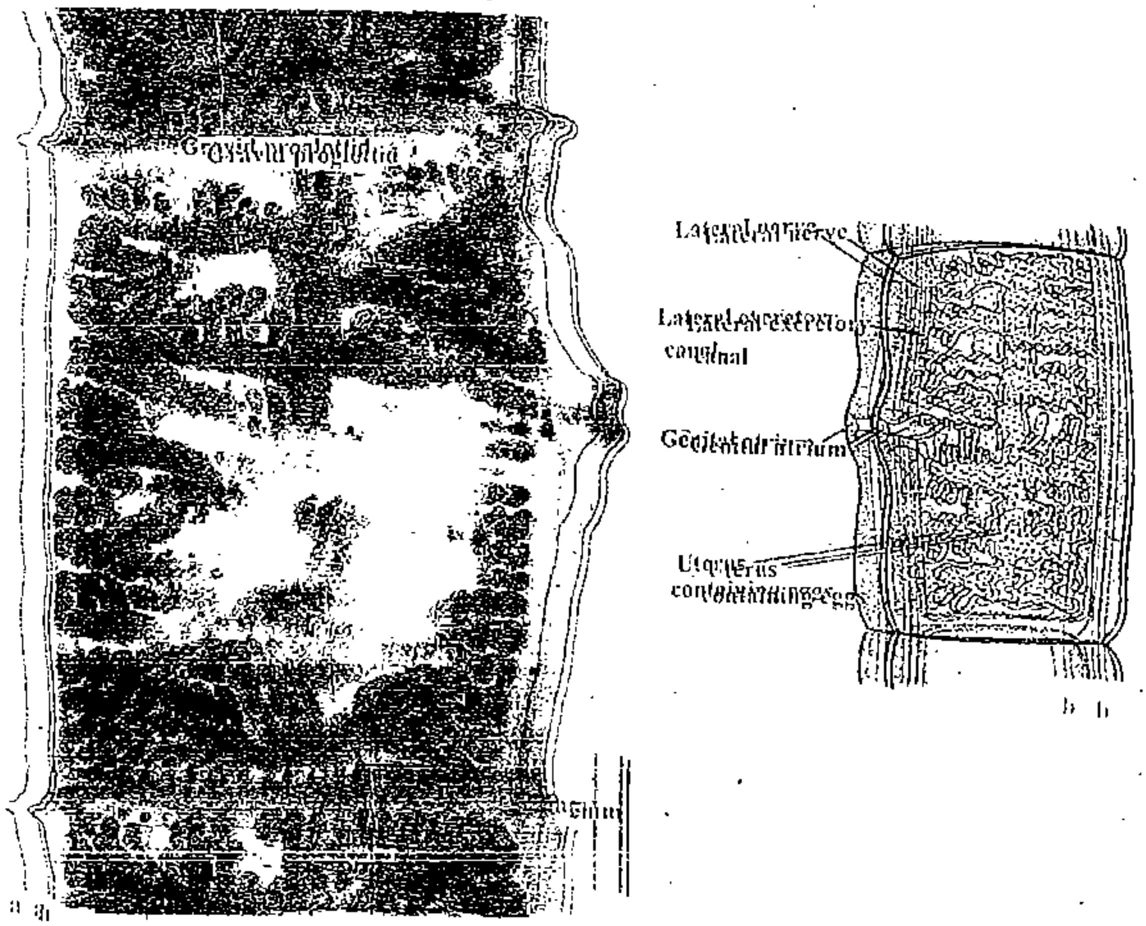


Fig. 10.10: Gravid proglottid of *Taenia solium*. (a) As viewed from prepared slide (b) Drawing of gravid proglottid as interpreted from slide.

4. All other organs atrophy in the gravid proglottid and hence are not found.
5. Ripe proglottids are detached from the strobila by the process of apolysis.
6. Detached gravid or ripe proglottids pass out from the intestine of the human host along with faeces.

C. T.S. of Mature Proglottid of *T. solium* passing through uterus and genital atrium.

T.S. of mature proglottid passing through uterus and genital atrium (Fig. 10.11) reveals the following histoligical structures:

1. Body wall consists of cuticle, circular muscles, longitudinal muscles and sub cuticular cells:
   (i) *Cuticle* is thin and elastic.
   (ii) *Circular muscles* form two layers: one layer below cuticle and another layer dividing the parenchyma or packing tissue of the body into a dense outer cortical region and clear inner, medullary region.
   (iii) *Longitudinal* muscles are well developed.
2. Body cavity is absent and interior of proglottid is filled with parenchyma.
3. On both lateral sides can be observed the lateral longitudinal nerve cords and lateral excretory canals.
4. Towards the central areas of the transverse section the uterus can be observed, containing developing egg capsules.
5. Lateral to the uterus are present sections of the testes on both sides.
6. Just lateral to the testes towards the outer side are seen the cross-sections of vasa efferentia.
7. Alimentary system is totally absent.

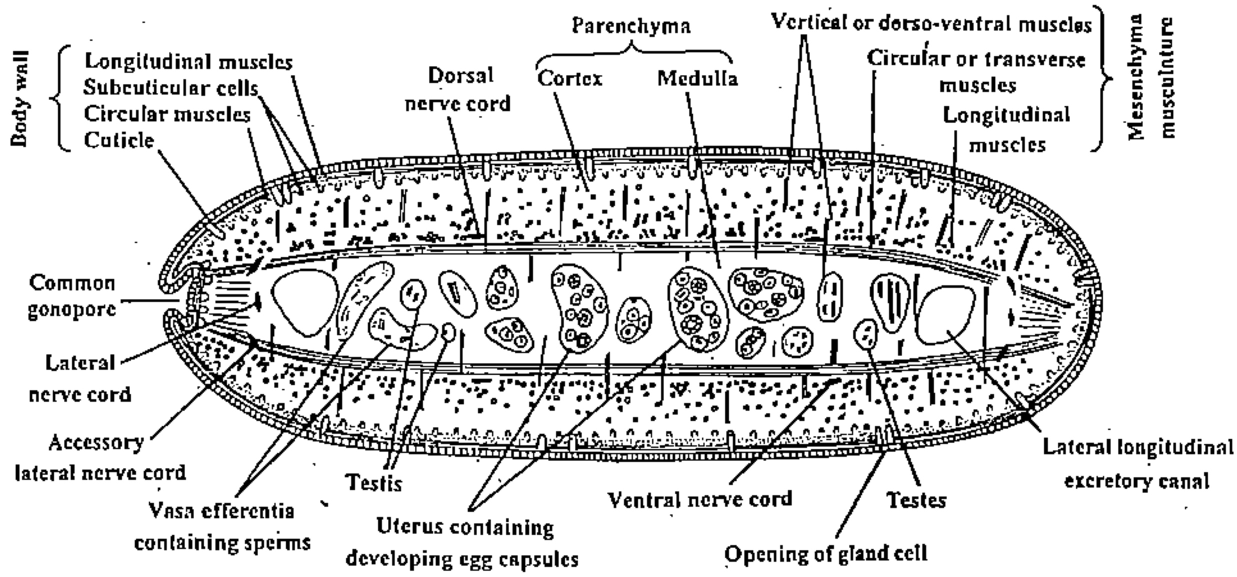


Fig. 10.11: T.S. of mature proglottid of *Taenia solium* passing through uterus and genital atrium.

10.8 TERMINAL QUESTIONS

1. Give the common names of
   i) *Dugesia*..
   ii) *Fasciola*..
   iii) *Taenia*..

2. What are the major set of organs found in platyhelminths?
   ....
   ....

....

....

....

3. List the main body regions of *Taenia solium.*

....

....

EXERCISE 11 PLATYHELMINTHES : LARVAL STAGES OF *FASCIOLA HEPATICA* AND *TAENIA SOLIUM*

Structure

11.1 INTRODUCTION

You have already studied the representative species of classes Turbellaria, Trematoda and Cestoda of Phylum Platyhelminthes. In this laboratory exercise you will study permanent slides of larval forms of the liverfluke, *Fasciola hepatica* and the human tapeworm *Taenia solium*, both of which have complicated life cycles with unusual larval stages.

Objectives

After performing this exercise you will be able to:

- identify, describe and draw labelled diagrams of the larval stages – **miracidium, sporocyst, redia, cercaria, metacercaria** of *Fasciola hepatica.*
- identify, describe and draw labelled diagrams of the larval stage **cysticercus** larva of *Taenia solium.*

11.2 MATERIAL REQUIRED

1. Compound microscope.
2. Prepared slides of larval stages of *F. hepatica* – miracidium, sporocyst, redia and cercaria
3. Prepared slide of Cysticercus larva or bladder worm of *Taenia solium.*

11.3 LARVAL STAGES OF *FASCIOLA HEPATICA*

Fasciola hapatica reproduces both sexually and asexually. Cross-fertilization is of common occurrence. Copulation takes place in the bile duct of the main host sheep. Sometimes self-fertilization also occurs.

Examine the prepared slides of the larval stages of *F. hepatica* and note the features listed under each case.

11.3.1 Miracidium Larva

Miracidium (Fig. 11.1) is the first stage larva that comes out from the fertilized egg.

i) Miracidium is an oval, microscopic, flattened larva which appears conical in shape.
ii) Body is uniformly covered with epidermal plates. There are 21 plates arranged in 5 rows. First to fifth row contain 6,6,3,4,2 epidermal plates respectively.
iii) Anterior end of the larva is projected into a conical lobe called **apical papilla** which acts as a boring organ.
iv) Internal structures of the miracidium which can be seen include, the triangular sac called **apical gland** attached to the apical papilla, a pair of bag-like

penetration gland located on each side of apical gland (also called cephalic glands), two eye spots, two flame cells, rudimentary gut and germ cells.

[Miracidium larva comes out from the egg shell of the fertilized egg by eroding the operculum with the help of proteolytic enzyme. It is the first larval stage in the life cycle of *F. hepatica*. It is a free swimming stage in fresh water. Miracidium larva swims freely in water for 4-30 hours in search of a suitable intermediate host which may belong to the genus *Limnea* or *Planorbis*. If the larva does not come in contact with a suitable host it dies. Miracidium larva enters the snail and destroys its tissues. It penetrates through the pulmonary chamber; during this period it loses its cilia, epidermal plates, brain, eye spots, apical and penetration glands as well as primitive gut.]

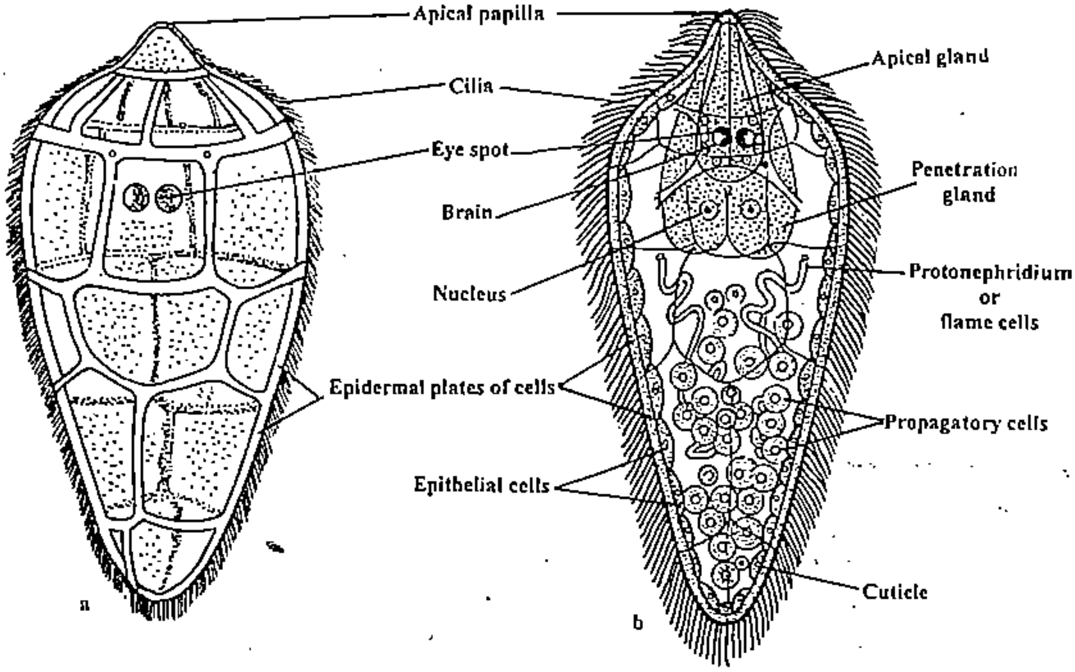


Fig. 11.1: Miracidium larva of *Fasciola hepatica*. (a) External structure. (b) Internal structure.

11.3.2 Sporocyst Larva

Sporocyst (Fig. 11.2) is the second larval stage in the life cycle of *F. hepatica*. It develops from the miracidium larva within the pulmonary chamber of its snail host. It shows extreme degree of parasitism. As a result alimentary canal and locomotry organs are absent.

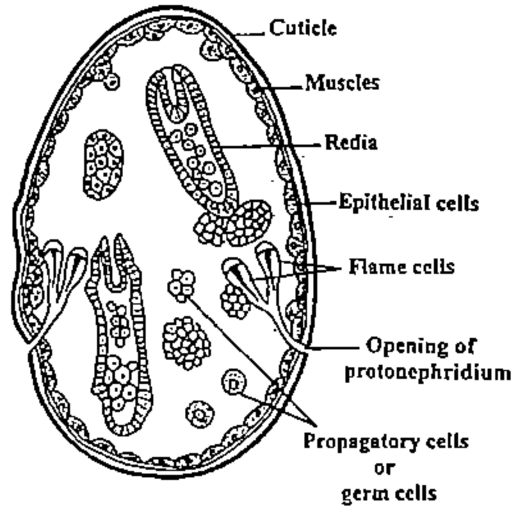


Fig. 11.2: Sporocyst Larva of *Fasciola hepatica*.

i) Sporocyst is an elongated sac-like structure, covered with cuticle.
ii) Body wall of the sporocyst consists of sub epithelial cells, mesenchyme and muscle layers.
iii) Body sac contains germ cells and flame cells.
iv) It is a non-feeding stage.
v) Germ cells within the sporocyst give rise to the next larval stage known as redia larva which develop within it. One sporocyst may give rise to 5-6 redia.

11.3.3 Redia Larva

Redia (Fig. 11.3) is the third larval stage in the life cycle of *F.hepatica*. Redia develops from the germ cells of the sporocyst and comes out of the sporocyst by rupturing the sporocyst wall. Redia then migrates to the liver of the snail.

i) Each redia measures about 1.3-1.6 mm in length.
ii) Body of redia is elongated, cylindrical and sac-like.
iii) Body-wall is composed of tegument, epithelial layer and delicate mesenchyme.
iv) Anterior end consists of mouth which leads into a muscular pharynx with pharyngeal glands and sac like intestine.
v) Just behind the pharynx is a muscular ring-like swelling called collar which helps the redia in locomotion.
vi) Just posterior to the collar is a permanent aperture called **birth pore** through which another generation of redia called second generation of redia or the next larval stage, the cercaria exits to the outside.
vii) Posterior region has two stumpy processes called **lappets** which help the redia in anchoring to the tissues of the snail and are also helpful in locomotion.
viii) The space between the body wall and intestine contains a few germ cells.
ix) Germ cells often give rise to second generation of daughter rediae.
x) The germ cells of redia as well as germ cells of daughter redia give rise to the next larval stage called cercaria.

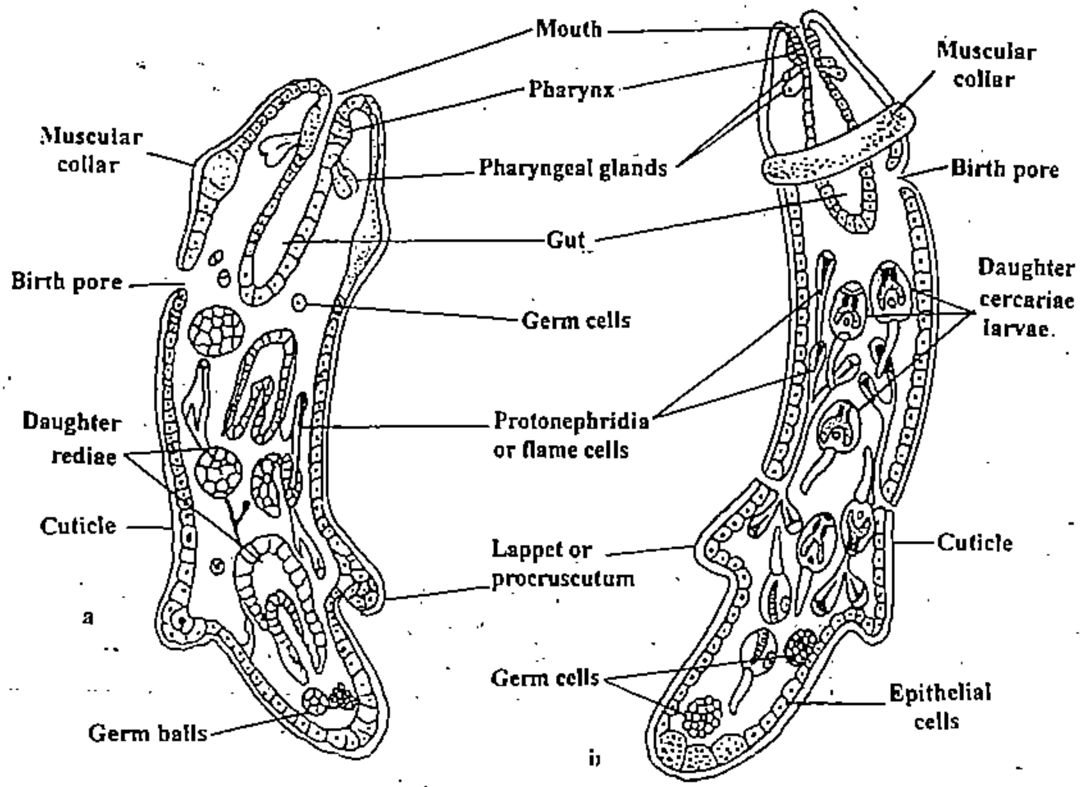


Fig. 11.3: Redia larva of *Fascoila hepatica.* (a) with daughter rediae. (b) with cercaria.

11.3.4 Cercaria Larva

Cercaria larva (Fig. 11.4) is the fourth larval stage in the life-cycle of *F. hepatica*. It is a free living stage produced by the redia larva (See Box 11.1 and also Fig. 11.6).

i) It has a flat and oval body about 35 mm in length and a long tadpole like tail.
ii) Cercaria moves by muscular undulations of the tail.
iii) Cercaria has two suckers an anterior, **oral sucker** surrounding the mouth and a **ventral sucker** situated in the middle of the body.
iv) Body space is filled with **parenchyma** and contains a few **cystogenous glands** on each side which form the cyst of the future larva.
v) The alimentary canal consists of mouth, muscular pharynx, oesophagus and bifurcated and inverted Y-shaped intestine.
vi) It also possesses an **excretory bladder** with a pair of **protonephridial canals** and a number of **flame cells**.
vii) Cercaria also has two large non-functional **penetration glands** as well as rudiments of reproductive organs which have originated from germ cells.
viii) Cercaria is a young fluke of sexual generation.
ix) Cercaria larva first comes out of the redia through its birth pore and then also from the body of its snail host.

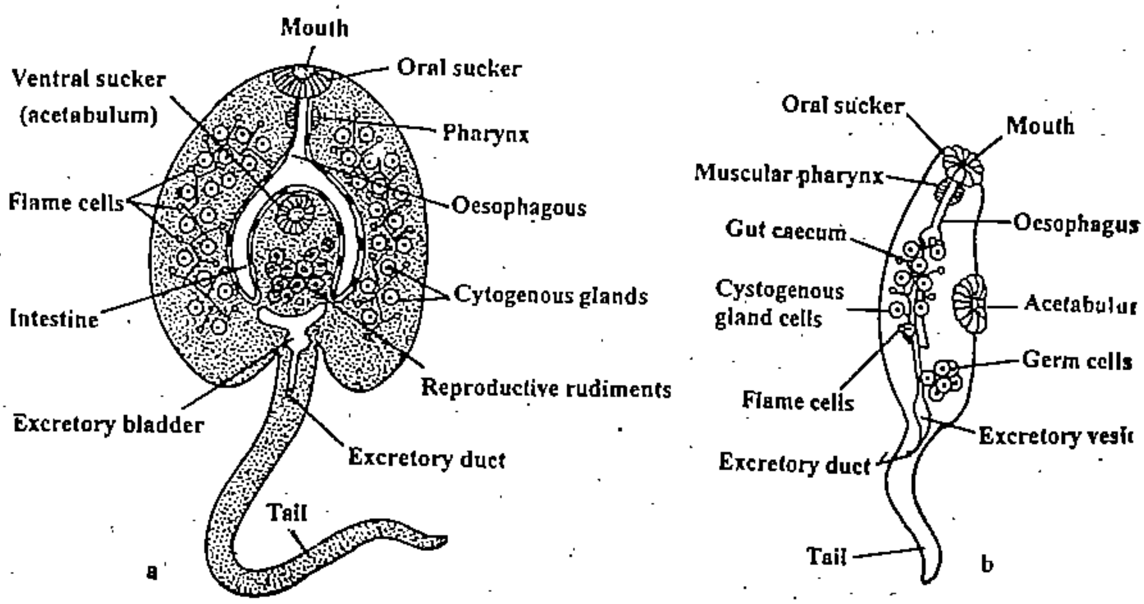


Fig. 11.4: Cercaria larva of *Fasciola hepatica*. a) Dorsal view. b) Lateral view.

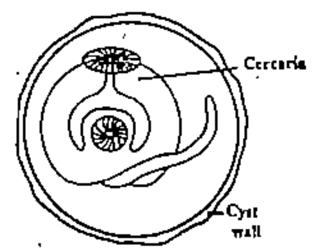


Fig. 11.5: Metacercaria larva.

[The free swimming cercaria larva swims for 2-3 days and then attaches to the aquatic plants where it gets enclosed in a cyst. The encysted larva is called **metacercaria** (Fig. 11.5) larva. The metacercaria larva is the infective stage for the final host, the sheep which gets the infection when it swallows the metacercaria larva along with its food. Metacercaria is the 5th larval stage of *F.hepatica*. It is 0.2 mm in size and is called a juvenile fluke. Its further development takes place in the final host the sheep. Metacercaria can also infect humans (See Box 11.1 and Fig. 11.6 also).]

Box 11.1: Life history of *Fasciola hepatica*.

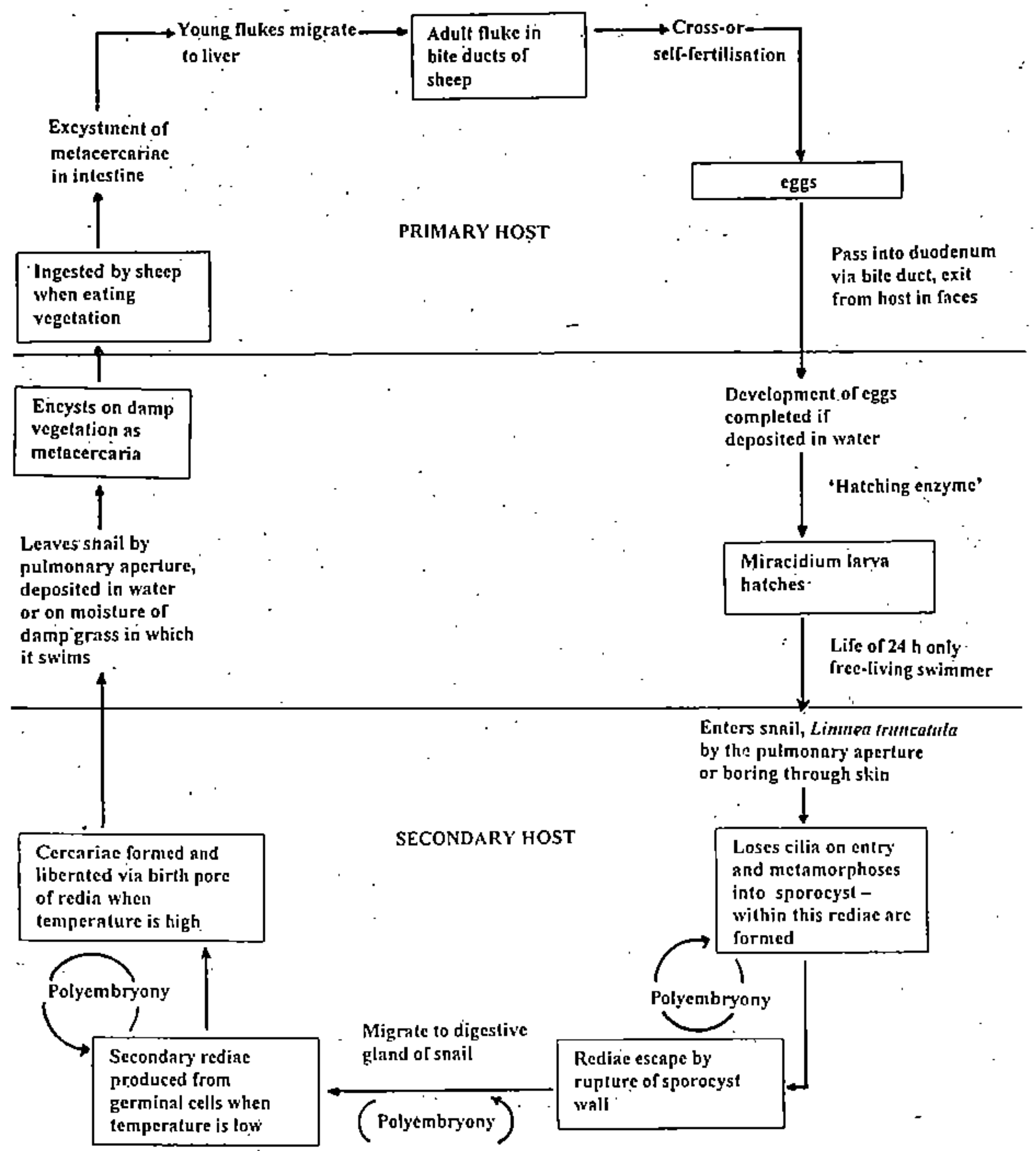


Fig. 11.6: Summary of the stage-by-stage life history of *Fasciola hepatica*. This should help you to sequence out the larval stages if placed in a jumbled manner as an exercise in practical.

11.4 LARVAL STAGE OF *TAENIA* – CYSTICERCUS

The pork tapeworm (*T. solium*) and beef tapeworm (*T. saginata*) which are endoparasites of humans who are the final hosts for these worms have an unusual larval stage in their life cycle which is called bladder worm or cysticercus (Fig. 11.7). Cysticercus larva develops in the muscles of pig in case of *T. solium* for which the pig is the intermediate host and in cattle in case of *T. saginata* in which cattle is the intermediate host. The contaminated pork or beef is known as measly pork or beef and becomes the source of infection in humans.

Examine the cysticerus larva under the microscope and note the following:

i) Bladder worm consists of a single layered, large ovoid sac or bladder-like structure with an invaginated **proscolex** which measures 6-18 mm in length at the anterior end.

ii) Proscolex contains **suckers, hooks** and **rostellum.**

iii) Bladder is generally filled with clear watery fluid having mostly plasma of the host.

iv) Bladder wall consists of an outer cuticle and inner mesenchyme.
[Further development of cysticercus larva takes place only when it is eaten by a human host, otherwise it lodges in the tissue of the host and gets calcified. After entering the stomach of the human host the proscolex gets evaginated, suckers and rostellum come out and anchor to the mucous membrane and the larva develops further into the adult by proliferation (Fig. 11.7).]

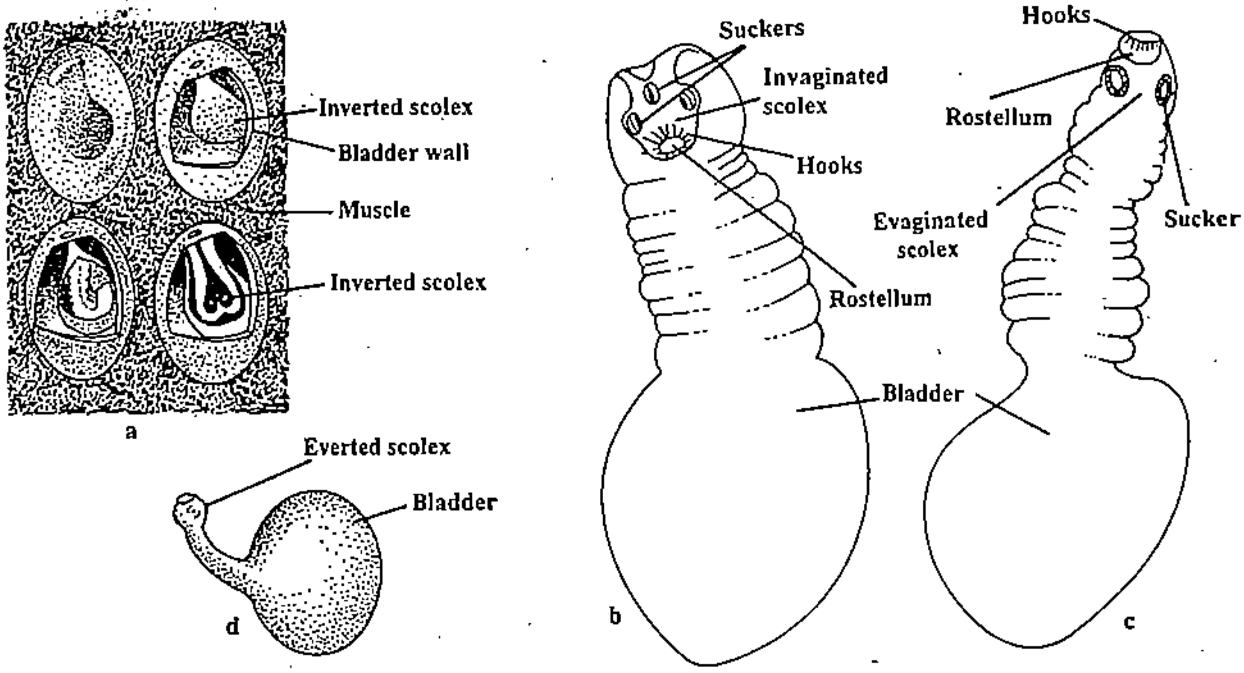


Fig. 11.7: Cysticercus of *Taenia*. (a) Four cysticerci in pork muscle, progressively dissected to show the bladder wall, inner envelope and invaginated scolex. (b) Cysticercus larva with invaginated scolex. (c) Cysticercus with evaginated scolex and (d) Cysticercus with evaginated scolex and neck ready to become attached to intestinal wall of host.

11.5 TERMINAL QUESTIONS

1. List the internal structure of miracidium larva.

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2. What features of the sporocyst larva indicate its parasitic nature?

3. What larval stages do the rediae give rise to?

4. What kind of existence does the cercaria larva lead and which larval stage does it give rise to?

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5. Where is the bladder worm found? Describe its structure.

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EXERCISE 12 NEMATODA : OBSERVATION AND CLASSIFICATION OF SPECIMENS AND MICROSCOPIC STUDY OF SECTIONS OF *ASCARIS*

Structure

12.1 INTRODUCTION

The present laboratory exercise is based on Unit-4 (Section 4.7) of Block 2 of the Theory Course LSE-09 which deals with the features of Phylum Nematoda. You will recall from that unit that members of Phylum Nematoda (Greek *nematos*: thread) popularly called thread worms are wrongly referred to as worms, since these are not worms. In this unit you will study with the help of permanent slides the distinguishing features of the type specimen *Ascaris lumbricoides* of Phylum Nematoda.

Objectives

After performing this exercise you should be able to:

- identify the genus of the common human intestinal round worm *Ascaris* (male and female) as an example of Phylum Nematoda and give its scientific name.
- classify *Ascaris lumbricoides* upto the level of order.
- list common features of *A. lumbricoides* and also give its special feature justifying its classification.
- draw labelled diagrams of the male and female *Ascaris*.
- identify, describe and draw labelled diagrams of transverse sections (T.S.) of male and female *Ascaris lumbricoides*.

12.2 REVIEW OF CHARACTERISTICS OF PHYLUM NEMATODA AND ITS POSITION IN ANIMAL CLASSIFICATION

Nematodes may be free-living or parasites of plants or animals. However, all nematodes are similar in structure, irrespective of whether they are free-living or parasites of plants or of animals and they never vary much in form, even in their larval stages. Before studying the type specimen – *Ascaris* of nematode let us first review the characteristic features and classification of nematodes.

12.2.1 Features of Phylum Nematoda

Phylum characteristics of Nematoda which are the world's most abundant multicellular organisms are as follows:

i) Nematodes occur in all types of habitat – fresh water, marine waters and terrestrial habitats and may be free living or parasitic on plants or animals.

ii) Nematodes are usually long, cylindrical animals with tapered rounded ends, though some parasitic forms become sac-like in shape.

iii) Nematodes are bilaterally symmetrical, unsegmented or superficially segmented, triploblastic, pseudocoelomate animals.

iv) Nematodes are termed peseudocoelomate since their body cavity is a pseudocoelom which occurs between gut and body wall and develops embryologically from the blastocoel of the blastula embryo.

v) Nematode body wall is composed of (i) an outermost, strong, flexible, non-cellular-cuticle layer, (ii) an inner epidermis and (iii) an innermost layer of longitudinal muscles.

vi) The pseudocoel cavity is small and is filled with the intestine and the reproductive system which consist of ovary and oviducts in females or vas deferens and testes in males.

vii) Digestive system consists of a straight tubular gut which includes mouth, muscular pharynx, pharyngeal glands and long intestine, that open posteriorly to the outside by a subterminal-anus.

viii) Nematodes have specialized mouth parts, particularly in parasitic forms.

ix) Nervous system is simple, consisting of a circumpharyngeal nerve around the pharynx that posteriorly gives rise to two nerves which run the length of the nematode, one on the dorsal (back) and one on the ventral (belly) side. A few tiny sense organs are located on the head of the nematode.

x) Excretory system is present. In some nematodes, specialized excretory cells are found; in some examples canals may be present, while still in some others both excretory cells and canals may be found.

xi) Flame cells are absent.

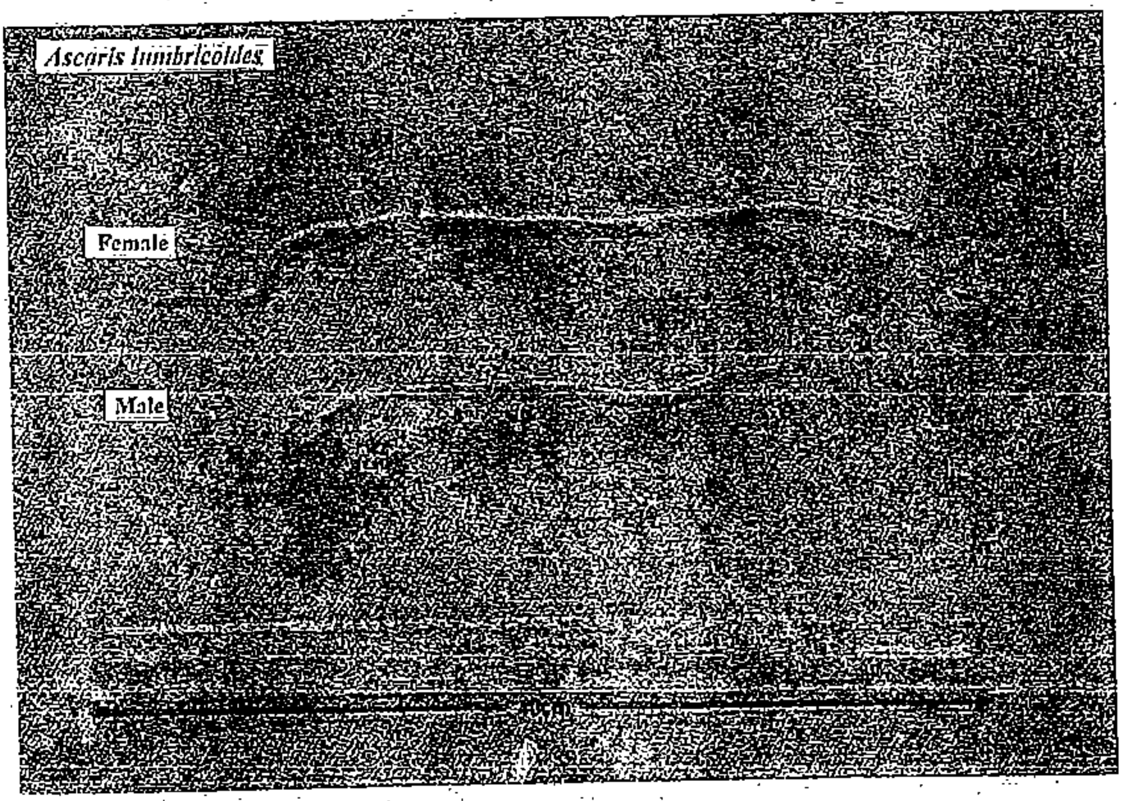

Fig. 12.1: Relative size of sexes of *Ascaris*. a) female, b) male.

xii) Respiratory and circulatory systems are absent in nematodes.

xiii) Nematodes reproduce sexually. Most species have separate males and females and so nematodes are called dioecious. Males are usually smaller than the female of the species (Fig. 12.1).

[Fertilization is internal. Parasitic round worms often have complex life cycles, involving two hosts or more.]

12.2.2 Systematic Position of Nematoda in Classification

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall. Many capable of movement or movement of some of their body parts or capable of movement at some time in their life cycle; hetrotrophic nutrition.
Sub-kingdom	**Eumetazoa**	Animals with tissues and organs.
Grade – I	**Bilateria**	Bilateral animals.
Division A	**Protostomia**	Cleavage is determinate and commonly spiral, mouth arising from blastopore.
Sub-group	**Ecdyzoa**	Moulting animals.
Phylum	**Nematoda**	Bilaterally symmetrical, triploblastic, pseudo-coelomate, vermiform, non-segmented moulting animals with body covered with cuticle.

12.3 MATERIAL REQUIRED

1. Museum specimens of male and female *Ascaris lumbricoides*.
2. Permanent slides of transverse sections through body of male and female *Ascaris*.
3. Compound microscope.
4. Lab record book
5. Pencil.
6. Pen.
7. Eraser.

12.4 METHOD

Carefully examine the entire male and female specimens of *Ascaris lumbricoides*. Note the common features of the two sexes as well as their differences. Draw labelled diagrams of male and female *Ascaris* in your practical record file. Also, study the transverse section of the body of male and female *Ascaris lumbricoides* under microscope and note their similarities and dissimilarities. The points listed in this exercise and the drawings already given, will help you to perform your task.

12.5 MALE AND FEMALE *ASCARIS LUMBRICOIDES* – THE TYPE SPECIMEN OF PHYLUM NEMATODA

Ascaris lumbricoides unlike most free-living nematodes and a large number of parasites of plants and animals are not tiny or microscopic. Instead they are about 25 cm long and easily visible to the naked eye. *Ascaris lumbricoides* is an intestinal parasite of human beings and spends its adult life in the human intestine. Its main features are as follows:

Features

i) *Ascaris lumbricoides* is commonly called round worm (Fig. 12.1 and 12.2 a & b).
ii) Body is elongated, cylindrical, tapering at both ends.
iii) Body surface is marked with four longitudinal lines, one mid-dorsal, one midventral and two lateral lines.
iv) Mouth is provided with three lips (i) a median dorsal lip and (ii) a pair of symmetrical submedial ventral lips.
v) Sexes are separate and sexual dimorphism is well marked.
vi) Male is smaller than female and measures 15 to 31 cm in length (Fig. 12.1 and 12.2) with posterior end curved ventrally (Fig. 12.2 e and 12.2 h).

vii) Female is large, measuring a length of 20 to 35 cm with posterior end straight and blunt (Fig. 12.2 g).

viii) Male has single testis and seminal vesicle. Seminal vesicle leads to the exterior via an ejaculatory duct located alongside the anus. It is also provided at the posterior end with a pair of curved spicules known as penial setae which are the copulatory organs. Males also possess pre- and post-anal papillae, which are lacking in female (Fig. 12.2 h).

ix) The female has 2 ovaries, 2 oviducts and 2 uteri joining at a single vagina and opening through a gonopore also called genital aperture which lies at a distance of about one-third of the length of the body from the anterior end.

x) Excretory pore is small and lies on the ventral side about 2 mm away from the anterior end.

xi) Life cycle is simple and monogenetic. No secondary host is involved.

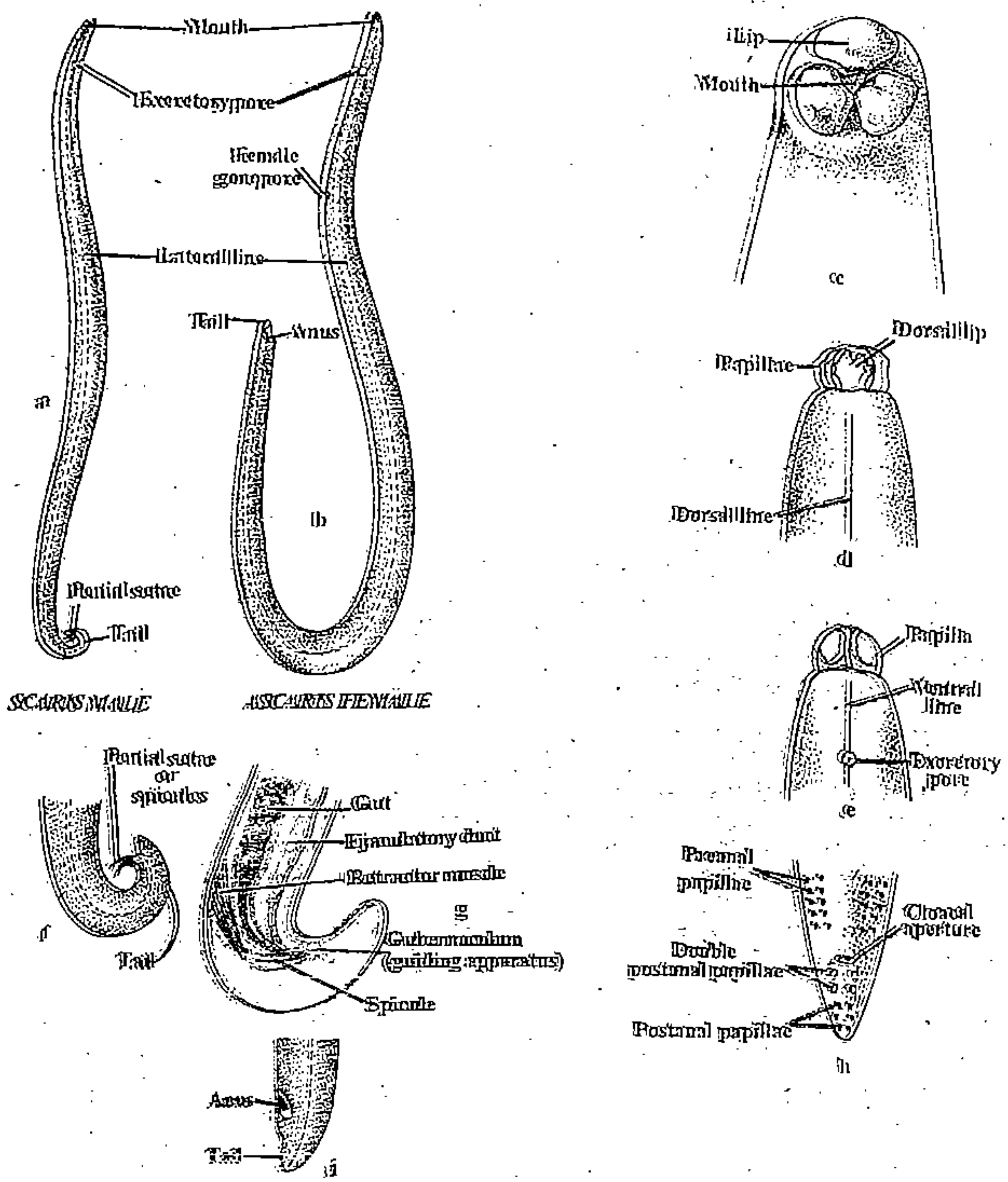

Fig. 12.2: *Ascaris lumbricoides.* a) Male. b) Female. c) Entire view of mouth and lips ("En face view"). d) Anterior end in dorsal view. e) Anterior end in ventral view. f) External view of posterior end of male. g) Internal view of posterior end of male. h) Posterior end of male in ventral view showing papill^ ^) Posterior end of female.

Geographical Distribution

Ascaris is cosmopolitan in distribution. It is more prevalent in Pacific Islands, Korea, Philippines, China and India (Fig. 12.1).

Habit and Habitat

Ascaris lumbricoides is a common endoparasite found in the small intestine of humans in all parts of the world. 500-5000 adult ascaris may be present in a single host. They may cause abdominal discomfort and colic pain with diarrhea and vomiting. These symptoms may be called ascariasis

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall. Many capable of movement or movement of some of their body parts or capable of movement at some time in their life cycle; hetrotrophic nutrition.
Phylum	**Nematoda**	Bilaterally symmetrical, triploblastic, pseudo-coelomate, vermiform, non-segmented moulting animals with body covered with cuticle.
Class	**Secernentea (Phasmidia)**	Body covered with a pair of minute, sensory pouches (phasmids) near posterior tip; similar pair of sense organs at anterior end called amphids which are poorly developed; excretory system with one or two lateral canals, with or without associated glandular cells; both free-living and parasitic forms.
Order	**Ascaridida**	Parasitic in intestine of vertebrates; three prominent lips, pharynx without a posterior bulb; tail in female straight and blunt while in males it is curved with two copulatory spicules.
Genus	***Ascaris***	
Species	***lumbricoides***	
Common name	**Round worm**	

12.6 TRANSVERSE SECTION OF BODY OF *ASCARIS LUMBRICOIDES.*

The transverse sections of male and female *A. lumbricoides* exhibit some differences based on their sex.

12.6.1 T.S. of Female *Ascaris* (Fig. 12.3)

1. Body wall consists of the following:
   (a) **Cuticle** is the outermost layer. It is a thick, tough, elastic membrane covering the epidermis.
   (b) **Epidermis**, also called subcuticle, lies below the cuticle and is syncytial.
   (c) **Muscle** layer is the innermost layer of the body wall and is composed of a single layer of spindle-shaped muscle cells arranged longitudinally.
2. Epidermis is thickened into ridges in four regions which project into the body cavity as the four longitudinal chords (also called lines) of which two are lateral, one dorsal and one ventral.
3. Presence of the four longitudinal chords results in the easy identification of four bands of muscles - two dorso-lateral and two ventro-lateral.
4. Two lateral excretory canals are visible inside the two lateral lines or chords.
5. Dorsal and ventral nerves run in the dorsal and ventral lines respectively.
6. The space between the body wall and alimentary canal is the pseudocoel (false body cavity). Pseudocoel has fibrous tissue and fixed cells called coelomocytes or pseudocoelocytes or giant cells.

7. Pseudocoelom contains the transversely cut portions of alimentary canal, uteri, oviducts and ovaries.
8. In ovaries lumen is absent. Ovaries have a central rachis with the young eggs clustered around it.
9. Uterus has a wide lumen which is loaded with unfertilized eggs. Eggs have single nucleus and cytoplasm.
10. Oviducts contain eggs in lumen.
11. Ovary, oviduct and uterus are elongated and coiled structures for which reason they appear more than one in sections.
12. Intestine is visible as a dorso-ventrally flattened structure formed of a single layer of columnar epithelial cells, lined externally by a thin layer of cuticle. Intestine has no muscle layer.

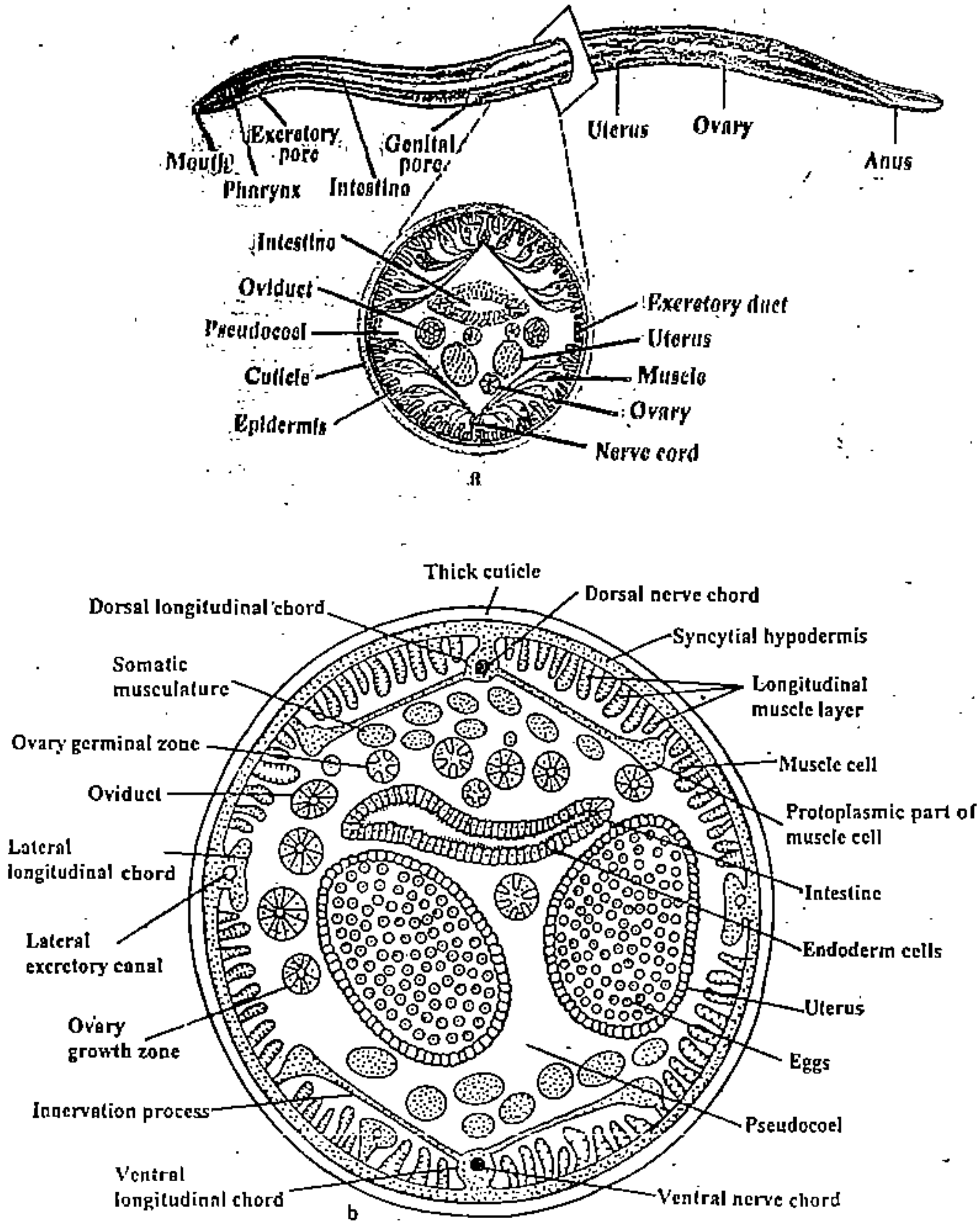

Fig. 12.3: Transverse Section of female *Ascaris*. a) As seen under the slide. b) As interpreted from slide.

12.6.2 T.S. of male *Ascaris* (Fig. 12.4).

1. Body wall consists of the following:

(a) **Cuticle** is the outermost layer. It is a thick, tough, elastic membrane covering the epidermis.

(b) **Epidermis**, also called subcuticle, lies below the cuticle and is syncytial.

(c) **Muscle** layer is the innermost layer of the body wall and is composed of a single layer of spindle-shaped cells arranged longitudinally.

2. Epidermis is thickened into ridges in four regions which project into the body cavity as the four longtudinal chord (also called lines) of which two are lateral ones, one dorsal and one ventral.
3. Presence of the four longitudinal chords results in the easy identification of four bands of muscles- two dorso-lateral and two ventro-lateral.
4. Two lateral excretory canals are visible within the two lateral lines or cords.
5. Dorsal and ventral nerves run in the dorsal and ventral lines respectively.
6. The space between the body wall and alimentary canal is the pseudocoel (false body cavity). Pseudocoel has fibrous tissue and fixed cells called coelomocytes or pseudocoelocytes or giant cells.

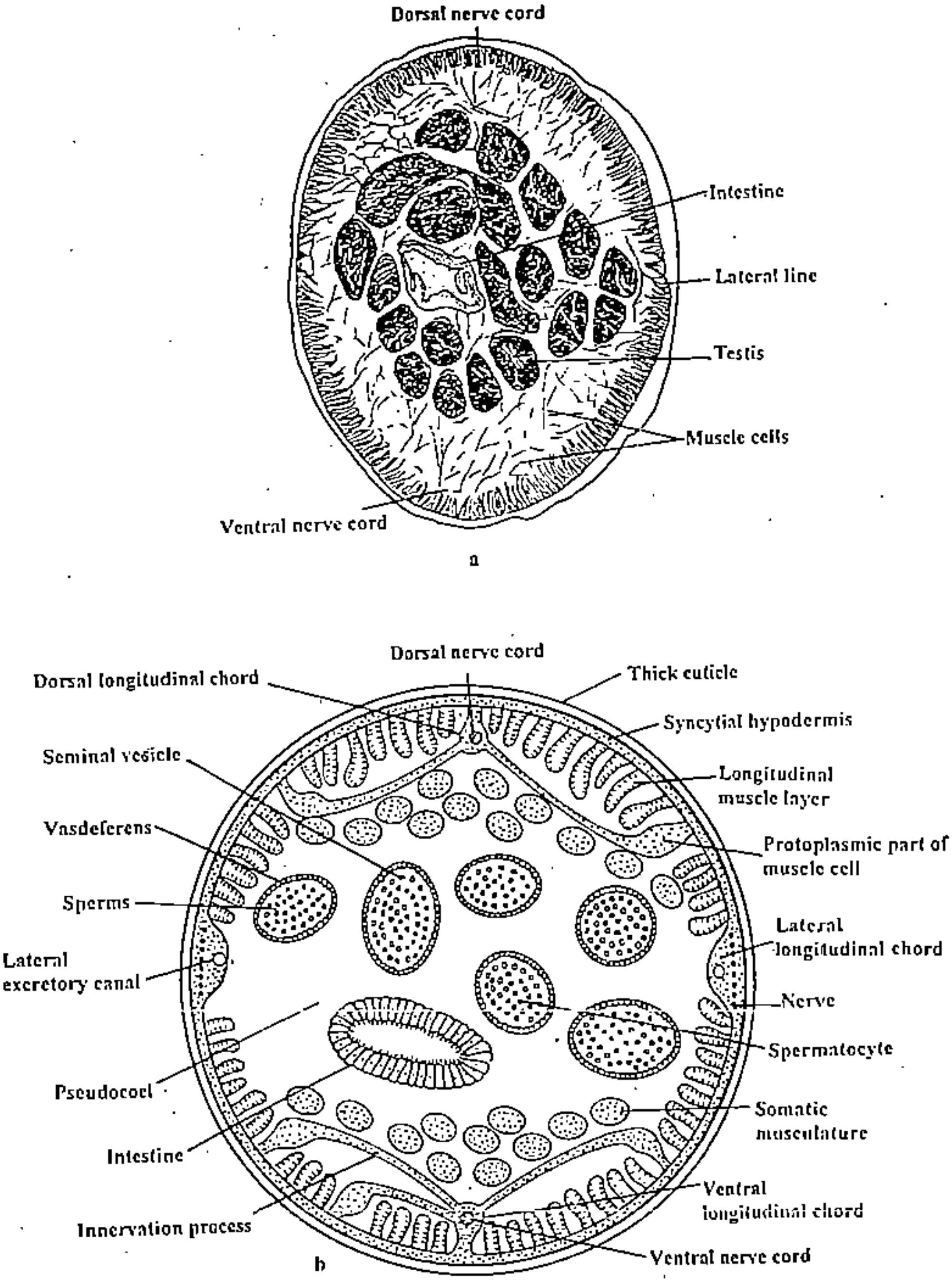

Fig. 12.4: T.S. of male *Ascaris*. a) as seen in a slide. b) drawing as interpreted from the slide.

7. Transverse section also shows alimentary canal, testis, vasdeferens and seminal vesicles lodged within the pseudocoel.
8. Variously cut portions of the coiled testes are seen in the section. The testes do not have a lumen but possess a central rachis.
9. Sperm duct and seminal vesicles have lumen, filled with abundance of sperms.
10. Intestine is visible as a dorso-ventrally flattened structure formed of a single layer of long endodermal, nucleated epithelial columnar cells.

12.7 TERMINAL QUESTIONS

1. How would you externally distinguish between male and female *Ascaris lumbricoides*?

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2. What is the economic importance of *Ascaris lumbricoides*?

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3. What are the differences between the male and female T.S. of *Ascaris lumbricoides*?

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EXERCISE 13 ARTHROPODA-I – CHELICERATA AND CRUSTACEA: OBSERVATION AND CLASSIFICATION OF SPECIMENS AND STUDY OF NAUPLIUS LARVA

Structure

13.1 INTRODUCTION

In this exercise you will examine and identify some of the common representatives of Arthropoda. The phylum Arthropoda as the name signifies (*arthros* = joined + *podos* = foot) are the animals which possess jointed appendages. Arthropoda constitutes the largest phylum of animal kingdom comprising animals like crabs, lobster, scorpion, spiders, millipedes, centipedes and insects such as cockroaches, bedbugs, houseflies, mosquitoes, butterflies, honeybees etc. In this exercise you will study examples of Chelicerata, Crustacea as well as the nauplius larva as the first larval stage of all crustaceans.

Objectives

After performing this exercise you should be able to:

- identify the arachnid and crustacean specimens – spider, *Palamnaeus* (scorpion), *Limulus* (king crab), spider *Aranea, Penaeus/Palaemon* (crayfish), *Sarcoptes* (itch mite), *Daphnia, Balanus, Sacculina, Scolopendra, Eupagurus* (hermit crab) and Nauplius larva, belonging to phylum Arthropoda and give their scientific and common names.
- classify the identified arthropods up to the level of the class
- list characters justifying their classification and mention special features, if any
- identify *Peripatus* and observe its special characters
- mention the habitat and geographical location of the identified genera
- draw labelled diagrams of the identified specimens
- mention economic importance, if any, of each of the identified genera.

13.2 MATERIAL REQUIRED

1. Preserved specimens/permanent slides of the following animals:

   Palamnaeus (Scorpion)
   Limulus (King crab)
   Aranea (Spider)
   Sarcoptes (itch mite)
   Daphnia

Balanus (Rock Barnacle)
Sacculina
Palaemon (Prawn)
Eupaguras (Hermit crab)
Nauplius larva

2. Compound Microscope
3. Hand Lens
4. Magnifying glass
5. Practical Record Book
6. Pencil
7. Rubber

13.3 GENERAL CHARACTERS AND CLASSIFICATION OF ARTHROPODA

These are metamerically segmentged animals with an exoskeleton of cuticle. Schizocoelic coelom is much reduced and is replaced by perivisceral haemocoel, which is filled with blood. Circulatory system is of open type. True nephridia are absent, but coelomoducts act as gonoducts and often as excretory organs. Body of the animal is bilaterally symmetrical. They also bear paired appendages. The phylum Arthropoda is divisible into Chelicerate and Crustacea. In this exercise you will only examine and identify the Arachnida, Crustacea and in the next exercise we will deal with uniramia and onychophora. You will examine, identify and draw labelled line diagrams of the preserved specimens/ permanent slides of the whole mounts of the animals. You are supposed to write the comments on the observations you have made.

13.4 SUBPHYLUM CHELICERATA – CLASSES ARACHNIDA AND MEROSTOMATA

The subphylum Chelicerata includes familiar horse shoe crab, spiders, scorpions, ticks and mites.

1. Body consists of an anterior prosoma and a posterior opisthosoma.
2. Prosoma bears the appendages invoived in feedings and locomotion.
   Opisthosoma may have exterior segmentation but appendages are either absent or considerably reduced.
3. Their main appendages are chelicerae and pedipalpi.
4. Antennae and mandibles are absent.
5. These are the first land animals in evolution of arthropoda which have successfully colonised the terrestrial environment.

13.4.1 Class – Arachnida

The class Arachnida (*arachne* = spider) has terrestrial and few aquatic animals. It includes spider, scorpions and mites.

1. Prosoma bears six pair of appendages: one pair of chelicerae, one pair of pedipalpi and four pairs of walking legs.
2. Abdomen is generally devoid of appendages.
3. Respiratory organs are tracheae, book lungs and book gills.
4. Excretion is performed by malpighian tubules and coxal glands.
5. Sexes are separate but sexual dimorphism is not conspicuous.

So, you have refreshed your background knowledge of the characters of subphylum Chelicerata and class Arachnida. Let us now study individuals examples under the class Arachnida.

1. Example – *Palamnaeus* (Scorpion)

Examine the specimen both from dorsal and ventral sides. Observe the following features :-

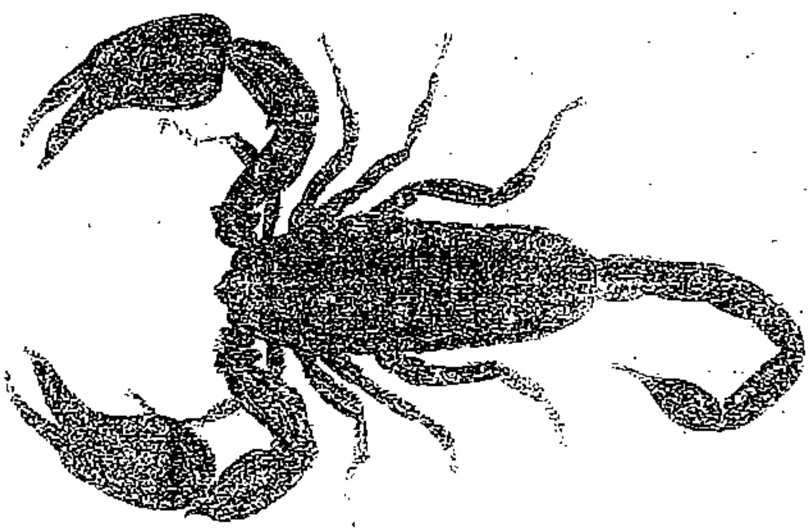
(i) It has dark coloured body to match with the surroundings. The underside is pale yellow.

(ii) Body is divided into **prosoma** or cephalothorax and **opisthosoma** or abdomen. Prosoma is covered by square shaped shield of dorsal carapace.

(iii) Dorsal **carapace** has right and left frontal lobes. It also bears a pair of **median** eyes with 2-13 pairs of smaller **lateral eyes** on the antero-lateral margins. Eyes are simple in structure. On the ventral surface of the prosoma there is a single, median, small, triangular plate, the **sternum**. It lies between the coxa of the 3rd and 4th pair of legs.

(iv) Opisthosoma is distinguished as anterior mesosoma and posterior metasoma. Mesosoma consists of seven segments. Each segment is covered by tergal plates dorsally and sternal plates ventrally. Both are joined laterally by pleural membrane.

(v) Sternum of the first mesosoma bears genital aperture which is covered by a genital operculum. Sternum of second segment bears comb-like appendages called pectines. Pectine has small comb-like 24-26 bristles.



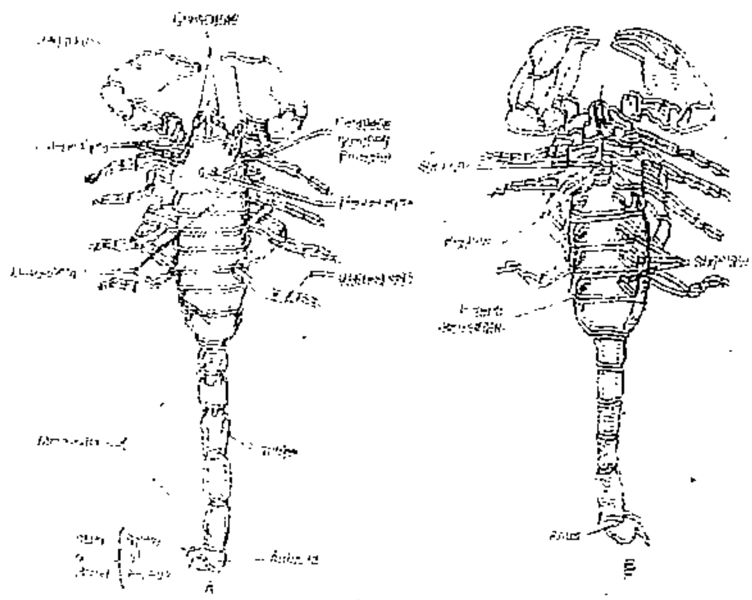


Fig. 13.1 *Palamnaeus*, A -Dorsal view; B - Ventral view.

(vi) Metasoma or post-abdomen is slender and consists of five cylindrical segments with a **telson or sting**. The sting comprises an ampulla and a distal spine or aculeus. Ampulla contains poison glands with an opening at the tip of the distal spine.

(vii) Scorpion has six pairs of appendages. These are a pair of **chelicerae**, a pair of **pedipalpi** and four pairs of **walking legs**. Chelicerae are three-segmented with two distal segments forming chela. Pedipalps have six joints, walking legs are composed of coxa, trochanter, femur, tibia and three tarsi.

(viii) Respiratory system is highly characteristic consisting of 4 pairs of book lungs or pulmonary sacs. Paired book lungs are situated on the ventro-lateral sides of the 3rd, 4th, 5th and 6th mesosomal or preabdominal segments.

(ix) Sexes are separate.

Habit and Habitat

This scorpion is nocturnal found under stones or bark of trees or in burrows.

Geographical Distribution

Most tropical and subtropical countries. Very common in India, most prevalent in Maharashtra, Assam, Rajasthan, Saurashtra, Uttar Pradesh, etc.,

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Jointed appendages, segmented body
Subphylum	**Chelicerata**	Main appendages are chelicerae and pedipalpi, body divided into prosoma and opisthosoma
Class	**Arachnida**	Four pairs of walking legs
Genus	***Palamnaeus***	
Species	***bengalensis***	
Common name	**Scorpion**	

2. Example – *Aranea* (Spider)

Examine the specimen and observe the following features:

(i) Four pairs of walking legs.

(ii) Body comprises prosoma and opisthosoma, both are connected by a pedicel.

(iii) Prosoma bears eight dorsal eyes and six pairs of appendages and is covered by a carapace.

(iv) Chelicerae are subchelate and contain poison glands.

(v) Pedipalps are simple and six jointed, chelate walking legs are often hairy.

(vi) Opisthosoma lacks appendages but bears three pairs of spinnerets which help in spinning the thread for the web.

(vii) Ducts arise from the silk glands in the posterior side, opening on the spool or spigot at the tip of the spinnerets. Several strands from single spool combine to form a silk thread. Thread is elastic at first but later it hardens and forms the web.

(viii) Respiration occurs through book lungs and tracheae.

(ix) Excretion by malpighian tubules and coxal glands.

(x) Sexes are separate. Male spiders are smaller than females.

(xi) Their legs are longer and bear additional chemo-sensors for detecting willing females.

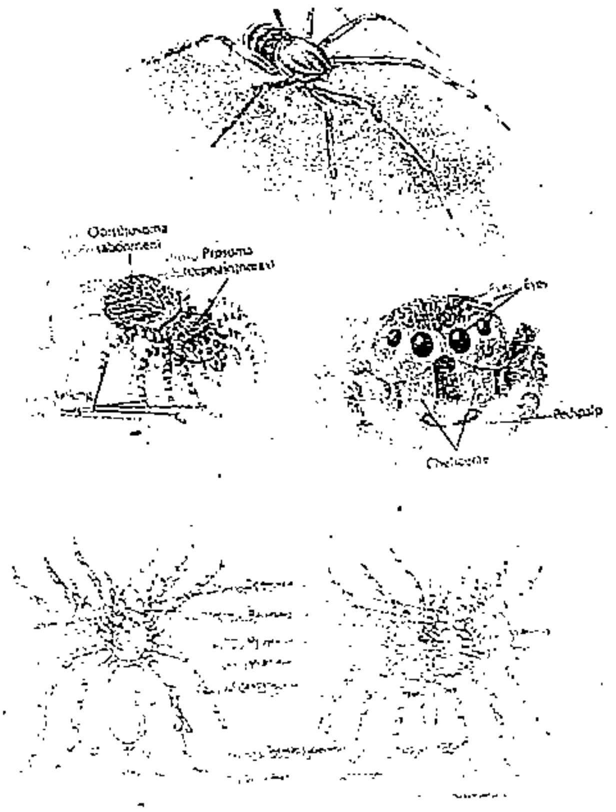


Fig. 13.2 *Aranea* (Spider) , A -Dorsal view; B – Ventral view.

Habit and Habitat

Spider *Aranea* is commonly called as orb webbed spider. It is found in jungles, deserts, caves and even houses and gardens. There is one species *Aranea* which is found in fresh water. Success of the spider is based on several factors like venom for their defence, mobility and their outstanding eyes.

Geographical Distribution

Cosmopolitan, it is found in India, Bangladesh, Myanmar, Africa, U.S.A , etc.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Jointed appendages, segmented body
Subphylum	**Chelicerata**	Main appendages are chelicerae and pedipalpi, body divided into prosoma and opisthosoma
Class	**Arachnida**	Four pairs of walking legs
Genus	***Aranea***	
Common name	**Orb webbed spider**	

3. Example – *Sarcoptes scabei* (itch mite)

Observe the permanent slide under the microscope and note the following characters:

(i) Body is oval or rounded and dorsoventrally flattened. There are heavy transverse striations and the posterior legs carry bristles.

(ii) Mouth parts are chelicerae, four pair of legs and legs are provided with suckers
(iii) Appendages are reduced.
(iv) They have tracheal system with spiracles and lack specialised respiratory organ. Direct exchange of gases occurs through thin body surface.
(v) Heart and arteries greatly reduced.

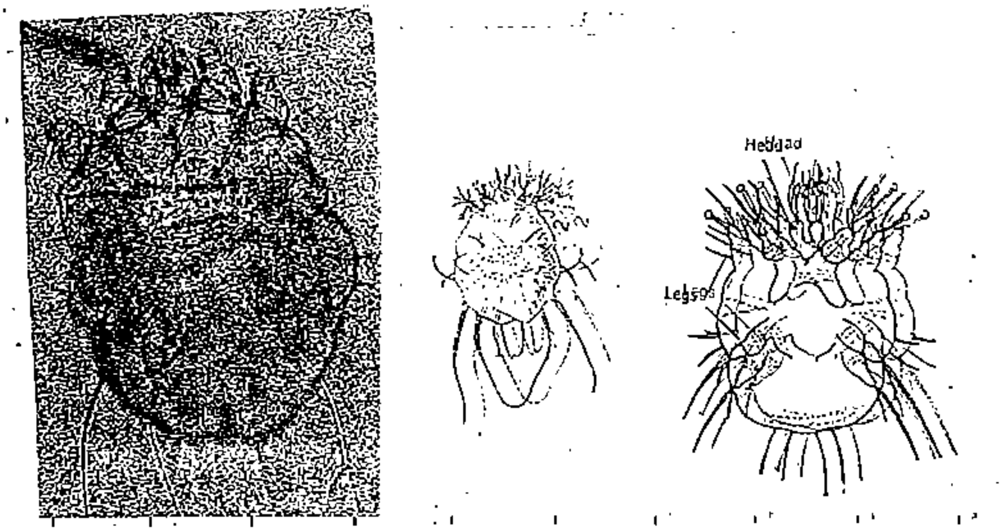


Fig. 13.3 *Sarcoptes* (Itch mite).

Habit and Habitat

Sarcoptes scabei is a parasite that lives in the human skin. Infestation of this animal causes itch (scabies). Males are 2-3 mm long and females are double the size.

It enters the skin through epidermis. Its compact round shape enables smooth and easy movement in the skin. Infection is carried out through contact of the infected skin.

Geographical Distribution

Sarcoptes scabei found almost throughout the world.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Jointed appendages, segmented body
Subphylum	**Chelicerata**	Main appendages are chelicerae and pedipalpi, body divided into prosoma and opisthosoma
Class	**Arachnida**	Four pairs of walking legs
Genus	***Sarcoptes***	
Species	***scabei***	
Common name	**Itch mite**	

13.4.2 Class Merostomata

The Class Merostomata are aquatic chelicerates in which five or six pairs of abdominal appendages are modified into gills. At the end of body there is a sword like telson.

4. Example *Limulus* (king crab)

King crab (also called horse shoe crab) is not really a crab, true crabs are included in malacostraca. King crab is the largest living merostome. It comes under the category of living fossils.

Examine the specimen from both dorsal and ventral sides and look for the following features:

(i) *Limulus* is horse-shoe shaped crab with dorsally convex carapace covering prosoma. The posterior side of the body is fitted into the slots of carapace.
(ii) A long caudal spine extends from the rear of the opisthosoma. Spine helps in locomotion. It is neither offensive nor defensive in function.
(iii) Ventral side bears segmental appendages. Flanking labrum are chelicerae. Three segmented chelicerae form the pincers, forming a chelate appendage.
(iv) Opisthosoma is hexagonal broadly joined to prosoma and consists of mesosomatic segments, an unsegmented vestigial metasoma.
(v) The next four pairs are chelated legs and the 6th pair are non-chelate legs. Just behind the mouth an oral plate-like appendage called chilaria is present.
(vi) The mesosomatic appendages are flattened and plate-like. The first pair is united in the middle to form a genital operculum. Exopodite of the remaining five pairs bears respiratory book gills.
(vii) Horse shoe crab eats polychaetes, small mulluscs and soft invertebrates of the ocean floor.
(viii) The foregut of *Limulus* includes an oesophagus and a gizzard, the midgut comprises a stomach and paired hepatic caecae and an intestine.

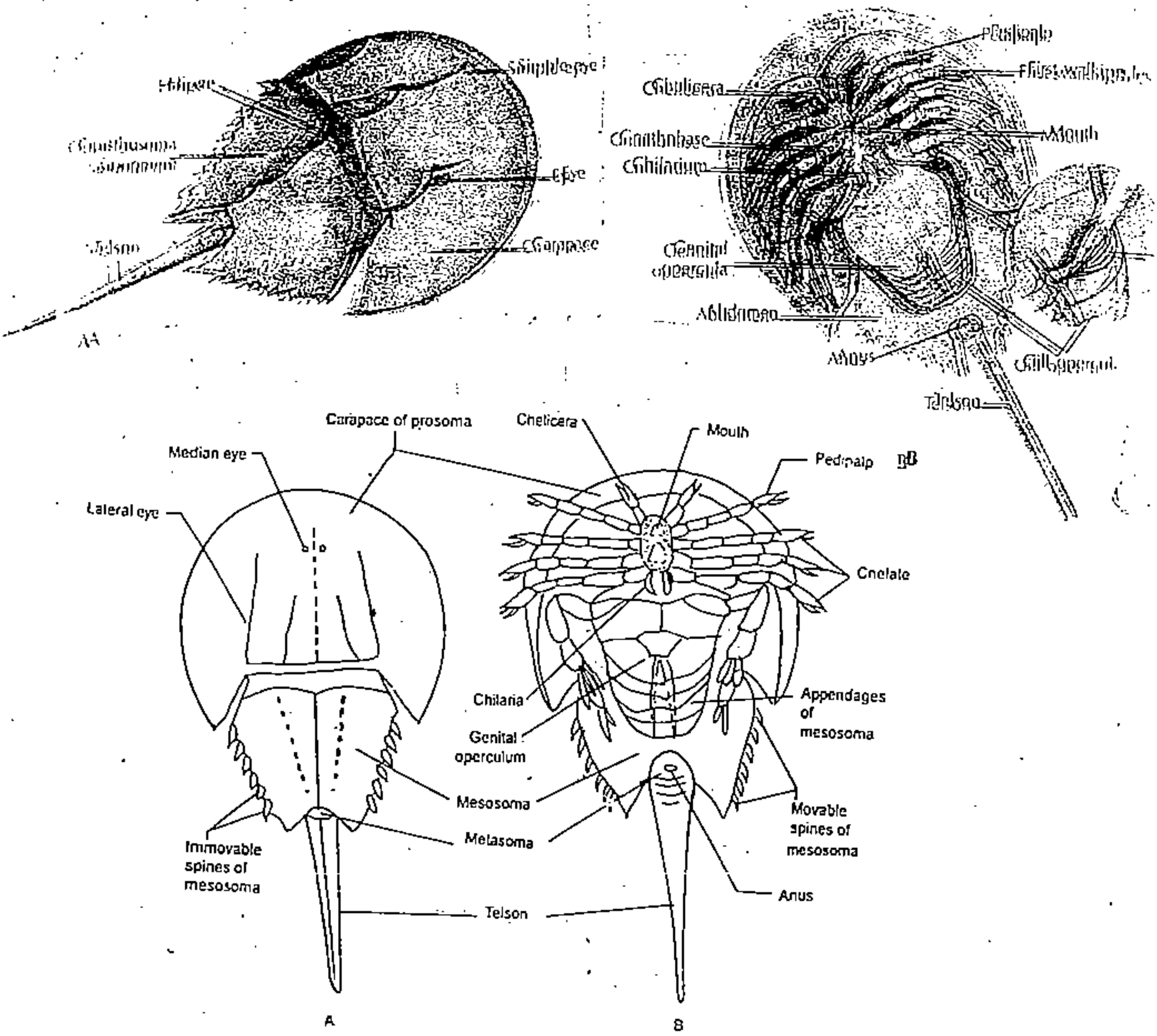


Fig. 13.4: *Limulus*. A – Dorsal view; B – Ventral view.

Habit and Habitat

Marine in shallow waters, found burrowing in sand, sluggish and mostly buried in sand. Feeds on soft mollusca and other small animals.

Geographical Distribution

North Western Atlantic coast, Gulf of Mexico, West Indies, also South East Asian Pacific coasts.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Jointed appendages, segmented body
Subphylum	**Chelicerata**	Main appendages are chelicerae and pedipalpi, body divided into prosoma and opisthosoma
Class	**Merostomata**	Five or six abdominal appendages modified into gills
Subclass	**Xiphosura**	Sword-like telson at the end of the body
Genus	***Limulus***	
Common name	**King crab or horse shoe crab**	

13.5 SUBPHYLUM – CRUSTACEA

General Features

Crustaceans body is covered externally by chitinous cuticle and bilaterally symmetrical, triploblastic and is divisible into three regions head, thorax and abdomen.

Crustaceans are mainly aquatic arthropods with gills for respiration but a few live in moist places. These possess telson and variable number of metameres. A cephalothorax is present in most of the crustacea, formed by the fusion of the head and thoracic metameres into a uniform tagma. Cephalothorax has usually a carapace. Head bears a pair of compound eyes and five pairs of appendages. Thorax and abdomen bear five pairs of biramous appendages in each segment. The group shows diverse adaptation of the appendages. Basic structure of these limbs is modified for divergent function. It consists of proximal protopodite and two distal branches. Protopodite has coxa or coxopodite and a basis or basopdite. The latter has two elements-inner endopodite and outer exopodite, coxopodite extensions are called epipodites.

In most crustacean groups tagmatization includes the formation of a carapace on the cephalothorax. Appendages are associated with the functions of locomotion, respiration and feeding. Appendage adaptation may involve atrophy or hypertrophy of any of the basic elements described above. Respiration is either by gills or by body surface. Coelom is greatly reduced and forms haemococl. Excretory organs are modified coelomoducts which may be either maxillary glands or antennary (green) glands. Heart lies in dorsal pericardial sinus which communicates by valvular ostia. Sexes are separate and show sexual dimorphism. Development includes metamorphosis with free larval stages.

13.5.1 *Daphnia*

Examine the permanent slide of *Daphnia* (Water flea) and observe the following features:

i) It is small about 1-2 mm in length.

ii) Trunk bears six paired appendage, one pair of large biramous antennae, five pairs of leaf- like appendages.
iii) One sessile compound eye.
iv) Body is enclosed in a carapace which ends into dorsal spine.
v) Female carries eggs and embryos in large brood pouches situated between abdomen and posterior part of the carapace.

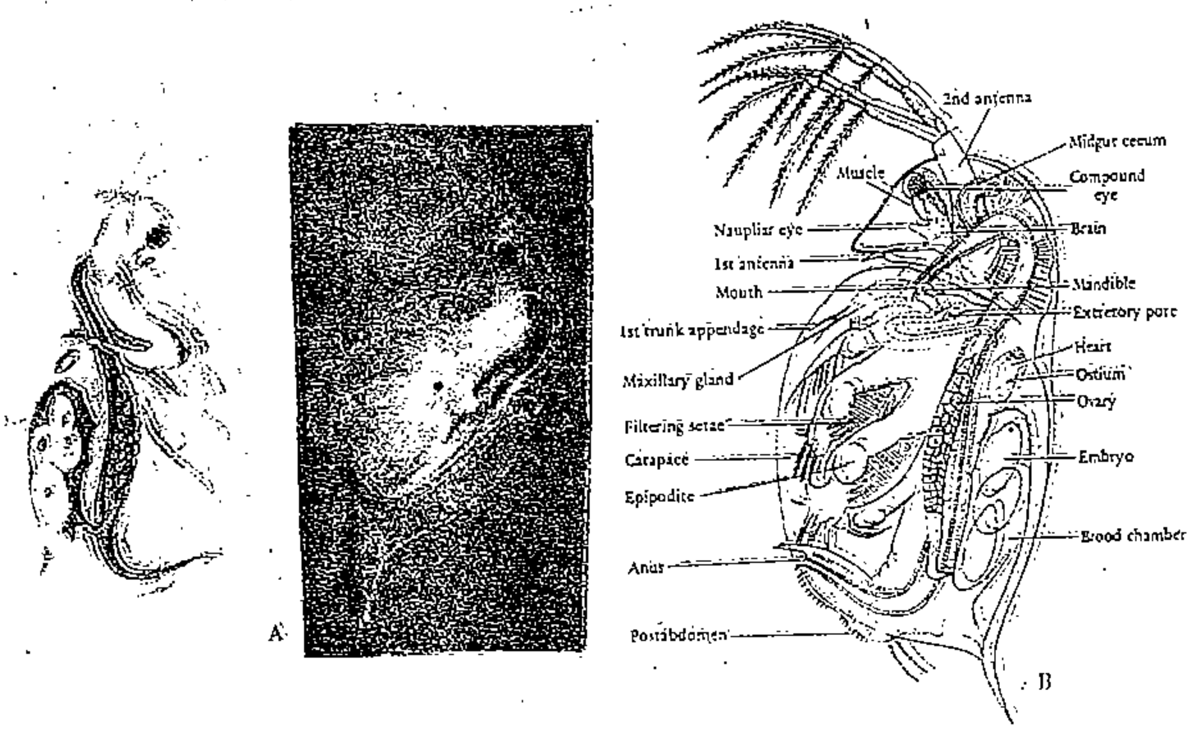


Fig. 13.5: *Daphnia* (Water flea) A - natural; B - semi diagrammatic.

Habit and Habitat

Found in fresh water ponds, streams and ditches.

Geographical Distribution

Widely distributed in South East Asia, Europe and U.S.A.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Jointed appendages, segmented body
Subphylum	**Crustacea**	Biramous appendages
Class	**Branchiopoda**	Trunk appendages flat and leaf-like
Genus	***Daphnia***	
Species	***pulex***	
Common name	**Water flea**	

13.5.2 *Balanus*

Examine the specimen of *Balanus* (Acorn or rock barnacle) kept inside the jar and note the following features :

(i) Body is enclosed by six calcareous shell plates – one dorsal keel or **carina,** one **rostrum** and two pairs of **lateral plates**. Shell is directly attached to the rock because peduncle is absent which is otherwise present in other barnacles.

(ii) The opening of the shell is provided with a four fold cover consisting of two **scuta** and two paired plates, the **terga**.

(iii) Six pairs of **thoracic legs** protrude out through the openings of the shell for capturing food particles.

(iv) Animals arc **hermaphrodite.**

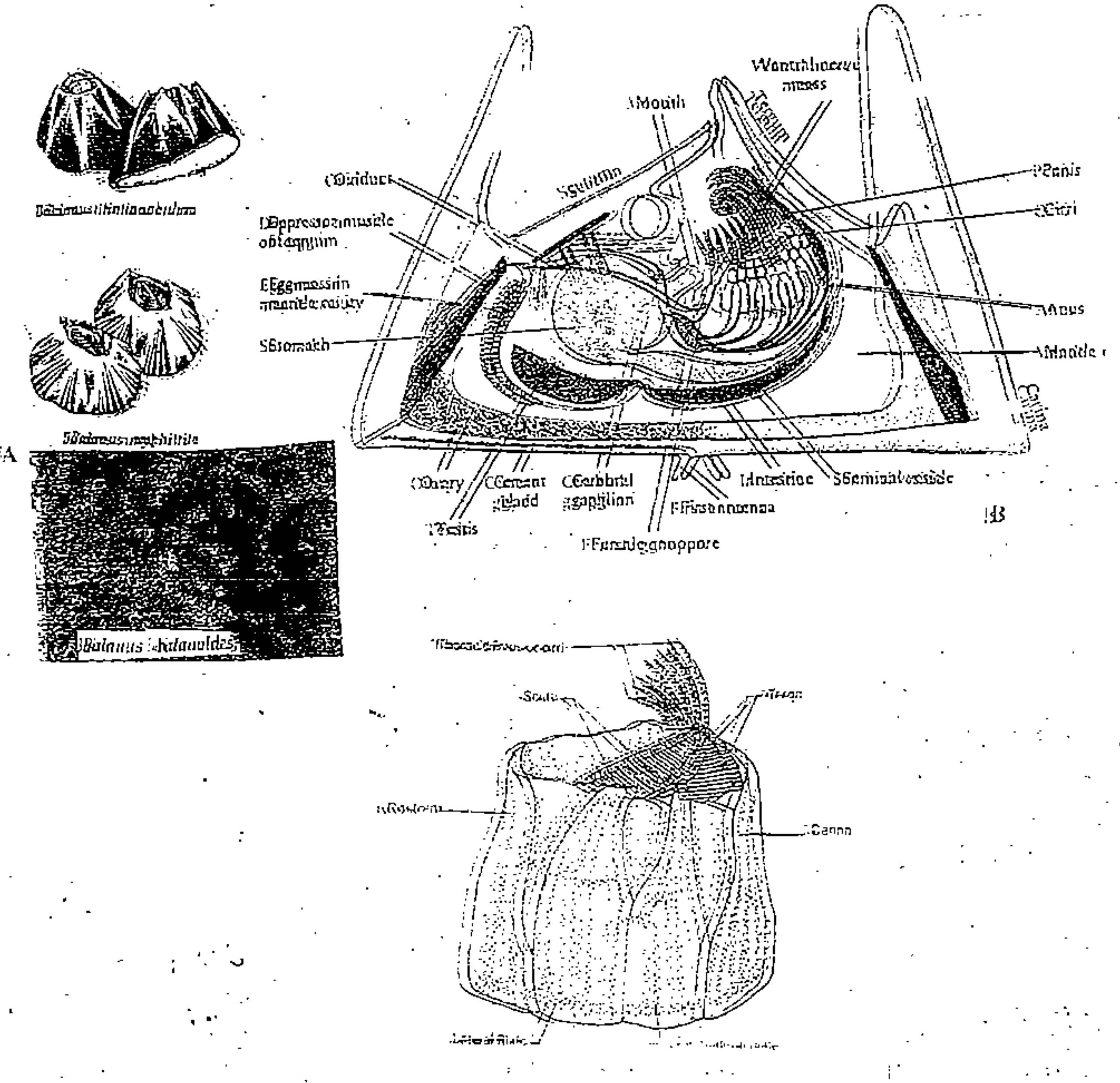


Fig. 13.6: ***Balanus*, A – Natural, B – Diagram of Internal structure of a barnacle.**

Habit and Habitat

Attached to rocks and molluscan shells below high tide mark.

Geographical Distribution

Cosmopolitan, specially found along Pacific Coast, North Atlantic Coast, etc.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Jointed appendages, segmented body
Class	**Crustacea**	Biramous appendages
Sub class	**Cirripedia**	Biramous appendages fringed with tufts of setae
Genus	***Balanus***	
Common name	**Acorn or rock baracle**	

[The sub-class Cirripedia includes mostly rocky coast line barnacles. They were originally confused with molluscs because they possessed thick calcareous shells. Their internal anatomy and larval stages focus relationship with crustaceans. Almost 900 species have been described so far.]

13.5.3 *Sacculina*

Examine the specimen of crab in jar and observe the parasite located between the crab's thorax and abdomen. Note the following features:

It shows extreme degeneration due to the parasitic mode of life. It loses all arthropodan characters and resembles the mycelium of fungus. A cypris larva destined to become female enters the gill chamber of the host crab and attaches to the gill. Following metamorphosis of the cypris, a proliferation in the host's integument is made permitting the entrance of a mass of differentiated cells of the parasite. Within the host, growth of parasite takes place through the ramification of a nutrient-absorbing root-like system. Sexual development involves the formation of an external brood chamber.

(i) It is a crustacean by development, which shows a nauplius stage.

(ii) The young *Sacculina* attaches ventrally to the crab's body between thorax and abdomen.

(iii) Then loses its organs and sends root-like processes in the body of the host and turns into an ovoid sac. This opens externally by genital or cloacal aperture.

(iv) Presence of *Sacculina* causes many changes in the sex characters of the host, including parasitic castration. The male host acquires female characters while female ovaries become degenerated.

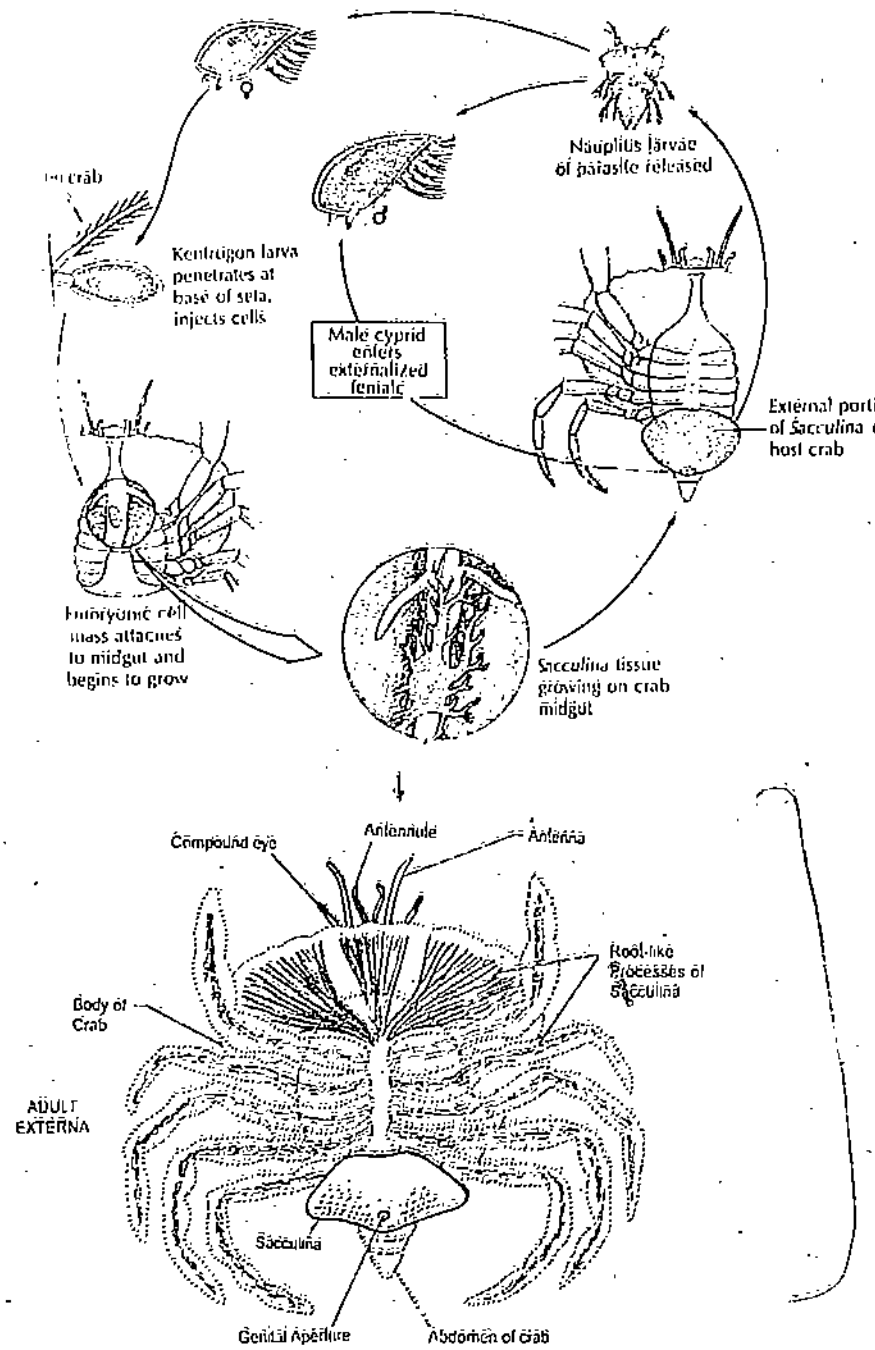


Fig. 13.7: *Sacculina* parasitizing a crab

Habit and Habitat

Found as a parasite on crab

Geographical Distribution

Cosmopolitan

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Jointed appendages, segmented body

Class	**Cirripedia**	Biramous appendages
Subphylum	**Crustacea**	Biramous appendages fringed with tufts of setae
Genus	***Sacculina***	

13.5.4 *Palaemon*

Examine the specimen in jar and note the following features:

(i) Palaemon (Prawn) has a spindle-shaped body which is bilaterally symemetrical. Size varies from 2.13 to 90 cm.

(ii) They are pale yellow in colour. Body is divided into anterior **cephalothorax** and posterior movable **abdomen**.

(iii) It possesses an exoskeleton of hard **cuticle**.

(iv) A continuous dorsal shield, covering cephalothorax is called **carapace** or dorsal plate which is a fused structure. Dorsal shield is produced into a **rostrum**.

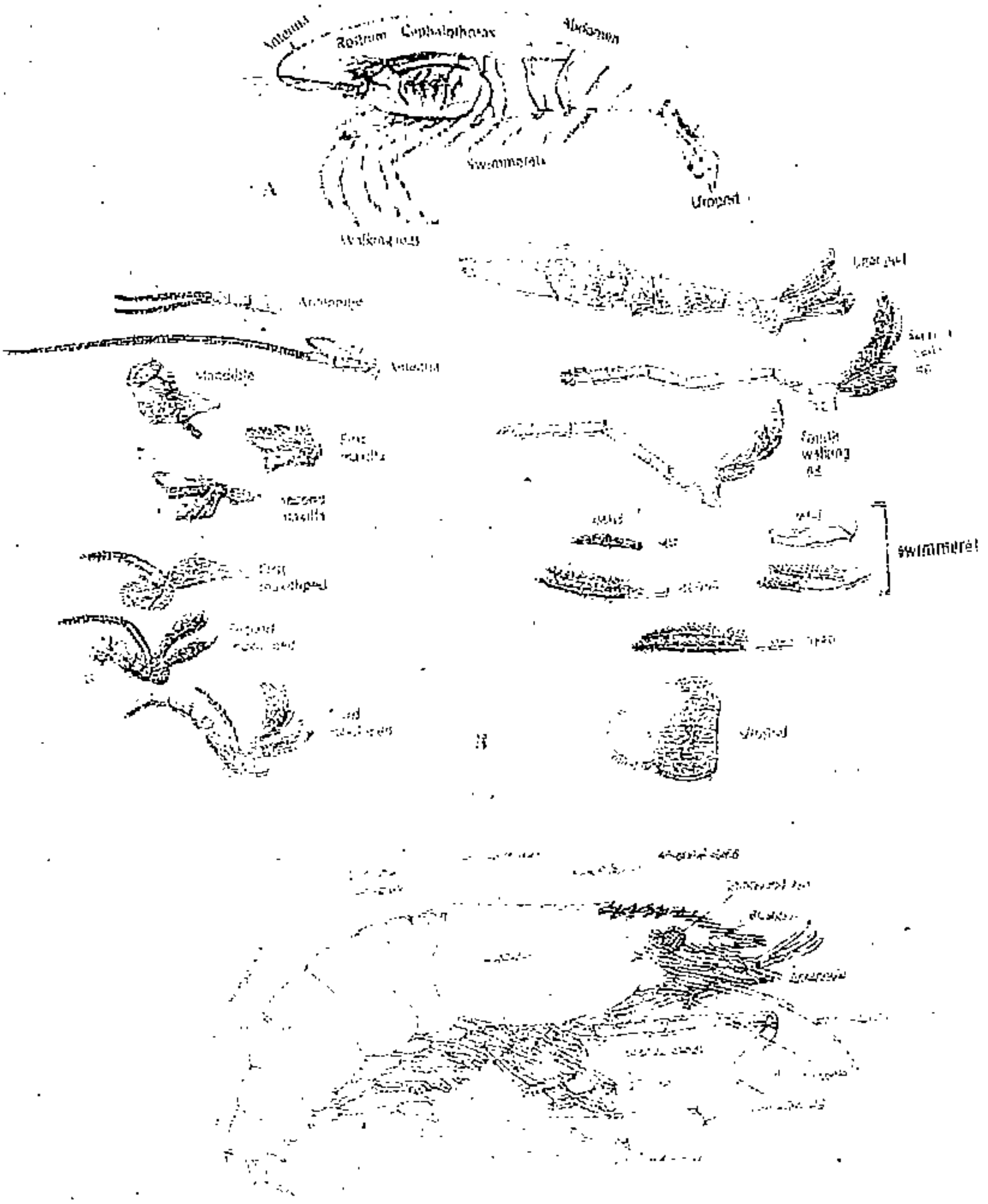


Fig. 13.8: *Palaemon*, A – adult prawn; B – appendages.

(v) All the base of the rostrum on either side is an orbital notch which accommodates the stalk of compound eye. It also has two short spines on either side called **antennal** and **hepatic spines** respectively.
(vi) Hard pieces of skeleton covering abdomen are called **sclerites**. The sclerites are joined by membrane.
(vii) **Mouth** lies anteriorly as a mid-ventral slit in the cephalothorax.
(viii) From the ventrolateral margins of each segment arises as a pair of **appendages** or limbs.
(ix) Each appendage has **protopodite** or coxa and upper **basopodite** or basis. From the protopodite arise two rami an inner **endopodite** and outer **exopodite.**
(x) There are nineteen pairs of biramous appendages consisting of antennules, antennae, mandibles and maxillae on head as cephalic appendages. Antennules bear statocyst on precoxa. Three pairs of thoracic appendages consist of maxillipedes. Cephalothorax also bears five pairs of **walking legs**. They perform multiple function of balancing, sensory, food handling, walking and swimming etc. Abdomen bears six pairs of **pleopods.**
(xi) Respiration is performed by epipodites or **gills** present in the anterior part of the gill chamber.
(xii) It is dioecious and shows sexual dimorphism.

Habit and Habitat

Found in fresh water ponds, ditches lakes streams and rivers. Nocturnal hiding during the day and comes to surface at night

Geographical Distribution

Commonly found in India

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Jointed appendages, segmented body
Subphylum	**Crustacea**	Biramous appendages
Class	**Malacostraca**	Thorax with walking legs, abdominal appendages are the swimming legs
Genus	***Palaemon***	
Common name	**Prawn**	

13.5.5 *Eupagurus*

Eupagurus (Fig. 13.9) is an example of hermit crabs. Examine the specimen (occupying the inside of the empty gastropod shell) and see Fig. 13.10 and note the following feature.

(i) Cephalothorax is broad, flattened with hard shell, antennules are short but antennae are long. Eye stalks are elongated.
(ii) The first three pairs of legs are chelate and last two are small and non-chelate. Right leg is larger than the left.
(iii) For the protection of soft body it stays in the gastropod shell.
(iv) All internal structures become spirally twisted and the abdominal appendages of right side get atrophied.
(v) Last pair of appendages i.e. uropods become hook-like for holding the columella of the shell. Right claw which is modified, covers the shell as operculum and it also captures the prey.

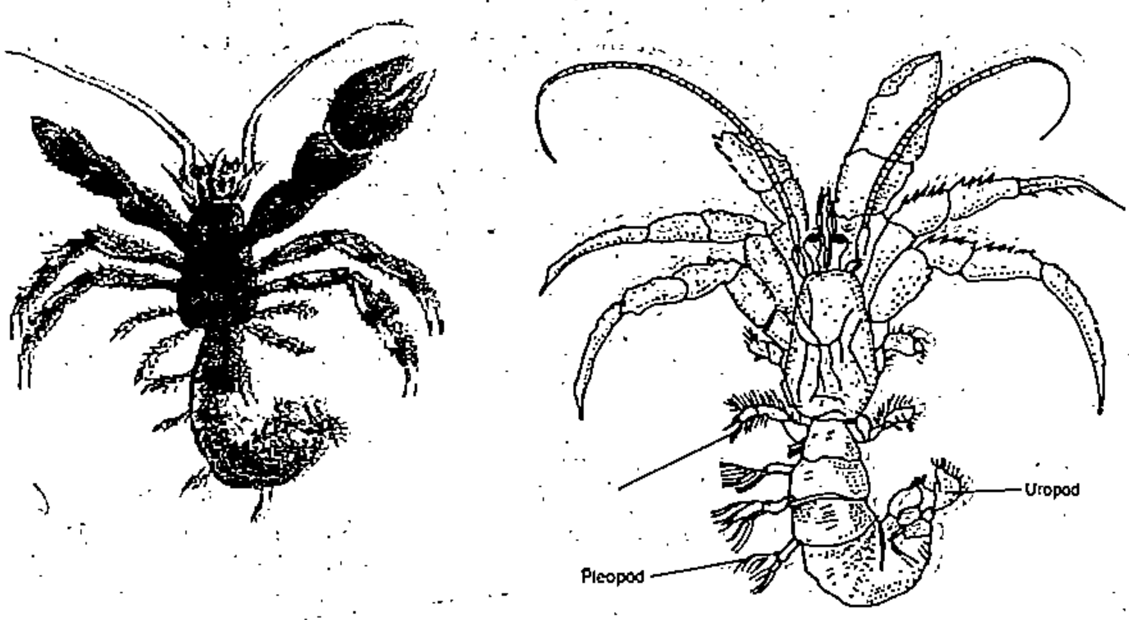


Fig. 13.9: ***Eupagurus.***

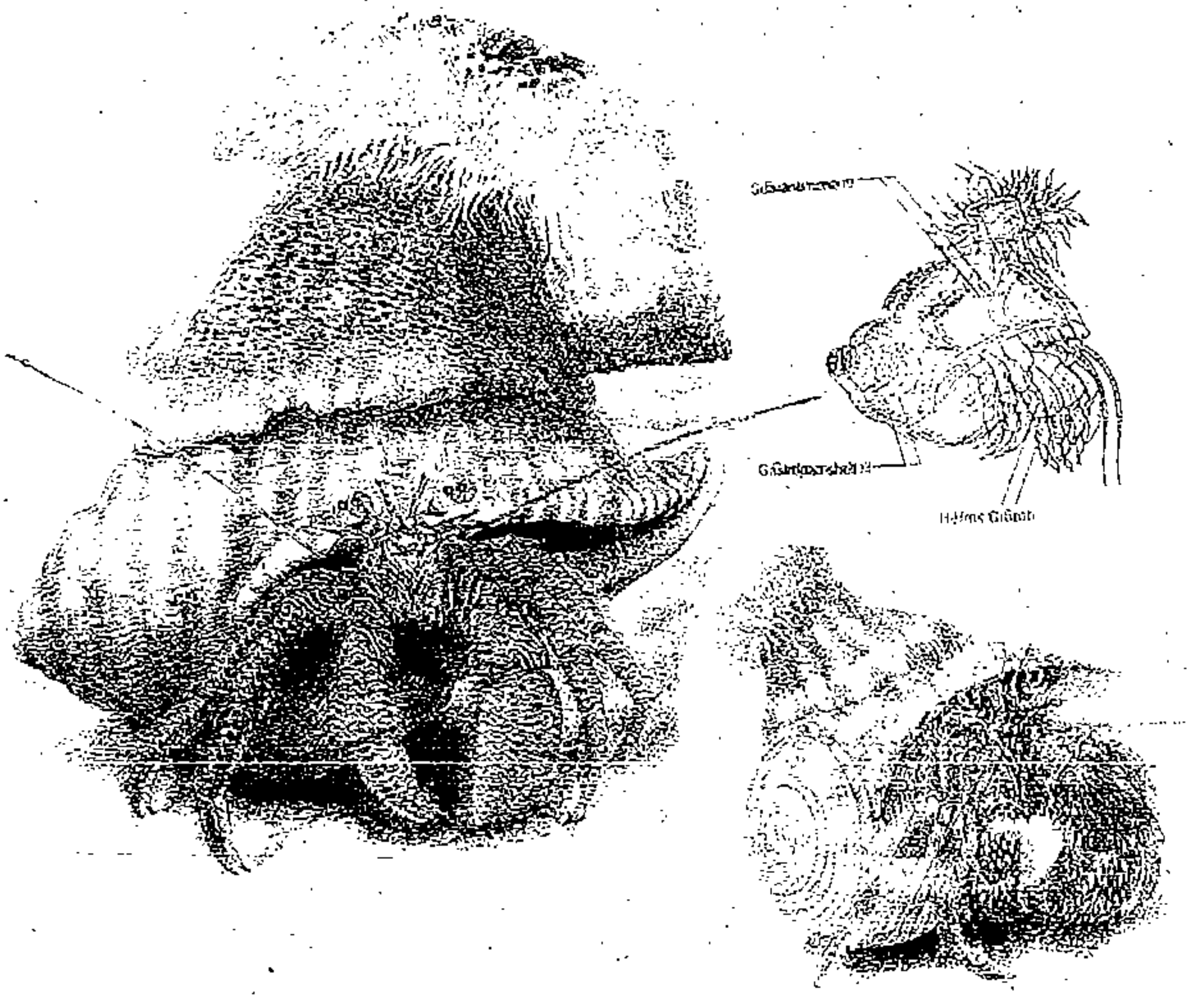


Fig. 13.10: Hermit crab and sea anemone.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Jointed appendages, segmented body
Subphylum	**Crustacea**	Biramous appendage
Class	**Malacostraca**	Thorax with walking legs, abdominal appendages are the swimming legs
Genus	***Eupaguras***	
Common name	**Hermit crab**	

[Most often a sea-anemone attaches on the outside of the gastropod shell and hermit crab lives inside the shell. Hermit crab is a good example of commensalisms (sharing common food with reference to the hermit crab and the sea anemone). The hard shell and sea-anemone protect the body of the hermit crabs from sea enemies. Stinging cells of sea-anemone do not allow fishes to come near the shell. In return the hermit crabs provide ride to the sea-anemone and access to a variety of food.]

13.6 NAUPLIUS LARVA OF CRUSTACEANS

Examine the permanent slide of nauplius under low power of microscope and observe Fig. 13.11. Note the following features:

(i) Oval or pear-shaped unsegmented body having a broad anterior head region, an intermediate trunk region and a posterior bilobed anal region.

(ii) 1^{st} pair of appendages are unbranched or uniramous (these become the antennules of the adult).

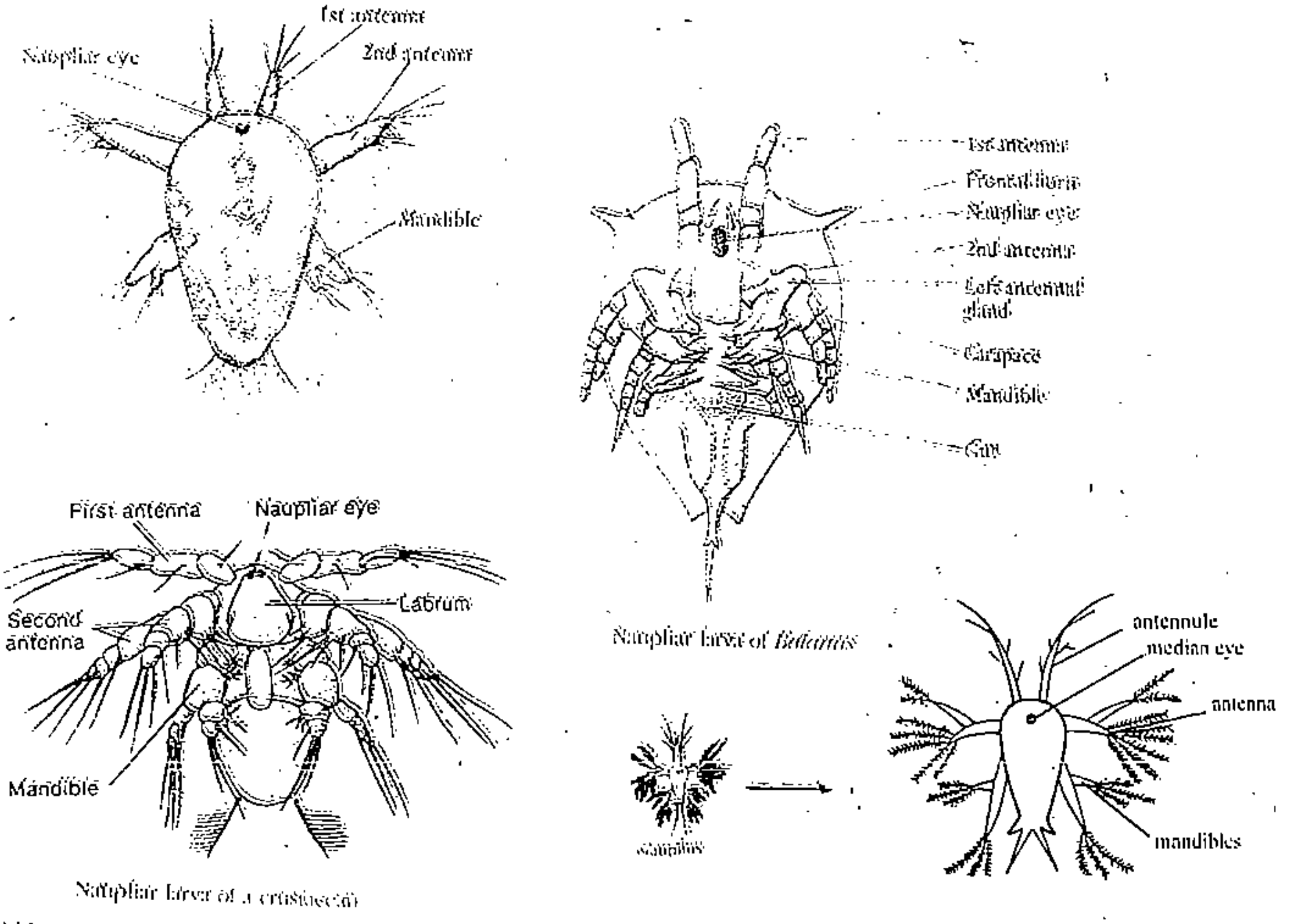


Fig. 13.11: Nauplius larva.

(iii) Appendages of the second and third pairs are biramous (two branches) and are called the antennary and mandibular feet respectively, (they form the antennae and mandibles of the adult).
(iv) Head region bears a conspicuous sessile median eye.
(v) The mouth opens anteriorly between the bases of antennary and mandibular feet.
(vi) Anus lies at the extremity of the caudal region.
(vii) Alimentary canal is straight and made of foregut, midgut and hindgut (mouth and alimentary canal are lacking in the nauplius of Cirripedia).
(viii) Larva is without a heart and has no segmented ventral nerve cord.

You should sketch what you observe under the microscope in your record notebook, label and verify the descriptive features of the larva listed above.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Jointed appendages
Class	**Crustacea**	Biramous appendages

13.8 TERMINAL QUESTIONS

1. On what basis can you identify *Sacculina* as belonging to the phylum arthropoda?

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2. How would you define the subphylum crustacea in a single sentence?

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3. What are the special features of nauplius larva so as to link it with class Crustacea?

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4. Draw a labelled diagram of Nauplius larva giving salient-features and scientific classification.

....

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5. Indicate whether the following statements are **True** or **False**.

   i) Nauplius is a stage in the development of Crustacea.
   ii) Nauplius is a microscopic structure.
   iii) Nauplius has 3 pairs of appendages.

EXERCISE 14 ARTHROPODA-II – SUBPHYLUM UNIRAMIA : CLASSES CHILOPODA AND PAUROPODA AND PHYLUM ONYCHOPHORA

Structure

14.1 INTRODUCTION

The subphylum is called Uniramia because of the presence of unbranched appendages. These animals have non-jointed mandibles, unbranched appendages without any palps. They have only a single pair of antennae that correspond to the second cephalic segment (second antennae). Malpighian tubules act as excretory organs. This subphylum has 10,1300 species belonging to classes Chilopda, Pauropoda, Symphyla and Insecta. Here in this exercise we will take the class Chiopoda and Pauropoda only, class Insecta being a very large group will be taken up separately in the next exercise No. 15.

Phylum Onychophora with the single example *Peripatus* has a unique position showing affinities with annelids, arthropods and molluscs.

Objectives

After performing this exercise you should be able to:

- identify the specimens of *Scolopendra, Julus* and *Peripatus*,
- classify the identified specimens and justify their classification,
- mention the habit and habitat of the specimens,
- list the affinities of Peripatus with annelids, arthropods and molluscs.

14.2 MATERIAL REQUIRED

Preserved specimens of:
Scolopendra (centipede)
Julus (millipede)
Peripatus

14.3 CLASS CHILOPODA

14.3.1 General Features

There are many trunk segments each bearing a single pair of legs. The head bears a single pair of antennae, mandibles and two pairs of maxillae. The 2nd maxillae fuse to form a labium. A poison gland is also present in these animals.

14.3.2 Study of the specimen *Scolopendra*

Centipedes are active and aggressive carnivores. About 3000 species have been discovered so far. These are found under surfaces of stones, soil and humus, and barks and logs.

Examine the specimen and note the following features:

(i) Centipedes feed on terrestrial invertebrates worms, snails and other arthropods.
(ii) Body is enlongated and dorsoventrally flattened.
(iii) Head is distinct and bears a pair of antennae, a pair of mandibles and two pairs of maxillae.
(iv) Trunk segments are numerous and each segment bears one pair of legs. The first pair of trunk legs are clawed and forwardly directed to form maxillipedes that bear a sharp claw connected with poison glands.
(v) Genital opening is situated at the hind end of the body.
(vi) Sexes are separate.

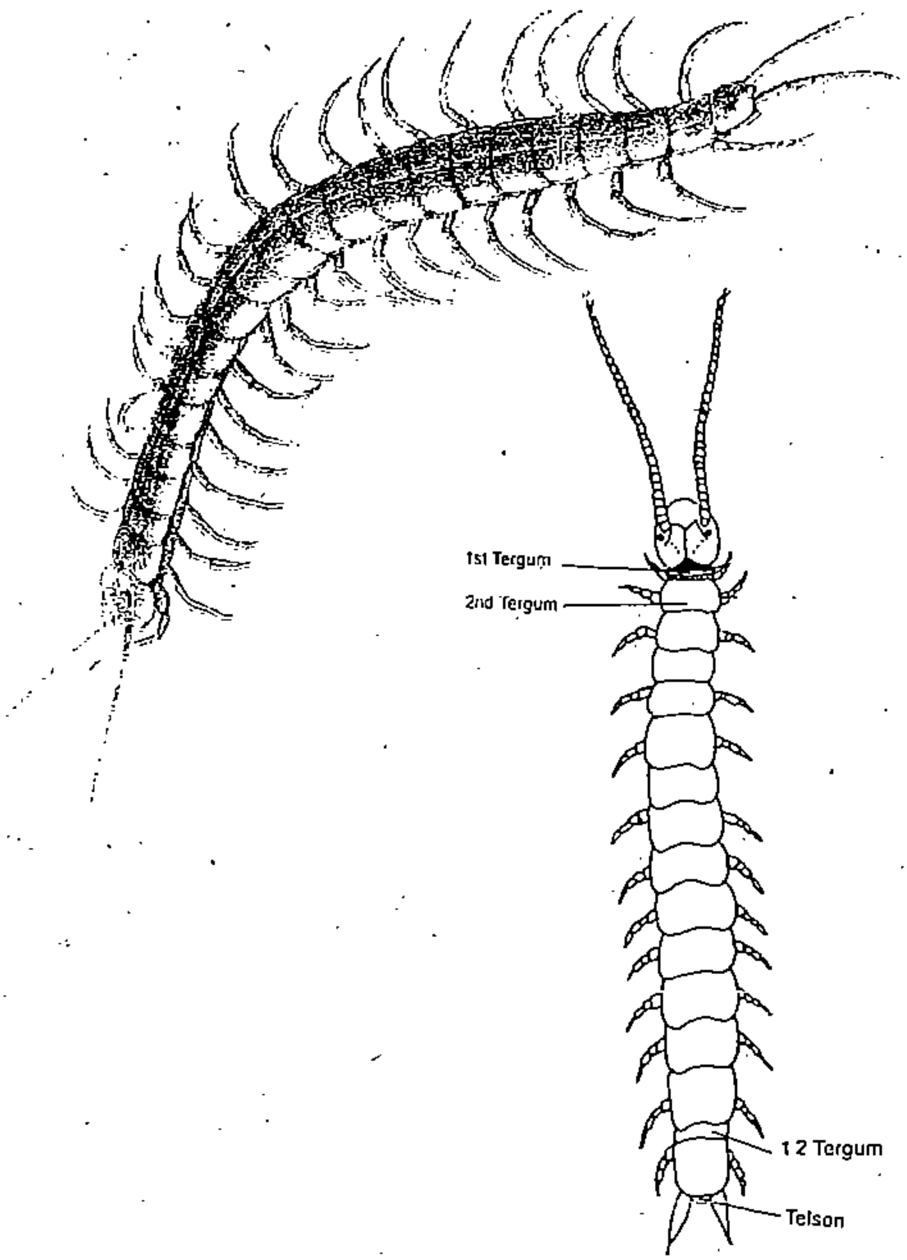

Fig. 14.1: *Scolopendra.*

Habit and Habit

Lives in soil and humus, beneath stones, barks and logs. Predacious.

Geographical Distribution

Inhabits both tropical and temperate regions of the world.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Jointed appendage, segmented body.
Subphylum	**Uniramia**	Unbranched appendages
Class	**Chilopoda**	Numerous trunk segments each bearing a pair of legs
Genus	***Scolopendra***	
Species	***gigantica*** (large variety)	
Common name	**Centipede or Scutigera**	

14.4 CLASS PAUROPODA

14.4.1 General Features of Pauropoda

There are eleven trunk segments. The head bears one pair of antennae, one pair of mandibles and one pair of maxillae. Each trunk segment bears a pairs of legs and is devoid of blood vascular system and trachea.

14.4.2 Study of specimen *Julus*

Examine the specimen of *Julus* and note the following features:

(i) Body consists of many segments.

(ii) Head bears short seven-jointed antennae, a pair of maxillae and a pair of mandibles forming a gnathochilarium.

(iii) On the dorsal surface there are six tergites which produce segmental coupling. This reduces undulations during movement.

(iv) Heart and tracheae are absent. Direct diffusion of respiratory gases through the skin takes place.

(v) Each trunk segment except the first four and last segment bears two pairs of legs.

(vi) Poison jaws are absent, sting glands are present at the sides of the body.

(vii) Sexes are separate, genital opening on the 3rd segment behind the head.

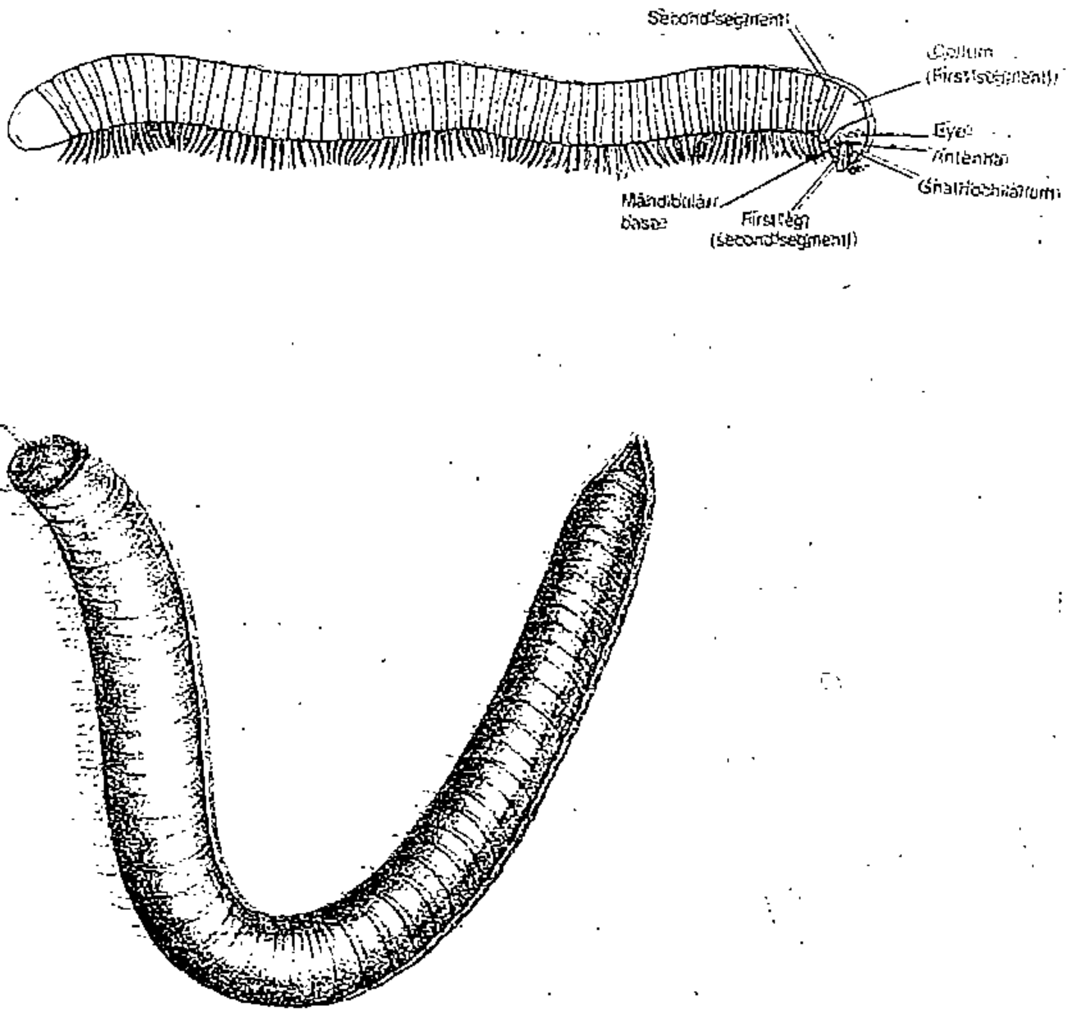

Fig. 14.2: *Julus*.

Habit and Habitat

They live in soil and humus and eat fungus and decaying matter. It is found rolled up under stones.

Geographical Distribution

Cosmopolitan, found in India.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Jointed appendage, segmented body
Subphylum	**Uniramia**	Unbranched appendages
Class	**Pauropoda**	Head bears antennae, one pair of mandibles, one pair of maxillae
Genus	***Julus***	
Common name	**Millipede or Spirobolus**	

It was earlier considered under class Myriapoda. They are commonly known as millipedes. About 380 species have been described so far. They are found hidden in dark and damp places.

14.5 PHYLUM ONYCHOPHORA

14.5.1 Study of the specimen *Peripatus*

Onychophora (*Onycho* – claws, *phoros* – bearing) means claw bearing animals. Onychophorans bridge the gap between annelids and arthropods. They have a wide discontinuous distribution around the world.

Examine the specimen and observe the following characters:

(i) External segmentation is absent.
(ii) Skin has its own characters.
(iii) Antennae are not similar to those of arthropods.
(iv) A condition of three segmented head is a link character between arthropoda and annelida. Segments behind head are similar.
(v) Tracheae and their arrangement are different from arthropods. It has numerous spiracles on each segment.
(vi) Ventral nerve cords are widely separated.

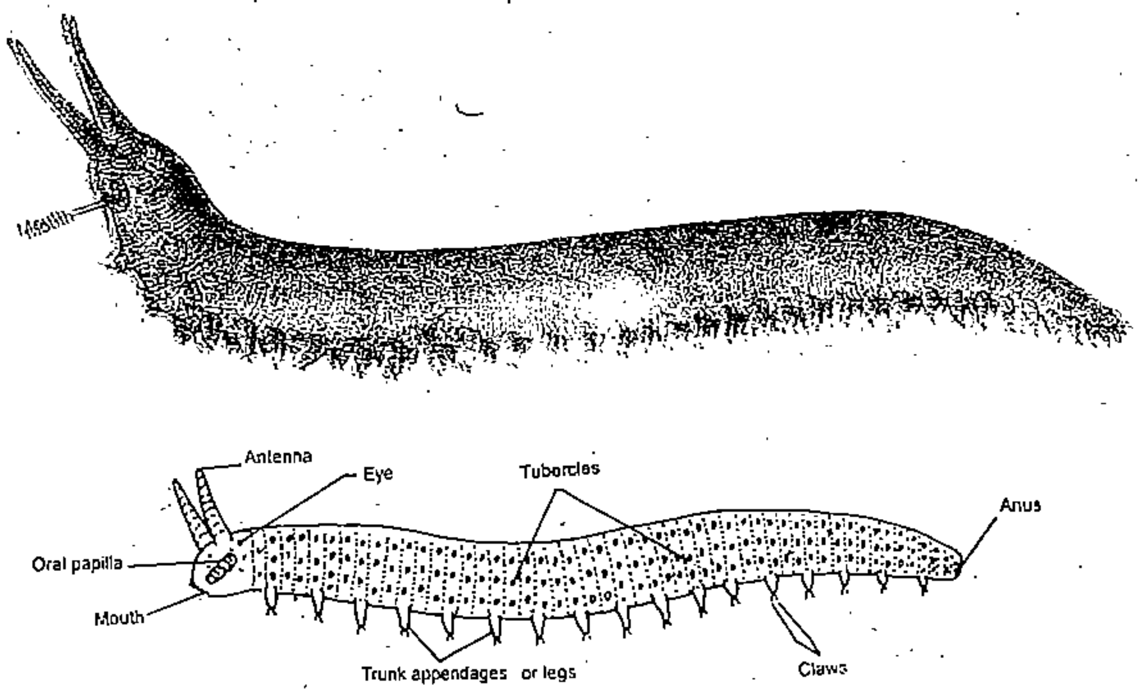

Fig. 14.3: *Peripatus*. External features in lateral view.

Habit and Habitat

In moist ground, crawling under debris.

Geographical Distribution

Abundantly found in South Africa and Australia.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Onychophora**	Claw-bearing, unsegmented, possess nephridia
Genus	***Peripatus***	

14.5.2 *Affinities*

Peripatus shows striking similarities with three phyla, namely Annelida, Arthropoda and Mollusca. These are as follows:

a) **ANNELIDIAN AFFINITIES**

1. Body has long trunk and vermiform structure which resembles annelidan contour.
2. Head is absent.
3. Eyes are simple
4. Body wall consists of thin cuticle underlying circular and longitudinal muscles fibres.
5. Appendages are hollow and unjointed. It shows peristaltic movements like earthworm to perform locomotion.
6. Hollow, stumpy appendages which are extensions of the body wall, similar to the parapodia of annelida.

b) **ARTHROPODAN AFFINITIES**

1. Body is covered with chitinous cuticle.
2. Appendages bear claws.
3. Jaws are modified appendages.
4. Legs bear definite musculature.
5. Haemocoel present and perivisceral part of coelom is absent.
6. Thacheae serve as respiratory structures opening to the outside by spiracle.

c) **MOLLUSCAN AFFINITIES**

1. It looks like a slug.
2. Nervous system resembles polycophoran and prosobranchiates.

Because of their above mentioned affinities they are considered as a connecting link between arthropoda and annelida.

14.6 TERMINAL QUESTIONS

1. List any two most characteristic differences between centipedes and millipedes.

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....

....

2. What is so peculiar about the appendages of *Peripatus*?

....

....

3. List any three features each in which *Peripatus* resembles (i) Annelida and (ii) Arthropoda.

(i) Resemblance with Annelida

....

....

(ii) Resemblance with Arthropoda

....

....

EXERCISE 15 ARTHROPODA – III (INSECTA) : OBSERVATION AND CLASSIFICATION OF SPECIMENS

Structure

15.1 INTRODUCTION

In the previous unit (Unit – 5) you have examined the representatives of arthropoda. In this unit, you will learn about some of the representatives of insects. You have already studied that insect body is distinctly divisible into head, thorax and abdomen. The head bears mouth parts, a pair of compound eyes and a pair of antennae; the thorax is three-segmented, generally with two pairs of wings and three pairs of jointed legs (hence also the name Hexapoda for the insects); the abdomen is usually 11-segmented and is devoid of appendages.

Objectives

After performing this exercise you should be able to

- identify the insect specimens like Silverfish (*Lepisma*), Dragonfly, Locust, *Mantis*, *Gryllus*, *Pediculus*,
- classify the identified insects upto the level of the order,
- list the characters justifying their classification and mention special features, if any,
- mention the habit and geographical location of the identified insects,
- draw labelled diagrams of the identified insects,
- mention the economic importance, if any, of the identified insects.

15.2 MATERIAL REQUIRED

1. A compound microscope
2. A magnifying glass
3. Dried and preserved specimens of *Lepisma*, dragonfly, *Schistocerca gregaria*, *Mantis* and *Gryllus*
4. Permanent whole mounts of *Pediculus* and *Lepisma*
5. A piece of thermocol of the size of 4"X4"
6. A moderately soft pencil and an eraser.
7. Drawing sheets.

15.3 *LEPISMA* (Silver-fish)

Examine the specimen and note the following features:

Pasted on a small triangular piece of hard paper. (Permanent mount may also be observed under microscope).

(i) *Lepsima* (Silver fish) is silvery white in colour, and has a "fish-like" body (pointed at both ends), hence its common name silverfish. Its peculiar colour is due to silvery white scales covering the entire body.

(ii) The body is divisible into head, thorax, and abdomen (Fig. 15.1).

(iii) The head bears a pair of eyes on its dorso-lateral sides, and a pair of long hair-like antennae.

(iv) The thorax is 3-segmented, and bears a pair of jointed legs on each segment. [Do you see any wings in this insect? No, there is none, *Lepsima* is an apteron (a = without + *pteron* = wing) insect.]

(v) The abdomen is 11-segmented. Look at the tip of the abdomen carefully. It bears 2 pairs of abdominal appendages, one pair of anal cerci, and a long, thread-like telson.

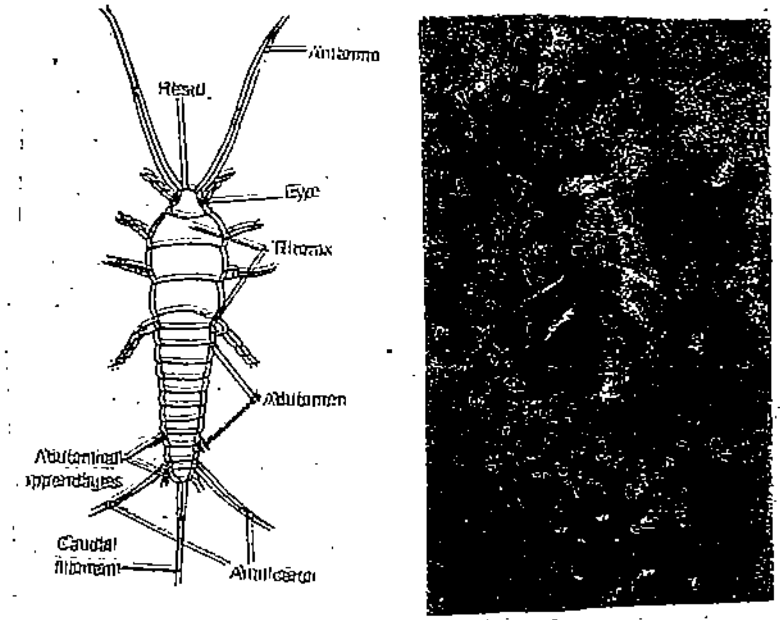

Fig. 15.1: *Lepsima.*

Habits and Habitat

Lepsima is a small-sized (about 4-5 mm long) insect, commonly occurring in damp places and feeding on the starch of starched clothes and the gum paste in the book binding including paper. As such it is a household pest but of a minor importance.

Geographical Distribution

Almost throughout the world.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	because it has a metamerically segmented body with jointed legs.
Class	**Insecta**	because its body is divisible into head, thorax and abdomen and thorax bears three pairs of legs
Sub-class	**Pterygota**	because wings are absent and there is no metamorphosis during development,
Order	**Thysanura**	because it has many-segmented cerci and a large median caudal telson.
Genus	***Lepisma***	
Common name	**Silver fish**	

15.4 DRAGONFLY

Fix a dried, and well-stretched preserved specimen on a thermocol sheet and observe the following features:

(i) The body is divisible into a large head, robust thorax and long abdomen.

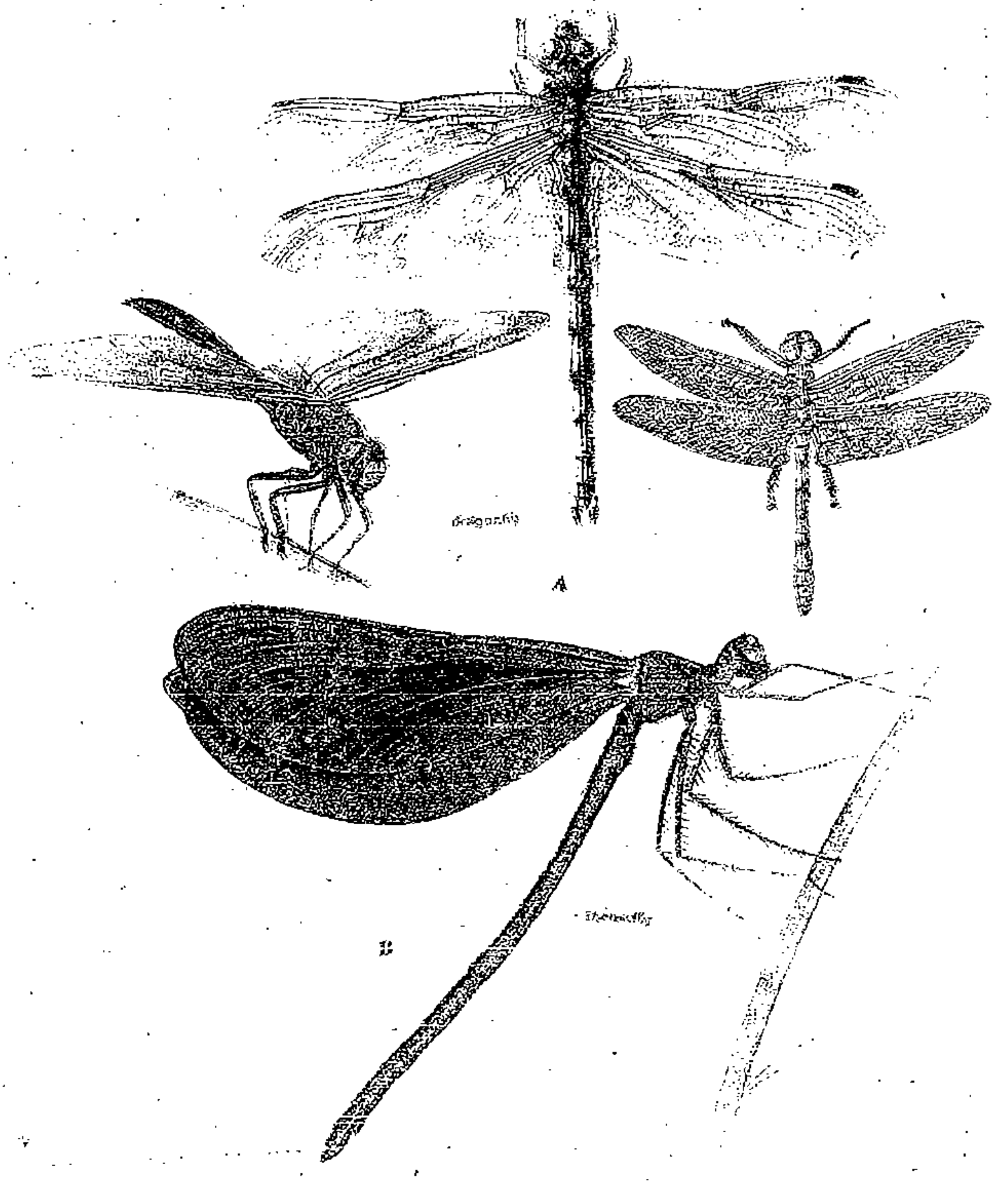

Fig. 15.2: A - Dragon flies, B - Damsel-fly.

(ii) The head bears a pair of prominent compound eyes (each consisting of about 30,000 visual units called ommatidia), and pair of inconspicuous antennae.
(iii) The thorax is 3-segmented.
(iv) Each thoracic segment bears a pair of jointed legs.
(v) Two pairs of large, membranous wings on the second and third thoracic segments. The wings are held horizontally while the insect is resting.
(vi) Look at the apex of the anterior margin of each wing. You can very clearly see a coloured spot called as "Pterostigma" (Fig. 15.2).
(vii) Observe the posterior margin at the base of hind wings. It is produced backward in the form of a lobe-like structure. Presence of this lobe is a characteristic feature of dragon-flies, and helps in distinguishing them from their close relatives – the damsel flies, which do not show this projection.
(viii) The abdomen is very long and cylindrical, with male copulating organ located on the second and third sternite.

Habits and Habitat

Commonly found flying in the air in the vicinity of water (ponds, etc). Predatory in habit, being strong hunters.

Geographical Distribution

It has a cosmopolitan distribution, especially found in India, Sri Lanka, Myanmar, Malaysia, Asia, USA and Europe.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	because it has a metamerically segmented body with jointed legs.
Class	**Insecta**	because its body is divisible into head, thorax and abdomen and thorax bears three pairs of legs
Sub-class	**Pterygota**	because wings are present and there is metamorphosis during development,
Order	**Odonata**	because mouth parts are of biting type, wings membranous and held horizontally, nymphs are aquatic with rectal gills.
Common name	**Dragon fly**	

15.5 LOCUST

Fix a dried, preserved and well-stretched specimen of Locust (*Schistocerca gregaria*) on a thermocol sheet and observe the following features:

(i) The body is robust with head broadly joined with the thorax.

(ii) The head bears a pair of short antennae, and a pair of well-developed compound eyes (Fig. 15.3).

(iii) The forewings are leathery to form tegmina black spots, while the hind wings are large and membranous. The hind legs are long and stout and are meant for jumping.

(iv) The abdomen consists of ten segments with a vestigial eleventh segment.

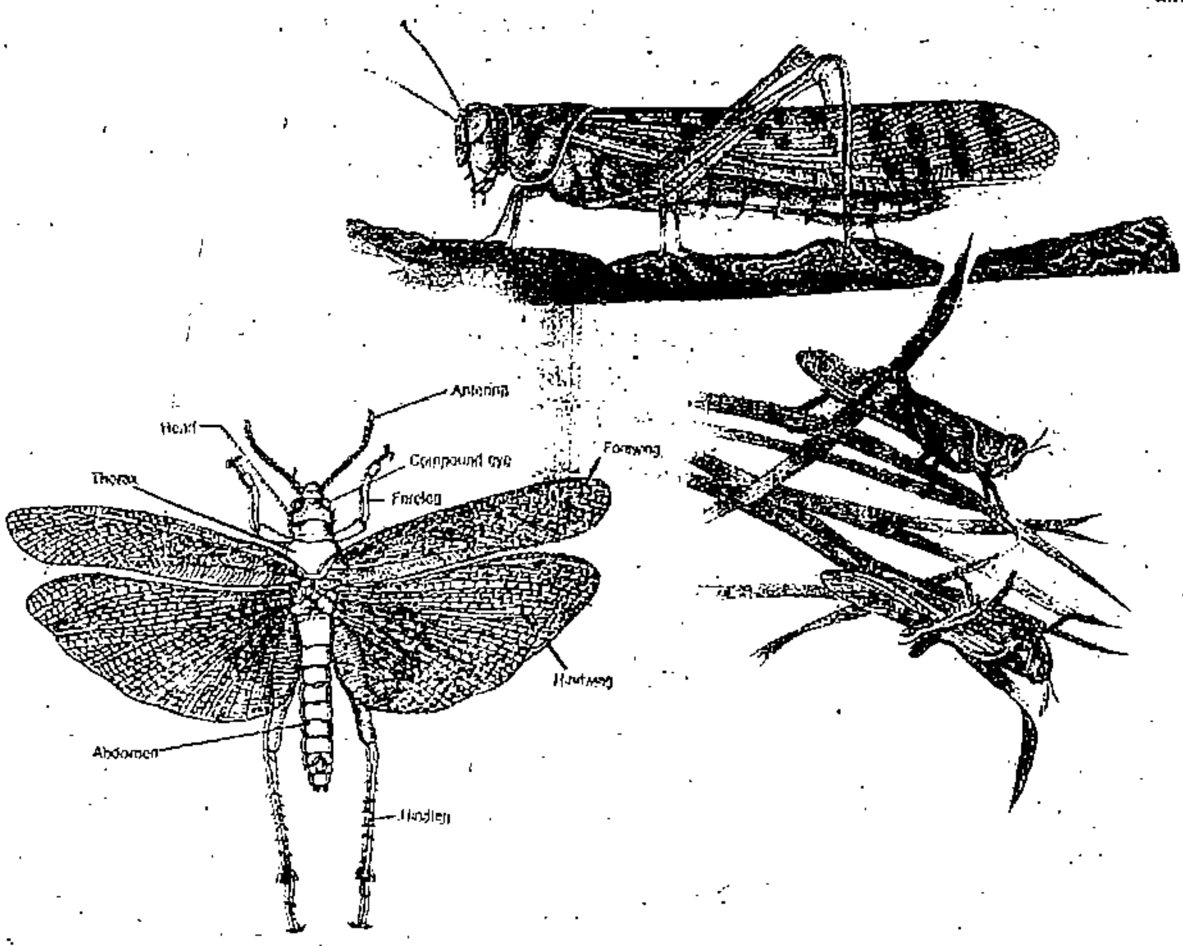

Fig. 15.3: Locust-*Schistocerca gregaria*

Habits and Habitat

Locusts are found in the deserts in the tropical regions of the world; they are herbivores and gregarious migrating (swarming) in great numbers.

Locusts are agricultural pests of great importance and are the worst destroyer of standing crops and orchards.

Geographical Distribution

Locusts are found in the deserts of Africa, Arabia, Iran, Afganistan, Pakistan and North-West India.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	because it has a metamerically segmented body with jointed legs.
Class	**Insecta**	because its body is divisible into head, thorax and abdomen and thorax bears three pairs of legs
Sub-class	**Pterygota**	because wings are present and there is metamorphosis during development,

Order Orthoptera because it has biting and chewing type of mouthparts; the forewings are leathery, while hind wings are membranous.

Genus *Schistocerca*
Species *gregaria*
Common name Locust

15.6 *MANTIS* – Praying Mantis

Fix a dried, preserved and well-stretched specimen of Praying mantis (*Mantis religiosa*) on a thermocol sheet and observe the following characters:

(i) The elongated body is of green colour and is divisible into head, thorax and abdomen.
(ii) Head is small and triangular, bears large compound eyes and three simple eyes called Ocelli.
(iii) The antennae are long and filiform.
(iv) Mouth parts are of biting and chewing type.

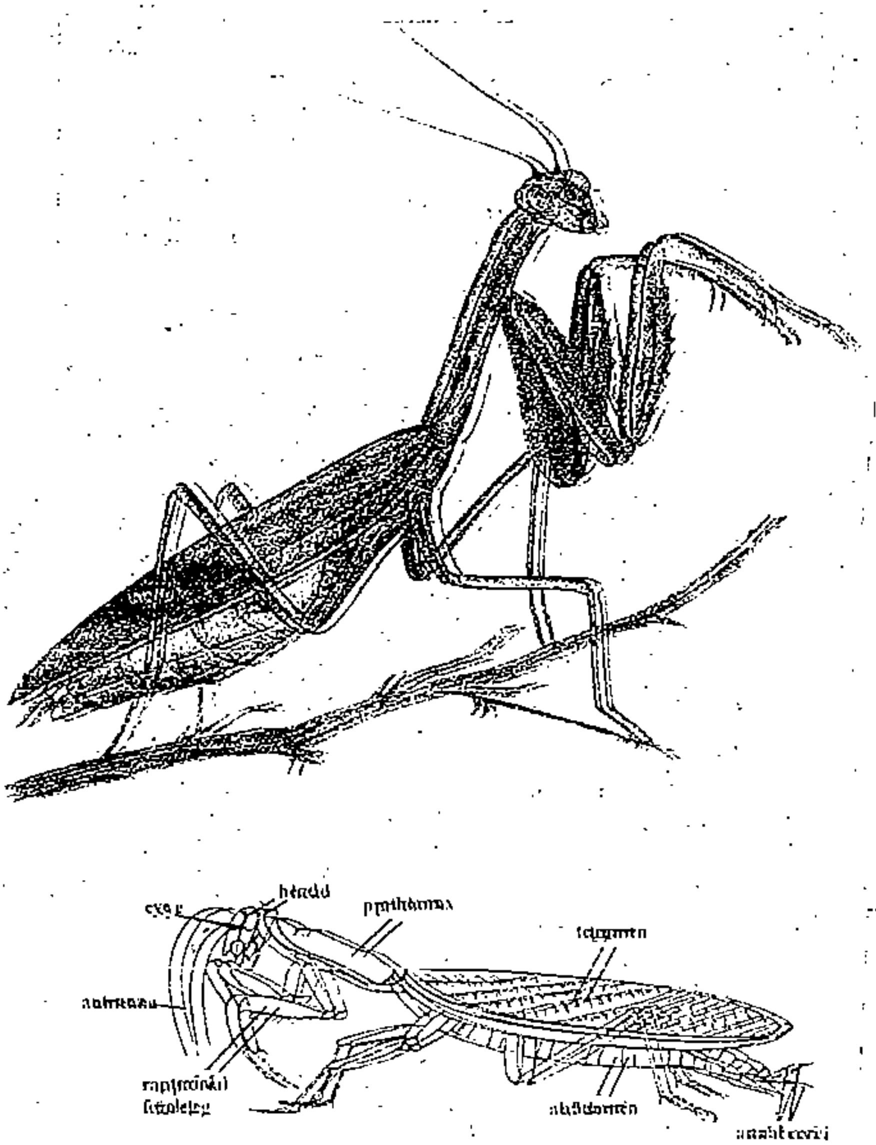

Fig. 15.4: *Praying Mantis*

(v) Prothorax is much elongated with the raptorial forelegs modified for grasping and holding the prey (fore legs are usually held folded facing forward, and hence the popular adjectival name "praying").
(vi) Wings are membranous, folded and overlap the sides of the body.
(vii) Abdomen is 10-segmented.

Habits and Habitat

Mantis is found in grassy fields and areas of plantation. It is a voracious carnivore devouring living insects. It lies in wait for the prey, the forelegs are raised in an attitude of "prayer", hence the name praying mantis.

Geographical Distribution

Various species of mantis are found in USA, Africa, Southern Europe and Western Asia.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	because it has a metamerically segmented body with jointed legs.
Class	**Insecta**	because its body is divisible into head, thorax and abdomen and thorax bears three pairs of legs
Sub-class	**Pterygota**	because wings are present and there is no metamorphosis during development,
Order	**Orthoptera**	because it has biting and chewing type of mouthparts; the forewings are leathery, while hind wings are membranous.
Genus	***Mantis***	
Species	***religiosa***	
Common name	**Praying mantis**	

15.7 *GRYLLUS*

Fix a dried, preserved and well-stretched specimen of Gryllus (Cricket) on a small thermocol sheet and observe the following features:

(i) The body is divisible into head, thorax and abdomen.
(ii) Head bears a pair of compound eyes, and a pair of simple eyes known as ocelli.
(iii) A pair of long filiform antennae.
(iv) Mouth parts are well-developed and are of biting and chewing type.
(v) Forewings are hard and are called as tegmina, while the hindwings are membranous.
(vi) The tibia of the forelegs bear tympanic (sound perceiving) organs.
(vii) Hind legs are long and stout and are adapted for jumping (Fig. 15.6)
(viii) The female possesses a well-developed ovipositor for depositing the eggs in crevices and holes.
(ix) It has a stridulating (sound producing) organ, consisting of a file at the base of the forewing and a scraper at the edge of the forewing. The scraper rubs the file and produces sounds specially during night time.

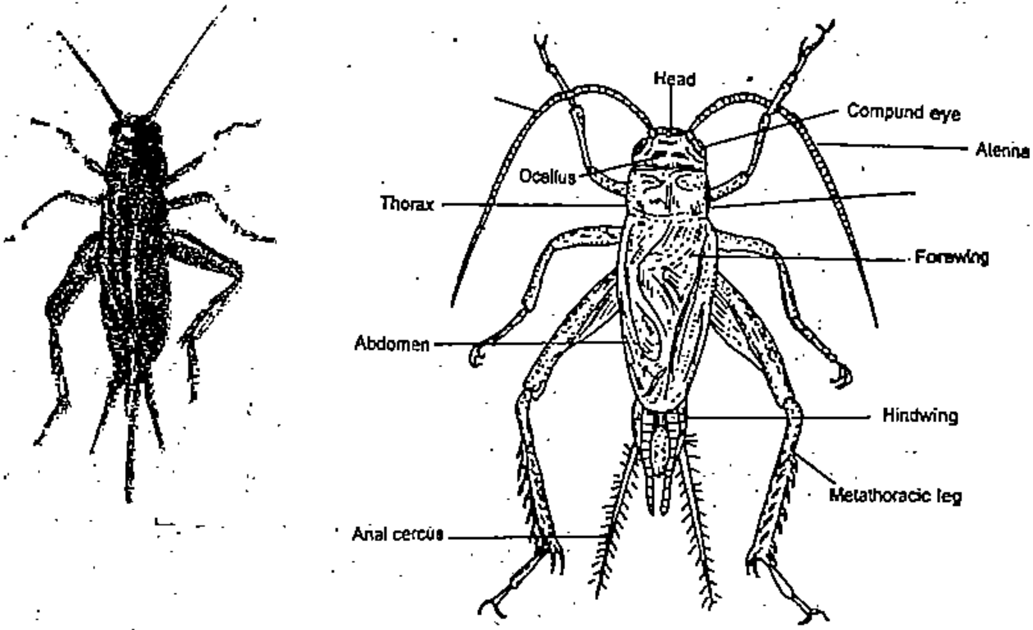

Fig. 15.5 *Gryllus* (cricket)

Habits and Habitat

Gryllus is a common household insect. It is found in damp, warm places like under logs, boxes, stones and in the kitchen. It comes out only during night (such insects are known as nocturnal), and are omnivorous. They are very destructive, damaging the household belonging, like clothes, books, food, etc.

Geographical distribution

Gryllus is found in India, Sri Lanka, Myanmar, USA, Canada and Europe.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	because it has a metamerically segmented body with jointed legs.
Class	**Insecta**	because its body is divisible into head, thorax and abdomen and thorax bears three pairs of legs
Sub-class	**Pterygota**	because wings are present and there is metamorphosis during development,
Order	**Orthoptera**	because it has biting and chewing type of mouthparts; the forewings are leathery, while hind wings are membranous.
Genus	***Gryllus***	
Common name	**Cricket**	

15.8 *PEDICULUS*

Put a prepared (permanent) slide of *Pediculus* (Head louse) under the microscope and observe the following features:

(i) It is a small-sized, dorso-ventrally flattened insect of pale brown colour with dark markings along the sides. (Its dorso-ventrally flattened body makes this insect to fit into the narrow spaces between the hairs of the host).

(ii) The body is divisible into head, thorax and abdomen.

(iii) The head is small, bears a pair of compound eyes, and a pair of 5-segmented antennae.

(iv) The mouth parts are of piercing and sucking type.

[Do you see any wings on this insect? No, there are none, Wings are secondarily lost. Loss of the wings in *Pediculus* is a parasitic adaptation].

(v) It has three pairs of legs. Each leg bears a large curved claw adapted for clinging to the hairs of the host (humans).

(vi) Abdomen is 9-segmented.

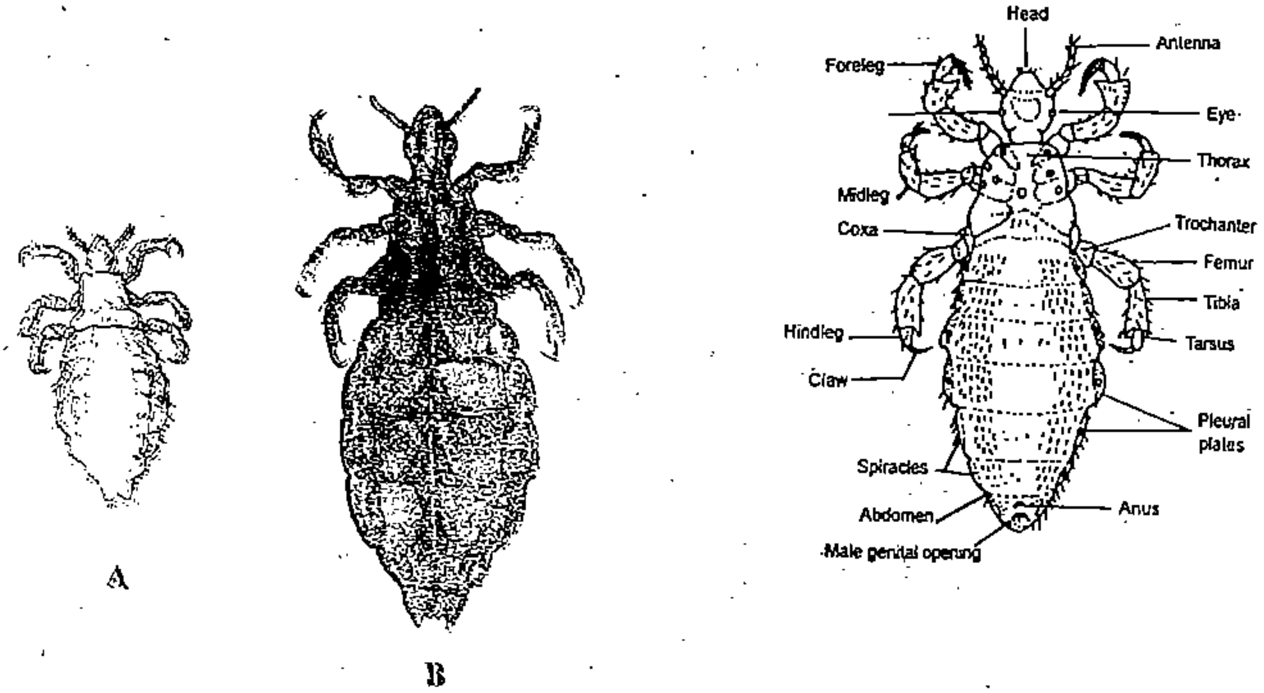

Fig. 15.6: *Pediculus humanus* A – Body louse, B - Head louse

Habit and Habitat

Pediculus humanus is an ectoparasite of humans. It occurs in two varieties viz. *Pediculus humanus capitis* (the head louse) that occurs clinging to the hairs of the head, and *Pediculus humanus corporis* (the body louse that harbous, the trunk region mostly clinging to undergarments) (Fig. 15.6). Head and body lice act as vectors of various humand diseases like relapsing fever, trench fever, and the dreaded epidemic form of typhus fever.

Geographical Distribution

Pediculus humanus is found all over the world.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	because it has a metamerically segmented body with jointed legs.

Class	**Insecta**	because its body is divisible into head, thorax and abdomen and thorax bears three pairs of legs
Sub-class	**Pterygota**	because wings are absent and there is no metamorphosis during development,
Order	**Anoplura**	Wings are secondarily absent; mouth parts are of piercing and sucking type; legs with claws for clinging to the hairs of the host.
Genus	***Pediculus***	
Species	***humanus***	
Common name	**Head louse/Body louse**	

15.9 TERMINAL QUESTIONS

1. Match the insects (given in column I) with their respective orders (given in column II).

I (Insect)		II (Order)	
i)	*Lepsima*	a)	Orthroptera
ii)	*Pediculus*	b)	Odonata
iii)	*Gryllus*	c)	Anoplura
iv)	*Dragonfly*	d)	Thysanura

2. Give two salient features of each of the following insects:

   i) *Mantis:*
   ii) *Lepsima:*
   iii) *Gryllus:*
   iv) Dragonfly:
   v) *Pediculus:*

3. State briefly how the following characters are advantageous to the insects which possess them:

   i) Biting and chewing type of mouth parts of Locusts ....
   ii) Raptorial fore legs of *Mantis* ....
   iii) Total loss of wings in *Pediculus* ....

EXERCISE 16 ARTHROPODA-IV: TWO SOCIAL INSECTS – HONEY BEE AND TERMITE FROM WET PRESERVED OR DRY MOUNTED SPECIMENS

Structure

16.1 INTRODUCTION

Insects of any species that live together in an organized group or colony in an integrated manner such that each contributes in some specialized way to the welfare of the group as a whole are known as **Social Insects**. Colonies of these social insects are **matriarch** i.e. all members of a colony are the offspring of a single female.

Diversity of castes (polymorphism) is observed in social insects and have a division of labour. Members are differentiated into distinct *castes*, which are specialized in structure, function (reproduction, feeding, guarding etc.) and behaviour. Principal castes are categorized as **reproductive** (Queen and King) and the **non-reproductive** or sterile members (workers and soldiers). More than 6000 species of insects exhibit social instinct. In this laboratory exercise, you will study two social insects – honeybee ('madhumakhi') and a termite (white ant or 'deemak'). Both these have highly developed social life and they live in societies.

Objectives

After performing this exercise you should be able to:

- identify, classify and give the scientific and common names of the common honeybee (*Apis*) and a termite,
- identify, classify and name the different castes of honeybee and termite,
- describe the distinguishing features of each of the castes identified,
- list the criteria of considering the particular species as an example of social insects and explain the term polymorphism as applicable to social insects,
- mention the habitat and geographical distribution of the identified genera, and
- mention the economic importance of honeybee and termites.

16.2 MATERIAL REQUIRED

1. A magnifying glass.
2. Compound microscope.
3. Dried preserved specimens of worker, drone and queen honey bee.
4. Dried preserved specimens of winged (alate) termites.
5. Wet preserved specimens of winged (alate) and queen termite.
6. Permanent whole mounts of worker, soldier and nasute termites.
7. Pencil and eraser.
8. Drawing sheets.

16.3 METHOD

Examine the specimens carefully under dissection microscope or using a hand lens and slides under low power of the compound microscope and compare what you have observed with the description and figures provided in the lab exercise. After viewing one specimen/slide you may move to the next until you complete viewing the entire series.

In your notebook sketch, label and write description of (i) queen, drone and worker castes of honeybee and (ii) queen, king, soldier and worker castes of termites.

16.4 HONEYBEE

16.4.1 General Account

Honeybees are social and colonial found all over the world. Honeybees belong to the order Hymenoptera.

In India, three common species of honeybee are found namely *Apis dorsata* (wild bee), *A. florea* and *A. indica*. *A. indica* is the domesticated species for commercial bee-keeping (apiculture).

Honeybee is characterized by two pairs of membranous wings and chewing and lapping mouth parts. The female has a poisonous sting. You can easily see a bee during flowering season of the year in the garden/park in your neighbourhood. The one you will see on a flower will be a worker bee. Its crop is modified into a honey sac and the ovipositor into the sting. The mouth parts, legs and wings show a high degree of specialization.

The honeybees feed on pollen and nectar of flowers and produce honey and beeswax. They communicate with each other through a sign language. Mating occurs in a nuptial (swarming) flight after which males die. Development occurs through complete metamorphosis including the following stages:

Egg ⟶ Larva ⟶ Pupa ⟶ Adult

Eggs hatch on the third day but for completion of metamorphosis and emergence as an adult or imago it takes on an average 13 days for queen, 18 days for worker and 21 days for drone.

The individuals of a flourishing bee colony belong to three types of *castes*. There is usually a single fertile female or **queen**, a few hundred fertile males or the **drones** and the rest, sometimes in thousands, are the sterile females or the **workers**.

16.4.2 OBSERVATIONS OF SPECIMENS OF HONEY BEE (*Apis indica/Apis dorsata*) – Worker, Queen, Drone

1) **Worker bee**

Non-reproducing female. Body divided into 3 parts: head, thorax and abdomen. (Fig. 16.1a)

Note the following features:

HEAD is a triangular structure and bears:

i) a pair of compound eyes;
ii) a group of three ocelli;
iii) a pair of short jointed antennae, and

iv) chewing and lapping type of mouth-parts (a microscopic slide of the permanent mount of mouth-parts of worker honey bee may be available to see the details). (Fig. 16.1b)

THORAX is divided into 3 segments: anterior prothorax; middle mesothorax and the posterior metathorax, each bears a pair of legs.

Mesothorax and metathorax carry a pair of wings on each.

LEGS

All the three pairs of legs are densely covered with hairs which aid in gathering pollen and are variously adapted. Each of the three legs show some characteristic features.

A) **Fore (prothoracic) legs**

i) **Eye brush** on the distal part of tibia for removing pollen and other particles from the surface of the compound eye.

ii) Distal posterior end of tibia has **velum** and **antennae comb** to clean the antennae.

iii) Posterior face of the metatarsal segment bears bristles forming a **pollen brush**. (Fig. 16.1c)

B) **Middle (Mesothoracic) legs**

In **mesothoracic** legs, the inner distal end of tibia is located a long spine like **pollen spur**. These are used to remove pollen from baskets and to dislodge wax from wax pockets on the ventral surface of the abdomen and transferring it for comb-building. (Fig. 16.1c)

C) **Hind (Metathoracic) legs**

i) **Pollen basket** on the outer surface of tibia. It is a depression partially covered by rows of long curved bristles arising from its margin.

ii) Inner surface of the metatarsus bears a series of transverse rows of hard bristles forming the **pollen combs**. (Fig. 16.1c)

WINGS

2 pairs of narrow wings, membranous and transparent. The two wings are coupled together by a series of minute hooks, called **hamuli**, so that they work together as one unit during flight.

ABDOMEN consists of six segments and bears the wax-glands (on the underside) and the sting (at the end).

Wax-glands are modified cells on the ventral surface of the last four segments of abdomen.

Sting is the modified **ovipositor.**

Worker bees are sterile or neuter females arising from fertilised eggs laid by the queen and they live for 4-6 weeks.

The worker bees are repairers, keepers, feeders, fanners, foragers and defenders of the colony.

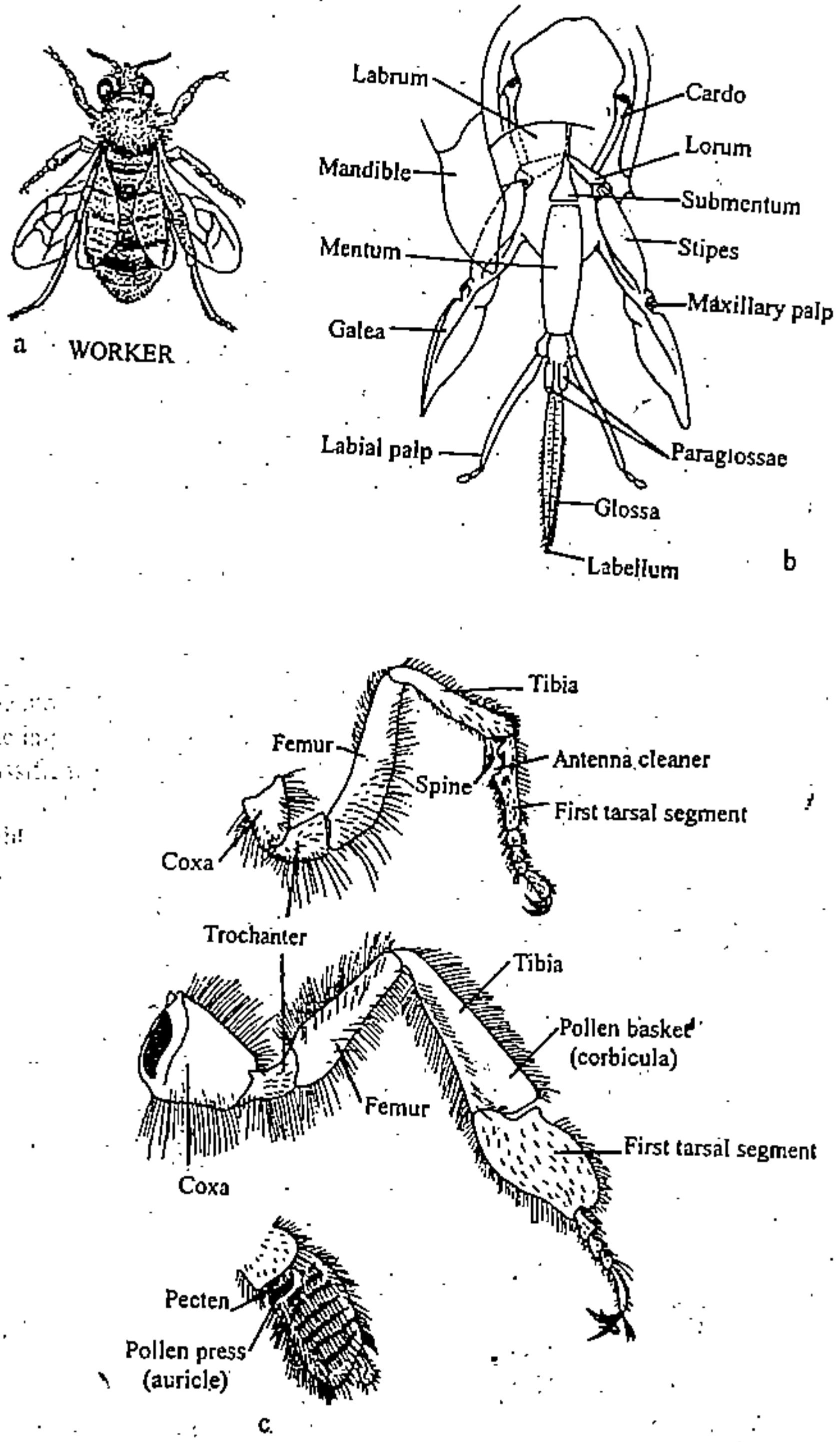

Fig. 16.1: Worker bee. (a) Dorsal view, (b) Dorsal view of the head and mouth parts of worker bee, (c) Each of the three pairs of legs showing special modification.

2) Queen bee

i) Only fertile female with immensely developed ovaries.
ii) Has elongated body with tapering abdomen and short legs and wings.
iii) Mandibles, mouth parts and stings are shorter than those of the worker bee (Fig. 16.2).
iv) Can not produce wax or honey.

v) Can not collect nectar or pollen as legs are devoid of pollen basket, pollen brush etc.
vi) Queen is specialized to lay eggs and mother of all members of the hive.
vii) Queen is a somewhat degenerate individual with a small brain and without salivary glands.
viii) Arises from the fertilized egg and larva that is specially fed on "royal jelly".
ix) Lives for about 5 years and lays several hundreds of eggs per day.

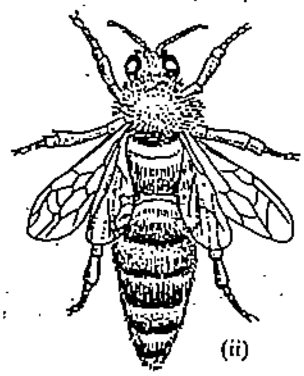

Fig. 16.2: Queen bee.

3) **Drones**

i) These are sexual male bees.
ii) Have stouter and broader built.
iii) Possess very large eyes, small pointed mandibles.
iv) Devoid of wax glands, no pollen collecting apparatus and no sting (Fig. 16.3).
v) Develop parthenogenetically from the unfertilized eggs laid by the queen.
vi) Function is only to mate with queen.
vii) Do not share any other job inside the hive.
viii) Cannot feed themselves, have to be fed by worker bees.
ix) Live for about five weeks.

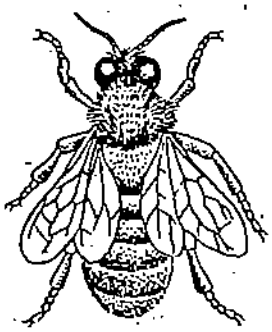

Fig. 16.3: Drone – male bee.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Bilaterally symmetrical, triploblastic and segmented. Body with chitinous exoskeleton. Jointed appendages.
Class	**Insecta**	Body differentiated into head, thorax and abdomen, 3 pairs of legs.
Division	**Endopterygota**	Wings develop internally and metamorphosis complete.

Order	**Hymenoptera**	Membranous wings, mouthparts rasping and lapping type (biting and sucking type), hind wings hooked to articulate with forewings.
Family	**Apidae**	
Genus	**Apis**	
Species	***indica***	
Common name	**Honey bee**	

16.5 TERMITE

The termites are the social insects living in colonies with an elaborate polymorphism. The termites occur throughout the tropics and warm temperate countries. More than 2300 different species are known to exist and they belong to class Insecta, order Isoptera.

16.5.1 General Account

The termites are greatly specialized and destructive insects and are remarkable for their social habits and the elaborate caste system. They either burrow in wood or make sub-terranean nest called **termatarium.** They feed mainly on wood (cellulose). The development occurs through incomplete metamorphosis. Winged termites are the sexual forms which swarm and make pairs of male and female which burrow in the soil and start new colonies.

Body size is small but slightly variable. Termites are soft-bodied insects with a delicate, thin and highly sensitive skin and often blind. Colour of the body is yellow, brown, black or pale but never white though they are called white ants.

Body is distinctly divided into head, thorax and abdomen. Mouth-parts are adapted for biting and chewing with greatly developed mandibles.

The termites exhibit polymorphism. Unlike bees each termite caste comprises both male and female individuals. The principal castes belong to two main categories *fertile castes* and *sterile castes*. The fertile individuals are **queen** and **king** while sterile castes are **workers, soldiers** or **nasutes** in some species. As opposed to worker bees which are sterile females, the worker, soldiers or the nasutes of termites are of both sexes. Of all the social insects only the termites have a king.

The eggs are pale, smooth, oval or elongated. The development is gradual, there is no larval or pupal stage. The *nymph* which hatches from the egg is like the adult except that it is smaller, has no traces of wings and is sexually immature. After moulting several times it reaches the adult stage. Each colony is founded by a *royal couple* (queen and king). In early years, only workers and soldiers are produced but later, *alates* or the winged forms are also produced. Sometimes, a colony contains several reproductive couples.

16.5.2 Observation of Specimens – Alates, Soldiers, Workers, Queen (physogastric) and King

1) Winged termite (alates)

i) Fertile or reproductive female which leaves in parent nest in swarming.
ii) Winged individual but wings are shed soon after swarming and only their truncated bases remain.
iii) Two pairs of wings are very similar in appearance, with strongly pigmented veins in the anterior portion and a basal (humeral) suture along which fracture of the wings occurs, wings are longer than the body (Fig. 16.4 a).
iv) Head is round or oval, carries well developed compound eyes, paired ocelli, moniliform (bead-like segmented) antennae and mandibulate mouth parts.
v) Legs (3 pairs) are very similar, having large coxae and segmented tarsi.

vi) Abdomen with ten obvious segments and 11^{th} tergum having fused with the tenth and 11^{th} sternum being represented by the paraprocts.
vii) Short, segmented cerci are present.
viii) External genitalia are absent.

In physogastric queen (advanced in age), abdomen becomes enormously swollen through hypertrophy of the ovaries and consequent stretching of the intersegmental membrane (Fig. 16.4 b).

i) 20 to 30 times larger than the worker.
ii) Lives for 6 to 9 years and lays several thousands eggs per day.

King termite looks like alate, its abdomen is not enlarged as seen in physogastric queen. Lives together with the queen, mating at frequent intervals.

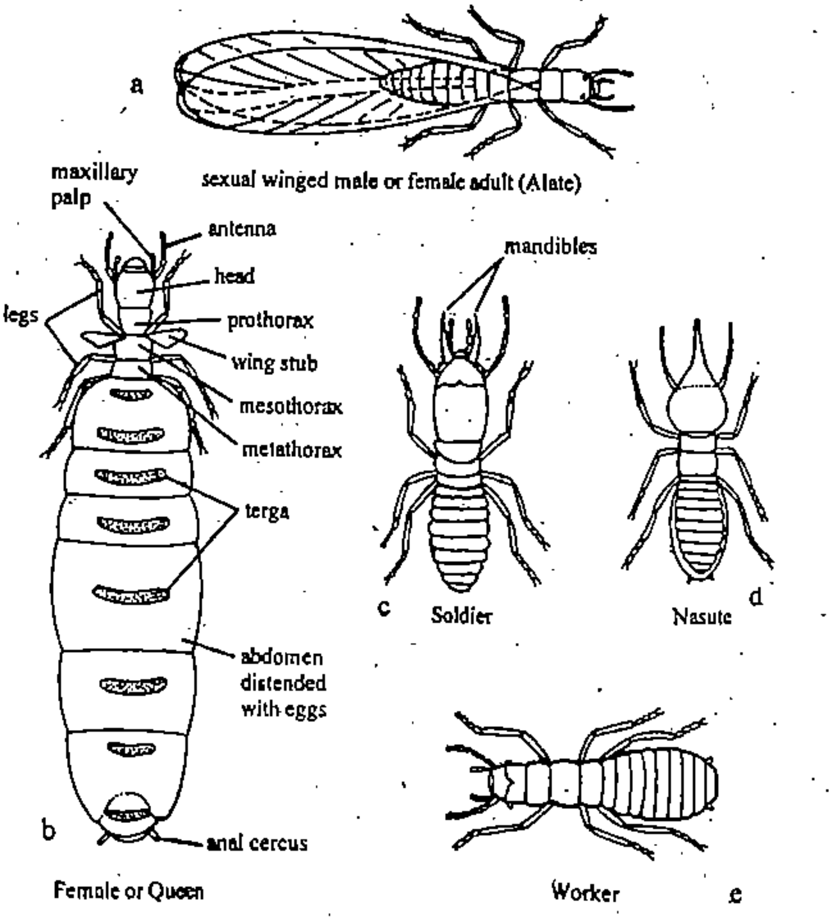

Fig. 16.4: a) Winged termite (alate). b) Queen termite (Physogastric female). c) Soldier termite. d) Nasute soldier (*Eutermes*). e) Worker termite (much enlarged).

2) Soldier termite

i) Wingless body with rudimentary reproductive organs.
ii) Body is divided into head, thorax, and abdomen with 3 pairs of legs (16.4 c).
iii) Head is large, well pigmented and bears a pair of antennae and mouth parts, eyes not well developed.
iv) Mandibles are very large and modified for biting and piercing (pincers).

In **nasute** soldiers of some other species, e.g. *Eutermes* the frons (front of head capsule) is enlarged to form a pointed **rostrum** containing frontal gland (Fig. 16.4 d).

These soldiers are highly specialized for defence function. Sticky secretion of the gland is inflicted upon their enemies in warfare.

3) Worker termites

i) Wingless body with rudimentary reproductive organs.
ii) Body is generally pale and weakly pigmented.
iii) Body divided into head, thorax and abdomen with 3 pairs of legs (Fig. 16.4 e).
iv) Head resembles that of a reproductive caste except that the compound eyes are reduced or absent and the mandibles are more powerful.
v) Carry out functions of keepers, feeders, foragers, nurses, etc.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Bilaterally symmetrical, triploblastic and segmented. With chitinous exoskeleton and joined appendages.
Class	**Insecta**	Body differentiated into head, thorax and abdomen, 3 pairs of legs.
Division	**Exopterygota**	Wings develop externally as buds.
Order	**Isoptera**	Social and polymorphic insects with two pairs of similar wings which are often shed.

Two common genera *Microtermes, Odontotermes*
Common name **Termites (White ant) (English)**
'Deemak' (Hindi)

16.6 TERMINAL QUESTIONS

1. Define the term "polymorphism" in relation to social insects and name various castes of honeybees and termites?

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2. Fill in the blanks

   i) Development of termites is by .... metamorphosis.

   ii) Larva is a stage in .... metamorphosis.

   iii) Nymph is a stage in .... metamorphosis.

   iv) Soldier caste exists in ....

3. Indicate whether the following statements are True or False.

   i) Termites are destructive insects.

   ii) Honeybees are good pollinating agents.

   iii) Honey and wax are produced by queen honeybee.

   iv) Among social insects, only termite colony has a king.

4. Differentiate between queen of honeybee and queen of termite by drawing a labelled diagram and giving their characteristic features?

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EXERCISE 17 ARTHROPODA-V : LIFE HISTORY STAGES OF *ANOPHELES, CULEX* AND *AEDES* MOSQUITOES FROM PERMANENT SLIDES

Structure

17.1 INTRODUCTION

All of us are familiar with mosquitoes due to their bites. Mosquitoes are tiny creatures, slender in appearance and are generally found in damp and marshy places near stagnant water. Mosquitoes are found all over the world except in hilly cold regions. You must have seen mosquito larvae, wriggling in the drains near your house or in stagnant pools of water in your neighbourhood. They are found specially abundantly in the tropics. The females are **sanguivorous** (blood-feeders), feeding on the blood of humans and other vertebrates. The males only suck the juices of flowers, fruits, etc. You will be able to distinguish male from female by the poorer development of their mouth parts and by their bushy antennae. Mosquitoes are nocturnal creatures biting only at dusk or night. They are important from the stand point of human welfare. They transmit several important human diseases like malaria, yellow fever, dengue, filariasis and Japanese encephalitis.

Objectives

After performing this exercise, you should be able to

- identify and differentiate between Anopheline and Culicine mosquitoes,
- identify life-history stages of *Anopheles, Culex* and *Aedes* mosquitoes,
- draw and label life-history stages of above three mosquitoes.

17.2 MATERIAL REQUIRED

1. Specimens/Mounts of eggs, larva, pupa and adults of *Anopheles, Culex* and *Aedes*.
2. Microscope (compound)
3. Practical Note book for record

17.3 METHOD

Examine the slides carefully under low power of the compound microscope and compare what you have observed with the description and figures provided in the lab exercise. After viewing one slide you may move to next until you complete viewing the entire series.

In your note book sketch, label and write the description. The slides which you will be examining and for which descriptions are provided are listed below:

1. Eggs of *Anopheles*
2. Eggs of Culicines – *Culex* & *Aedes*

3. Larva of *Anopheles*
4. Larva of *Culex*
5. Larva of *Aedes*

6. Pupa of *Anopheles*
7. Pupa of *Culex*
8. Pupa of *Aedes*

9. Adult *Anopheles*
10. Adult of *Culex*
11. Adult of *Aedes*

17.4 GENERAL DESCRIPTION ABOUT MOSQUITOES

Before you start studying the slides, carefully go through the description of life cycle of the mosquitoes given in the Introduction and the various figures provided throughout the laboratory exercise. This will help you to become familiar with the various developmental stages in the life-cycle of mosquito.

The mosquitoes belong to the order **Diptera**. There are about 2700 known species. The important genera are *Anopheles*, *Culex* and *Aedes*. Table 17.1 gives the classification of mosquitoes.

Table 17.1: Scientific classification of mosquitoes.

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Bilaterally symmetrical triploblastic and segmented. Limbs jointed, exoskeleton chitinous.
Class	**Insecta**	3 pairs of limbs/legs; Body differentiated into head, thorax and abdomen
Division	**Endopterygota**	Metamorphosis complete
Order	**Diptera**	Only one pair of wings (forewings) is present, hind wings reduced to halteres
Family	**Culicidae**	
Common genera	***Anopheles, Aedes, Culex***	
Common name	**Mosquito**	

The body of a mosquito is about 3 to 6 millimeter long, soft, slender and covered with scales. Colour of the body is greyish to black. Body is divided into three distinct parts: head, thorax and abdomen (Fig. 17.1).

Life cycle of mosquitoes is an example of complete metamorphosis. It includes the following stages:

Egg ⟶ Larva (Aquatic) ⟶ Pupa (Aquatic) ⟶ Adult (Terrestrial/aerial)

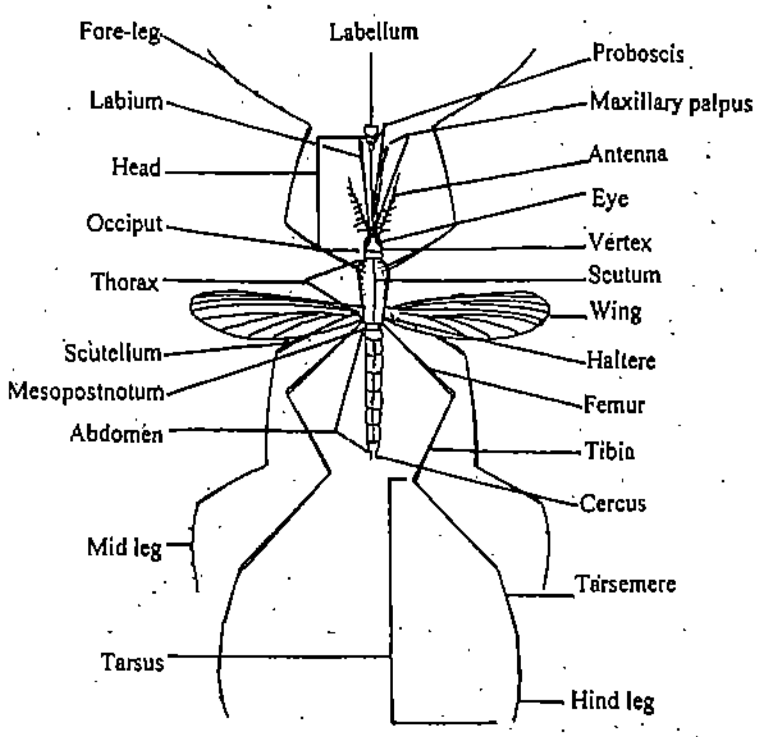


Fig. 17.1: General diagram of a female adult mosquito.

Table 17.2: Differences between Anopheline and Culicine mosquitoes.

Culicines	Anophelines
EGGS	
1. **Shape:** Elongated, cigar-shaped and no lateral air floats.	1. Boat-shaped with paired lateral air-floats which help in floatation.
2. **Manner of laying:** The eggs are laid vertically on the surface of water singly in *Aedes* and in raft in *Culex*.	2. Eggs are laid singly and horizontally on the water surface and remain separate.
3. **Number:** 100-170 eggs are laid at a time by female.	3. The number of eggs laid at a time varies from 80-140.
4. **Medium:** The eggs are laid in dirty water collected in the vicinity of houses in *Culex* while in *Aedes* eggs are laid on moist surface at the water's edge. Withstand desiccation.	4. The eggs are laid in clear and fresh water. (Fig. 17.2)
LARVA	
1. **Posture:** The larva hangs from the surface of water position forming an angle of 45° with the water surface with head down.	1. The larva lies horizontally parallel to water surface.
2. **Feeding habit:** It is bottom feeder, because the head lies at the bottom. It feeds on the microscopic organisms present at the bottom of the pond.	2. It is surface feeder and utilizes the food present in the upper strata of water.
3. **Respiratory siphon:** The respiratory siphon is long, tubular and conical, the opening of which can be closed by lid like terminal flaps.	3. The respiratory siphon is very much reduced or absent because the spiracles are situated on 8^{th} segment of abdomen.
4. **Dorsal hair:** Dorsal palmate hair are absent.	4. Palmate hair are present on the dorsal surface of abdominal segment from 2^{nd} to 7^{th}.
5. **Tracheal gills:** The last abdominal segment carries four tracheal gills.	5. Tracheal gills are wanting. (Fig. 17.2)
PUPA	
1. The respiratory trumpets are long and narrow and with small terminal aperture.	1. The respiratory trumpets are small, broad and with large terminal opening. (Fig. 17.2)

ADULT	
1. **Body built:** The body of *Culex* is well built with legs.	1. The body of *Anopheles* mosquito is slender and delicate and the legs are weak.
2. **Body colour:** The body is greyish and without hair. In *Aedes*, body highly ornamented with silvery spots/bands on thorax, abdomen, legs.	2. The body is greyish in colour and covered with hair.
3. **Wings:** Wings spotted with only dark scales.	3. Wings spotted with white and dark scales.
4. **Abdomen:** Abdomen is covered with uniform rows of overlapping flat white and dark scales.	4. Abdomen is without scales or with few scattered scales.
5. **Scutellum:** The scutellum is trilobed.	5. The scutellum is rounded.
6. **Resting posture:** When at rest, proboscis and body are not in a straight line, the abdomen being inclined towards resting surface.	6. When at rest, proboscis, head, throax and abdomen are in a straight line with abdomen pointing away from the resting surface making an acute angle with the surface.
7. **Maxillary palps:** The maxillary palps of male are longer than the proboscis and those of female are shorter than the proboscis.	7. The maxillary palps are as long as the proboscis in both the sexes, but are clubbed at the distal ends in male. (Fig. 17.2)

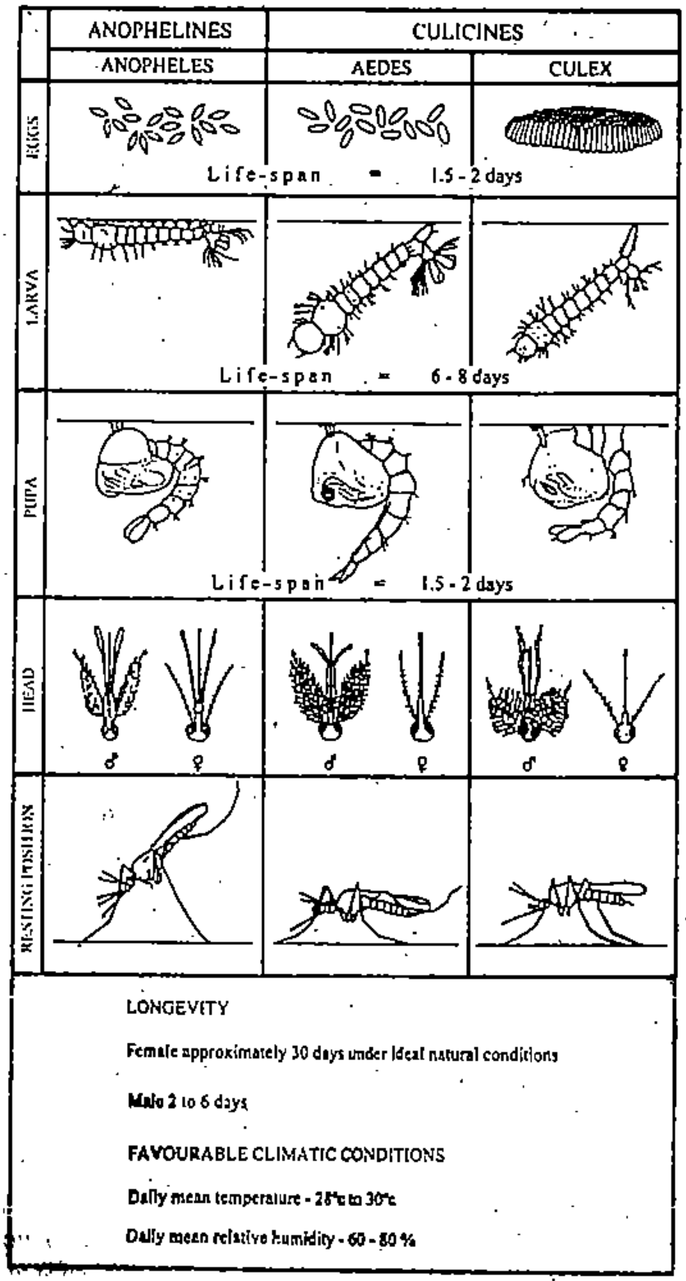


Fig. 17.2: Differences between various developmental stages of *Anopheles*, *Culex* and *Aedes* mosquitoes.

17.5 OBSERVATION OF LIFE-HISTORY STAGES OF *ANOPHELES, CULEX* AND *AEDES*

You are now familiar with the life-stages of mosquitoes. Now we provide you a brief description of stages of mosquito life cycle. You should sketch what you observe under the microscope in your notebook. Label and give the descriptive features.

17.5.1 Eggs

a. Eggs of *Anopheles*

i) About 0.5 – 1.0 mm in length.
ii) Boat-shaped and with paired lateral air-floats.
iii) Laid singly on clear water.
iv) Egg has a flattened upper surface the "deck" and keel-shaped lower surface remains submerged.
v) Colour of the eggs is brown but when freshy laid it is white (Fig. 17.3).

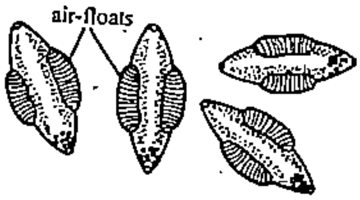


Fig. 17.3: Egg of *Anopheles.*

b. Eggs of *Culex*

i) Laid in raft
ii) Raft measures 3-4 mm long and 2-3 mm wide.
iii) Devoid of air-floats
iv) Eggs are tapered at the free end (Fig. 17.4).

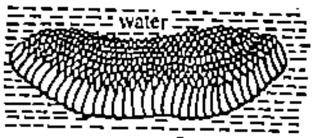


Fig. 17.4: Egg of *Culex.*

c. Eggs of *Aedes*

i) Elongated, tapered at the end and blackish in colour.
ii) Laid in a batch but not attached to each other
iii) Air-floats absent
iv) Laid on the moist surface at the water's edge and not the water itself.
v) Can withstand desiccation (Fig. 17.5).

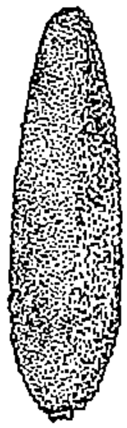


Fig. 17.5: Egg of *Aedes.*

17.5.2 Larvae

a. Larva of *Anopheles*

i) Commonly known as wriggler.
ii) Body elongated and differentiated into head, thorax and abdomen.
iii) Head with paired compound eyes, antennae, mandibulate mouth-parts and feeding brushes.
iv) Thorax is unsegmented and broader than the head or abdomen, flattened and limbless.
v) Thorax has several groups of hair.
vi) Abdomen is long and cylindrical, comprised of 9 segments.

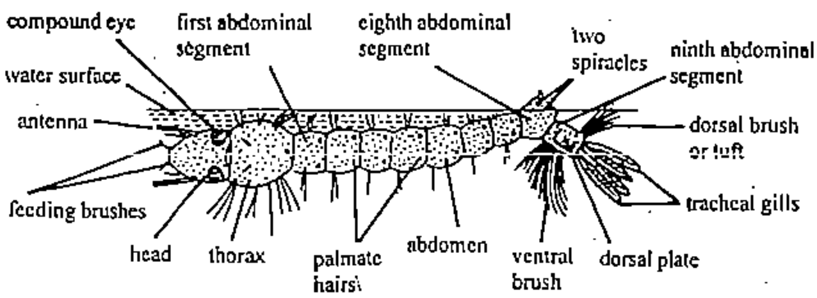


Fig. 17.6: Larva of *Anopheles.*

vii) First segments are similar and each has palmate hair.

viii) 8^{th} and 9^{th} segments are modified and 8^{th} segment bears the respiratory apparatus which consists of paired spiracles.
ix) Ninth abdominal segment bears rudder bristles and tracheal gills.
x) It rests horizontal and parallel to the water surface.
xi) Larva hatches into pupa (Fig. 17.6).

b. Larva of *Culex*

i) Body is divided into 3 parts: Head, Thorax and Abdomen.
ii) Head has a pair of compound eyes, a pair of jointed antennae, in front, you will see a pair of special branches of hair, known as *feeding brushes*.
iii) Thorax is slightly broader than head, unsegmented and limbless.
iv) Thorax bears 3 pairs of lateral tufts of hair, each tuft springing from a small tubercle.
v) On the dorsal side of 8^{th} abdominal segment is located a long tube which is *respiratory siphon*. At the tip of the siphon, a pair of *spiracles* are present, which are opening of tracheal system.
vi) To the last segment are attached four small leaf like *tracheal gills* surrounding the anus. These tracheal gills contain tracheae and probably take oxygen dissolved in water.
vii) The last segment also bears a tuft of rudder *bristles* which helps in swimming.
viii) Palmate hair are absent (Fig. 17.7).

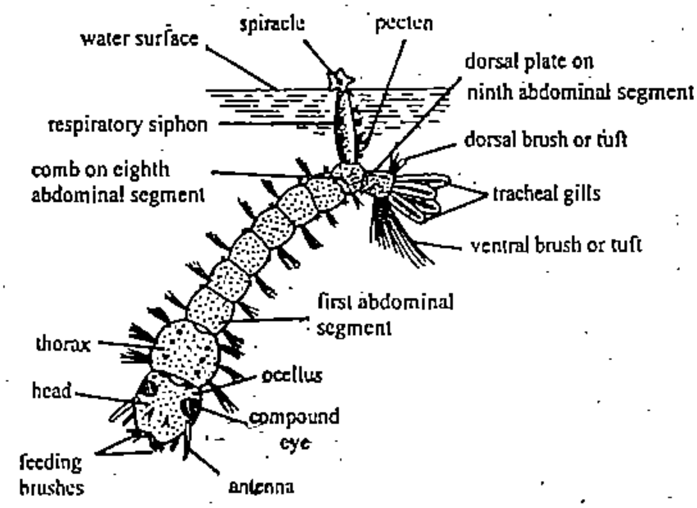


Fig. 17.7: Larva of *Culex*.

c. Larva of *Aedes*

i) Cylindrical and elongated form.
ii) White in colour except head and siphon which are black in colour.
iii) Head is globular and is small in relation to thorax.
iv) Head carries feeding brushes, antennae.
v) Antennae are small, cylindrical and smooth.
vi) Thorax is roughly globular in shape and contains lateral hair.
vii) Abdomen 9 segmented, 8 equal segments with a small additional terminal anal segment.
viii) Each segment carries a series of hair.
ix) At the posterior lateral aspects of the 8^{th} segment in each side is conspicuous row of spiny scales, comb teeth, forming a single row of 8-12 teeth.
x) Respiratory siphon on the 8^{th} segment.
xi) Anal gills on the last segment (Fig. 17.8).

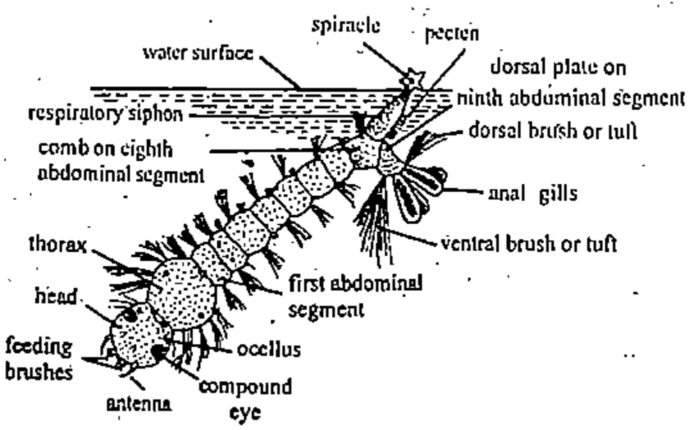
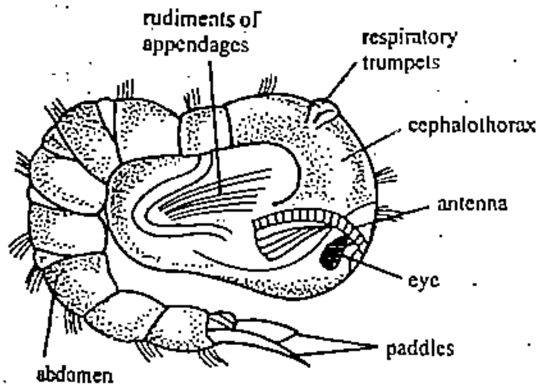


Fig. 17.8: Larva of *Aedes*.

17.5.3 Pupae

a. Pupa of *Anopheles*

i) Body comma-shaped, differentiated into cephalothorax and abdomen.
ii) Abdomen eight-segmented with the pair of paddles at the tip and flexed below the cephalothorax.
iii) Respiratory trumpets shorter than those of pupa of *Culex* and on the upper surface.
iv) Cephalothorax covered by transparent puparium.
v) Compound eyes on the sides of the head.
vi) Non-feeding stage but very active.
vii) Emerges into terrestrial imago (Fig. 17.9).



Pupa of *Anopheles*

Fig. 17.9: Pupa of *Anopheles*.

b. Pupa of *Culex*

i) Body comma-shaped, differentiated into cephalothorax and abdomen.
ii) Respiratory trumpets large and funnel-shaped.
iii) Cephalothorax covered by transparent puparium.
iv) Compound eye on the side of the head.
v) Non-feeding but very active stage.
vi) Emerges into adult mosquito which is terrestrial (Fig. 17.10).

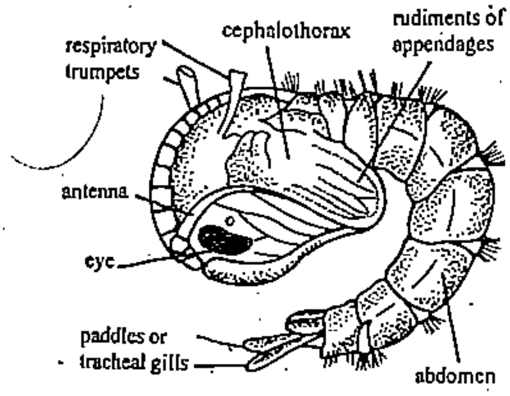


Fig. 17.10: Pupa of *Culex*.

c. Pupa of *Aedes*

i) Comma-shaped.
ii) Body divided into cephalothorax and abdomen which is flexible.
iii) Breathing trumpets are cylindrical in shape.
iv) Tail fins or paddles are almost circular in shape, being slightly longer than broad.
v) Non-feeding but very active stage.
vi) Intermediate stage between larval and adult mosquito (Fig. 17.11).

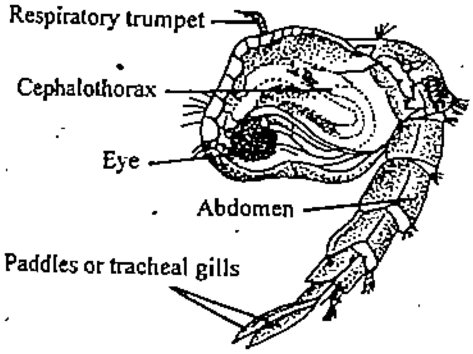


Fig. 17.11: Pupa of *Aedes*

17.5.4 Adults

a. Adult *Anopheles*

i) Body is divided into head, thorax and abdomen.
ii) Head bears mouth parts, compound eyes and antennae.
iii) Maxillary palps are as long as the proboscis in both the sexes but clubbed at the distal end in the male.
iv) The thorax carries a pair of wings, three pairs of legs and a pair of halteres.
v) Abdomen has 8 similar segments.
vi) Last segment is modified into terminalia for mating and for ovipositing.
vii) Rests at an angle keeping proboscis, head, thorax and abdomen in a straight line.
viii) Breeds in clean ponds, rain water collections, slow moving streams (Fig. 17.12).

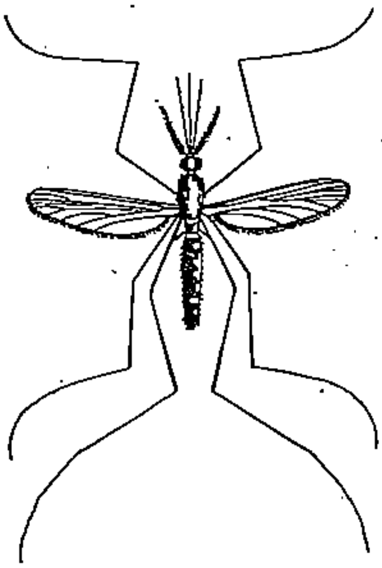


Fig. 17.12: Adult *Anopheles* mosquito.

b. Adult *Culex*

i) Stronger body than that of *Anopheles*.
ii) Body is divided into head, thorax and abdomen.
iii) Head bears mouth-parts, compound eyes and antennae.
iv) Maxillary palps of male are longer than the proboscis and those of females are shorter than the proboscis.
v) The thorax carries a pair of wings, three pairs of legs and a pair of halteres.
vi) Wings have only dark spots.
vii) Abdomen has 8 similar segments.
viii) Last segment is modified into terminalia for mating and for ovipositing.
ix) Rests parallel to the surface, proboscis and body being not in straight line, the abdomen being inclined towards the resting surface.
x) Breeds in polluted water pools such as soakage pits, and ponds of sewage works (Fig. 17.13).

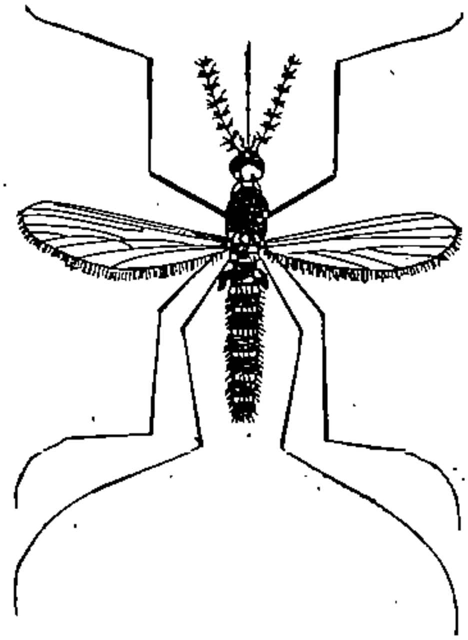


Fig. 17.13: Adult *Culex* mosquito.

c. Adult *Aedes*

i) Body highly ornamented and divided into head, thorax and abdomen.
ii) Head bears mouth-parts, compound eyes and antennae.

iii) Maxillary palps of male are longer than the proboscis and those of females are shorter than the proboscis.
iv) Thorax has relatively large accomodative legs, wings and the halteres.
v) Abdomen 9 segmented, 1st eight segments are similar, while 9th is modified for reproductive funtion.
vi) Brilliant silvery broad scales on the thorax and white spots on the legs.
vii) In abdomen markings are formed by white, pale or yellow scaling shown up on a black background.
viii) Basal banding on abdomen is pale.
ix) Container breeder i.e., breeds in vases, waterjars, tyres, desert coolers, overhead water tanks etc.
x) Urban mosquito (very common in cities)
xi) Bites during day time (Fig. 17.14).

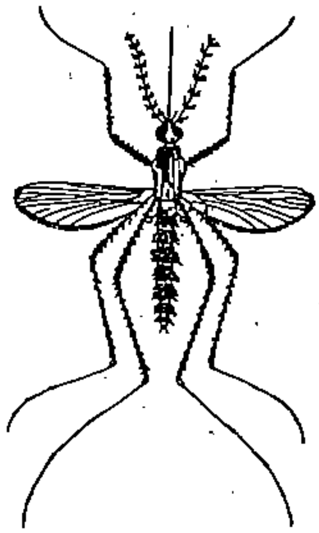


Fig. 17.14: Adult *Aedes* mosquito.

17.6 TERMINAL QUESTIONS

1. With the help of labelled diagram show the different stages in the life cycle of *Anopheles*. (No description)

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2. Draw a labelled diagram of larva and pupa of *Anopheles* and *Culex* mosquito.

3. Fill in the blanks.
   i) Life cycle of a mosquito is an example of .... metamorphosis.
   ii) A mosquito has .... pair of wings.
   iii) Body of mosquito is divided into .... regions.

EXERCISE 18 PREPARATION OF PERMANENT MOUNTS OF MOUTH-PARTS OF COCKROACH AND MOSQUITO

Structure

18.1 INTRODUCTION

The insects inflict losses and injuries to humans and their possessions by eating or feeding or by transmitting diseases through their bites. Hence, mouth-parts form very important organs of an insect. Depending upon the feeding habits, mouth-parts of insects show many specializations in form and development. The study of the mouth-parts of insects is one of the most important aspects as they play a major role in planning the pest control strategies. Mouth-parts include two distinct pairs of appendages, i.e. *mandibles*, and the *first pair of maxillae*; one median *labium* or lower lip represented by a united pair of second maxillae, and *labrum* or upper-lip and a *hypopharynx*. Two important modifications of the mouth-parts in consideration with the nature of food and the manner of feeding (biting and chewing type and piercing and sucking type) will be described in this exercise.

Objectives

After performing this exercise you should be able to:

- identify, and prepare the mounts of mouth-parts of cockroach and mosquitoes,
- distinguish between mouth-parts of cockroach and mosquitoes,
- distinguish between mouth-parts of *Culex* and *Anopheles* mosquitoes, and
- distinguish between mouth-parts of male and female *Culex* and *Anopheles* mosquitoes.

18.2 MATERIAL REQUIRED

1. Compound microscope
2. Potassium hydroxide (Caustic soda)
3. Test tube
4. Test tube holder
5. Bunsen burner
6. Petri dishes/Watch glass
7. Dissecting needles
8. Forceps (small)
9. Absolute alcohol
10. Clove oil/xylol
11. Canada Balsam
12. Microslides
13. Cover glass
14. Glycerine
15. Practical Record book
16. Specimens of Cockroach
17. *Culex* Mosquitoes (Male and Female)

18.3 METHOD FOR THE PREPARATION OF MOUNT OF MOUTH-PARTS OF COCKROACH

For examination of the mouth-parts, take out the head of a fresh specimen.

Macerate the muscle tissue of the head by boiling in 10 per cent caustic soda solution (Fig. 18.1 a). Use a pin in the test tube to reduce "bumping". Remove the test tube from the flame at frequent intervals and observe the head. When it sinks quickly and remains on the bottom of the test tube, it has been boiled enough.

Rinse thoroughly, being careful not to get any of the caustic soda on hands, clothes or table.

Removing the Mouth-Parts: Hold the cockroach head by means of a dissecting-needle inserted through the neck and remove the mouth parts one by one as described below. Use fine forceps to lift the labium, hold it near its base and pull gently (Fig. 18.1 b).

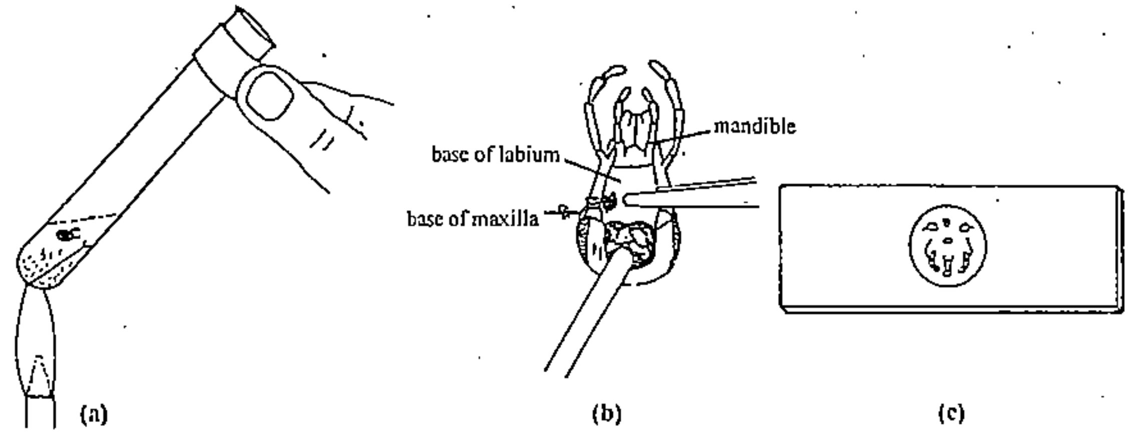

Fig. 18.1: (a) Boiling the macerated muscle tissue of head. (b) Lifting the labium with forceps. (c) Arrangement of mouth points to make tidy mount.

If the labium does not come away easily the muscle is insufficiently macerated and the head should be boiled again in caustic soda.

(NOTE: BE VERY CAREFUL NOT TO DAMAGE THE OTHER MOUTH-PARTS. USE A LENS IF NECESSARY TO IDENTIFY THE PARTS. NEVER LET THE HEAD OR MOUTH-PARTS BECOME DRY).

Place the labium in water in a watch glass/cavity block in a safe place.

Similarly, remove the maxillae and the hypopharynx, slipping the forceps under each part in turn and holding it as near the base as possible when making the final pull.

Place the maxillae and hypopharynx with the labium.

Similarly, remove the mandibles. Cut off the labrum with a small piece of the clypeus. Place the mandibles and labrum with the other mouth-parts.

Dehydration and mounting: Dehydrate the mouth-parts directly by soaking in 70% and then absolute alcohol. Clear in clove oil. Mount in balsam.

(Note: To make a tidy mount, place the mouth-parts in the arrangement shown in Fig. 18.1 c and as close together as possible without actually touching. Make a ring of balsam round them. The ring should be smaller in diameter than the cover-slip. Place a drop of balsam on the cover-slip. Invert the cover-slip rapidly and lower it gently into place so that the drop of balsam on it strikes the middle of the ring of balsam on the slide).

18.4 OBSERVATION OF COCKROACH MOUTH-PARTS UNDER MICROSCOPE

You are now familiar with the mouth-parts of cockroach. You should sketch the mouth-parts as you observe these under the microscope in the record notebook. Label and describe the various parts.

Mouth-parts of Cockroach:

i) Mouth-parts are of biting and chewing type or mandibulate type.
ii) Mandibles broad and plate-like with inner margins serrated, adapted for biting and chewing the food.
iii) Maxillae consist of:
   a) Basal part protopodite formed of cardo and stipes.
   b) Outer part exopodite forms maxillary palp.
   c) Inner part endopodite formed of lacina and galea.
iv) Labium forms the lower lip and is formed of:
   a) Basal part – having submentum, mentum and prementum.
   b) Outer part – represented by paired labial palps.
   c) Inner part – formed of paired glossae and paraglossae.
v) Hypophyrynx tongue-like with opening of salivary ducts.
vi) Labrum and epipharynx form upper-lip. (Fig. 18.2)

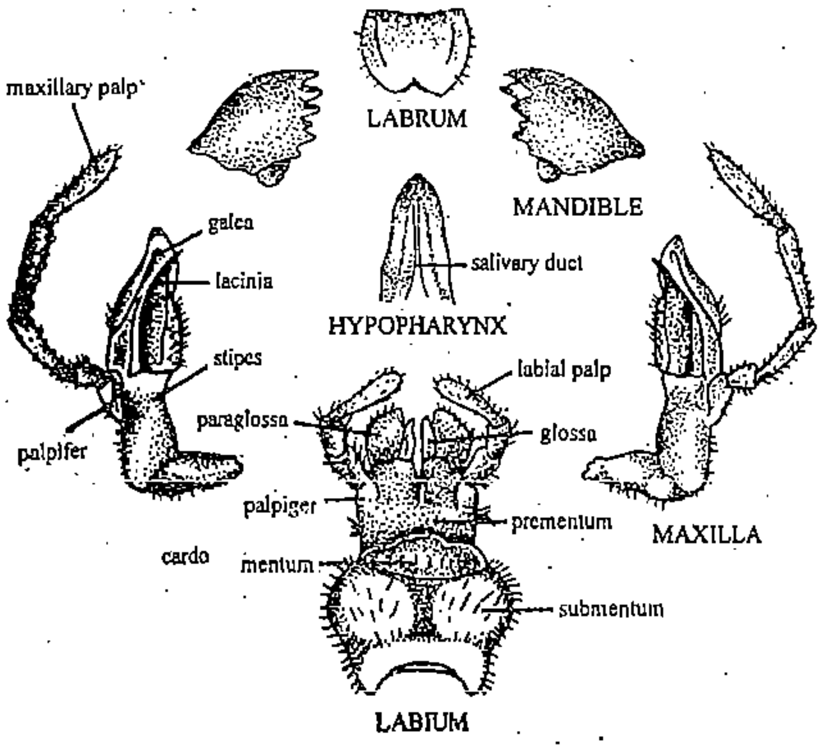

Fig. 18.2: Mouth-parts of Cockroach.

18.5 METHOD FOR THE PREPARATION OF MOUNTS OF MOUTH-PARTS OF MOSQUITO

1. Decapitate (remove the head) the mosquito (*Culex* or *Anopheles* whichever is provided) and treat the head with 10% potassium hydroxide solution either by leaving it in the solution for several hours at room-temperature or heating to boiling for 1-2 minutes. This process softens the stiff mouth-parts so that they will spread when the head is transferred to mounting media.
2. Rinse the head in water.
3. Transfer the head with the help of a dissecting needle to a drop of glycerine on a slide.
4. Put the coverslip.
5. Apply gentle pressure on coverglass with a needle to spread out the mouth-parts at least near the tips to make identification easier.

Mouth-parts of mosquito include the following:

i) The *labium*, which normally encloses several other parts making up the *proboscis*. The labium is grooved dorsally to receive these parts and provided distally with a pair of short labella that have been interpreted as the labial palp.
ii) A *pair of jointed maxillary palps*.
iii) A *pair of maxillae* which may be recognized by the distinct serration or teeth along the edge of the distal tip.
iv) A *pair of mandibles* with a blade-like tips which are very finely serrated.
v) The *labrum-epipharynx* which is much heavier than the mandibles and maxillae and is grooved ventrally and
vi) The slender *hypopharynx* with the salivary duct extending through the middle of it.

18.6 OBSERVATION OF MOSQUITO MOUTH-PARTS UNDER MICROSCOPE

You are now familiar with the mouth-parts of a mosquito. Sketch the mouth-parts of *Anopheles* and *Culex* mosquitoes (male and female) as you observe under the microscope, label and describe the various parts.

Mouth-parts of *Culex*

i) Mouth-parts piercing and sucking type with labium modified into an elongated proboscis.
ii) Maxillary palps very small at the base of proboscis in female and pointed and longer than the proboscis in male.
iii) Maxillae and mandibles in the form of elongated needle-like styles in females and adapted for cutting and making wound in the host skin, mandibles and maxillae reduced in males.
iv) Antennae are pilose with short and few hairs of bristles in female and bushy (plumose) in male. (Fig. 18.3)

Mouth-parts of *Anopheles*

i) Mouth-parts-piercing and sucking type with labium modified into an elongated proboscis.
ii) Maxillary palps are simple, and nearly equal to the proboscis, in males maxillary palps are club-shaped at the distal end.
iii) Mandibles, maxillae and hypopharynx in the form of elongated stylets. Mandibles and maxillae reduced in males.
iv) Antennae less bushy i.e. with small scanty hair in female and plumose (bushy) in males. (Fig. 18.4)

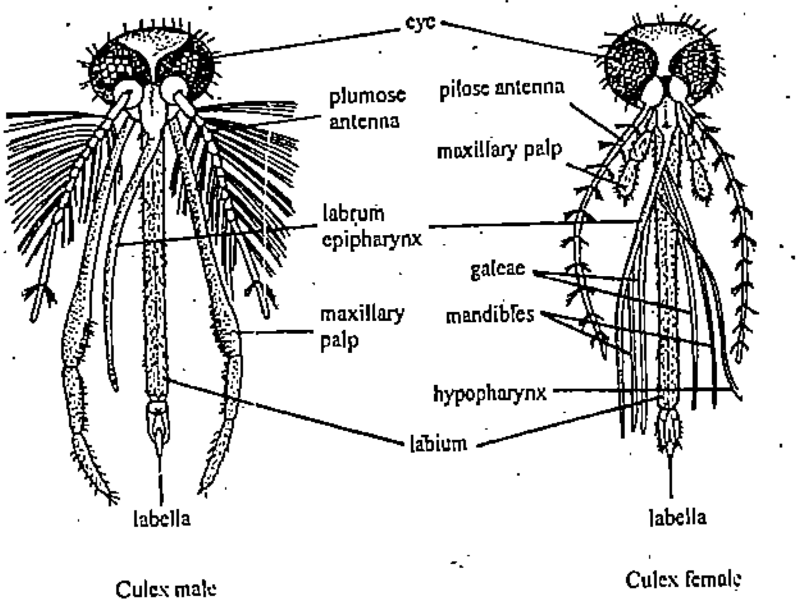

Fig. 18.3: Mouth-parts of *Culex*, A – Male, B – Female.

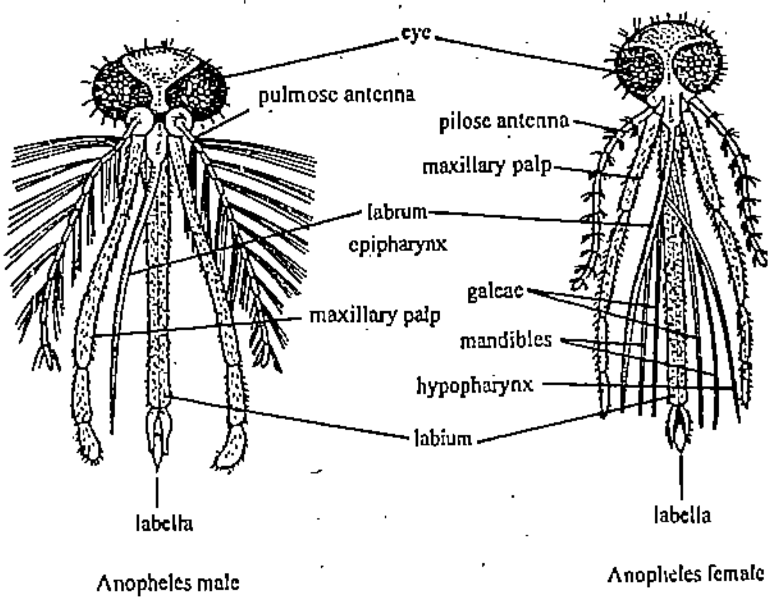

Fig. 18.4: Mouth-parts of *Anopheles*, A – Male B – Female.

18.7 TERMINAL QUESTIONS

1. Draw a labelled diagram of mouth-parts of cockroach and mention the method of feeding.

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2. List the differences between mouth-parts of i) male and female *Culex* and ii) male and female *Anopheles*.

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EXERCISE 19 STUDY OF THE FRUITFLY *DROSOPHILA* FROM MOUNTED SPECIMEN

Structure

19.1 INTRODUCTION

Drosophila commonly known as fruitfly or vinegar fly, belongs to the order Diptera of class Insecta under Phylum Arthropoda. It is a small insect about 2 mm size, has a yellowish brown to rusty brown body and clear, unmarked wings.

D. melanogaster is well-known as an excellent genetic material for chromosomal studies and is easy to culture. Its larvae can easily be reared on artificial media for experimental investigations.

Objectives

After performing this exercise you should be able to:

- identify the fly,
- describe its diagnostic features,
- draw a diagram to show its external features.

19.2 MATERIAL REQUIRED

1. Hand lens
2. Compound microscope.
3. Mount of *Drosophila*
4. Practical Record Book

19.3 METHOD AND OBSERVATIONS

Examine the permanent mounts of the specimens of adult fruit fly under low power of microscope and note the following features:

i) Small insect having only one pair of forewings with few veins.
ii) Hindwings are represented by a pair of balancers or halteres.
iii) Body divided into head, thorax and abdomen.
iv) Head bears large compound eyes, 3 ocelli and plumose type antennae, having 2 basal segments and a fringed flagellum.
v) Mouth-parts are of sucking type. Feeds upon fermenting fruits.
vi) Broad thorax bears bristles.
vii) Abdomen has dark posterior bands.
viii) Metamorphosis is complete consisting of egg, larva, pupa and adult.
ix) Examine the specimen to verify the features listed above.

You should sketch what you observe under the microscope in the record note book, label and give the descriptive features.

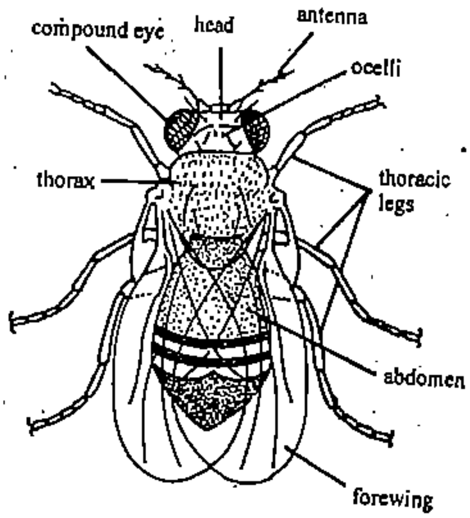

Fig. 19.1: *Drosophila melanogaster.*

Classification and its Justification

Drosophila : (Fruitfly)

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Arthropoda**	Bilaterally symmetrical, triploblastic and segmented. Limbs jointed, exoskeleton chitinous
Class	**Insecta**	3 pairs of legs, wings present
Division	**Endopterygota**	Metamorphosis complete
Order	**Diptera**	Forewings present, hind wings reduced to halteres
Family	**Drosophilidae**	
Scientific name	***Drosophila***	
Common name	**Vinegar fly, Fruit fly**	

Habit and Habitat

In the household, we usually come across these flies at the end of summer and the beginning of autumn, when they are seen flying showly in masses on fermenting fruits, very common on banana and on exposed foods. About 1000 species are known. It is a synanthropic (close association with human beings) species causing damage in the food industry, where absolute hygienic conditions are main defense against them. The larvae speed up the decomposition of fruits, vegetables, jams, cheese and foodstuffs and the adult fly causes further damage by spreading yeast cells over them.

Distribution

This is a cosmopolitan species distributed over the whole globe.

19.4 TERMINAL QUESTIONS

1. Draw a labelled diagram of *Drosophila* giving salient features?

2. Why *Drosophila* is called a synanthropic species?

3. Why is *Drosophila* classified under order Diptera of the class Insecta?

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EXERCISE 20 THE COMMON COCKROACH *PERIPLANETA AMERICANA* – EXTERNAL FEATURES, DISSECTION AND TEMPORARY MOUNTS

Structure

20.1 INTRODUCTION

Cockroach is a reddish brown insect and is cosmopolitan in distribution. Cockroach is one of the commonest insects, easy to obtain, maintain in the laboratory for variety of studies and for performing physiological experiments. It is large in size, easy to handle and convenient for dissection and mounts. Its body is dorsoventrally flattened, elongated and bilaterally symmetrical. You can distinguish a male and female cockroach by examining its external features. You can observe the male and female reproductive organs by dissecting it. While dissecting the head and upper region of cockroach, you can observe the mouth parts and salivary glands and mount them.

Objectives

After performing this exercise, you should be able to:

- trace its alimentary canal,
- mount its salivary glands,
- mount its mouths parts,
- trace male/female reproductive organs of cockroach and draw their labelled diagrams.

20.2 MATERIAL REQUIRED

1. Anaesthesized cockroach
2. Dissection Tray
3. Dissection Box
4. Record Book, pencil and eraser

20.3 EXTERNAL FEATURES OF COCKROACH

Take a freshly killed cockroach (killed with chloroform vapours) and put it in the dissecting dish. Identify and note the following features (Fig. 20.1):

1. Body is dorsoventrally flattened, elongated and bilaterally symmetrical.
2. Colour is reddish brown. There are two black patches on prothorax.
3. Body is covered by cuticular exoskeleton.
4. Body is differentiated into head, thorax and abdomen.

5. Head is roughly triangular and hangs at right angles to the axis of body. It bears compound eyes, antennae and mouth-parts.

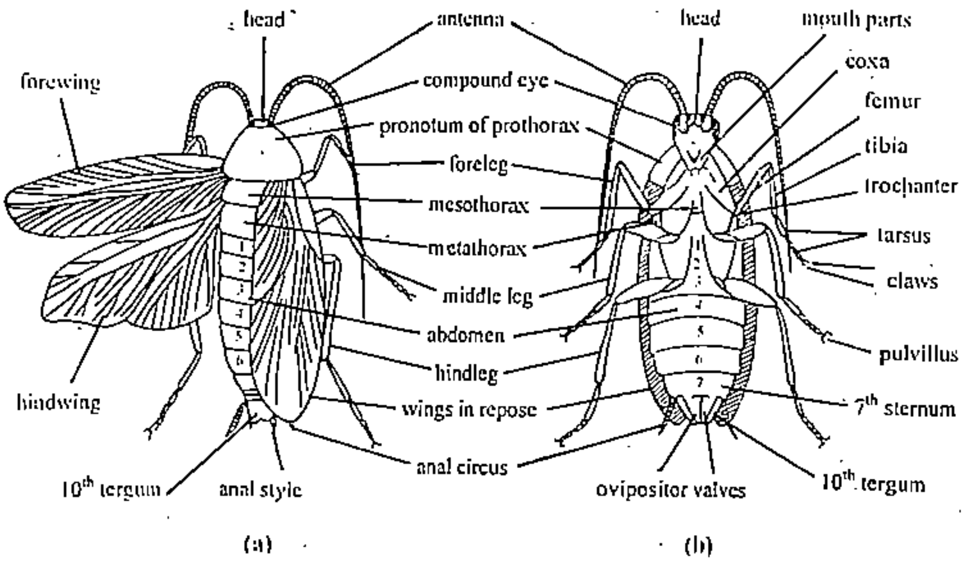


Fig. 20.1: (a) Dorsal view of a cockroach. (b) Ventral view of a cockroach.

6. Three segments in the thorax - prothorax, mesothorax and metathorax.
7. Two pairs of wings attached to mesothorax and metathorax dorsally.
8. Three pairs of legs attached to mesothorax and metathorax dorsally.
9. Out of two pairs of wings, first pair is thick and known as tegmina and second pair of wings is membranous.
10. Legs end in claws and are well adapted for walking on vertical surfaces. Each leg consists of coxa, trochanter, femur, tibia, tarsus, pulvillus and claws.
11. Ten segments in the abdomen which are without appendages. Terga of 8^{th} and 9^{th} are partially overlapped by the tergum of 7^{th} segment. Tergum of tenth segment is bifid and carries anal cerci in both sexes. In case of male the abdomen also carries in addition to a pair of anal cerci one pair of anal styles. In the first abdominal sides of the body, eight pairs of spiracles or stigmata are present.
12. There are 10 pairs of spiracles, two of which are located on the sides of meso- and metathorax and eight pairs on the sides of abdomen.

Differences between male and female cockroach are shown in figure (Fig. 20.2) and tabulated below:

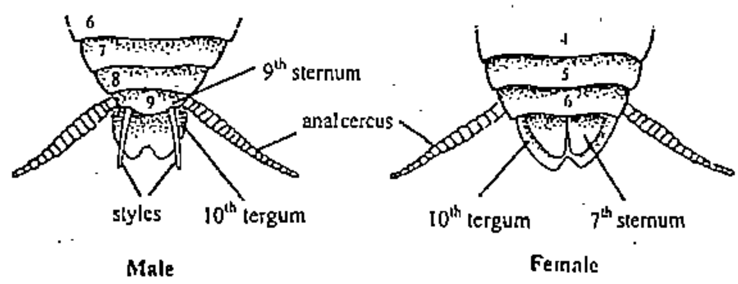


Fig. 20.2: Differences between male and female cockroach.

Table 20.1: Differences between Male and Female Cockroach

Male Cockroach	Female Cockroach
1. Abdomen narrow	1. Abdomen broad
2. Sternum of 7th segment not bifid	2. Sternum of 7th segment bifid and produced backwards into boat shaped genital pouch
3. Abdominal appendages - two pairs - anal cerci and anal styles	3. Abdominal appendages - one pair - only anal cerci (no anal styles)
4. Genital aperture between 9th and 10th sternum.	4. Genital aperture on 8th sternum.

20.4 DISSECTION

20.4.1 Alimentary Canal of Cockroach

Procedure:

1. Put chloroformed cockroach in the dissecting tray with ventral side facing upwards to determine the sex. Now invert it so as to face the dorsal side upward for proceeding with the dissection.
2. Remove the wings and give the incision along the lateral sides, thereby cutting the arthrodial membrane between terga and sterna.
3. Remove the tergal plates one by one carefully without disturbing the internal organs.
4. Remove all the fat bodies with the help of brush and expose the alimentary canal and display it on one side of the body.
5. Separate out salivary glands from the crop and spread them carefully.

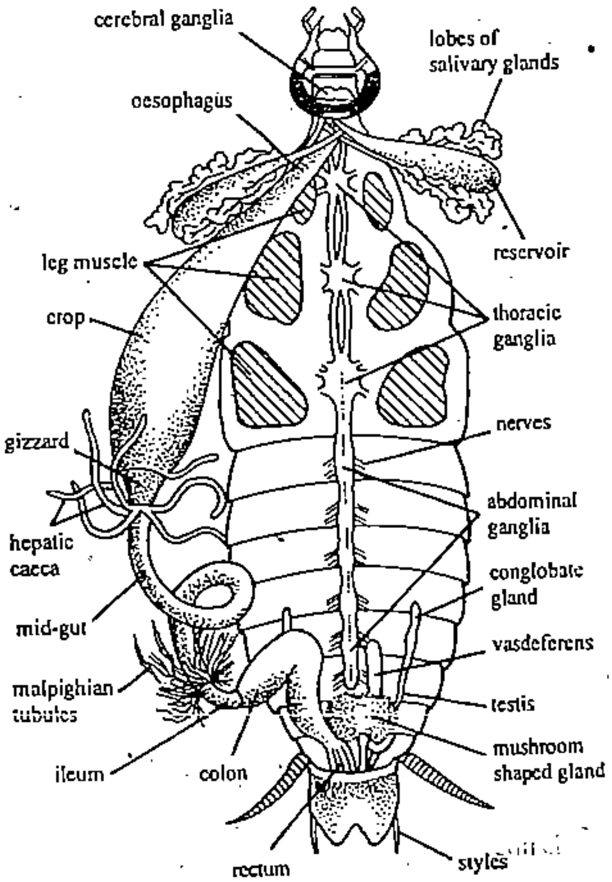


Fig. 20.3: Alimentary canal of a Cockroach.

Alimentary Canal

1. Oesophagus continues into the crop which is thin walled, elongated and pear-shaped structure extending upto the abdomen.

2. Gizzard is rounded in shape and is thick walled muscular structure present at the base of crop.
3. The mesenteron is characterized by the presence of eight tubular enteric caecae at the anterior end and numerous hair like malpighian tubules at the posterior end.
4. Ileum, colon and rectum not markedly differentiated.
5. Rectum opens to the exterior by anus.
6. A pair of salivary glands present in the prothorax. Each is differentiated into a receptacle and a glandular portion. Separate ducts arise from each of them and unite to form the common efferent salivary duct opening at the base of hypopharynx (Fig. 20.3).

Note: The same specimen could be used to proceed observations on reproductive system if not disturbed or mutilated, otherwise take a fresh specimen for the next dissection.

20.4.2 Male Reproductive Organs of Cockroach

Procedure

1. Take chloroformed male cockroach with dorsal side facing upwards and cut on either lateral side and pin the animal in the tray.
2. Without disturbing the fat bodies, remove the tergal plates one by one carefully.
3. Locate whitish honey comb like structures, the testes on either lateral side close to the arthrodial membrane from segment 4^{th} to 6^{th}.
4. After locating testes, remove fat bodies and alimentary canal.
5. Trace vas deferens from the posterior end of testis and clear up the remaining structures.
6. Cut the tergum of last abdominal segment in order to expose the genital chamber and its copulatory appendages.

Observations

1. Two testes present in segment fourth to sixth one on either side.
2. Two vasa deferentia arising one each from the posterior end of each testis.
3. One ejaculatory duct present midventrally as thick and wide muscular duct.
4. One mushroom gland - white mushroom-shaped structure present above the union of two vasa deferentia.
5. Conglobate gland is leaf like which is placed below the ejaculatory duct.
6. Around the male genital pore are found gonapophyses, pseudopenis, titilator, and right and left phallomeres (Fig. 20.4 a).

20.4.3 Female Reproductive Organs of Cockroach

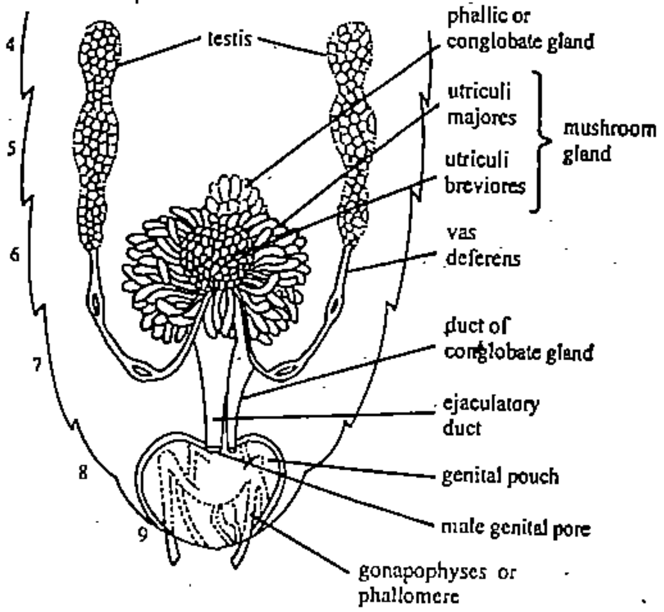
Procedure

Step 1 and 2 are same as in the procedure for male cockroach (having selected a female cockroach this time).

3. Locate two white prominent ovaries in the posterior part of abdomen and then remove the fat bodies with the help of the forceps and brush.
4. Locate two oviducts on either side attached to posterior margin of ovary.
5. Now remove last abdominal ganglion of the ventral nerve cord. Below this are located spermatheca and vagina.
6. The colleterial glands which are milky white and highly branched are present in the posterior part of abdomen.

Observations

1. Paired ovaries one on each side in the abdominal cavity and consists of 8 ovarioles.
2. Oviducts are short and wide tubes joining medially to open into the vagina.
3. Spermathecae which consists a sac-like structure and a filamentous coiled position is present at the junction of vagina with the genital chamber.
4. Colleterial glands open into the genital pouch (Fig. 20.4 b).



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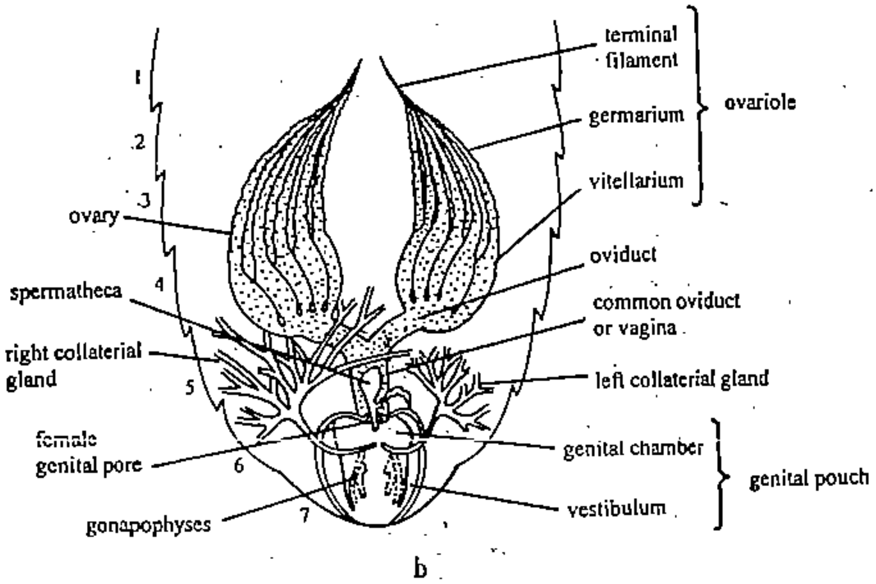

b

Fig. 20.4: Cockroach. a) Male reproductive system. b) Female reproductive system.

20.5 TEMPORARY MOUNTS

20.5.1 Mouth-Parts

You have already carried out an exercise on preparing permanent mount of mouth parts of cockroach in Exercise 18. Here, it is simply a repetition, but only to prepare a temporary mount so as to relate them with the alimentary canal.

Procedure

Remove the mouth parts one by one as described below and place them in a drop of water on a clean slide in a manner as shown in Fig. 20.5.

1. Hold cockroach on the neck region with your hand with ventral surface facing you.
2. Locate the lower lip (labium) of mouth which is a flattened plate on the floor.
3. Hold it from its base with the help of a pair of forceps and pull it out. This is labium.
4. Next, remove maxillae from the sides and then the mandibles underneath them.
5. Below the labium is present hypopharynx in the middle line.
6. Finally take out upper lip called labrum.

Observations

1. Mouth-parts mandibular type, i.e. biting and chewing type.
2. Mandibles plate-like and broad. The inner margins are serrated (toothed) adapted for biting the food.
3. Maxillae consist of:
   i) Protopodite – basal part, formed of cardo and stipes
   ii) Exopodite – outer part, forming maxillary palp.
   iii) Endopodite – inner part, formed of lacina and galea
4. Labium which forms the lower lip is composed of:
   i) basal part having submentum, mentum and prementum.
   ii) paired labial palps which represent the outer part.
   iii) inner part which is formed of glossae and paraglossae.
5. Hypopharynx tongue like with opening of salivary glands.
6. Upper lip formed by labrum and epipharynx (Fig. 20.5).

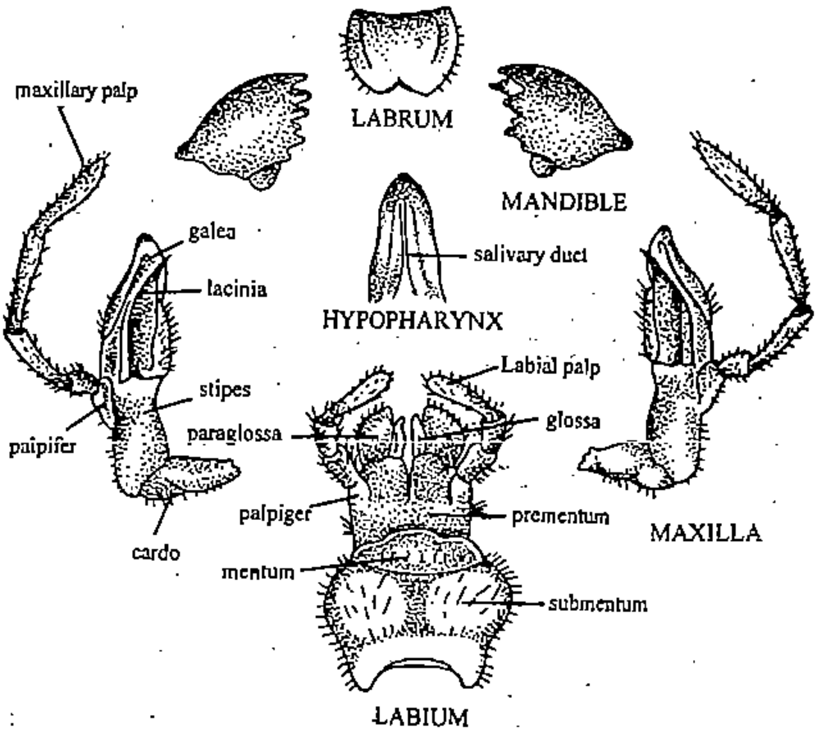

Fig. 20.5: Mouth-parts of cockroach.

20.5.2 Salivary Glands

Procedure

1. Pin a freshly chloroformed cockroach in the dissecting tray with the dorsal side facing upwards.
2. Cut open on either lateral side.
3. Remove tergal plates one by one upto the head region.
4. Locate the crop.
5. Carefully search for white coloured flattened glandular structure around the anterior part of the crop.
6. Clear them upto the neck. Then gently turn over the head.
7. Clear the neck region in order to expose the efferent salivary duct.
8. Remove the labium, hold the hypopharynx and pull out the glands.
9. Keep it in a watch glass in water.

   Or

   Stretch the glands on a slide and fix them in 70% alcohol, wash and do single (eosin or borax carmine) staining for mounting. Mount on a slide by properly stretching in water and put a coverslip.

Observations

1. Salivary glands are located in the prothorax of cockroach and open at the base of hypopharynx.
2. Each salivary gland has a glandular part and the reservoir.
3. In the glandular part, there are four main lobes. The lobes have separate salivary ducts, which ultimately join together to form the common salivary duct.
4. There are two reservoirs with separate ducts.
5. Ducts of reservoirs join the common salivary duct to form efferent salivary duct.
6. Salivary glands are source of digestive enzymes which help in digestion of food (Fig. 20.6).

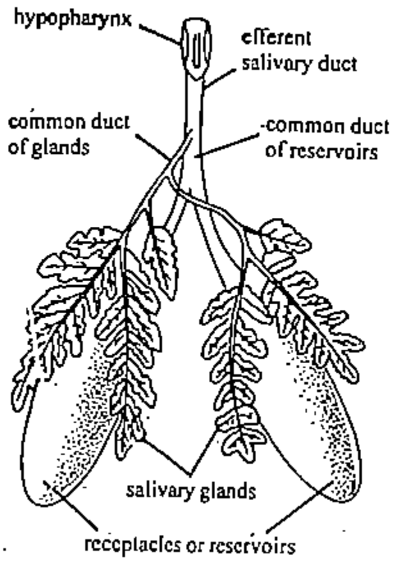

Fig. 20.6: Salivary glands of cockroach.

20.6 PRECAUTIONS TO BE TAKEN IN DISSECTIONS

1. In fixing animal, stick the pins obliquely and not vertically so that their heads do not come in the way or obscure the dissection.
2. Never cut away any thing until you are quite certain about what you are removing.
3. Dissections should be done in water. The water must completely submerge the dissection.

4. Always keep the water clean in the dissecting dish during dissection by changing it, whenever required so that visibility remains good.
5. Black paper your dissection for good display.
6. *Invertebrates* are always dissected from the dorsal side.

20.7 TERMINAL QUESTIONS

1. Which type of mouth-parts are present in cockroach and what for?

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2. How can you differentiate male and female cockroach just by observing them externally?

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3. List the parts of alimentary canal in a sequence starting from mouth and ending at anus.

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EXERCISE 21 ECHINODERMATA : OBSERVATION AND CLASSIFICATION OF SPECIMENS AND STUDY OF ONE REPRESENTATIVE LARVA

Structure

21.1 INTRODUCTION

This lab exercise is based on unit 6, (section 6.3) Block 2 of the LSE-10 course which dealt with phylum Echinodermata. You will recall that Phylum Echinodermata includes spiny skinned animals which are exclusively marine (Gr. **echinus**: spiny; **derma**: skin). They have the following characters which are not found in animals belonging to any other phylum:

i) Bilaterally symmetrical larvae but radially symmetrical adults. Thus they exhibit secondarily **pentamerous**, **radial symmetry** found in adults.
ii) A skeleton made of calcareous plates or ossicles ,bearing projecting **spines**.
iii) Small pincer-like bodies present among plates called **pedicellariae**.
iv) Organs called "**tube feet**" or **podia** responsible for locomotion.

You shall be able to see the above-mentioned features when you handle echinoderms. Echinoderms also possess certain unique features which can be seen after dissecting the animals. These features are:

(i) a system of coelomic channels forming a water vascular system with external tubular projections used in feeding and locomotion.
(ii) a blood lacunar system called the haemal system.

In this exercise you will study the type specimens of Phylum Echinodermata and the bipinnaria larva which occurs in the life-cycle of echinoderms

Objectives

After performing this exercise you should be able to:

- identify and give the scientific and common names of *Antedon*, *Asterias*, *Ophiura*, *Echinus*, *Holothuria*.
- classify the identified Echinoderms up to the level of classes and list characters justifying their classification and mention special features, if any
- differentiate between stalked and unstalked echinoderms.
- relate the structure of echinoderms with their habitat, which is the deep sea.
- mention habitat and geographical distribution of identified enchinodermata genera.
- draw labelled diagrams of the identified genera of echinoderms.
- identify, describe and draw labelled diagram of **bipinnaria** larva of *Asterias* from permanent slide.

21.2 MATERIAL REQUIRED

1. Preserved specimens of *Antedon, Asterias, Ophiura, Echinus* and *Holothuria.*
2. Permanent slide of bipinnaria larva.
3. Compound microscope.
4. Drawing sheets, pen, pencil, ruler, eraser.

21.3 SCHEMATIC CLASSIFICATION AND FEATURES OF PHYLUM ECHINODERMATA

Before you proceed with the practical on Echinodermata let us refresh your knowledge about classification of this phylum.

21.3.1 Position of Echinodermata

Classification with its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Sub-kingdom	**Eumetazoa**	Animals with tissues and organs.
Grade I	**Bilateria**	Bilateral animals
Division	**Deuterostomia**	Cleavage is radial and usually indeterminate, mouth arising some distance interiorly from blastopore. Mesoderm and coelom develop primitively from out-pocketings of the primitive gut.
Phylum	**Echinodermata**	Secondary radial symmetry, endoskeletal plates.

21.3.2 General Features of Echinoderms

(i) Body exihibits radial symmetry.
(ii) Animals shows pentamerous organization of different parts, that is, parts are arranged in multiples of five.
(iii) A distinct anterior end or head is absent.
(iv) The surface of the body bearing the mouth is termed the oral surface. The opposite surface is called aboral surface. In the natural position, the aboral surface is directed upwards and the oral surface downwards.
(v) The radii along the arms are termed ambulacra and the alternating interradii are termed adambulacra (singular : adambulacrum).
(vi) The tube feet are present,
(vii) The calcareous plates are present.

21.3.3 Further Classification of Phylum Ecinodermata

Phylum Echinodermata

Subphylum **Pelmatozoa** (Echinoderms having a stalk on the aboral side)
- **Class Crinoidea** – the only living class e.g. Feather star

Subphylum **Eleutherozoa** (Stalkless Echinoderms)
- Classes
  - **Concentricycloidea** – Sea daisies
  - **Asteroidea** – Star fishes
  - **Ophiuroidea** – Brittle stars
  - **Echinoidea** – Sea urchins, Sea dollars
  - **Holothuroidea** – Sea cucumbers

21.3.4 Distinguishing Features of Subphyla – Pelmatozoa and Eleutherozoa

The Phylum Echinodermata is divided into two subphyla, the Pelmatozoa and Eleutherozoa. The distinguish features of these phyla are given in table 21.1

Table 21.1: Main features of subphyla Pelmatozoa and Eletherozoa

PELMATOZOA	ELEUTHEROZOA
Body is in form of cup or calyx, borne on aboral stalk during part or all of life;	Members of this group are free and not bound. Body is star-shaped;
Oral surface is directed upward;	Oral surface directed towards substratum that is oral-aboral
Open ambulacral grooves present;	Axis is parallel to substratum; Body with or without arms; Ambulacral grooves open or closed
Madreporite absent,both mouth and anus on oral surface;	
Several fossil classes in addition to living class Crinoidea.	

From the above table you can make out that phylum Echinodermata is divided into two subphyla of which Subphylum Pelmatozoa includes only one living class, Crinoidea. On the other hand, stalkless Subphylum Eleutherozoa includes five classes Concentricycloidea, Asteroidea, Ophiuroidea, Echinoidea and Holothuroidea. So if you were to classify an echinoderm for example the starfish *Pentaceros*, you would do it as follows:

Classification with its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Echinodermata**	Secondary radial symmetry, endoskeletal plates, pentaradiate, coelomate, with spiny skin and water vascular system.
Subphylum	**Eleutherozoa**	Stalkless and free-living; tubefeet with suckers; mouth on the oral surface and anus on the aboral surface.
Class	**Asteroidea**	Body star-shaped; bases of anus not distinctly marked off from the disc; oral surface directed downwards and aboral surface upwards; ambulacra form prominent grooves provided with tube feet.
Genus	***Pentaceros***	
Common name	**Star fish**	

21.4 TYPE SPECIMENS OF ECHINODERMATA

Before we begin the study of the selected specimens of the following echinoderms – Feather star, Brittle star, Sea urchin, Sea cucumber and Star fish. You should be aware that though members of the various classes of echinoderms often appear to be superficially different, however their structure is fundamentally similar. For example, sea cucumbers lack the five arms of sea stars, but they do have five bands of tube feet and thus show the same basic pentaradiate symmetry.

21.4.1 *Antedon*

Antedon (Fig. 21.1) is commonly called **"feather star"** or **"sea lily"**

Examine the specimen and note the following features:

(i) The body of *Antendon* is made of a central convex disc of calyx and **five** equidistant, elongated slender radiating **arms**.
(ii) Each arm is divided into two branches at the base, so there are in effect ten long arms.
(iii) The arms are slender, flexible, movable and bear small spine-like structures or **pinnules** on the two sides.
(iv) The body has a distinct upper **oral** and lower **aboral surface.**
(v) Aboral surface bears several root-like, slender, curved, jointed cirri supported by small ossicles which help to attach *Antedon* to rocks.
(vi) Oral surface is covered with a soft and leathery skin, called **tegmen** and this surface bears the **mouth** and **anus** on the same side of the calyx. The anus is borne on a tiny papilla and is excentric whereas the mouth is in the center.
(vii) Five **ambulacral ciliated grooves** radiate from the mouth towards the arms. Each groove divides into two and runs along the oral surface of each arm.
(viii) The intervening body surface is the **adambulacra**.
(ix) **Tube feet** or **podia** are without suckers and can be seen along the edges of ambulacral groove.
(x) The exoskeleton is made of calcareous ossicles or plates.

[Sexes are separate; and gonads are present at the dilated bases of pinnules. Development includes a pentacrinoid larva with jointed stalk.]

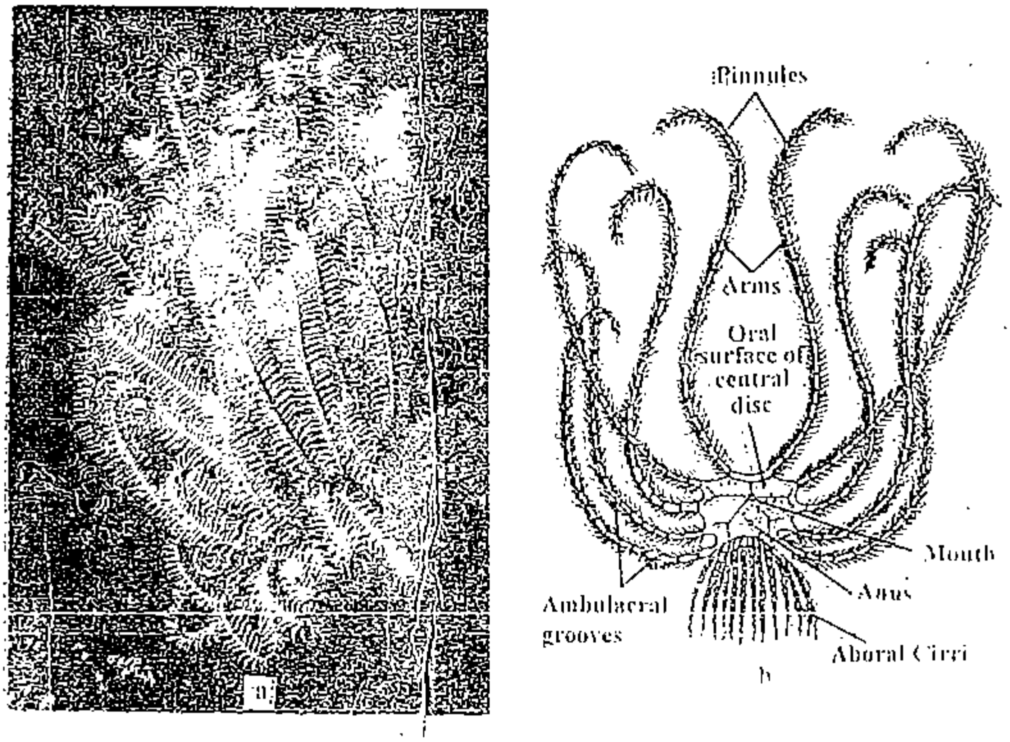

Fig.21.1: Feather star. a) A living feather star in its natural environment. b) Drawing of oral view of feather star, *Antedon*.

Habit and Habitat

Marine, attached to rocks in the sea at moderate depths

Geographical distribution

Antedon is world-wide in distribution, found in all seas. It is commonly found along Atlantic Coast.

Classification and its Justification

Kingdom	**Animalia**	Animals; multicellular organisms with cells that lack a cell wall; many capable of movement or movement of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Echinodermata**	Secondary radial symmetry, endoskeletal plates, pentaradiate, coelomate, with spiny skin and water vascular system.
Subphylum	**Pelmatozoa**	Stalked and fixed forms; mouth and anus both dorsal; tube feet absent.
Class	**Crinoidea**	Body cup-shaped; arms five and bifurcated at base.
Genus	***Antedon***	
Common name	**Feather Star or Sea lily**	

21.4.2 *Ophiura*

Ophiura (Fig. 21.2) is a cosmopolitan "brittle star" or "serpent star"

Study the specimen of *Ophiura* and note the following features:-

(i) Its has a flat pentagonal **central disc** covered with radial shields and membranous small calcareous plates.
(ii) **Five arms** radiate from the disc. They are also covered with calcareous plate. The lateral plates on the arms bear spines.
(iii) Arms are clearly demarcated from central disc.
(iv) **Mouth** is present on the **oral surface**. It has **five angles**.
(v) In each radius, there are two bursal slits.

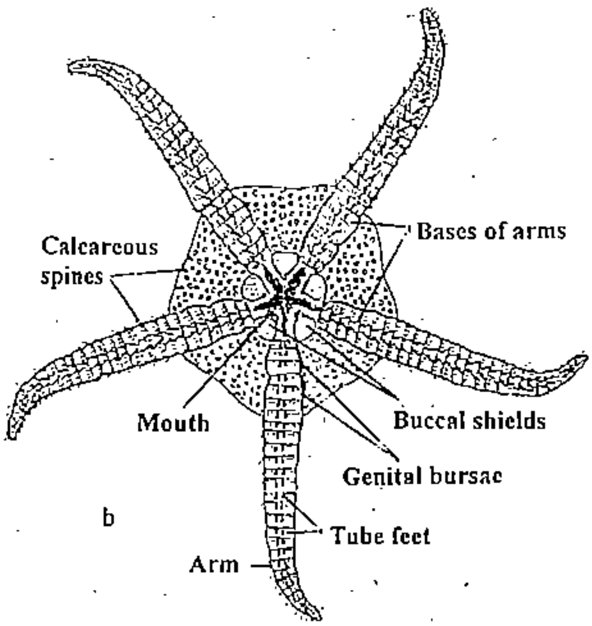

Fig. 21.2: Brittle star (*Ophiura*). a) A living specimens in its natural environment. b) Drawing of specimen (oral view).

Habit and Habitat

Marine, deep sea forms. They are carnivorous and coil their arms around prey.

Geographical Distribution

It is cosmopolitan in distribution

Classification with its Justification

Kingdom	**Animalia**	Animals; multicellular organisms with cells that lack a cell wall, many capable of movement or movement of their body parts or capable of movement at some time of their life; heterotrophic nutrition.
Phylum	**Echinodermata**	Secondary radial symmetry, endoskeletal plates, pentaradiate, coelomate, with spiny skin and water vascular system.
Subphylum	**Eleutherozoa**	Stalkless and free-living, tube feet with suckers; mouth on the oral surface and anus usually on aboral surface.
Class	**Ophiuroidea**	Oral and aboral surfaces distinct, bases of the arms distinctly marked off from the disc, ambulacral grooves, anus, and intestine absent, madreporite on the oral surface; bursae usually ten.
Genus	***Ophiura***	
Comman name	**Brittle Star or Serpant Star**	

21.4.3 *Echinus*

Echinus (Fig 21.3) is commonly known as sea urchin

Examine the specimen and note the following features:

(i) *Echinus* (Fig. 21.3) has a **globular body** which is somewhat flattened at the two poles forming a distinct oral pole and an aboral pole.
(ii) Body is enclosed in a rigid, globular shell called test or **corona** which is made of closely fitting calcareous plates.
(iii) **Mouth** is present in the oral pole. It is surrounded by a circular area of soft membrane called the **peristome**. .
(iv) The anus is a much smaller aperture, present on the aboral pole and is surrounded by an area call **periproct**.
(v) Entire surface of animal except for the peristome and periproct is covered with movable **spines**, articulated to the shell.
(vi) In between the spines are found two sets of structures-(i) **pedicellariae** with three jaws and (ii) sphaeridia.
(vii) Surrounding the peristome are **branchiae.**
(viii) The surface of the shell has alternating ambulacral and inter-ambulacral areas.
(ix) In the ambulacral area lie **tube** feet or **podia** in a double row. So there are five ambulacral areas and five double rows of podia.

[Sexes are separate. Gonads form five large masses. Development is through an echionopluteus larva. A special masticating apparatus made of several calcareous plates called **Aristotle's lantern** (Fig. 21.3 c) is present and teeth (tips of plates) protrude through the mouth.]

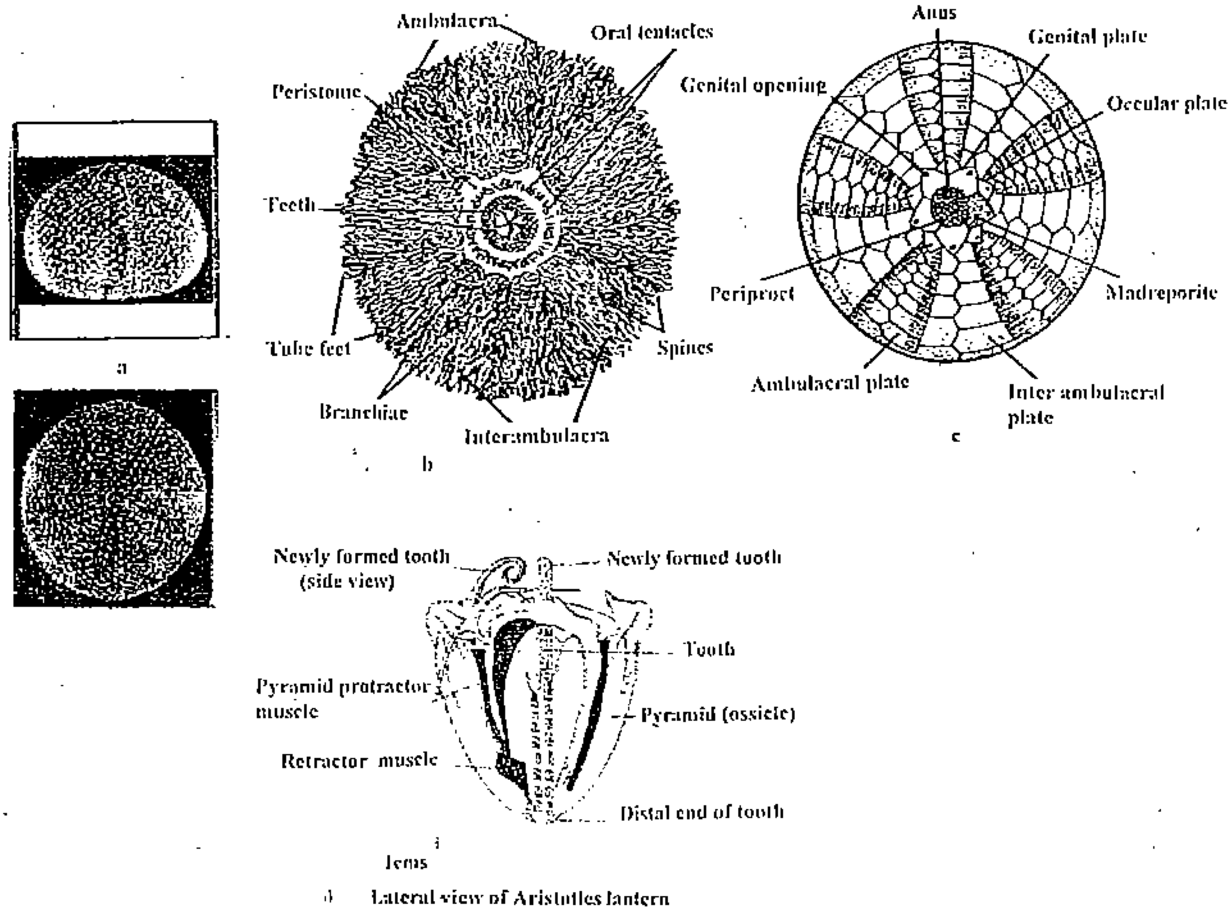

Fig. 21.3: *Echinus* (urchin). a) Skeletons or tests of dead *Echinus*. b) Drawing of specimen of *Echinus* in oral view. c) Drawing of *Echinus* in aboral view. d) Lateral view of Aristotle's lantern.

Habit and Habitat

Marine, benthoic, occurs between the intertidal zone to 5000 meters.

Geographical Distribution

Echinus is widely distributed in the Atlantic, Mediterranean and Pacific ocean.

Classification with its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Echinodermata**	Secondary radial symmetry, endoskeletal plates, pentaradiate, coelomate, with spiny skin and water vascular system.
Subphylum	**Eleutherozoa**	Stalkless and free-living, tube feet with suckers; mouth on the oral surface and anus usually on aboral surface.

Class	**Echinoidea**	body spherical, enclosed in a shell or test, ambulacral grooves and anus absent; pedicellariae stalked and three-jawed.
Genus	***Echinus***	
Common name	**Sea urchin**	

21.4.4 *Holothuria*

Holothuria is commonly called **"Sea cucumber"**.

Study the specimen and note the following features:

(i) *Holothuria* (Fig. 21.4) is black in colour and measures about 30 cms in length when fully extended.
(ii) The body is elongated through the oral-aboral axis.
(iii) The body is **bilaterally symmetrical.**
(iv) The **mouth** and **anus** are at the two opposite ends of the body.
(v) **Mouth** is anteriorly placed and surrounded by 15-30 peltate tentacles termed **oral tentacles.**
(vi) The **madreporite** is internal.
(vii) Body bears numerous **podia** or tube feet which are in the five ambulacral areas. Podia are locomotory on ventral surface and papillate on the dorsal surface.
(viii) Body wall is leathery having a skeleton of minute ossicles.
(ix) The skin is soft and without spines and pedicellariae

[**Respiratory trees** are well developed. Cuverian tubules are present. Sexes are separate, gonads consist of a single tuft attached to left side of dosal mesentry. Development includes an **auricularia larva**]

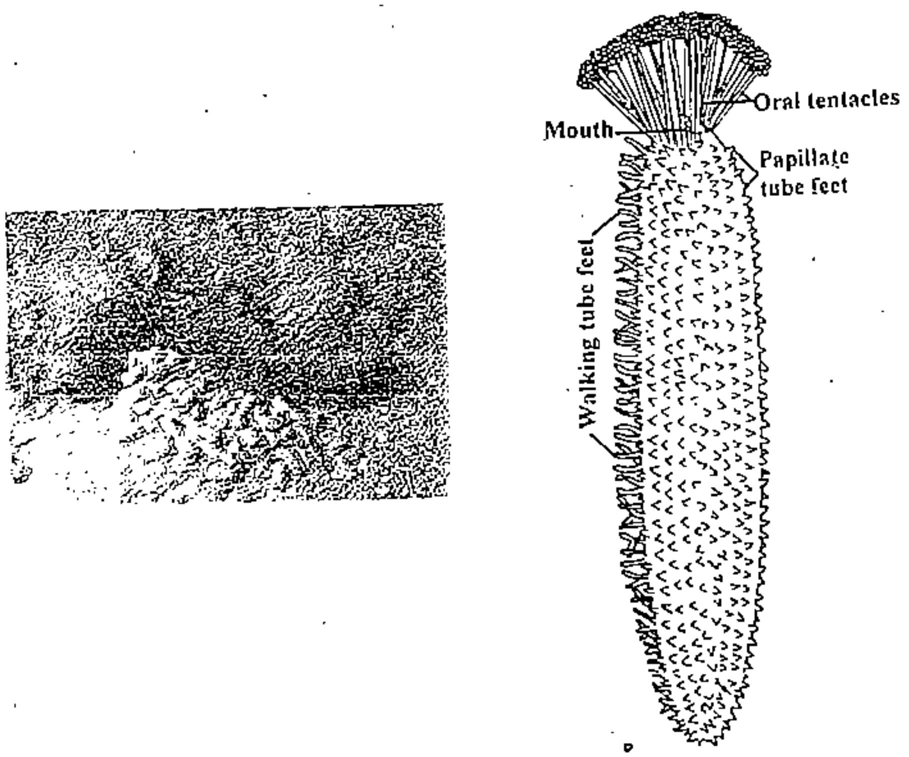

Fig. 21.4: *Holothuria* (sea cucumber). a) A living specimen of *Holothuria edulis* in its natural environment. b) Drawing of museum specimen of *Holothuria* sp.

Habit and Habitat

Holothuria is found in the shallow tropical sub-tropical waters of Indo-Pacific sea. It feeds by pushing sand containing organic food into the mouth with the help of tentacles. When chased by a predator, *Holothuria* eviscerates or throws out contents of its body to divert the attention of the predator.

Geographical distribution

Holothuria is found distributed in India, West Indies and Florida.

Classification with its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Echinodermata**	Secondary radial symmetry, endoskeletal plates, pentaradiate, coelomate, with spiny skin and water vascular system.
Subphylum	**Eleutherozoa**	Stalkless and free-living, tube feet with suckers; mouth on the oral surface and anus usually on aboral surface.
Class	**Holothuroidea**	Body cylindrical, elongated in oral-aboral axis.
Genus	***Holothuria***	
Common name	**Sea cucumber**	

21.4.5 Star fish – *Asterias*

Asterias is commonly known as sea star or star fish (Fig. 21.5).

Examine the specimen of Asterias and note the following features:

(i) The body is star-shaped, consisting of a **central disc** with 5 radiating **arms** which are broad at their base and tapering towards their extremities.

(ii) Body is flat with distinct oral and aboral surfaces. Oral surface is directed downwards and aboral surface is directed upwards.

(iii) Mouth is also called actinostome and is pentagonal in shape. It lies in the center of the oral disc on the oral surface and is surrounded by a membranous peristome.

(iv) From the mouth leading into the arms are five ambulacral **grooves**, one in each arm. Each ambulacral groove is bordered laterally by two or three rows of movable calcareous spines, the **ambulacral spines**.

(v) Each ambulacral groove contains two double rows of **podia** or **tube feet**, which serve as organ of locomotion.

(vi) Aboral surface bears a number of short, stout spines arranged in irregular rows, numerous dermal brachiae among spines and a smaller aperture, the **anus** which is situated more or less excentrically on the surface.

(vii) Madreporite is a thick, calcareous circular plate situated on the aboral surface between two arms. The arms between which the madreporite is situated are called **bivium**, the other three arms are called **trivium**.

(viii) Water vascular system is well-developed.

[Sexes are separate. Fertilization is external. Development includes a free-swimming bipinnaria larva.]

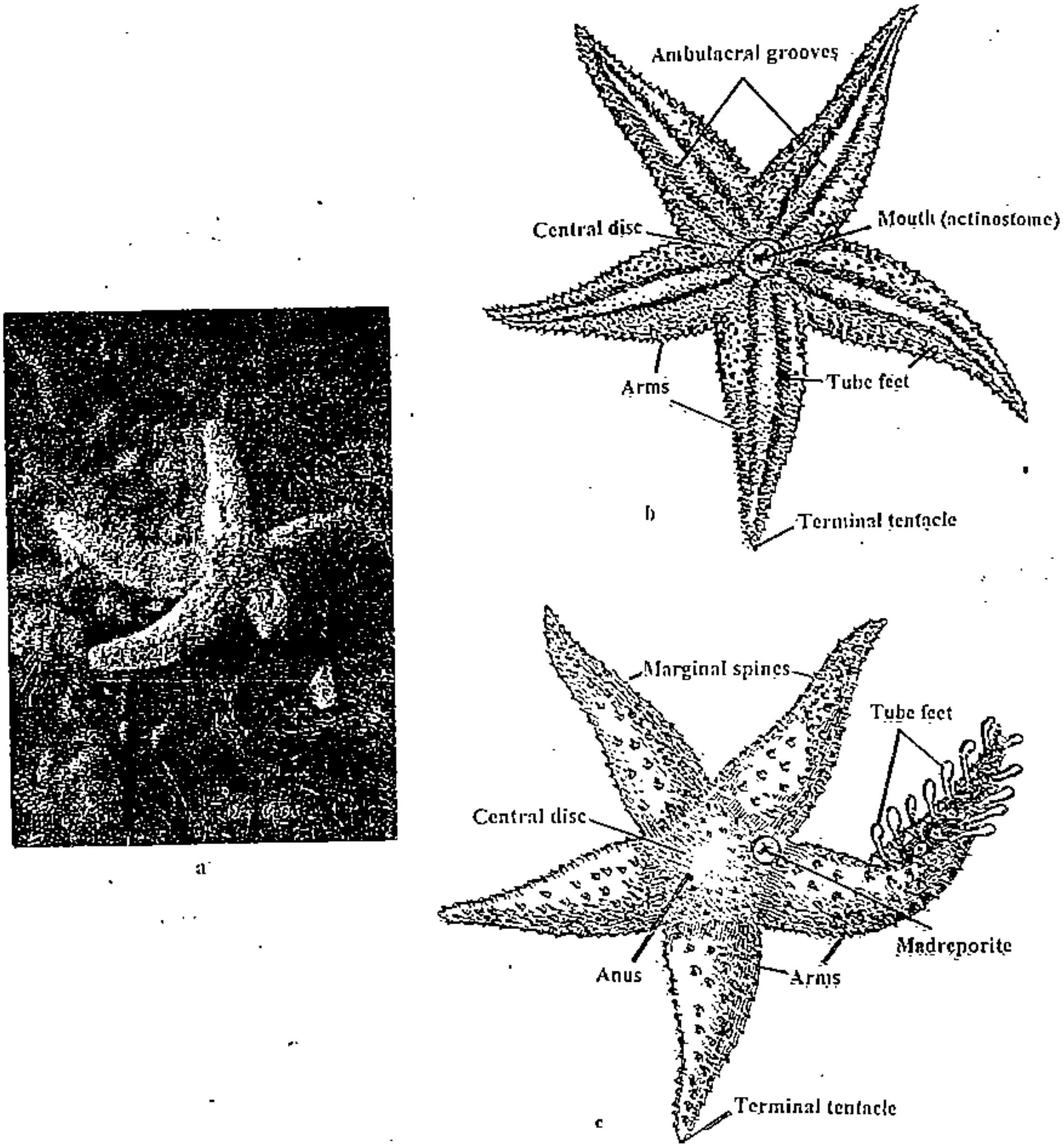

Fig. 21.5: Sea star (*Asterias*). a) A living specimen in its natural environment. b) Drawing of specimen of *Asterias* in oral view. c) Drawing of specimen of *Asterias* in aboral view.

Habit and Habitat

Asterias is a marine, carnivorous echinoderm living in the deep sea. It eats molluscs.

Geographical Distribution

Asterias is found in shallow waters in North Temperature seas and found abundantly on North Atlantic Coast. It is found in India and U.S.A.

Classification with its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Echinodermata**	Secondary radial symmetry, endoskeletal plates, pentaradiate, coelomate, with spiny skin and water vascular system.

Sub phylum	**Eleutherozoa**	Stalk-less and free-living, tube feet with suckers; mouth on the oral surface and anus usually on aboral surface.
Class	**Asteroidea**	body star-shaped, bases of anus not distinctly marked off from the disc; oral surface directed down wards and aboral surface upwards; ambulacral form prominent grooves, provided with tube feet.
Genus	***Asterias***	
Common name	**Sea star or starfish**	

21.5 STUDY OF BIPINNARIA LARVA

Bipinnaria is the larval stage of star fish and is free living

Examine the slide of bipinnaria larva (Fig. 21.6) under the compound microscope (low power) and note the following:

i) It is **bilaterally symmetrical** and somewhat **angular in shape.**
ii) It is **transparent** and has **arms** or projections in the body. The arms are (a) a median dorsal arm; (b) two antero-dorsal arms; (c) two postero-dorsal arms (d) two post-oral and (e) two postero-lateral arms.
iii) **Ciliated bands** are present on the body. Two lateral ciliary bands connect in front of the mouth as a **pre-oral loop.** The other band forms a **post-anal** loop around the anus.
iv) The **alimentary canal** is **complete** and the larva feeds on diatoms.
v) The alimentary canal consists of a **mouth** leading into **esophagus,** the **stomach** and the **intestine** opening to the outside by the **anus.**

[The bilaterally symmetrical bipinnaria larva metamorphoses into a radially symmetrical adult star fish.]

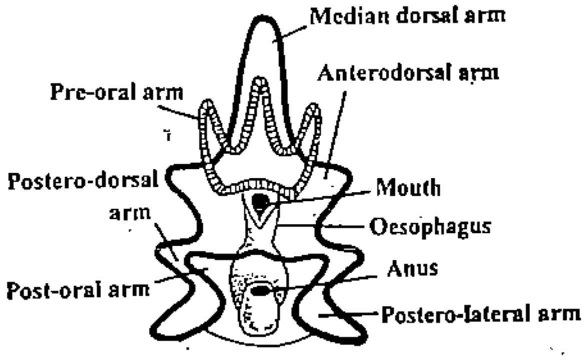

Fig. 21.6: Bipinnaria Larva of star fish

Habit and Habitat

The bipinnaria larva swims freely in sea water and feeds on diatoms.

Geographical Distribution

Asterias and its bipinnaria larva are found in shallow waters in North Temperate seas and are also found abundantly on North Atlantic Coast. It also occurs in India and U.S.A.

21.6 TERMINAL QUESTION

1. Name the two subphyla of the phylum Echinodermata.

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2. Which is the subphylum that includes stalked echinoderms?

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3. To which class of Echinodermata do sea urchins belong?

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4. If you are given an assortment of invertebrates, how will you pick out the echinoderms using any two distinguishing features?

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5. From among a tray of sea stars (starfish) and brittle stars, how will you separate the two? Give only two distinguishing features.

....

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....

EXERCISE 22 HEMICHORDATA : OBSERVATION AND CLASSIFICATION OF SPECIMEN *BALANOGLOSSUS* AND ITS TORNARIA LARVA

Structure

22.1 INTRODUCTION

This laboratory exercise is based on unit 1(Section 1.2) of Block 1of the LSE-10 theory course. You will recall that Hemichordates are vermiform (worm-like) animals which have few characters like those of the chordates, hence the name hemichordata (*hemi* : half; *chorda* : string or cord). Hemichordates belong to the deuterostome branch of the animal kingdom and are enterocoelous coelomates with radial cleavage. They show some of both echinoderm and chordate characteristics. A chordate plan is suggested by gill-slits in the pharynx and a restricted dorsal tubular nerve cord in the collar region. On the other hand, similarity to echinoderms is shown in (i) larval features and (ii) in having an epidermal nerve net. In this unit you will study the type specimen *Balanoglossus* of the phylum Hemichordata and the tornaria larva which is typically found in its life cycle.

Objectives

After performing this exercise, you should be able to

- identify *Balanoglossus* as a hemichordate and give its scientific and common name.
- classify *Balanoglossus* up to the level of order.
- mention the habitat and geographical distribution of *Balanoglossus*.
- list characters justifying classification of *Balanoglossus* and mention special features justifying also the name Hemichordata.
- draw a labelled diagram of *Balanoglossus*.
- identify, describe and draw a labelled diagram of tornaria larva of *Balanoglossus*.

22.2 MATERIAL REQUIRED

1. Preserved specimen of *Balanoglosus*.
2. Permanent slides of whole mount of tornaria larva in dorsal and ventral view.
3. Compound microscope.
4. Drawing sheets, pen, pencil, ruler, eraser.

22.3 GENERAL FEATURES AND SCHEME OF CLASSIFICATION OF PHYLUM HEMICHORDATA

These are about 90 species of hemichordates. All are marine and live in the open sea or in muddy sediments. Hemichordata were once included in the phylum Chordata and were grouped as invertebrate (backboneless) chordates under **'protochordates'** (first chordates). They have a dorsal nerve cord, often hollow, developed from the dorsal epidermis. The longitudinal stiffening stomatochord is no more thought to be the homologue of the notochord and this distinction justified the separation of the hemichordata from the chordata. Let us review the general features of hemichordates.

22.3.1 General Features

Two typical characters of the Hemichordata that can be observed and used to identify them are:

i) Soft, worm-like or short unsegmented body.
ii) Body is divided into a (i) proboscis (ii) collar and (iii) trunk which are distinguishably visible.

Two more typical features can be seen only after dissecting a hemichordate. These are

i) A 'notochord' like projection at the anterior end. It is endodermal in origin and not a notochord (which is mesodermal in origin).
ii) An intra-epidermal nervous system.

22.3.2 Classification

Phylum – Hemichordata

Classes: Enteropneusta | **Pterobranchia**

22.3.3 Features of the two classes

Enteropneusta (*enteron* : gut, *pneustos* : breathed)	Pterobranchia (Gr. *pteron* : wing (feather) + *branchion* : gills)
i) Stalk is absent ii) Proboscis is cylindrical and tapering iii) Collar is without ciliated arms or lophophore Example – *Balanoglossus*	i) A stalk for attachment ii) A shield like proboscis iii) Collar with ciliated arms or lophophore. Example – *Cephalodiscus*

22.4 *BALANOGLOSSUS* – TYPE SPECIMEN OF CLASS ENTEROPNEUSTA

Balanoglossus (Fig. 22.1) is commonly called tongue worm or acorn worm (GK: **balanos**: acorn or oak fruit; **glossus**: tongue).

Examine the specimen and note the following features:

1. *Balanoglossus* has a soft, elongated, worm-like body which has a ciliated surface.
2. Body length reaches 10-50 cms and is divided into short conical **proboscis**, **collar** and long **trunk**.
3. **Proboscis** is cylindrical, tapering and muscular. Near the base is a proboscis pore which is the opening of the coelom (present within the proboscis) to the exterior.
4. **Collar** is a short, cylindrical, muscular band enclosing a pair of coelomic cavities (**collar coelom**). The collar opens by a pair of collar pores on the dorsal surface. The rim of the collar encloses the mouth which is permanently open.
5. The trunk is superficially ringed and divided into 3 parts (a) anterior **branchiogenital part** containing **genital ridge** that carry gonads. This part can be demarcated from the outside as it has gill-slits but the contents cannot be

seen without dissection. (b) **hepatic region.** (c) the **posterior end** which is the **trunk** region.

6. The **mouth** lies at the base of proboscis and is encircled by the edge of the collar.
7. In the hepatic region are present double rows of **hepatic caeca.**
8. **Alimentary canal** is straight and **anus** is at the end of the trunk.
   (Sexes are separate and fertilization is external. Development includes a free-swimming pelagic larva called tornaria larva.)

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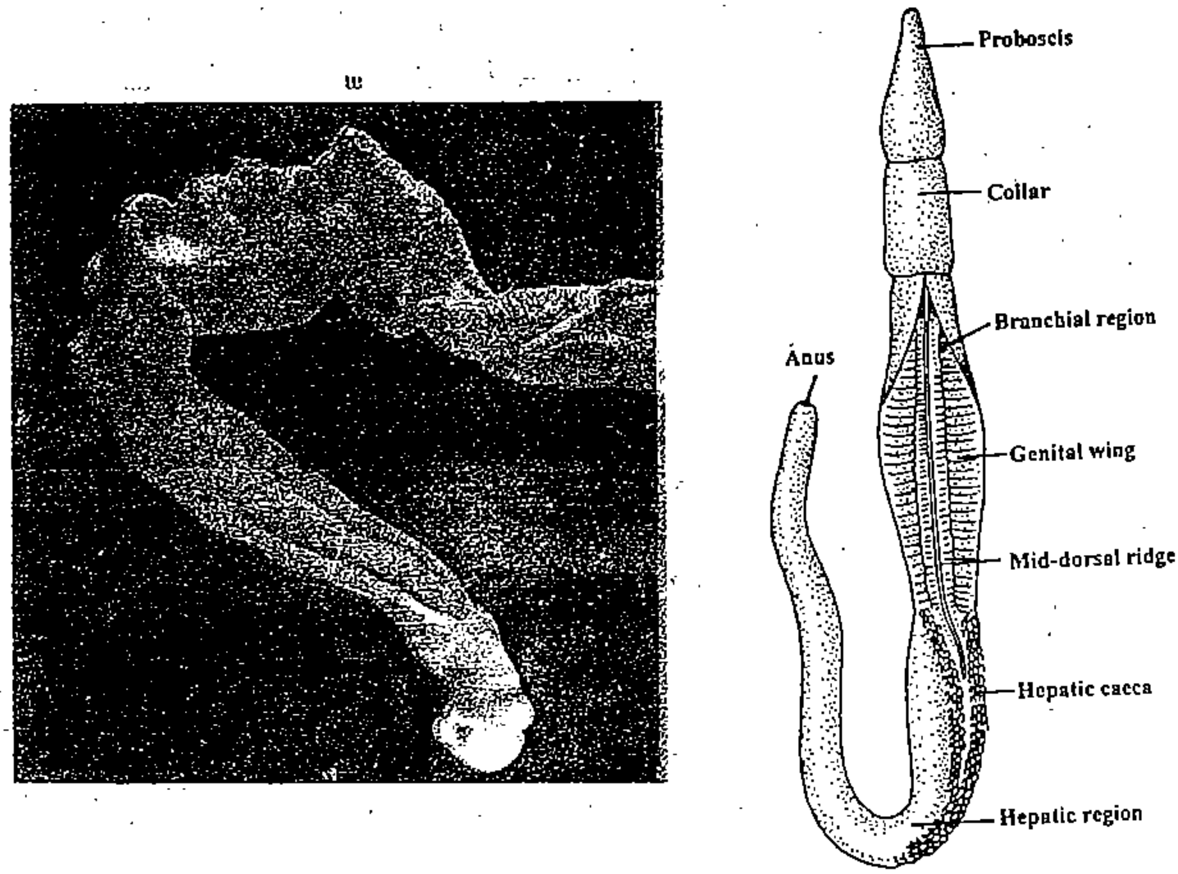

b

Fig. 22.1: *Balanoglossus.* a) Living specimen. b) Drawing of museum specimen.

Habit and Habitat

Balanoglossus is a marine worm-like animal which lives in a U-shaped burrow made by its proboscis at the bottom of sand in intertidal zone. It feeds on microscopic organic matter and resorts to filter-feeding.

Geographical Distribution

Balanoglossus is cosmopolitan or world-wide in distribution.

Classification and its Justification

Kingdom	**Animalia**	Animals; multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Hemichordata**	Solitary, soft bodied coelomate with numerous gill slits.
Class	**Enteropneusta**	Alimentary canal straight, two rows of caeca.

Genus *Balanoglossus*
Common name **Tongue worm or acorn worm**

22.5 STUDY OF TORNARIA LARVA

Tornaria larva (Fig. 22.2) is typical in the life-history of hemichordates.

Examine the permanent slide and note the following features:

1. The tornaria larva usually has an ovoid bell-shaped body which is extremely transparent. It swims freely in water.
2. The body of tornaria larva is variously folded into lobes.
3. The margin of lobes is bordered by **cilia:**
4. There are **two circlets of cilia.**
   (i) an **oral circlet** of cilia surrounding the mouth or circumoral ciliary band (often not clearly visible in slides).
   (ii) a **posterior ciliated band** or **telotroch** that occurs as a ring in front of the anus.
5. The alimentary canal is very simple having a mouth, oesophagus, stomach and intestine.
6. The mouth is ventral and anus is posterior and terminal.
7. Water sac is also found in the body of larva which opens outside through the dorsal pore, the hydropore.
8. An apical sensory plate with two eye spots and a of tuft of sensory hairs occurs at the centre of the narrow anterior end.
   (Tornaira larva feeds on minute organisms and when full grown, metamorphoses into adult.)

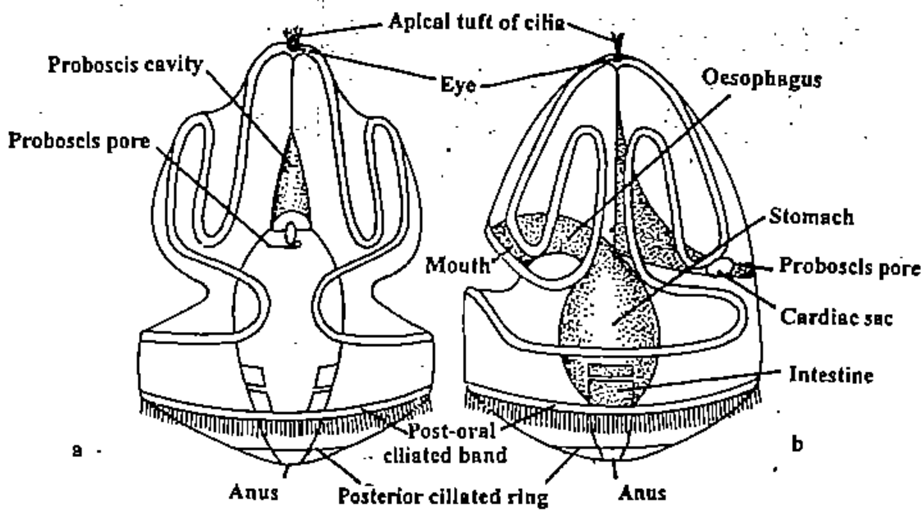

Fig. 22.2: Tornaria larva of the hemichordate of *Balanoglossus*. a) Dorsal view. b) Ventral view.

22.6 TERMINAL QUESTIONS

1. Name the three principal body regions of *Balanoglossus*.

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   ....

2. Classify *Balanoglossus* up to class.

   ....

   ....

   ....

   ....

3. Name the free swimming ciliated larva of *Balanoglossus*.

....

....

....

NOTES

UGZY -03

ANIMAL DIVERSITY LAB

Uttar Pradesh
Rajarshi Tandon Open University

Block

2

CHORDATES

List of Exercises

BLOCK 2 CHORDATES

In this block you will do 16 practical exercises relating to chordates. These exercises focus on the following aspects of practical work.

	Exercise No.
Study of museum specimens and permanent slides	23,24,25,27,28,29,30,31,34
Adaptation of beaks and claws in Birds	32
Comparative oesteology	33
Dissections of Specimens and mounting of certain body parts	26,35,36,37
Field trip	38

7

The coverage of chordate classes in the laboratory course emphasises the unifying architectural and functional theme of each group. In studying the preserved representatives, you will learn about the general characters of the concerned phylum and classify each specimen upto order level and state the genus to which it belongs. With the help of observed characters you will be able to justify the classification of each specimen taken for study. Wherever possible you will be expected to write the species and common name of the identified specimens. The habit, habitat as well as the geographical distribution of the identified specimens has also been given.

Your study will also include the modifications of beaks and feet of birds to suit their habitat and feeding habits and the comparative oesteology of frog and fowl.

In this laboratory course you will dissect dogfish and make permanent mounts of some of its organs. You will also learn to dissect the rat which will help you to get an idea of the morphology, general anatomy, digestive system, circulatory system and urinogenital system of mammals.

The last exercise is a field trip in which you are expected to visit any one of the following – a zoo, a national park, wild life sanctuary, breeding park etc. This will enable you to develop your skills of observation and making accurate records of what you see. It might also provide an opportunity to learn about the habit, habitat and behavioural aspects of some of the animals you have studied in the LSE-10 course in their natural environment.

Note: In Exercise 26 you will not be performing the major and minor dissections of *Scoliodon* as sharks have been declared endangered species under Schedule-I of Wild Life Protection Act. See letter on the next page. You will only be expected to study permanent mounts given in this exercise.

सत्यमेव जयते

श्रीमती मेनका गांधी
SMT. MANEKA GANDHI

सामाजिक न्याय और
अधिकारिता राज्य मंत्री
(स्वतंत्र प्रभार)
शास्त्री भवन
नई दिल्ली-110001
भारत
MINISTER OF STATE FOR
SOCIAL JUSTICE AND EMPOWERMENT
(INDEPENDENT CHARGE)
SHASTRI BHAWAN
NEW DELHI-110001
INDIA

July 31, 2001

Dear Vice Chancellor,

Wide Gazette Notification (copy enclosed), the Ministry of Environment & Forests, Government of India, have notified that sharks have been included in Schedule-I of the Wildlife Protection Act, 1972.

It has however, been learnt that a number of universities have included the dissection of sharks in their zoology syllabus.

As sharks have now been declared endangered species under Schedule-I of the Wildlife Protection Act, instructions may be issued that sharks should not be included in any dissection or practicals course of the university.

I may be apprised of the action taken on the matter.

With regards,

Yours sincerely,

Maneka Gandhi

(SMT. MANEKA GANDHI)

EXERCISE 23 PROTOCHORDATA (ACRANIA) : OBSERVATION AND CLASSIFICATION OF SPECIMENS

Structure

23.1 INTRODUCTION

The last major group of the animal kingdom is Phylum Chordata. It is derived from two Greek words, "*chorde*" meaning a string or chord (referring to notochord) and "*ata*" means bearing. The chord means stiff, rod-like structure along the back i.e. the *chorda dorsalis* or **notochord** (Gr., *noton*: back, *chorda*: string).

All the chordates possess three outstanding unique characteristics at some stage in their life history, i.e., a dorsal, hollow or tubular **nerve cord**, a longitudinal supporting stiff but flexible **notochord** and a series of **pharyngeal gill-slits**. A naked skin is hardly seen in chordates. (Some sort of structures like scales, feathers, hairs etc. are usually present)

Phylum Chordata has a superiority over other phyla, in possessing a living endoskeleton. This living endoskeleton permits greater freedom of movement and helps in growth.

The present laboratory exercise is based on Unit 1 (section 1.5 and subsection 1.5.1 and 1.5.2) of the LSE-10, theory course in which you studied Protochordates. Protochordates as you will recall retain three basic chordate characters and are considered most primitive chordates. Protochordates (Gr., *protos*: first; *chorde*: chord) are all marine, small, primitive or lower chordates, lacking a head, a skull or cranium, a vertebral column and jaws. This group is divided into 2 subphyla: (1) **Urochordata** and (2) **Cephalochordata** mainly on the basis of presence of notochord.

Protochordates have little economic value but they have great phylogenetic significance for the zoologists and that is why studies of Protochordata become very important. They show immense affinities and common origin with the living vertebrates.

Objectives

After performing this exercise you should be able to:

- identify and give the scientific and common names of specimens of *Herdmania* and *Doliolum* belonging to the Subphylum Urochordata. List characters justifying their classification and mention special features, if any.
- identify and give the scientific and common name of the specimen *Branchiostoma* belonging to Subphylum Cephalochordata. List characters justifying their classification and mention special features, if any.

- draw labelled diagram of each of the identified genera.
- mention the habitat, geographical location and economic importance, if any, of each of the identified genera.
- classify the identified Protochordates up to the level of classes.

23.2 MATERIAL REQUIRED

1. Preserved specimens of:
   i) *Herdmania*
   ii) *Branchiostoma* (Amphioxus)
   iii) Slides of whole mounts of *Doliolum* and *Branchiostoma*
2. Laboratory manual
3. Practical Record File
4. Pen, Pencils, Eraser, Ruler

23.3 GENERAL CLASSIFICATION OF GROUP PROTOCHORDATA

Position of Protochordates in the Animal Kingdom

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Protochordata (Acrania)**	Marine small forms; notochord is either found in the larval stage or as such persists throughout life; cranium, jaws and paired appendages absent.

OUTLINE CLASSIFICATION OF GROUP PROTOCHORDATA

KINGDOM : ANIMALIA
- Phylums
  - **NONCHORDATA**
  - **CHORDATA**
    - Groups
      - **PROTOCHORDATA**
        - Subphylums
          - **UROCHORDATA (Tunicata)**
            - Classes
              - Ascidiacea
              - Thaliacea
              - Larvacea
          - **CEPHALOCHORDATA**
            - Class
              - Leptocardii
      - **VERTEBRATA (Craniata)**

23.4 SUBPHYLUM UROCHORDATA

Before you take up the type specimens of Subphylum Urochordata namely *Herdmania* and *Doliolum* for study, it will be desirable to recapitulate some of the general aspects of the subphylum. Urochordates are called sea squirts or ascidians. The subphylum Urochordata includes about 2000 species of sedentary tunicates, out of which nearly 95% are sea squirts. Besides this there are nearly 100 pelagic species. Urochordates are exclusively marine and cosmopolitan and are found in all seas and at all depths.

The subphylum Urochordata is divided into three classes: **Ascidiacea**, **Thaliacea** and **Larvacea**. For the detailed classification, you must refer to Unit-1 (Subsection 1.5.1) of Block 1 of LSE 10. In this exercise we have only given the features of those classes whose specimens you will study in the laboratory.

23.4.1 General Characters of Urochordata are as follows

i) Mostly sedentary (fixed) but some are pelagic or free swimming.
ii) Simple (solitary) or aggregated in groups, i.e., composite (colonial).
iii) Their size varies from 0.25 to 250 mm with variance in body shape and hues.
iv) Adults have degenerated bodies, which are saclike, unsegmented and without appendages.
v) Tail is absent in adults.
vi) Body is covered by a protective tunic or test, which is composed largely of **tunicine** (an organic base similar to cellulose) so these are also known as **tunicates**.
vii) A terminal branchial aperture and a dorsal atrial aperture are usually present.
viii) Notochord, a chordate feature is present only in the larval form and confined to the tail, hence the name Urochordata.
ix) Dorsal tubular nerve cord is found only in larval stage.
x) An endostyle, homologous with thyroid is present.
xi) Tunicates are hermaphrodites.
xii) Development is indirect as it includes a free-swimming tailed larva with basic chordate chracters. Metamorphosis is retrogressive, whereby, many larval features (including the chordate characters) get degenerated or completely lost in adults.

23.4.2 Class Ascidiacea: Type specimen - *Herdmania*

Examine the specimen of *Herdmania pallida*. Also with the help of figure 23.1 note the following features:

i) The bag-like body is laterally compressed and somewhat oblong or rectangular in shape.
(Fresh animals are pink as they possess superficial vascular ampullae in the test, a characteristic feature of ascidians.)
ii) When the foot is present the body can be divided into two parts; body proper and foot.
iii) The test is a protective covering as well as an accessory respiratory organ, besides also being a receptor organ. It is soft, leathery and translucent.
iv) The test is composed of clear gelatinous matrix, interlacing fibrils, corpuscles, nerve and other types of cells and calcareous spicules. Calcareous spicules are of two types: (i) megascleres and (ii) microscleres and form the endoskeleton of tunicates.
v) The distal end of the body has two short, cylindrical projections called, the **branchial** and **atrial** siphons, guarded by branchial and atrial aperture.
vi) The branchial siphon marks the anterior end and is wider and more outward than the atrial siphon.
vii) The foot is entirely rough due to sand particles, pebbles, etc.
viii) **Ascidian tadpole** larva is a very significant stage of *Herdmania* as it has the two most important diagnostic features of chordates i.e. a dorsal tubular nerve cord and a notochord (though restricted to the tail region only). The short-lived larva undergoes metamorphosis, losing its nervous system as well as the tail to become a degenerated adult.

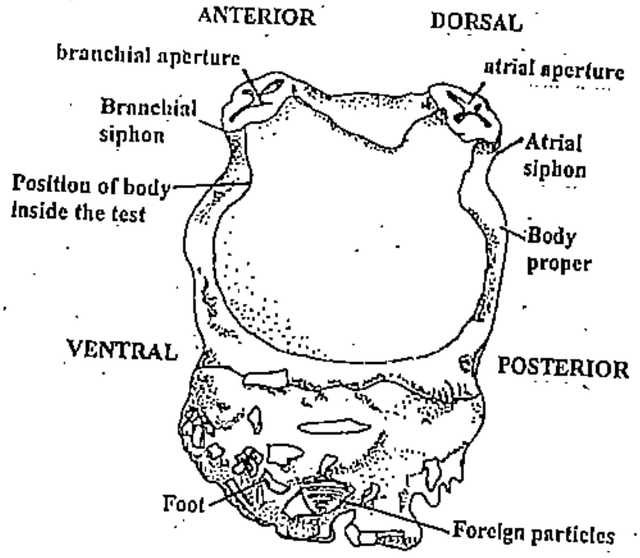


Fig. 23.1: External features of *Herdmania*.

Habit and Habitat

Herdmania is generally found at places having abundant polychaete fauna and chanks.

Herdmania is solitary and marine. It remains embedded in sand or mud by means of a large, conical extended foot. A large number of organisms inhabit the test of *Herdmania*, some of these are attached to its surface, while others are more or less embedded within its substance.

It feeds on microscopic plants and animals. Sometimes, an individual becomes attached as a commensal to the shell of a living gastropod. This way it avails of better opportunities of food, oxygen and dispersal. The mollusc in turn is protected as the tunicate is unpalatable on account of its spicules.

Geographical Distribution

Herdmania is marine, found in all seas and at all depths, extending from the arctics to the tropics and from the littoral zone down to the abyssal depths of over 4 kilometers. *Herdmania* is common in Indian seas too. Twelve species are known, out of which four are found in Indian Ocean; these are *H. pallida*, *H. ceylonica*, *H. mauritiana* and *H. enurensis*.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Protochordata (Acrania)**	Marine small forms; notochord is either found in the larval stage or as such persists throughout life; cranium, jaws and paired appendages absent.
Subphylum	**Urochordata**	Free swimming tunicate larva, sessile adults, solitary or colonial; cuticular test containing tunicine.

Class	Ascidiacea	Permanent well-developed test, persistent gill-slits; branchial-sac large and perforated by numerous gill-slits.
Genus	*Herdmania*	
Species	*pallida*	
Common name	Sea squirt	

Features of Special Interest

Herdmania is called sea squirt because when disturbed in a living state, this animal emits jets of water simultaneously or independently through its branchial and atrial apertures. Larval stage is free-swimming but adults are sessile.

The foot varies in character according to the nature of the substratum. If the substratum is fine sand, the foot has an oval shape and a smooth surface and the test is quite hard in consistency. But it is the other way if the substratum consists of coarse and broken shell pieces.

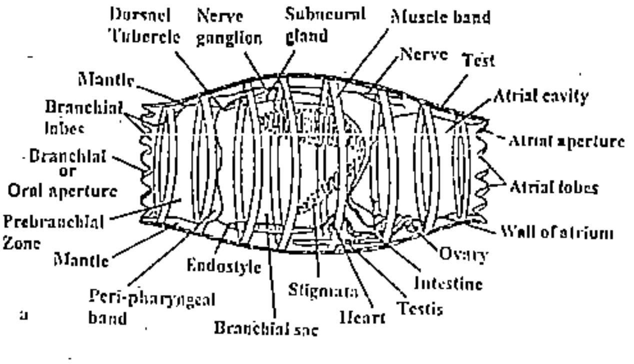
23.4.3 Class Thaliacea: Type specimen – *Doliolum*

Doliolum occurs in two phases: a solitary sexual **gonozooid** which alternates with a colonial asexual **gregaria** or **oozoid**, thus, exhibiting an alternation of generations between two morphologically distinct phases in its life cycle.

Examine the specimens of *Doliolum* (Fig. 23.2) with a hand lens and under the microscope. Note down if the specimen given is a gonozoid (tailless) or asexual oozoid (tailed).

A. Sexual Gonozooid or Solitaria Phase (Fig. 23.2 a)

i) The body is cask-shaped measuring 1 to 2 cm in length.
ii) It is a solitary phase, where the animal has thin, transparent test and barrel shaped body.
iii) The mantle is encircled by eight complete muscle bands, the first and last muscle bands act as sphincters, hence also, the name *Cyclomyaria* for its order **Doliolida.**
iv) The mouth and atrial apertures are at opposite ends of the barrel.
v) The propulsion occurs when contractions of muscles drive water through the posterior end.
vi) Reproduction is specialized. The fertilized egg develops into a larva having a notochord and a tail, otherwise, its body is similar to that of adult.
vii) The larva changes into an asexual oozooid.



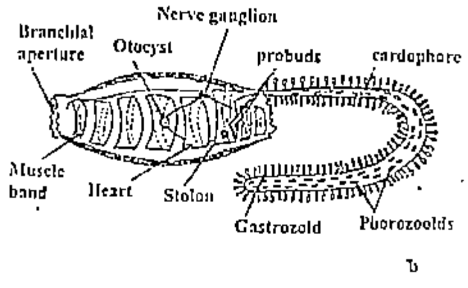


Fig. 23.2: *Doliolum*. a) Sexual form. b) Asexual form.

B. Asexual Oozooid or Gregaria Phase (Fig. 23.2 b)

i) The postero-dorsal **cadophore** and ventral **stolon** formed in the larva increase as the tail aborts gradually.

ii) There are nine complete muscle bands, which increase in thickness.

iii) Retrogression occurs, whereby stigmata, endostyle, and alimentary canal degenerate.

iv) The **probuds** are formed, which divide numerously and form three kinds of **zooids.**

(a) **Trophozooids** or **gastrozooids** – for nourishment and respiration of the colony. These do not undergo any further development.

(b) **Phorozooids** – act as nurses and become detached.

(c) **Gonozooids** – are fixed on the stalks of **phorozooids**, which form the sexual stage or adult.

Habit and Habitat

It is pelagic and free swimming.

Geographical Distribution

It is a thaliacean with cosmopolitan distribution. It is found in phytoplanktonic zone in tropical and sub-tropical seas. The species is common up to 200 m but **nurse** forms are also found from 3000 m.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Protochordata (Acrania)**	Marine small forms; notochord is either found in the larval stage or as such persists throughout life; cranium, jaws and paired appendages absent.
Subphylum	**Urochordata**	Free swimming tunicate larva, sessile adults, solitary or colonial; cuticular test containing tunicine.
Class	**Thaliacea**	Free swimming pelagic forms; single or colonial, transparent body; test is a permanent structure; muscular fibres of the body wall are arranged in ring-like bands; remarkable alternation of generations.
Genus	*Doliolum*	

23.5 SUBPHYLUM CEPHALOCHORDATA

The subphylum Cephalochordata includes only a single Class **Leptocardii** which has a single Family **Brachiostomidae**. There are only 2 genera, viz. *Branchiostoma* (*Amphioxus* : Gr. *amphi*-on both sides; *oxys*, sharp) with 8 species and *Asymmetron* with 7 species. They are marine, solitary and small fish-like forms. The chordate characters are retained throughout life.

23.5.1 General Characters

1. The name Cephalochordata is derived from the fact that the notochord extends forward inside rostrum even beyond the so-called brain. The subphylum comprises a few, small and marine fish-like protochordates.

2. Cephalochordates are marine, widely distributed in shallow waters.
3. These are mostly sedentary.
4. Body is small, slender and transparent.
5. Paired appendages are lacking. Median fins are present.
6. Exoskeleton is absent and muscles are dorso-lateral, which are segmented into myotomes.

23.5.2 Class Leptocardii: Type specimen – *Branchiostoma* (*Amphioxus*)

Examine the specimen of *Branchiostoma lanceolatum* (whole mount and/or museum specimen) and note with the help of figure 23.3 the following features:

i) Both the ends of the body of *Amphioxus* (Fig. 23.3) are sharp and pointed so that it looks like a lance (a weapon, sharp at both ends) and hence is commonly called as 'lancelet'.

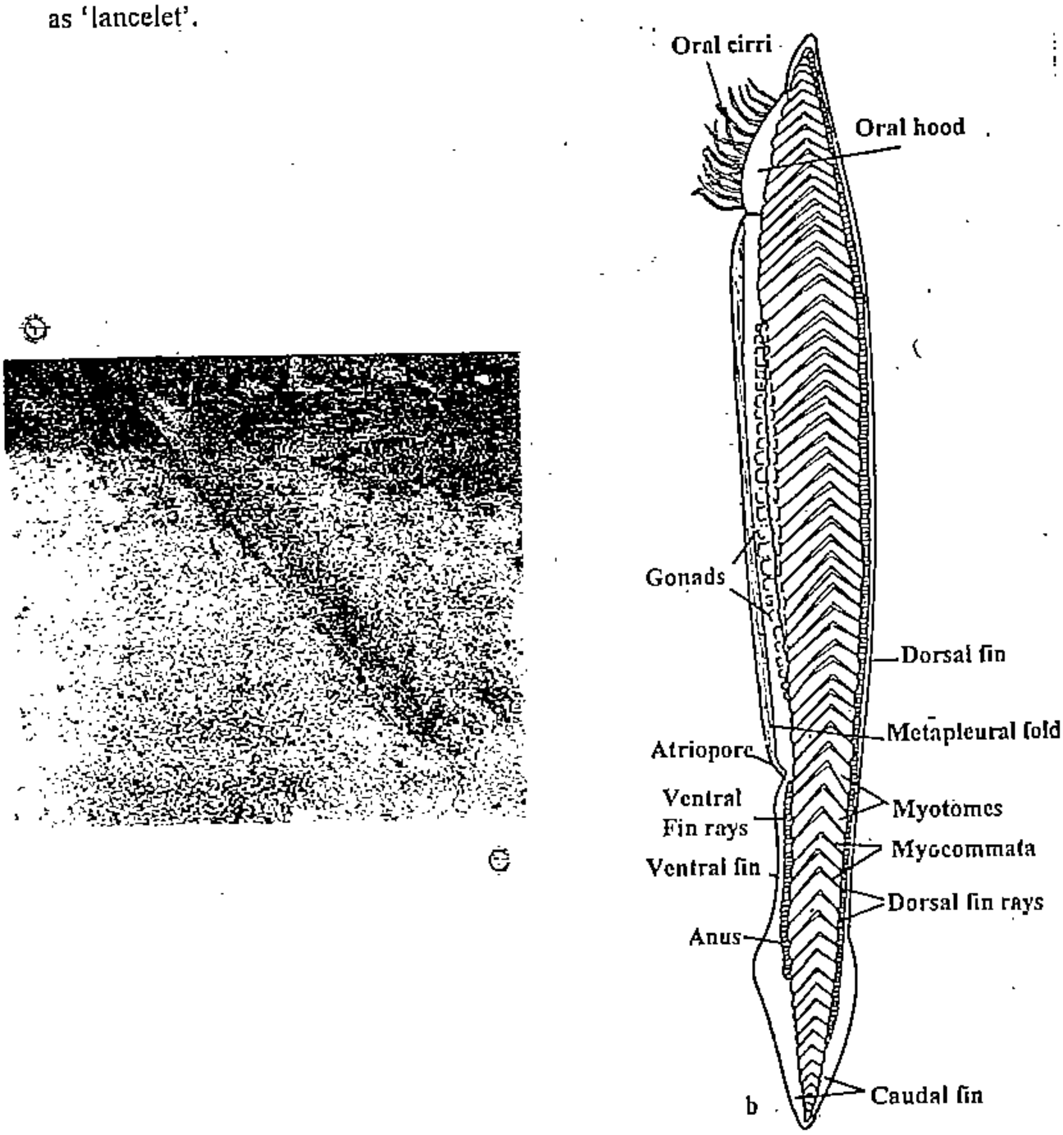


Fig. 23.3: *Branchiostoma* (*Amphioxus*). a) Seen lying in its normal position, partly buried in sand (Note the v-shaped myomeres used in swimming to new sites and burrowings. b) Drawing of *Amphioxus*.

ii) Body is laterally compressed and streamlined, which is an adaptation for burrowing as well as swimming.
iii) The posterior end is more tapering and pointed than the anterior end.
iv) The trunk bears three openings, mouth, **atriopore** and anus. The entire body can be divided into (i) Cephalic (ii) Abdominal and (iii) Atrial regions.
v) Anteriorly, there is a tentaculated oral hood, which is formed by the dorsal and lateral projections of the body.

vi) Anteriorly free ventro – lateral edges or margins called the oral hood have 10 to11 pairs of slender, stiff and ciliated oral or **buccal cirri**. Buccal cirri bears sensory papillae too.

vii) The paired fins are absent in *Branchiostoma* but longitudinal, unpaired median fin can be recognised.
   - A dorsal fin in the Form of a fold of skin extends along the whole surface.
   - A caudal fin is present around the tail whereas, ventral fin runs mid-ventrally in the posterior part of the body from caudal fin to the **atriopore**.
   - Dorsal and ventral fins (or ridges) are supported by small rectangular **stiffeners** called fin-ray boxes. There is one row of such boxes in the dorsal fin and a double row (right and left) in the ventral fin, caudal fin has no stiffeners.

viii) Two **metapleural** folds, which are hollow and membranous run longitudinally along the ventro-lateral margins from oral hood to atriopore.

ix) On each lateral side of the body are a series of <-shaped **myotomes** or muscle bands, which are visible through the transparent body wall of the animal.

(This animal wonderfully depicts the four distinctive hall marks of the Phylum Chordata, dorsal tubular nerve cord, a notochord, gill-slits for filter feeding and a post anal tail for propulsion. It is considered an animal of classical Zoology as it represents a combination of primitive, specialized and degenerate features.)

Economic Importance

In China and Japan, this animal is sold in bulk as food.

Habit and Habitat

Branchiostoma leads a double mode of life. For most of the time, it remains buried in the sand in an upright condition with only the anterior end protruding above the sand (Fig. 23.3 a). At night or dusk, it comes out of the sand and swims actively by lateral undulating movements of its body caused by muscles.

It swims vertically in water. When disturbed it jumps out of its burrow, swims a short distance, drives back into sand keeping the head downwards and makes a U-turn inside, so that the anterior end comes up again above the sand.

It feeds on planktonic microorganisms brought along with a respiratory-cum-food water current, which constantly enters the mouth. Thus, the mode of feeding is ciliary like those of Urochordates.

The notochord that extends in front of mid-brain is a peculiarity not found in other chordates.

Geographical Distribution

It is cosmopolitan in distribution and is reported from different oceans of the world. It is more common in warmer seas, such as, Mediterranean and especially abundant near the coasts of United States, British Seas and even as far north as the coast of Norway.

These animals are collected in large numbers off the coasts of China and Japan, . The species common on the Indian sea coasts are *B. indicum*, *B. pelagicum*, *B. carribaeum* and *B. lanceolatus* (*lanceolatum*).

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.

Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Protochordata (Acrania)**	Marine small forms; notochord is either found in the larval stage or as such persists throughout life; cranium, jaws and paired appendages absent.
Subphylum	**Cephalochordata**	Solitary forms; nervous and blood vascular system in general pattern to higher chordates, notochord extends throughout the length of the body and persists throughout life.
Class	**Leptocardii**	Lancets; small fish-shaped chordates; metameric; body supported by well developed notochord; no vertebrae; no brain; no anterior array of sense organs; jawless filter feeders; mouth surrounds by an oral hood.
Genus	***Branchiostoma (Amphioxus)***	
Common name	**Lancelet**	

23.8 TERMINAL QUESTIONS

1. Why is *Herdmania* called a tunicate?

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2. Name the two external openings of *Herdmania*.

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3. What are the bright red patches on the test of a sea squirt?

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4. What are the two forms of *Doliolum*?

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5. What are the two characters of solitaria phase of *Doliolum*?

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6. What is the common name of *Branchiostoma*? Why is it so called?

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7. How is lancelet easily identified?

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8. Give one main difference between fishes and *Branchiostoma* pertaining to fins.

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9. List two major chordate characters found in *Branchiostoma*.

(1)..

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(2)..

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EXERCISE 24 CYCLOSTOMATA : OBSERVATION AND CLASSIFICATION OF SPECIMENS AND STUDY OF AMMOCOETE LARVA

Structure

24.1 INTRODUCTION

This exercise is based on section 2.2 (Unit 2) of Block 1, of LSE-10 theory course. As you will recall, members of Superclass Cylcostomata (lampreys and hagfishes) are distinguished from all other living Craniata by three main characters: (i) possession of a suctorial mouth devoid of functional jaws, (ii) a single nostril and (iii) absence of lateral appendages or paired fins. Gill chambers in Cyclostomata are round pouches, hence the name **marsupiobranchii**, with gill slits in 1-16 pairs. The tail of Cyclostomes is diphycercal. The skeleton is cartilaginous. Superficially, the Cyclostomes look like eels. The geographical distribution is interesting in that each branch of it contains genera that are mainly northern and others that are exclusively southern.

Objectives

After performing this exercise you will be able to:

- identify and give the scientific and common names of the specimens of *Petromyzon* and *Myxine* belonging to Superclass Cyclostomata,
- classify the identified cyclostomes up to the level of class,
- list characters justifying the classification of the identified genera and mention special feature, if any, and draw labelled diagram of each of the identified genera,
- mention the habit and habitat and geographical distribution, and economic importance, if any, of each of the identified genera.

24.2 MATERIALS REQUIRED

1. Museum specimens of the following cyclostomes:
   i) *Petromyzon*
   ii) *Myxine*
   iii) *Ammocoete* Larva
2. Laboratory manual
3. Practical Record Book
4. Pen, Pencils, Eraser, Ruler

24.3 GENERAL SCHEME OF CLASSIFICATION OF SUPERCLASS AGNATHA (CYCLOSTOMATA)

KINGDOM ANIMALIA

- Phylums
  - **Chordata**
    - Groups
      - **Protochordata**
        - Subphylums
          - **Urochordata**
          - **Cephalochordata**
      - **Vertebrata (Craniata)**
        - Superclasses
          - **Agnatha (Jawless fishes) Cyclostomes**
            - Classes
              - **Cephalaspidomorphi**
              - **Myxini**
          - **Gnathostomata Jawed fishes (Pisces) and tetrapods**
  - **Non Chordata**

Features of classes of Superclass – Agnatha

Superclass Agnatha (Jawless fishes) or Cyclostomata (Gr. *cyklos*, circular and *stoma*, mouth) comprises only two classes: (i) Cephalaspidomorphi and (ii) Myxini.

Class I – Cephalaspidomorphi (Gr., *kephale*, head, *aspidos*, shield, *morphe*, form)	**Class II – Myxini (Gr. *myxa*, slime)**
1. These are commonly called lampreys and are found both in marine and fresh water. 2. Body is slender, eel-like, rounded with naked skin. 3. One or two median fins, no paired appendages. 4. Sucker-like oral disc and tongue with well developed teeth. 5. Seven pairs of gills each with external gill opening. 6. Eyes well developed in adult. 7. Sexes are separate, long larval stage, consisting of *ammocoete* larva. 8. Examples are lampreys which are about 30 species, with common example of *Petromyzon* and its *ammocoete* larva. 17 species are found in North America.	1. These are commonly called hagfishes, which are all marine. 2. Body slender, eel-like, rounded with naked skin containing slime glands. 3. No paired appendages present, no dorsal fin (the caudal fin extends anteriorly along the dorsal surface). 4. Biting mouth with two rows of eversible teeth. 5. Five to sixteen pairs of gills with a variable number of gill openings. 6. Eyes are degenerate. 7. Sexes separate (ovaries and testes in same individual but only one is functional, so partially hermaphroditic), no larval stage and development is direct. 8. Example – *Myxine* (hagfish)

24.4 CLASS CEPHALASPIDOMORPHI: TYPE SPECIMEN - *PETROMYZON*

Petromyzon is commonly known as 'sea lamprey' or 'lamper eel'.

Examine the specimen of *Petromyzon marinus* (Fig. 24.1 a to 24.1 c). Rotate the jar from all sides to note the details as follows:

i) Body is cylindrical, elongated, eel-like, stout with unpaired fins (Fig. 24.1 a).
ii) Unpaired or median fins in the form of two membranous median dorsal fins present near the posterior end.

iii) A caudal fin supported by fin-rays is also present. An anal fin is present in females behind anus.
iv) Body is divided into head, trunk and a laterally compressed tail.
v) Exoskeleton is absent and the skin is naked and slimy and heavily pigmented.
vi) Mouth is in the form of suctorial funnel. It bears overlapping oral fimbrae along its marginal membrane, hooks and radiating rows of horny teeth. It is used for sucking (Fig. 24.1 b).

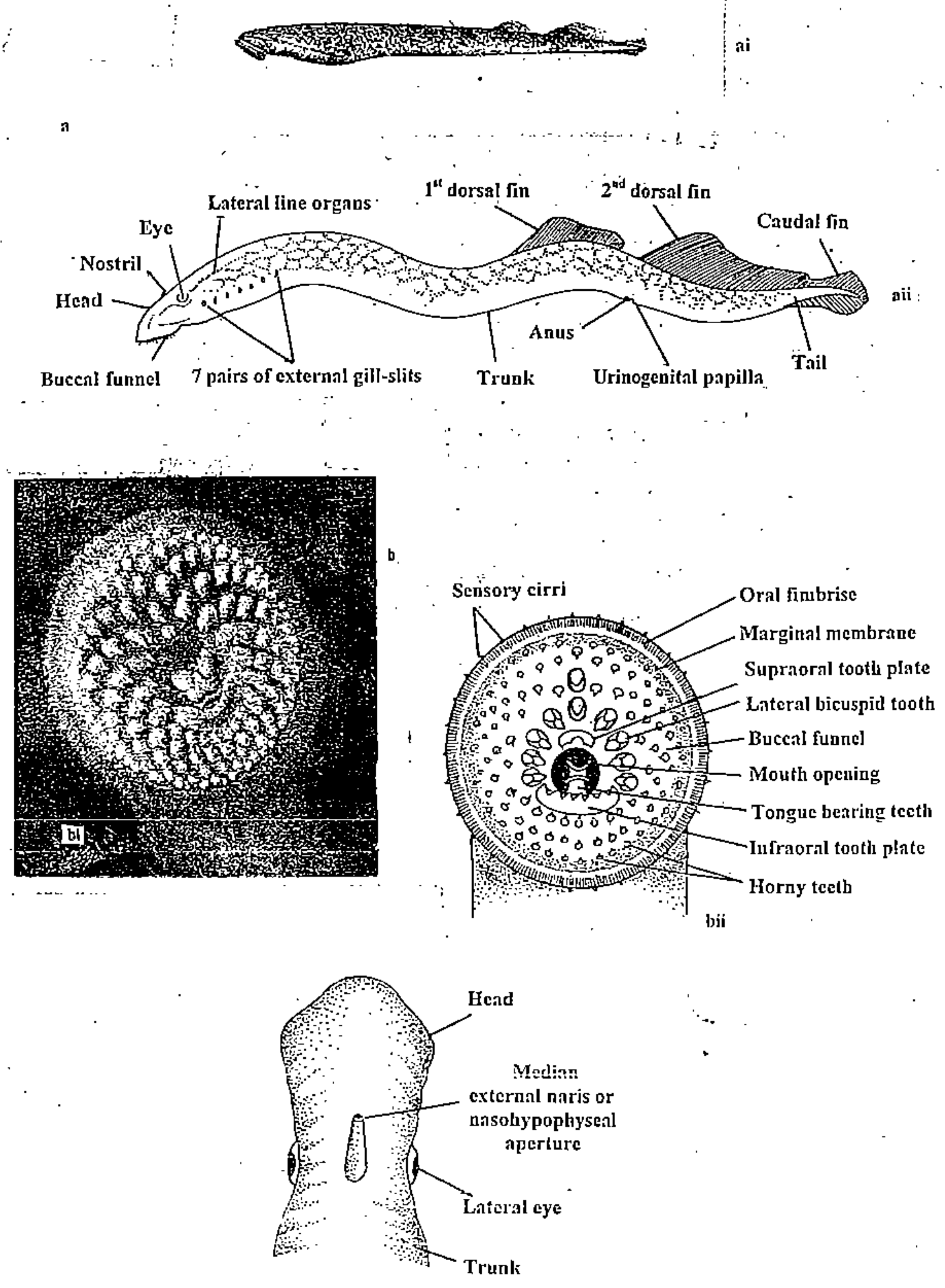

Fig. 24.1: *Petromyzon*. a) Entire (ai & aii). b) Buccal funnel (bi & bii) in ventral view. c) Head in dorsal view.

vii) A long rasping, protrusible and piston-like tongue is present, but jaws are absent.

viii) Head bears one pair of large lateral eyes, covered by a transparent area of skin (Fig. 24.1 c).

ix) Pineal eyes are present behind the nasohypophysial sac (Fig. 24.1 c).

x) Single nostril present mid-dorsally on the head. The nasal sac does not communicate with mouth (Fig. 24.1 c).

xi) Pharynx is perforated with 7 pairs of round gill slits and branchial basket is well formed.

xii) Cloaca is present on ventral side, at the junction of trunk and tail. (Fertilization is external. Development is indirect with a larval form known as **ammocoete.**)

Feature of Special Interest

Secondary sexual characters develop in females as a prominent anal fin, and in males as a penial tube and a thickening at the base of dorsal fin.

Habit and Habitat

Petromyzon or lamprey lives as ectoparasite on aquatic (marine) vertebrates (Fig. 24.2) and is anadromous in habit, i.e., it ascends fresh water rivers and streams for spawning. Lampreys stop feeding during migratory phase.

Lampreys build their nests in shallow water. The gamete cells are carried by the current of water into the interstices of the stony rim of the nest. The eggs are embedded in the nest by both the parents through their vigorous tail movements, which stir up the sand from the floor of the nest. When spawning is complete, the adults drop away from the nest and die within several days.

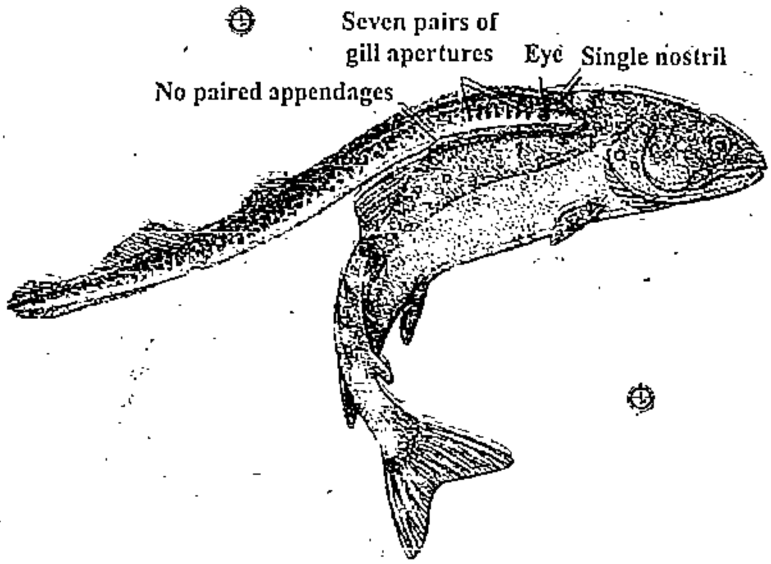

Fig. 24.2: *Petromyzon* attached to host fish.

Geographical Distribution

Petromyzon has a world-wide distribution and is found both in sea water of coastal regions and fresh water of streams and lakes in North America, Europe, West Africa, Japan, Chile, Australia, New Zealand and Tasmania.

Economic Importance

It causes serious deterioration of the great lake fisheries in the United States by sucking the blood of fish. Its salivary juice prevents coagulation of blood of the victim, i.e., it has anticoagulant property.

Larval lampreys are used as bait for sport fishing and commercial fishing.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood red containing R.B.C.
Superclass	**Agnatha (Cyclostomes)**	Jaws and paired appendages absent.
Class	**Cephalaspidomorphi**	Eel-like with suctorial mouth having horny teeth; median fins and a single nasal aperture; mouth without tentacles; nasal aperture is mid-dorsal and terminal; gills open to independent gill-slits, nasohypophysial sac does not communicate with the pharynx; well-developed and a complete branchial basket present.
Genus	***Petromyzon***	
Species	***marinus***	
Common name	**Sea Lamprey**	

24.5 AMMOCOETE LARVA OF *PETROMYZON*

It is a free-swimming larva of *Petromyzon*.

Examine the specimen of Ammocoetes larva (Fig. 24.3) and note the following features:

i) Ammocoete larva hatches out of egg of *Petromyzon*.
ii) Ammocoete larva has a long, slender body with an oral hood surrounding the mouth, much like the amphioxus.
iii) Ammocoete larva is without exoskeleton but is covered by thick mucous.
iv) Paired fins are absent but confluent median fin without fin rays is present.
v) There are two dorsal fins and a caudal fin around the tail.
vi) Mouth is not funnel-like, and the buccal cavity is without teeth, hooks and papillae.
vii) Jaws are absent but mouth (buccal cavity) is guarded by dorsal and ventral lips. Dorsal lip is circular and hood-like. Buccal cavity is provided with a number of buccal tentacles or oral cirri but is devoid of teeth and tongue.
viii) At the posterior end of the buccal cavity is present the velum, which is followed by pharynx.

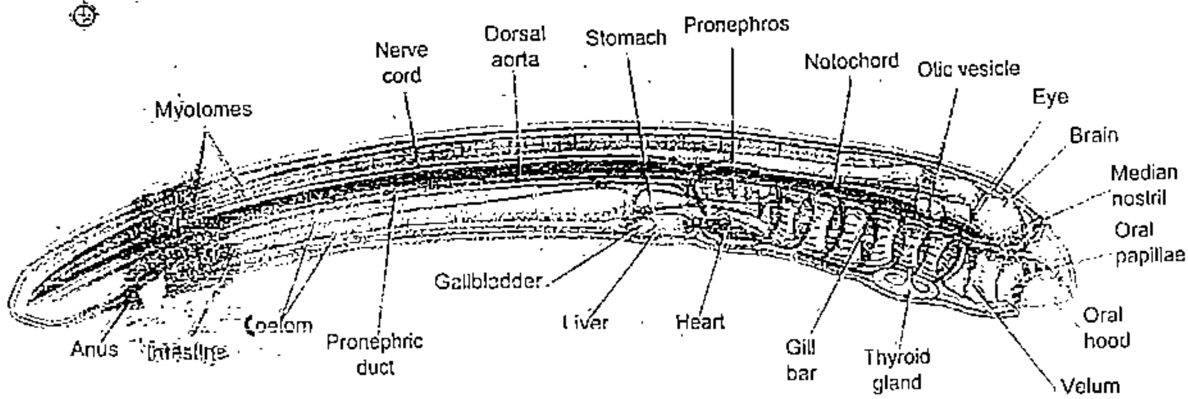

Fig. 24.3: Ammocoete larva.

ix) Two eyes one on each side of the mid-brain are present. Eyes are subcutaneous (hidden under the skin) and a single nostril is present as a median aperture.
x) External and internal nasal apertures and penial organs are absent.
xi) Seven pairs of gill slits are present in the pharynx.
xii) Pharynx possesses peripharyngeal groove and an endostyle, which is akin to thyroid gland of higher vertebrates and lies on ventral surface of the pharynx.
xiii) Anal aperture is present on ventral side at the junction of trunk and tail.

Habit and Habitat

Ammocoete larva is a fresh water larvae. It exhibits a prolonged larval period of 5 to 8 days. It shows anadromous type of nature in young stages and catadromous type of nature in adulthood. It is a filter feeder but instead of drawing water by ciliary action into the pharynx as amphioxus does the ammocoete produces feeding current by muscular pumping action much like modern fishes. The larva lies in mud and feeds on small organisms brought by the currents of water produced by muscular action of the branchial apparatus.

Geographical Distribution

It is found in the fresh waters, where it hatches and continues to grow. The young lamprey returns to sea water after metamorphosis is complete and becomes an adult.

Special Features

Ammocoete larva is of great phylogenetic significance because it exhibits characters of a generalized chordate and resembles adult *Amphioxus* in many respects. It is a connecting link between Cyclostomata and Cephalochordata.

24.6 CLASS MYXINI: TYPE SPECIMEN – *MYXINE*

Myxine is commonly known as 'hag fish' or 'slime eel'.

Examine the specimen of *Myxine glutinosa* (Fig. 24.4) carefully and note the following features:

i) Body is cylindrical, elongated, eel-like with feebly developed dorsal fin being continuous with the caudal fin (Fig. 24.4 ai & aii).
ii) Paired fins are absent. A caudal and a ventral fin are present. The caudal fin extends anteriorly along the dorsal surface.
iii) Fins are not supported by fin-rays.
iv) Body is differentiated into head, trunk and tail.
v) Exoskeleton (any kind of scales) is absent but mucus glands are numerous and arranged in two rows all along the body length.
vi) Eyes are subcutaneous, greatly reduced and covered with a pigmented fold of the skin.
vii) Branchial basket reduced. Pharynx is perforated with paired round gill-slits, 12 in number (six pairs), which open externally through one pair of common gill-slit.
viii) Mouth is subterminal, suctorial without jaws but with a single, hooked palatine tooth. It is guarded by wrinkled and soft lips with 4 pairs of tentacles (barbells) around it (Fig. 24.b).
ix) The single, median and terminal nasal aperture lies close to the mouth and communicates with it.
x) Hagfish is hermaphrodite, protandrous (testes maturing first) with single ovotestis.

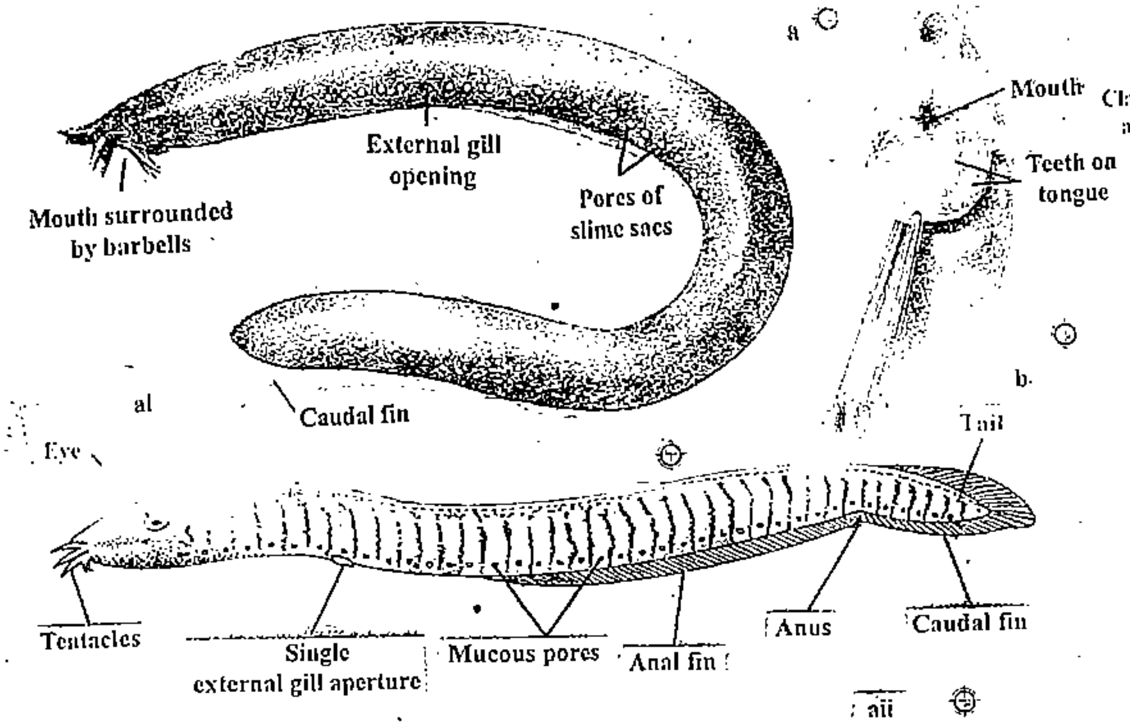

Fig. 24.4: *Myxine* (hagfish). a) Entire animal (ai & aii). b) Ventral view of head showing horny plates used to grasp food during feeding.

Habit and habitat

Myxine is found buried in the sand, mud or sea bottom up to the depth of 300 fathoms. It is marine and quasiparasite, feeding as a scavenger on dead and dying fish, annelids, molluscs and crustaceans. It burrows into the body of its host for consuming flesh, and hence it is also called a **borer** (Fig. 24.5).

Hagfishes are nocturnal feeders. During the daytime they lie buried in the sea bottom at depths of over 2000 feet. These fishes do not migrate to spawn but spawn on ocean floor. The eggs hatch into miniature adults without passing through a larval stage. For feeding and defense it draws the body into a knot and squeezes out.

Hagfishes are renowned for their ability to generate enormous quantities of slime. On contact with sea-water, the fluid forms a slime so slippery that the animal is almost impossible to grasp.

A medium sized *Myxine* can gelatinise as much as 500 cc of sea-water in less than a min.

Fig. 24.5: A hagfish attacks a fish which it hooks by twisting itself around the fish's body and then bores into the victim's flesh in order to eat the flesh.

Geographical Distribution

It is distributed in the deep waters of Atlantic, Pacific Oceans and in the sea water of South America. There are about 11 described species of *Myxine* out of which the best known *Myxine glutinosa* is found in North America.

Features of Special Interest

Hagfishes preserve many characteristics of early chordates and thus depict the organization of chordates before jaws were evolved.

Classification and its Justification

Kingdom	**Animalia**	Animals; multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Agnatha (Cyclostomata)**	Jaws and paired appendages absent.
Class	**Myxini**	Eel-like with suctorial mouth, median fins and a single nasal aperture.
Genus	*Myxine*	Mouth is terminal with 8-tentacles; nostril is median and terminal, nasophypophysial sac communicates with the mouth, gill slits are 1-15 pairs.
Species	***glutinosa***	
Common name	**Hagfish or Slime eel**	

24.6 TERMINAL QUESTIONS

1. What does the term Cyclostomata mean?

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2. How many pairs of gill-slits are found in *Petromyzon*?

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3. Name the larval stage of lamprey.

4. Elaborate on the statement "Lampreys are carnivores".

5. Why do lampreys migrate? Are lampreys anadromous or catadromous?

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6. Why is *Myxine* called a borer?

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7. How do hagfishes become slimy?

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EXERCISE 25 CHONDRICHTHYES : CARTILAGINOUS FISHES – OBSERVATION AND CLASSIFICATION OF SPECIMENS

Structure

25.1 INTRODUCTION

This laboratory exercise is based on cartilaginous fishes which you have already studied in Unit 2 (Subsection 2.2.1) of Block 2 of LSE-10 of the theory course. You will recall that the cartilaginous fishes are known as Chondrichthyes (Gr., *chondros*, cartilage and *ichthyes*, fish). This class comprises approximately 800 living species and is an ancient, compact and highly developed one. In this exercise you will study some representative members of Subclass Elasmobranchii, (Gr. *elasmos*, plate and *branchia*, gills) belonging to Class Chondrichthyes. The elasmobranchs include sharks, rays, skates, chimaeras, etc.

Objectives

After performing the exercise you will be able to:

- identify and give the scientific and common names of the specimens of *Scoliodon*, *Pristis*, *Torpedo* and *Trygon* belonging to the cartilaginous fishes,
- classify the identified cartilaginous fishes up to the level of class,
- list characters justifying the classification of the identified genera of cartilaginous fishes, draw their well labelled diagrams and mention special features, if any,
- mention the habit and habitat and geographical location and economic importance, if any of each identified genus of the cartilaginous fish.

25.2 MATERIAL REQUIRED

1. Museum specimen of the following cartilaginous fishes:
   i) *Scoliodon* (dogfish)
   ii) *Pristis* (sawfish)
   iii) *Torpedo* (electric ray)
   iv) *Trygon* (sting ray)
2. Laboratory manual
3. Laboratory Practical file
4. Pencil, eraser and ruler

25.3 GENERAL FEATURES AND CLASSIFICATION OF CHONDRICHTHYES

Members of class chondrichthyes retain their cartilaginous embryonic endoskeleton throughout their life. It is not replaced by bone though calcium salts are sometimes deposited within it in order to strengthen it. The general position of cartilaginous fish is given in Fig. 25.1. The class Chondrichthyes is divided into two sub-classes: (i) Elasmobranchii and (ii) Holocephali.

KINGDOM ANIMALIA
- Phylums
  - **CHORDATA**
    - Groups
      - **Protochordata**
      - **Vertebrata (Craniata)**
        - Superclasses
          - **Agnatha (without jaws)**
          - **Gnathostomata (Jawed fishes and tetrapods)**
            - Classes
              - **Chondricthyes**
                - Subclasses
                  - **Elasmobranchii**
                  - **Holocephali**
              - **Osteichthyes**
              - **Amphibia**
              - **Reptilia**
              - **Aves**
              - **Mammalia**
  - **NON CHORDATA**

Placoid scales (Cartilaginous fishes)

Fig. 25.1: Placoid scales are small, conical tooth-like structures and are characteristic of the cartilaginous fishes, the chondrichthyes.

Features of Chondricthyes

1. The cartilaginous fishes are mostly marine and predaceous.
2. They have fusiform or spindle-shaped body.
3. Their fins are both median and paired, all supported by fin-rays. Pelvic fins bear claspers in males.
4. Tail is heterocercal.
5. Skin is tough. It contains minute placoid scales (Fig. 25.1) and mucous glands.
6. Endoskeleton is entirely cartilaginous without any bones.
7. Mouth is ventral and jaws have teeth.
8. Sexes are separate, gonads are paired and gonoducts open into cloaca.
9. These fishes are oviparous or ovoviviparous and fertilization is internal.

25.4 SUBCLASS ELASMOBRANCHII : STUDY OF TYPE SPECIMENS

Elasmobranchs have five to seven separate gill openings on each side: operculum or gill-cover is absent, dorsal fin(s) and spines, if present, are rigid; males usually possesses claspers but clasper organs not found on head; dermal placoid scales often present; palatoquadrate (upper jaw) not fused to cranium (suspension amphistylic or hyostylic); branchial basket mostly behind the neurocranium; tooth replacement relatively rapid; teeth numerous; some ribs usually present; spiracle opening (remains of hyoidean gill slit) usually present.

Elasmobranchs are typically predaceous fishes that rely more on smell than on sight for obtaining their food (the olfactory capsules are relatively large and the eyes are relatively small).

In the present laboratory exercise you will study the specimens of *Scoliodon*, *Pristis*, *Torpedo* and *Trygon* belonging to Order Selachii.

25.4.1 *Scoliodon*

Scoliodon (Fig. 25.2) is commonly known as **dogfish shark**.

Examine the specimen and note the following features:

i) Body of *Scoliodon* is elongated, fusiform or spindle-shaped and laterally compressed. It is highly streamlined, offers least resistance to water, making efficient and rapid movements with minimum wastage of energy.

ii) Colour of the body is dark grey dorsally and pale white ventrally. This serves as a camouflage against predators in water. Body surface is rough due to backwardly projecting spines of **placoid** scales embedded in the skin.

iii) A fully grown individual measures about 60 cm in length and the body is divisible into three regions head, trunk and tail;

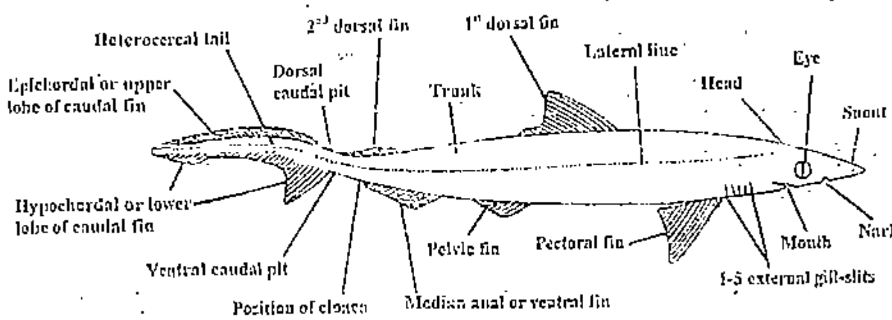
   a. Head is dorso-ventrally flattended and produced into a pointed **rostrum** or **snout**. Two prominent circular eyes are present on either side of head. A movable nictitating membrane situated antero-ventrally can be spread over eye at the time of danger.

   b. Trunk tapers behind gradually.

   c. Tail is **heterocercal** i.e., its posterior end is turned up and fringed with a caudal fin made up of two unequal lobes.

iv) A transverse **crescentric** mouth lies antero-ventrally on the head and bears 1 or 2 rows of sharply pointed teeth in upper and lower jaws.
Two crescentric nares (external nostrils) are also present ventrally, anterior to mouth. They are only olfactory.
Behind the eyes and anterior to each pectoral fin are present a series of five oblique, vertically elongated external gill slits or branchial clefts. These are respiratory in function.

a



b

Fig. 25.2: *Scoliodon*. a) Photograph of a small species of dogfish shark in its natural habitat. b) Museum specimen of common Indian dogfish (*Scoliodon*).

v) Fins are flap-like outgrowths of body-wall, which are directed posteriorly but are supported internally by cartilaginous rods and horny fin-rays. Median fins comprise two dorsal, one caudal and one ventral fin. The first dorsal fin is triangular in shape and situated a little in front of the middle of the body. The second dorsal fin is also triangular but much smaller and lies between the first dorsal fin and tip of the tail. The **ventral** or **anal** fin lie in front of the caudal fin.

vi) The larger anterior pectoral fins and the much smaller posterior pelvic fins are present as lateral fins. In the **male** dogfish, the medial part of each pelvic fin is produced into a grooved stiff and rod-like **intromittent** organ called **clasper** which is used in copulation.

vii) Lateral line is present on either side of the body as a faint line that extends from head to the posterior end of the tail.

viii) Sexes are separate, fertilization is internal and development is direct.

ix) It is viviparous giving birth to the living young ones that develop inside the uteri.

Economic Importance

S. sorrakowah is commonly studied almost everywhere in India. The dogfish is chosen for study as it is cartilaginous and can be easily dissected, has a suitable size, is not a popular fish to eat, has generalized piscean characters and its structure depicts the basic vertebrate plan. *Scoliodon* is however eaten by poor people living along the sea-coasts. Its dried skin provides shagreen.

Habits and Habitat

Scoliodon is marine being an inhabitant of the open seas. It is carnivorous and predaceous. It feeds on crabs, worms, lobsters and fishes. It is a fast swimming fish and catches hold of the prey by the sharp teeth.

Geographical Distribution

Scoliodon is distributed in the Indian, Pacific and Atlantic Oceans. Of the total of 9 species known, 4 are found in the Indian waters and these are *S. sorrakowah*, *S. dumerelii*, *S. palasorrah* and *S. walbeehmi*. The common Indian dogfish is *S. sorrakowah*, which means "black shark" in Tamil (*Sorra*, a shark + *kowah*, black).

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Chondrichthyes (Pisces)**	Cold blooded vertebrates, gills for respiration, fins for locomotion; streamlined body covered with scales. Cartilaginous endoskeleton; skin has tough but minute placoid scales.
Subclass	**Elasmobrachii**	Plate-gilled fishes. 5-7 separate gill openings.
Order	**Selachii**	Includes the shark rays and skates. Sharks with lateral gill openings; anterior edge of the pectoral fin not attached to the side of head and pectoral girdle halves not joined dorsally. Rays and skates with ventral gill openings, anterior

		edge of the enlarged pectoral fin attached to the side of the head, and pectoral girdle halves joined dorsally.
Suborder	Squaloidea	Two dorsal fins, with or without spines, anal fin absent; five gill slits, spiracles present.
Genus	*Scoliodon*	
Common name	**Dogfish shark**	

25.4.2 *Pristis*

Pristis is commonly known as **sawfish** (Fig. 25.3).

Examine the specimen and note the following features:

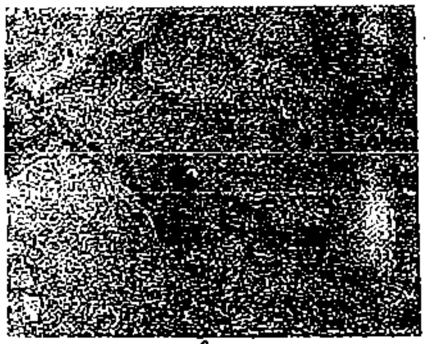
i) These are also hypotrematic elasmobranchs but do not have flattened bodies.
ii) The sawfish may attain a length of 3 to 6 metres.
iii) Rostrum or snout is an elongated blade-like structure armed on either lateral side with a row of sharp tooth-like scales (denticles), which make it a formidable weapon for defense as well as food capture.
iv) Spiracles are present behind the eyes.
v) Dorsal fins are large with the first dorsal fin being opposite to the pelvic fin.
vi) Tail is well developed and terminates in heterocercal caudal fin.

Features of Special Interest

As the sawfish swims through schools of small fishes, it swings the saw from side to side, thus disabling many of them and eating them at leisure.

Economic Importance

This fish is invaluable for liver oil of high vitamin value and for skin which is used for making scale boards.



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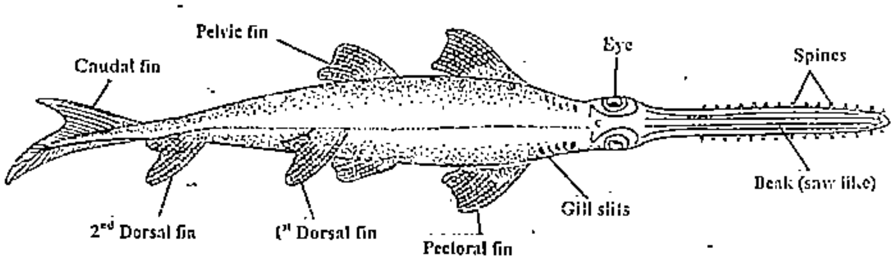

b

Fig. 25.3: *Pristis* (sawfish). a) In its natural habitat. b) Museum specimen.

Habit and Habitat

The fish is predaceous with food chiefly comprising small fishes, flesh of whales and other marine animals.

Geographical Distribution

This fish is marine and is found in Mediterranean and Atlantic Oceans particularly in America, West Indies, China and Gulf of Mexico. There are 2 species in India, *P. cuspidata* and *P. microdon*.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	Gnathostomata	Jaws and paired appendages are present.
Class	**Chondrichthyes (Pisces)**	Cold blooded vertebrates, gills for respiration, fins for locomotion; streamlined body covered with scales. Cartilaginous endoskeleton; skin has tough but minute placoid scales.
Subclass	**Elasmobrachii**	Plate-gilled fishes. 5-7 separate gill openings.
Order	**Selachii**	Includes the shark rays and skates. Sharks with lateral gill openings; anterior edge of the pectoral fin not attached to the side of head and pectoral girdle halves not joined dorsally. Rays and skates with ventral gill openings, anterior edge of the enlarged pectoral fin attached to the side of the head, and pectoral girdle halves joined dorsally.
Suborder	**Batoidea**	All rays and skates. Body dorsoventrally flattened, trunk and tail muscles reduced; gill openings ventral; spiracles present: anterior edge of pectoral fin greatly enlarged and attached to side of head.
Genus	***Pristis***	
Common name	**Sawfish**	

25.4.3 *Torpedo* (*Astrape*)

Torpedo (Fig. 25.4) is commonly known as electric-ray.

Examine the specimen and note the following features:

i) Body is circular and dorso-ventrally flattened with enormous pectoral fins for swimming.
ii) Pectoral fins are joined to head and trunk, so they look like a disc.
iii) The semicircular anterior margin of the disc is supported in the centre by a branched pre-nasal rostrum and laterally by the branched pre-orbital cartilage.

iv) Skin is smooth.

v) Mouth is transverse and ventral.

vi) Quandrangular naso-frontal lobe is present.

vii) A pair of large electric organs, one on either side in between the pectoral fins and head are present.

viii) A pair of large spiracles with valves are situated dorsally on the head.

ix) Five pairs of gill slits are present on the flat ventral surface of the head.

x) Tail is slender with a dorsal and a caudal fin.

xi) They are modern derivatives of sharks and specialized for bottom-dwelling.

Features of Special Interest

Certain dorsal muscles have modified into a powerful electric organ on either side between the eye and pectoral fin. They are capable of giving a powerful electric shock to stun their prey and enemies. Therefore, these organs are excellent for predation and defense purposes and give a powerful electric shock of about 100 volts.

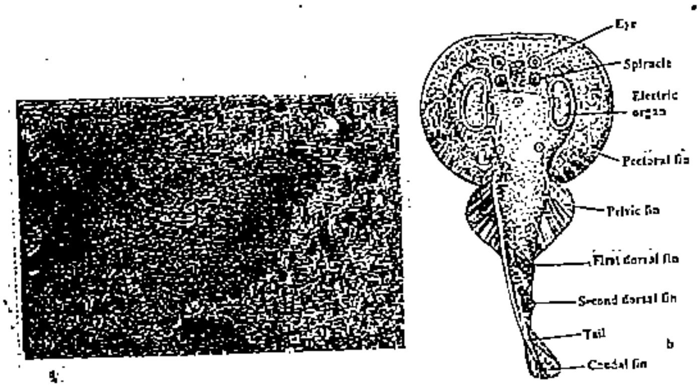

Fig. 25.4: *Torpedo* (electric ray). a) A Californian electric ray in its natural habitat. b) Museum specimen of electric ray.

Habit and Habitat

The electric rays conceal themselves in the sand rather than retreating. These fishes often eat bony fishes as large as is possible for them to swallow.

Geographical Distribution

Torpedo is found in Mediterranean and Red Sea, Atlantic and Pacific Oceans. *T. marmorata* is found in Indian Ocean.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.

Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Chondrichthyes (Pisces)**	Cold blooded vertebrates, gills for respiration, fins for locomotion; streamlined body covered with scales. Cartilaginous endoskeleton; skin has tough but minute placoid scales.
Subclass	**Elasmobrachii**	Plate-gilled fishes. 5-7 separate gill openings.
Order	**Selachii**	Includes the shark rays and skates. Sharks with lateral gill openings; anterior edge of the pectoral fin not attached to the side of head and pectoral girdle halves not joined dorsally. Rays and skates with ventral gill openings, anterior edge of the enlarged pectoral fin attached to the side of the head, and pectoral girdle halves joined dorsally.
Suborder	**Batoidea**	All rays and skates. Body dorsoventrally flattened, trunk and tail muscles reduced; gill openings ventral; spiracles present: anterior edge of pectoral fin greatly enlarged and attached to side of head.
Genus	*Torpedo (Astrape)*	
Common name	**Electric ray**	

25.4.4 *Trygon*

Trygon (Fig. 25.5) is commonly known as **sting ray.**

Examine the specimen and note the following features:

i) The body is dorso-ventrally flattened which is broader than long and looks like a sub-rhomboidal disc with the pectoral fins.
ii) The pectoral fins are enlarged, confluent with the sides of the head and fused from head to trunk. Pelvic fins are small.
iii) The tail is long, slender, flexible, whip-like, with a small caudal fin and armed with a stinging spine.
iv) It is the dorsal fin which at the base forms a large and barbed or serrated spine. The spine is provided with a poison gland in the skin.
v) Mouth is ventral in position. Nasofrontal flap is present in front of mouth.
vi) Only 5 pairs of gills slits are present on the flat, ventral surface of the head.
vii) A pair of eye and a pair of large spiracles with valves are present dorsally on the head.
viii) Claspers are present near the pelvic fin in the male.

Features of Special Interest

The serrated spine can be driven into the body of anyone stepping on the ray, inflicting a painful and dangerous, slow healing wound. It is an extremely venomous fish. Pliny among classical writers seems to have suspected the presence of venom in this fish, "Nothing is more terrible than the sting that arms the tail of *Trygon*. When driven into a root of tree, it causes it to wither. It can pierce armour like an arrow, it is as strong as iron, yet possesses venomous properties".

Economic Importance

Trygon inflicts painful wounds on the victim including human by means of the sting on tail which leads to **gangrene** or **tetanus**. Its liver is used for extracting liver oil.

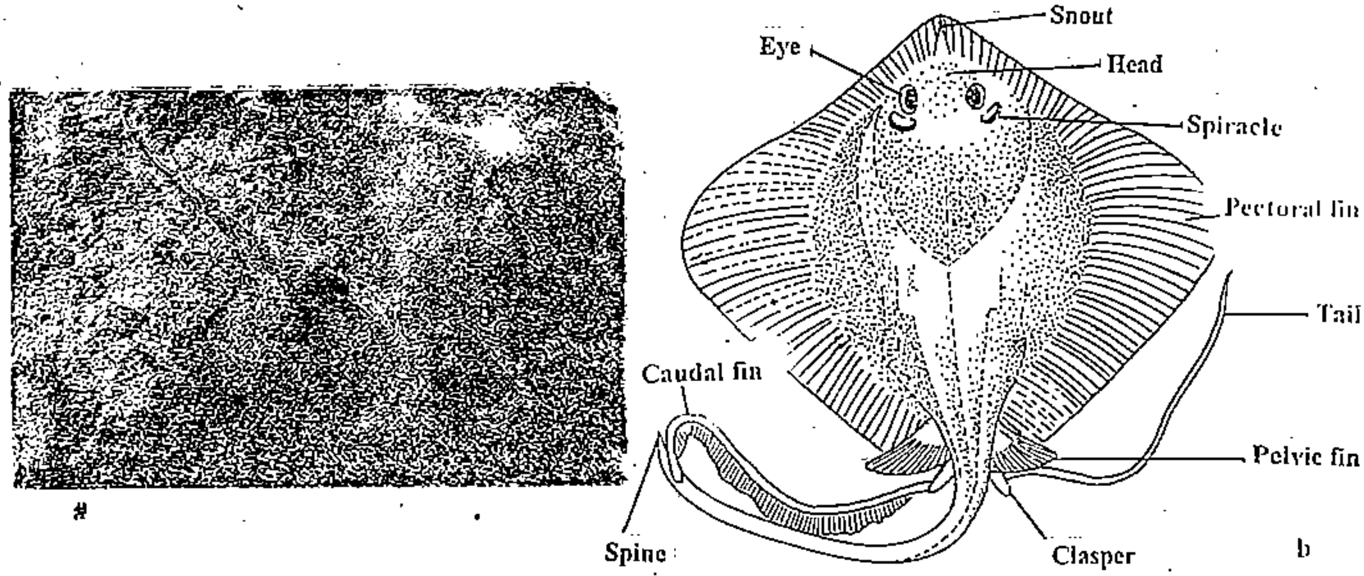

Fig. 25.5: *Trygon* (Stingray). a) A southern sting ray in its natural habitat. b) Museum specimen of the sting ray.

Habit and habitat

The sting rays lie half buried in sand and are bottom dwellers along the sea-coasts. This gives them special protection from predators approaching them from above.

Geographical Distribution

Trygon is found in tropical and subtropical seas.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Chondrichthyes (Pisces)**	Cold blooded vertebrates, gills for respiration, fins for locomotion; streamlined body covered with scales. Cartilaginous endoskeleton; skin has tough but minute placoid scales.
Subclass	**Elasmobrachii**	Plate-gilled fishes. 5-7 separate gill openings.
Order	**Selachii**	Includes the shark rays and skates. Sharks with lateral gill openings; anterior edge of the pectoral fin not attached to the side of head and pectoral girdle halves not joined dorsally. Rays and skates with ventral gill openings, anterior edge of the enlarged pectoral fin attached to the

		side of the head, and pectoral girdle halves joined dorsally.
Suborder	**Batoidea**	All rays and skates. Body dorsoventrally flattened, trunk and tail muscles reduced; gill openings ventral; spiracles present: anterior edge of pectoral fin greatly enlarged and attached to side of head.
Genus	*Trygon* (*Dasyatis*)	
Common name	Sting ray	

25.5 TERMINAL QUESTIONS

1. What are the common names of the following?
   i) *Scoliodon* ....
   ii) *Pristis* ....
   iii) *Torpedo* ....
   iv) *Trygon* ....

2. Name common species of *Scoliodon* that you have studied and explain the reason for its popular name dogfish.
   ....
   ....

3. Explain why the *Scoliodon* is said to be viviparous.
   ....
   ....

4. What is the significance of the rostrum of *Pristis*?
   ....
   ....

5. Both *Torpedo* and *Trygon* are called ray fishes. Yet how do they differ?
   ....
   ....
   ....

EXERCISE 26 *SCOLIODON* : THE DOGFISH – MAJOR AND MINOR DISSECTIONS AND OBSERVING PERMANENT MOUNTS

Structure

26.1 INTRODUCTION

Scoliodon (dogfish) is the commonest cartilaginous fish convenient for dissections. It has a spindle-shaped and laterally compressed body. The entire surface is rough due to the presence of placoid scales. Trunk bears median unpaired fins and lateral paired fins. Tail is heterocercal and bears a caudal fin.

Objectives

After performing this exercise, you will be able to:

- trace its alimentary canal,
- trace afferent branchial arteries,
- trace cranial nerves,
- mount internal ear,
- observe the permanent mount of placoid scales from *Scoliodon* and cycloid and ctenoid scales from *Labeo* and *Anabas*,
- observe the permanent mount of ampulla of Lorenzini.

26.2 MATERIAL REQUIRED

Preserved *Scoliodon*
Preserved *Labeo*
Preserved *Anabas*
Dissection [illegible]
Dissection [illegible]
Potassium hydroxide
[illegible]
Burner/Spirit Lamp
Permanent slides of :
  Placoid scale of *Scoliodon*
  Cycloid scale of *Labeo*
  Ctenoid scale of *Anabas*
  Ampulla of Lorenzini of *Scoliodon*
Practical Record Book

26.3 EXTERNAL FEATURES

Procedure: Take a form[illegible] [illegible]ved *Scoliodon*, and wash in tap water. Lay down the fish in a dissect[illegible] [illegible] and examine the external features from dorsal, lateral and ventral sides. D[illegible] lateral view of the specimen. Observe and note the following features (Fig. 26.1).

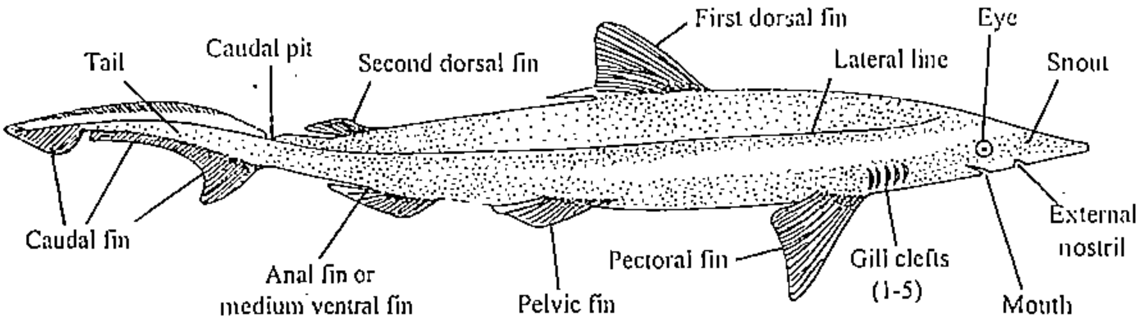

Fig. 26.1: External features of *Scoliodon*.

1. Size of adult female dogfish is larger than that of male dogfish. ([illegible] male possesses claspers attached to the pelvic fins)
2. Body is spindle-shaped and laterally compressed, whereas head is so[illegible]t dorsoventrally flattened.
3. The undersurface of body is yellowish white; the back and sid[illegible] of [illegible] brownish in colour.
4. The body is covered with backwardly directed spines of [illegible] scal[illegible] that [illegible] embedded in the skin and hence the body surface is rough [illegible] touch.
5. The body shows clear division into head, trunk [illegible] tail.

Head: It is flattened and produced into a sn[illegible]t in fr[illegible] f the m[illegible] te t[illegible] following structures in head:

i) Mouth is crescentic in shape, [illegible] te[illegible] the ve[illegible] surfac[illegible] is guarded by the upper and lo[illegible]. In [illegible] mouth a[illegible] resent [illegible] which are backwardly direct[illegible]
ii) Anterior to the mout[illegible] se[illegible] res wh[illegible] y placed small apertures on e[illegible]
iii) A pair of eyes [illegible] si[illegible] ed [illegible] th[illegible] side[illegible] large in size. Each eye con[illegible] s lo[illegible] e[illegible] d, upper e[illegible] d and a [illegible] nt nictitating membr[illegible]
iv) S[illegible]veral [illegible] re pr[illegible] d the lower surfaces of the [illegible]. Ea[illegible] the[illegible] al.
v) [illegible] e be[illegible] d, [illegible] re [illegible] its on either side.

Tru[illegible] [illegible] body starting from behind the gill slits up to the [illegible] re. [illegible] the [illegible] are paired lateral fins and median unpaired fins.

The pa[illegible] ol[illegible]

a) **Pe[illegible]** [illegible] pair. These are large fins which are found just behind the gill slit[illegible] zontal plane.
b) [illegible] **ins** [illegible] e pair. These are small in size and are found on either side of the [illegible] aperture.

[illegible] edian fins are:

[illegible] **irst dorsal fin:** It is found anterior to the middle part of the body and projects upward.

b) **Second dorsal fin:** It is smaller than the first dorsal fin and is found a little behind the first one.
c) **Ventral fin:** It is found on the ventral side, a short distance behind the second dorsal fin.

Tail: The portion of the body behind the cloaca is the tail. It propels the fish forward through the water by caudal fin. There are epicaudal and hypocaudal lobes in the caudal fin. A caudal pit is present at the junction of caudal fin and the tail.

Claspers (one pair) are found attached to the pelvic fins in male only. Sides of the fish contain lateral lines which are [illegible].

26.4 DIGESTIVE SYSTEM

Procedure: Take a fresh dogfish, wash in water and put it in the dissecting tray with the ventral surface facing upwards and fix the animal (fish) by pinning the pectoral fin. Give a longitudinal incision in the body-wall starting from the cloacal aperture end to the pectoral girdle and also cut transversely at each end of the longitudinal incision. Pin down the cut flaps. Now you may examine the internal organs (Fig. 26.2) as follows:

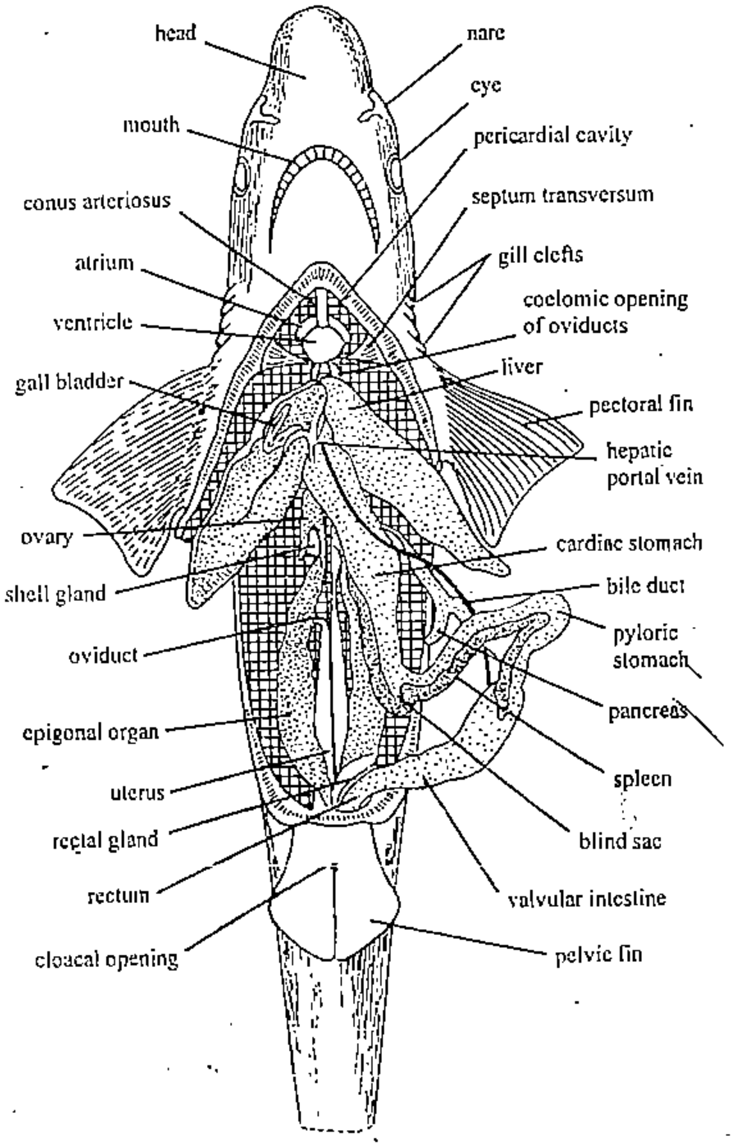

Fig. 26.2: Digestive system of *Scoliodon*.

Observations

1. Behind the pharynx is a short *oesophagus* which leads into the stomach.
2. The *stomach* is J-shaped and is divided into the proximal cardiac stomach and distal pyloric stomach which are joined by the blind sac.
3. Pyloric stomach opens into the wide *intestine*, which is internally folded into the *scroll valve*. The scroll valve can be seen by cutting the intestine transversely or longitudinally.
4. The intestine leads into cloaca. A relatively large rectal or [illegible] gland opens on the dorsal surface of *rectum*.
5. The *liver* is in the form of two large and elongated lobes ventral to cardiac stomach. The two lobes are jointed anteriorly, on the dorsal side is found the gall bladder.
6. The *pancreas* is in the form of bilobed compact gland situated in the angle between two limbs of stomach.
7. The *spleen* is found in the coils of the pyloric stomach.
[Other vascular organs which are visible along with the digestive system include pericardium, heart (atrium and ventricle), conus arteriosus, ventral aorta and septum transversum, testes, vasa deferentia, vesiculae seminales, sperm sacs (in male), ovaries, [illegible] with oviducal funnels, epigonal organs, shell glands, uterus (in female) and kidneys, ureters and cloaca.]

26.3 AFFERENT BRANCHIAL ARTERIES

Procedure: To expose the heart and afferent branchial arteries, first cut through the pectoral girdle and remove its middle portion. Locate the heart and remove the pericardium and then trace the afferent branchial arteries (Fig. 26.3).

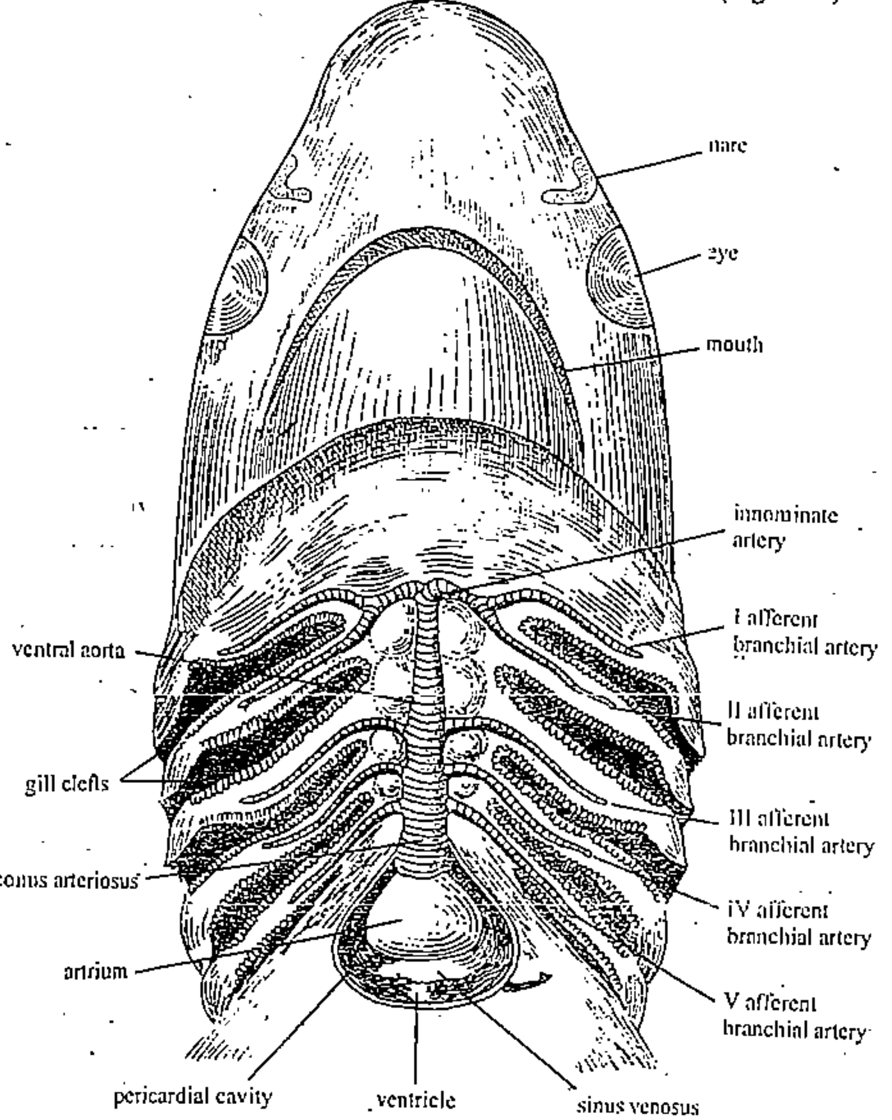

Fig. 26.3: Afferent branchial arteries of *Scoliodon*.

Observations

1. The *heart* is the dorso-ventrally bent muscular tube containing four chambers: sinus venosus, auricle, ventricle, and conus arteriosus.
2. *Afferent branchial arteries*: The conus arteriosus is continued forward as ventral aorta which gives rise to five pairs of afferent branchial arteries.

The ventral aorta runs up to the posterior border of the pharynx. Distally it divides into two innominate arteries; each of which again divides into I afferent branchial artery and II^nd afferent branchial artery, the III^rd, IV and V^th afferent branchial arteries originate directly from the ventral aorta [illegible] distal [illegible] each other. Hence there are five pairs of afferent branchial arteries which supply the five pairs of gills.

26.6 CRANIAL NERVES

Procedure: Take dogfish [illegible] and make a longitudinal incision in the integument in the [illegible] of the head from the pectoral fin region upto the snout. Carefully remove the flap of integument by giving the transverse incision at the level of pectoral fins. Remove the cranium wall to expose the cranial nerve on the right side and trace them from their origin up to their innervation. There are 10 pairs of cranial nerves but you have to expose only the V^th, VII^th, IX^th and X^th cranial nerves.

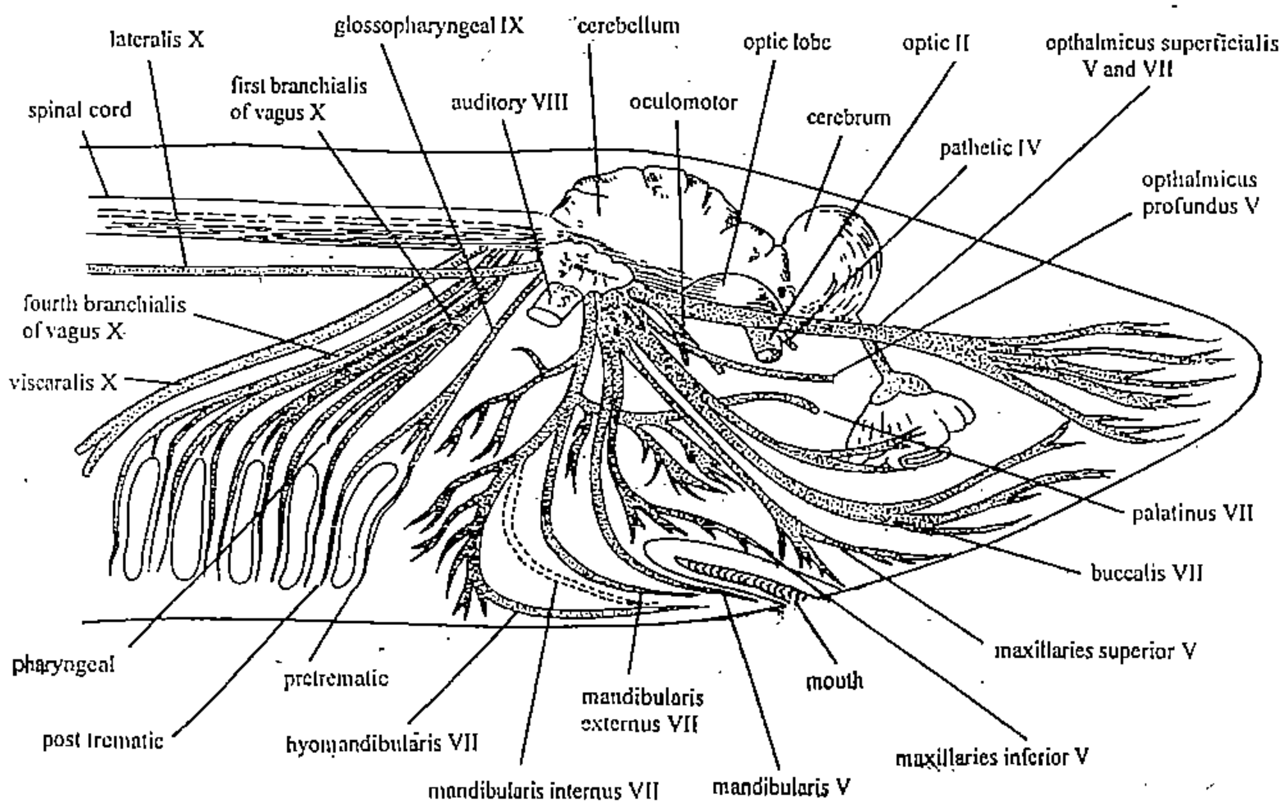

Fig. 26.4: Cranial nerves of *Scoliodon*.

Note the following cranial nerves: (Fig. 26.4)

1. Fifth or the Trigeminal nerve has four branches:
   i) Opthalmicus superficialis has two branches.
   ii) Maxillaris has two branches.
      a) Maxillaris superior
      b) Maxillaris inferior
   iii) Mandibularis

iv) Opthalmicus profundus

2. Seventh or the Facial Nerve has five branches:
   i) Opthalmicus superficialis
   ii) Ramus palatinus (GK *ramus*: branch)
   iii) Ramus buccalis
   iv) Ramus hyomandibularis has three further [illegible]es
      a) Mandibularis externus
      b) Mandibularis internus
      c) Hyoidean

3. Ninth or Glossopharyngeal nerve has two [illegible]ches:
   i) Pretrematic (GK *trema* = h[illegible]efering t[illegible] slit)
   ii) Posttrematic

4. Tenth or vagus nerve h[illegible] branc[illegible]
   i) Branchialis
   ii) Visceralis
   iii) Lateralis

After completi[illegible] the [illegible]ection, inse[illegible]er beneath the cranial nerves for the display of the d[illegible]tio[illegible]

26.7 I[illegible]

Pr[illegible]ure: T[illegible] which is also known as *membranous labyrinth* lies in the aud[illegible]psule[illegible] the orbit on either side. The auditory capsules are seen as bulg[illegible] either [illegible] Re[illegible]e the skin over the auditry capsule. You will observe [illegible]dges [illegible] ve[illegible], horizontal and posterior vertical semicircular canals. You [illegible] gen[illegible] [illegible]lage capsules with the help of forceps. Please take care not to injure the [illegible]mbranous lahyrinth. Then locate the three canals and proceed.

The i[illegible]a[illegible] consists of anterior vertical canal, horizontal canal and posterior [illegible]ntral[illegible]a[illegible]gena, cochlea, recessus utriculi, utriculus, and nerve supplies.

C[illegible]ull out the intemal ear with all its structures and place it in a watch glass conta[illegible]g some water. Study its various parts and draw a neat labelled diagram (Fig. 26.5).

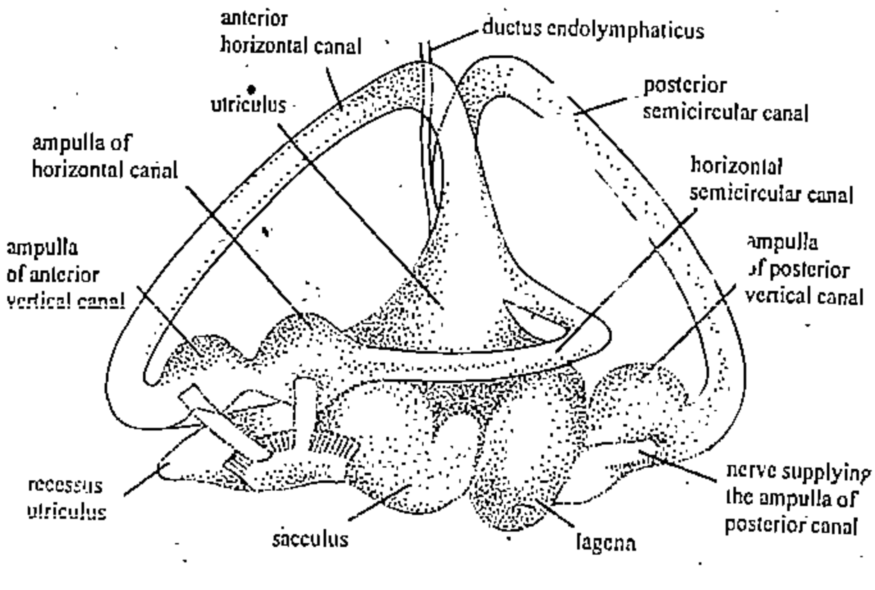

Fig. 26.5: Internal ear of *Scoliodon*.

26.8 PERMANENT MOUNTS

Placoid Scales – From *Scoliodon*

Procedure: Observe the following characters in the permanent slide of placoid scales of *Scoliodon*.

Observations

1. Placoid scales (odontoids) are minute dermal denticles closely arranged in regular oblique rows.
2. They form entire exoskeleton of dogfish and give a rough appearance to the skin.
3. Each placoid scale has a diamond shaped basal plate embedded in the skin and is derived from dermis.
4. Anteriorly each placoid scale has a prominent flat trident spine projecting out of the skin (Fig. 26.6).

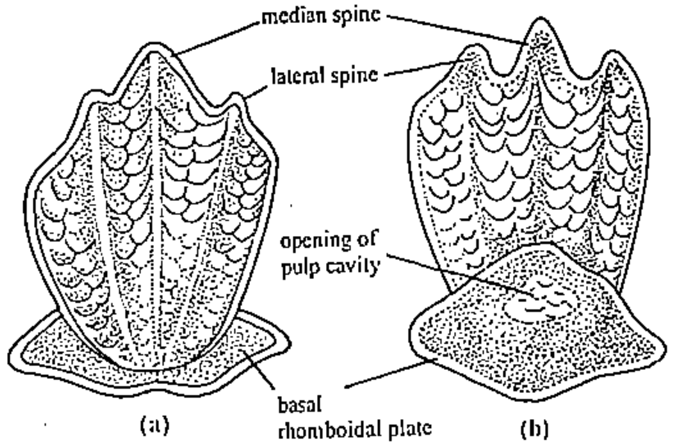

Fig. 26.6: Placoid scale of *Scoliodon*.

Cycloid Scales – From *Labeo* (Rohu)

Observe the lines of growth and nucleus in the permanent slide of cycloid scales of *Labeo*. (Fig. 26.7)

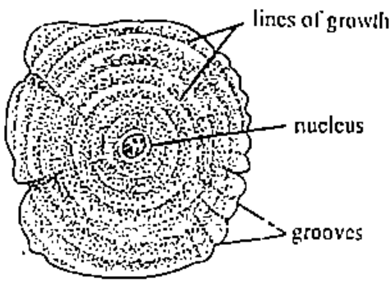

Fig. 26.7: Cycloid scale.

Ctenoid Scales – from *Anabas*

Observe the several concentric lines of growth, denticles or teeth and nucleus (Fig. 26.8) in the permanent slide of ctenoid scales of *Anabas*.

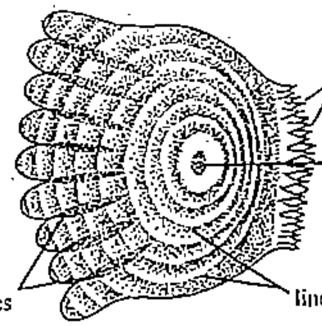

Fig. 26.8: Ctenoid scale.

26.9 AMPULLA OF LORENZINI

Ampulla of Lorenzini are found on the head of *Scoliodon*. There are several pores beneath the skin on the dorsal and ventral surface of the snout, each pore leads into a tubule of ampulla of Lorenzini.

Procedure: Observe the following characters in the permanent slide of ampulla of Lorenzini.

Observations

1. Each ampulla is made up of **ampullary sac.**
2. Each ampullary sac consists of eight to nine radially dilated chambers arranged round a central core, the **centrum.**
3. All the ampullary sacs are connected with a long tubule which opens at the surface of head through a pore known as **external aperture** (Fig. 26.9).

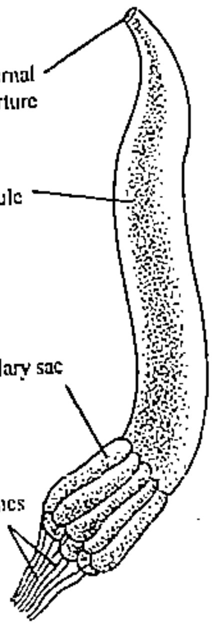

Fig. 26.9: Ampulla of Lorenzini.

4. All the groups of ampullae are innervated by the nerve branches of opthalmicus superficials, buccalis and hyomandibularis.
5. The ampullae lie together in clusters looking like bunches of grapes.
6. The ampullae of Lorenzini are thermoreceptors.

26.10 TERMINAL QUESTIONS

1. What is the function of ampulla of Lorenzini and where are they found?

2. What is the difference between cycloid and ctenoid scale?

3. How many pairs of cranial nerves are present in *Scoliodon*?

4. How do you distinguish between a male and female dogfish?

5. Which two pairs of cranial nerves show numerous principal branches?

EXERCISE 27 BONY FISHES : OBSERVATION AND CLASSIFICATION OF SPECIMENS

Structure

27.1 INTRODUCTION

The fishes are aquatic gnathostomes having a streamlined body. The paired appendages are pectoral and pelvic fins supported by fin rays. The median fins are two dorsal fins, an anal fin and a caudal fin. The exoskeleton is in the form of scales, dermal denticles or horny scutes. They have true jaws. The notochord is constricted into vertebrae. The respiration is by gills. The lateral line system is well developed.

In the modern bony fishes the endoskeleton is bony, skin with mucous glands. The body is either naked or with an exoskeleton of scales; the scales may be cycloid or ctenoid. The gill arches or branchial arches are 4 or 5 in number and the gill openings are covered with an operculum on each side supported by bones. The jaws are well formed ensheathed with membrane bones. Air bladder is usually present. The tail is diphycercal or homocercal. The mouth is usually terminal. The bases of the pectoral fin are not fleshy. The pectoral fins are supported by bony dermal fin rays or lepidotrichia, attached to the girdle directly. The jaw suspension is hyostylic. The internal nares are absent. Nervous system consists of a brain with small semicircular canals. Sexes are separate (sex reversal in some), gonads paired; fertilisation usually external; larval forms may differ greatly from adults.

Thus, the modern bony fishes are very widely diversified. They have conquered both fresh water and marine environment. They show a high degree of adaptive radiation. In the fresh water, the fishes are adapted to fast flowing streams in the hills, rivers, ponds, and lakes. In the marine medium they are present in the shore region, oceanic region and in the deep seas. Some of the bony fishes exhibit the phenomenon of migration for breeding purpose; from rivers to sea e.g. *Anguilla* (eel) (catadromous migration) and from sea to rivers e.g. *Salmo* (anadromous migration). This is of immense interest to ichthyologists. Some bony fishes exhibit parental care of many ways. Thus, an in-depth study of bony fishes is of great value to the students who are interested in the study of fishes.

Objectives

After performing this exercise you will be able to:

- identify the specimen of bony fishes and give their scientific/common name,
- classify up to order level,

- list their characters justifying the classification,
- explain their habit, habitat and distribution, and economic importance,
- draw labelled diagram of the specimens,

OUT LINE CLASSIFICATION OF BONY FISHES

Class	Subclass	Order	Example
Teleostomi or Osteichthyes	Actinopterygii	1. Clupeiformes	*Notopterus* (Chital)
		2. Cypriniformes	Division: Cyprini (*Labeo*, Rohu) Division: Siluri (Cat fish) *Clarias* – Magur *Wallago* – Malli/Lachi
		3. Anguilliformes	*Anguilla* (eel)
		4. Symbranchiformes	*Amphipnous* (Cuchia eel)
		5. Perciformes	*Anabas* (climbing perch)
		6. Beloniformes	*Exocoetus* (flying fish)
		7. Syngnathiformes	*Hippocampus* (Sea horse – male and female)
		8. Pleuronectiformes	*Synapta* (flat fish)
		9. Lophiformes	*Antennarius* (angler fish)

A table showing differences between cyclostomata, cartilaginous and bony fishes is given in Table 27.1. (Table 27.1 is given at the end of this exercise).

27.2 MATERIAL REQUIRED

Museum specimens of *Notopterus, Labeo rohita, Clarias, Wallago, Anguilla, Amphipnous, Anabas, Exocoetus, Hippocampus, Synpata, Synaptura, Antennarias.* The museum should be well equipped with the above listed specimens in the glass jars. The animal specimens may be procured from the museum specimen suppliers.

27.3 METHOD

Observe the specimens carefully and make labelled diagrams. Write the classification and justify the classification with reasons. Observe the characters in the specimen and note the special features in the specimen. This will enable you to make a proper identification of the specimen.

27.4 OBSERVATION

In each specimen, carefully observe the head, the trunk and the tail region. Examine the paired fins, their size, position and shape. In addition, examine the position of the median fins, their structure, and modification. Make a neat diagram of the specimen and label.

27.4.1 *Notopterus*

Characters

i) *Notopterus* (Fig. 27.1) is commonly known as 'Chitai' in Hindi.
ii) Body elongated, compressed sideways and oblong.
iii) Skin is covered with minute cycloid scales and they cover the head also.
iv) Body silvery white with a greenish tinge on the back.
v) Head small, snout obtuse and convex.
vi) Mouth terminal and wide with teeth on the jaws; barbels absent.

vii) Trunk has a humped dorsal profile with a small dorsal fin hence called feather back.
viii) Anal fin long and confluent with the caudal fin.
ix) Pectoral fins are small and placed anteriorly, whereas pelvic fins are reduced.
x) It is an edible fish.

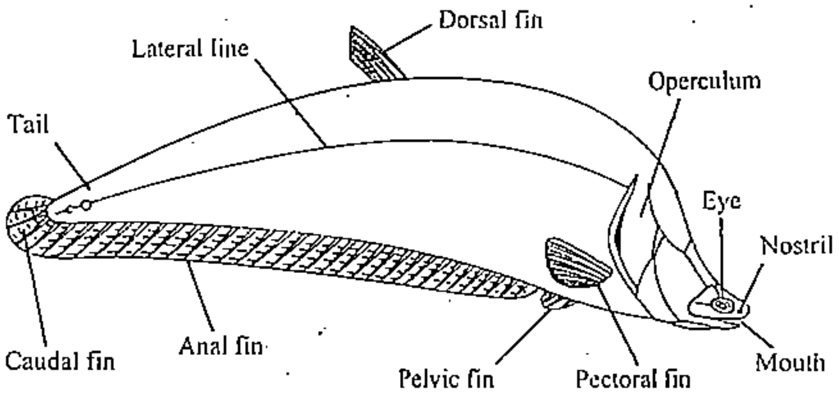

Fig. 27.1: *Notopterus* (Chital).

Habit and Habitat

Lives in fresh water rivers, lakes and ponds.

Geographical Distribution

India, Myanmar and Malayasia. It is carnivorous and feeds on molluscs, worms, crustaceans. Predaceous and surface and mid water feeder.

Classification and its Justification

Kingdom	Animalia	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	Vertebrata (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	Gnathostomata	Jaws and paired appendages are present.
Class	Osteichthyes	Endoskeleton bony, gill slits covered by operculum
Subclass	Actinopterygii	Single external gill opening on each side of the head. Paired fins are supported by fin rays.
Genus	*Notopterus*	
Common name	Chital or Feather back	

27.4.2 *Labeo rohita*

Characters

i) *Labeo rohita* (Fig. 27.2) is commonly called 'Rohu' in Hindi.
ii) Body laterally compressed, fusiform, attain maximum or one meter in length.
iii) It is blackish grey on the back and silvery white below.

iv) The body is covered with overlapping cycloid scales.
v) Head prominent with a blunt, oblong and depressed snout and is covered with small tubercles.
vi) Mouth sub-terminal, directed downwards and surrounded by thick lips.
vii) Upper lip with a pair of short barbels and lower lip fringed. Jaws without teeth.
viii) Dorsal fin large and placed about the middle of the body.
ix) Pectoral fin without spinous rays.
x) Tail small and homocercal.
xi) Air bladder physostomous and divided into an anterior and a posterior chamber.
xii) Weberian apparatus joins the air bladder with the internal ear.
xiii) Lateral line canal passes through the scales.

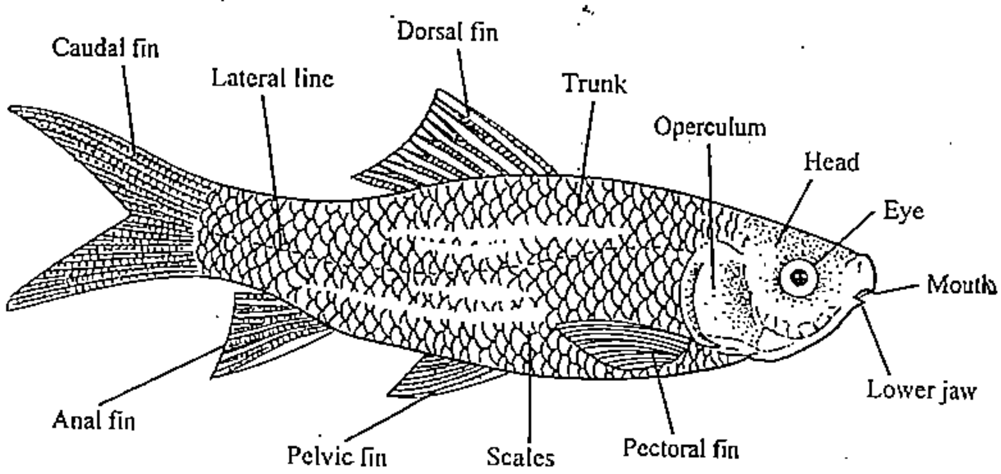

Fig. 27.2: *Labeo rohita* (Rohu).

Habit and habitat

Lives in rivers, ponds and lakes; used in pisciculture; column feeder; feeds on flora and fauna in deep waters. It is an edible fish.

Geographical Distribution

Widely distributed Indian carp. Found in tropical and subtropical regions.

Classification and its Justification

Kingdom	Animalia	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	Vertebrata (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	Gnathostomata	Jaws and paired appendages are present.
Class	Osteichthyes	Endoskeleton bony, gill slits covered by operculum
Subclass	Actinopterygii	Single external gill opening on each side of the head. Paired fins are supported by fin rays.
Order	Cypriniformes	Weberian apparatus present. Air bladder physostomous; tail homocercal, operculum supported by bones.
Division	Cyprini	Scales cycloid, barbels reduced, commonly called as carps.

Genus	*Labeo*	
Species	*rohita*	
Common name	Rohu	

27.4.3 *Clarias*

Characters

i) *Clarias* (Fig. 27.3) is known as 'Magur' in Hindi.
ii) Body is greyish black with a dorso-ventrally flattened head and laterally compressed trunk and tail.
iii) Skin naked without scales.
iv) Head covered with osseus plates both dorsally and laterally.
v) Barbels long, 4 pairs; 1 nasal, 2 maxillary and 2 pairs mandibular.
vi) Tail diphycercal with a rounded caudal fin.
vii) Dorsal and anal fins are long but not confluent with the caudal fin.
viii) Pectoral fins with spinous first ray.
ix) Air bladder physostomous and connected with the internal ear by Weberian ossicles.
x) Possesses an accessory respiratory organ which is a highly branched organ. It is called as labyrinthine organ and is highly vascularised.
xi) It is an edible fish.

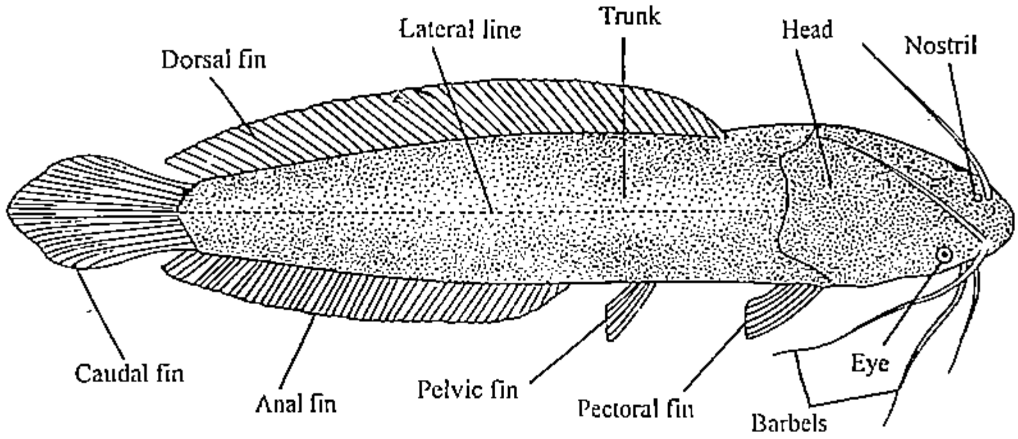

Fig. 27.3: *Clarias* (Magur).

Habit and Habitat

Lives in rivers, ponds and lakes. Carnivorous and generally mid-water and bottom feeders.

Geographical Distribution

Found in Sri Lanka, India and Malaysia.

Classification and its Justification

Kingdom	Animalia	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	Vertebrata (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	Gnathostomata	Jaws and paired appendages are present.
Class	Osteichthyes	Endoskeleton bony, gill slits covered by

		operculum
Subclass	Actinopterygii	Single external gill opening on each side of the head. Paired fins are supported by fin rays.
Order	Cypriniformes	Weberian apparatus present. Air bladder physostomous; tail homocercal, operculum supported by bones.
Division	Siluri	Scales absent; head with prominent barbels; commonly known as cat fishes.
Genus	*Clarias*	
Common name	Magur – Cat fish	

27.4.4 *Wallago*

Characters

i) *Wallago* (Fig. 27.4) is known as Malli/Lachi in Hindi.
ii) Body elongated, skin smooth, naked without scales.
iii) Body colour greyish brown with a purplish head and white belly.
iv) Mouth gape extends even behind the eyes.
v) Head large, dorso-ventrally flattened with two pairs of barbels of equal size.
vi) Dorsal fin small without spines.
vii) Anal fin long, distinct from the caudal fin.
viii) Tail homocercal, but the upper lobe of the caudal fin is slightly longer.
ix) Pectoral fins spinous and the spines are finely serrated.

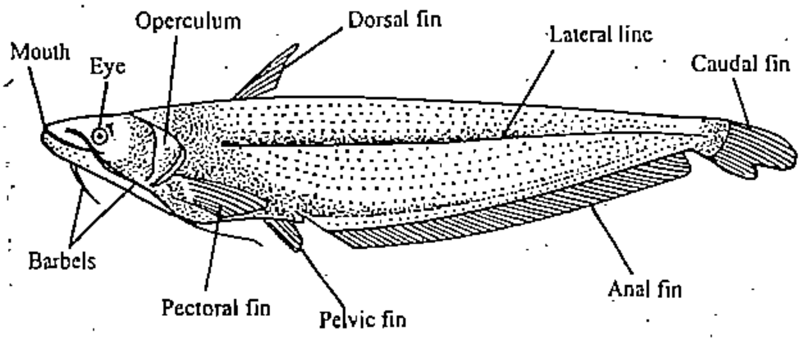

Fig. 27.4: ***Wallago*** **(Lachi/Catfish).**

Habit and Habitat

It is a fresh water catfish found in rivers, lakes and ponds, predaceous, feeds on young carps. It is an edible fish.

Geographical Distribution

Throughout India.

Classification and its Justification

Kingdom	Animalia	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	Vertebrata (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed;

		hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Osteichthyes**	Endoskeleton bony, gill slits covered by operculum
Subclass	**Actinopterygii**	Single external gill opening on each side of the head. Paired fins are supported by fin rays.
Order	**Cypriniformes**	Weberian apparatus present. Air bladder physostomous; tail homocercal, operculum supported by bones.
Division	**Siluri**	Scales absent; head with prominent barbels; commonly known as cat fishes.
Genus	***Wallago***	
Common name	**Malli/Lachi**	

27.4.5 *Anguilla*

Characters

i) *Anguilla* (Fig. 27.5) is commonly called as eel.
ii) The body is elongated and cylindrical in shape.
iii) Skin is brownish on the dorsal side and yellowish below.
iv) Skin with rudimentary scales arranged in oblique rows at right angles to one another.
v) Fins are soft; pectoral fins are short; pelvic fins absent.
vi) Dorsal and anal fins are elongated and continuous with caudal fin.
vii) Tail is long and cylindrical.
viii) It exhibits catadromous migration.

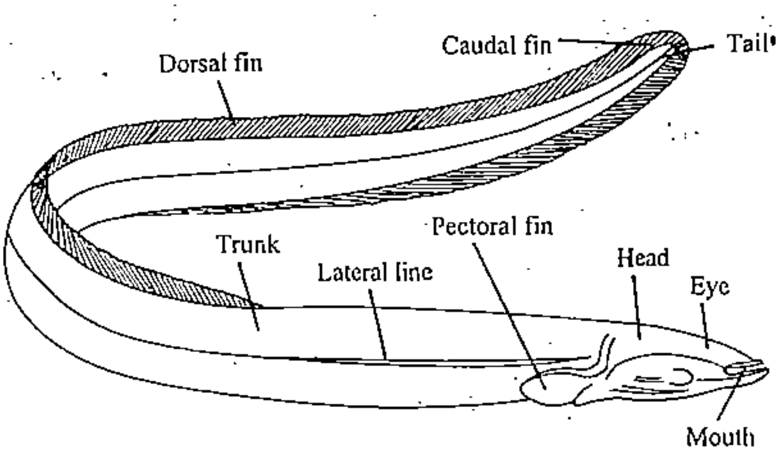

Fig. 27.5: *Anguilla* (Eel).

Habit and Habitat

Common in tropical and temperate regions of the world. It can live out of water for a short time. Cutaneous respiration is well marked.

Geographical Distribution

Anguilla is found in Gangetic estuaries, the Bay of Bengal, the India Pacific region to the seas of China and beyond. It lives in freshwaters in Europe and when mature migrates to Sargossa sea for breeding.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or

		capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Osteichthyes**	Endoskeleton bony, gill slits covered by operculum
Subclass	**Actinopterygii**	Single external gill opening on each side of the head. Paired fins are supported by fin rays.
Order	**Anguilliformes**	Body elongated, paired fins reduced. Skin with reduced scales. Anal and dorsal fins confluent with caudal fin.
Genus	***Anguilla***	
Common name	Eel	

27.4.6 *Amphipnous*

Characters

i) *Amphipnous* (Fig. 27.6) is known as blind serpent fish or cuchia eel.
ii) Body eel-like with reduced eyes.
iii) Dorsal, pelvic and anal fins are absent.
iv) Skin slimy and scales are buried in the skin.
v) Gills reduced and supplemented with two accessory respiratory air sacs.
vi) Air bladder, Weberian ossicles are absent.
vii) Tail with a membranous flap without rays.
viii) Mouth small and terminal.

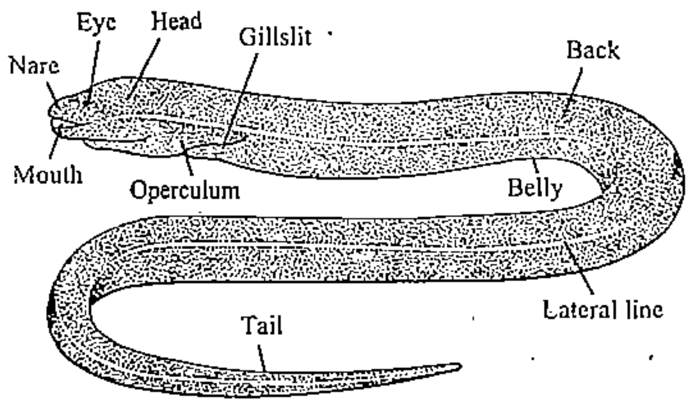

Fig. 27.6: *Amphipnous* (Blind serpent fish).

Geographical Distribution

Found in fresh and brackish water in India and Myanmar. More common in the rivers of Bihar, West Bengal and Bangla Desh.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.

Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Osteichthyes**	Endoskeleton bony, gill slits covered by operculum
Subclass	**Actinopterygii**	Single external gill opening on each side of the head. Paired fins are supported by fin rays.
Order	**Symbranchiformes**	Body eel-like, without scales, gills reduced, gill openings single; dorsal, pelvic and anal fins absent.
Genus	***Amphipnous***	
Common name	**Blind serpent fish/Cuchia eel**	

27.4.7 *Anabas*

Characters

i) *Anabas* (Fig. 27.7) is commonly known as climbing perch.
ii) Body laterally compressed and covered with cycloid and ctenoid scales. Scales are present on the head and operculum also.
iii) Dorsal and anal fins are long and differentiated into anterior spiny portion and posterior soft portion.
iv) Tail with rounded caudal fin.
v) Operculum spiny.
vi) Pectoral and pelvic fins are small; pelvic fins are thoracic in position.
vii) Air bladder physoclistous.
viii) Accessory respiratory organs in the form of labyrinthine plates that enable the fish to breathe atmospheric air and live out of water.
ix) It is an edible fish.

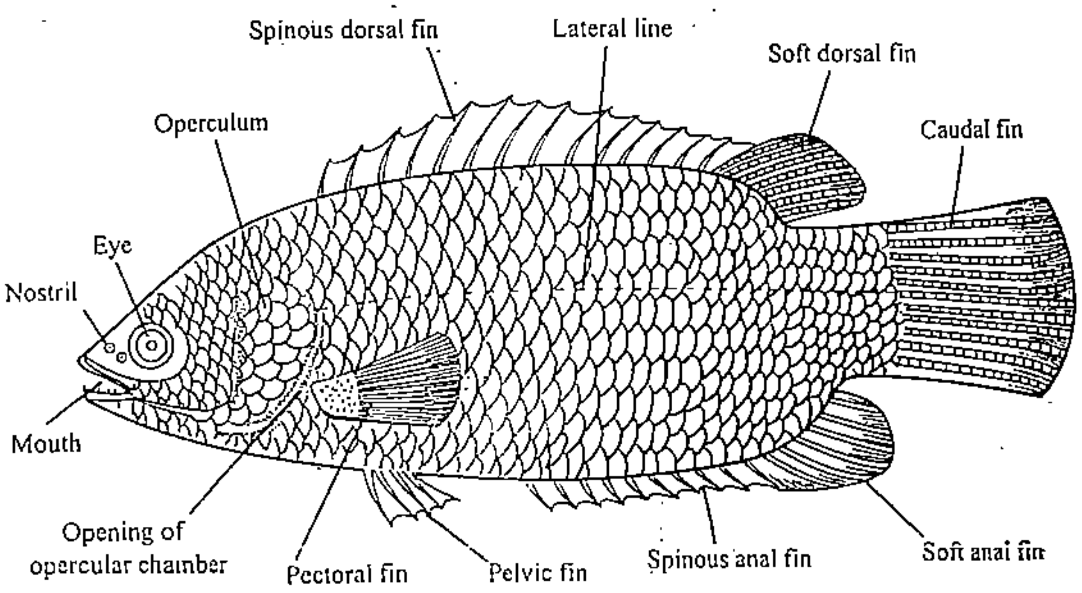

Fig. 27.7: *Anabas*.

Habit and Habitat

It is predatory feeding on shrimps and gastropods.

Geographical Distribution

Commonly found in fresh water and estuaries of India, Myanmar, Sri Lanka and Malaysia.

Classification and its Justification

Kingdom	Animalia	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	Vertebrata (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	Gnathostomata	Jaws and paired appendages are present.
Class	Osteichthyes	Endoskeleton bony, gill slits covered by operculum
Subclass	Actinopterygii	Single external gill opening on each side of the head. Paired fins are supported by fin rays.
Order	Perciformes	Dorsal and anal fins having spiny and soft rays; pelvic fins thoracic, air bladder physoclistous, Weberian apparatus absent.
Genus	*Anabas*	
Common name	Climbing perch	

27.4.8 *Exocoetus*

Characters

i) *Exocoetus* (Fig. 27.8) is commonly known as flying fish, because it can leap through air.
ii) Body elongated, laterally compressed, body silvery yellow and bluish above.
iii) Cycloid scales are present on the body.
iv) Eyes large; head covered with scales.
v) Mouth wide, terminal; both jaws are toothed and teeth of equal size.
vi) Dorsal and anal fins are short and opposite to each other near the tail region.
vii) Pectoral fins are large and help the fish to glide in the air.
viii) Tail homocercal; caudal fin large and bifid, the ventral lobe of the caudal fin is longer.

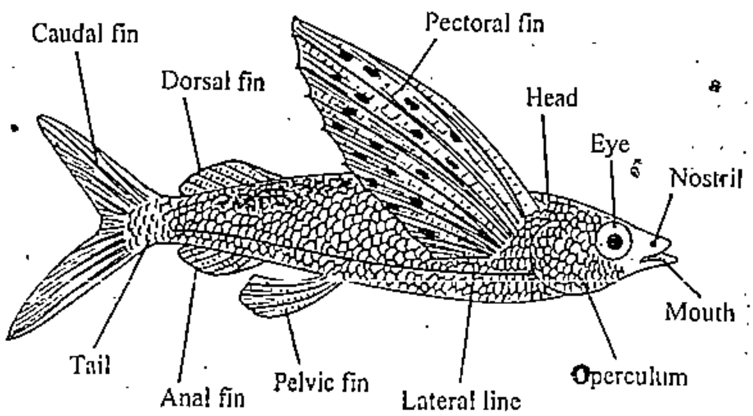

Fig. 27.8: *Exocoetus* (Flying fish).

Habit and Habitat

Marine fish that can leap in the air.

Geographical Distribution

Found in tropical and warm parts of Atlantic and Indian Oceans.

Classification and its Justification

Kingdom	**Animalia**	Animals; multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Osteichthyes**	Endoskeleton bony, gill slits covered by operculum
Subclass	**Actinopterygii**	Single external gill opening on each side of the head. Paired fins are supported by fin rays.
Order	**Beloniformes or Synantognathiformes**	Dorsal fin near the tail region and opposite to anal fin; fins soft and scales cycloid.
Genus	***Exocoetus***	
Common name	**Flying fish**	

27.4.9 *Hippocampus* (Sea horse – male and female)

Characters

i) *Hippocampus* (Fig. 27.9) (Sea horse) has a body curiously modified. The body is covered with ring-like exoskeletal plates or dermal scutes.

ii) Head produced into a tubular snout or rostrum with terminal edentulous and suctorial mouth. It resembles the head of a horse, hence called as sea-horse.

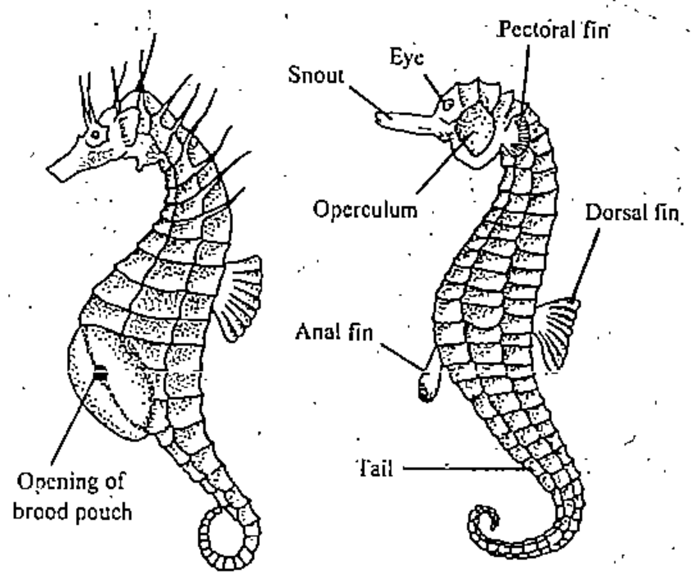

Fig. 27.9: *Hippocampus* (male) *Hippocampus* (female).

iii) Tail prehensile, without caudal fin.
iv) Pectoral fins short, and present at the base of the head. Pelvic, anal and caudal fins are absent.
v) Dorsal fin small and spinous.
vi) Mouth at the tip of the snout.
vii) Operculum is fused with the body wall leaving only a small branchial aperture directed upwards.
viii) Male possesses brood pouch for storing the fertilised eggs and thus exhibit parental care.
ix) The female is small-sized and brood pouch is absent.
x) Exhibits mimicry with sea weeds.

Habit and Habitat

Swims upright among the sea weeds.

Geographical Distribution

Found in tropical and temperate seas, particularly in Indian and Pacific oceans.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Osteichthyes**	Endoskeleton bony, gill slits covered by operculum
Subclass	**Actinopterygii**	Single external gill opening on each side of the head. Paired fins are supported by fin rays.
Order	**Syngnathiformes**	Jaws fused, tubular. First dorsal fin spinous. Other median fins and pelvic fins absent.
Genus	***Hippocampus***	
Common name	**Sea horse**	

27.4.10 *Synapta* (flat fish)

Characters

i) *Synapta* (Fig. 27.10) is commonly called as flat fish.
ii) Body is laterally compressed and head is dorso-ventrally flattened.
iii) Skull twisted, with both the orbits and eyes lying on one side.
iv) The side of the body with the eyes is pigmented and dorsal while the ventral side is unpigmented and white.
v) Pectoral and pelvic fins are poorly developed and soft.
vi) Dorsal and anal fins long and confluent with the caudal fin. The dorsal fin extends above the head.
vii) Small mouth, dentulous, protractile, feeds on molluscs.
viii) Tail homocercal and caudal fin rounded.
ix) Scales on the body ctenoid.
x) Air bladder absent.
xi) Swims by undulating movements of the body.

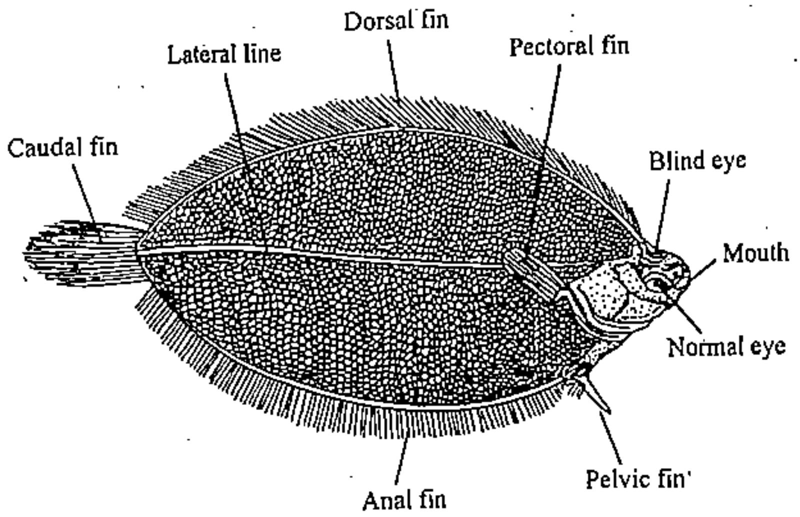

Fig. 27.10: *Synapta,*

Habit and Habitat

Bottom dwelling fish, found lying at the sea bottom from the blind side.

Geographical Distribution

Found in Atlantic and Pacific oceans.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Osteichthyes**	Endoskeleton bony, gill slits covered by operculum
Subclass	**Actinopterygii**	Single external gill opening on each side of the head. Paired fins are supported by fin rays.
Order	**Pleuronectiformes**	Body flat; skull twisted and both eyes lie on the same side; anal and dorsal fins extend all along the trunk.
Genus	***Synapta***	
Common name	**Flat fish**	

27.4.11 *Synaptura*

Characters

i) *Synaptura* (27.11) is known as flat fish.
ii) Other characters are similar to *Synapta*.
iii) *Synaptura* is larger in size and has a heavily pigmented body.

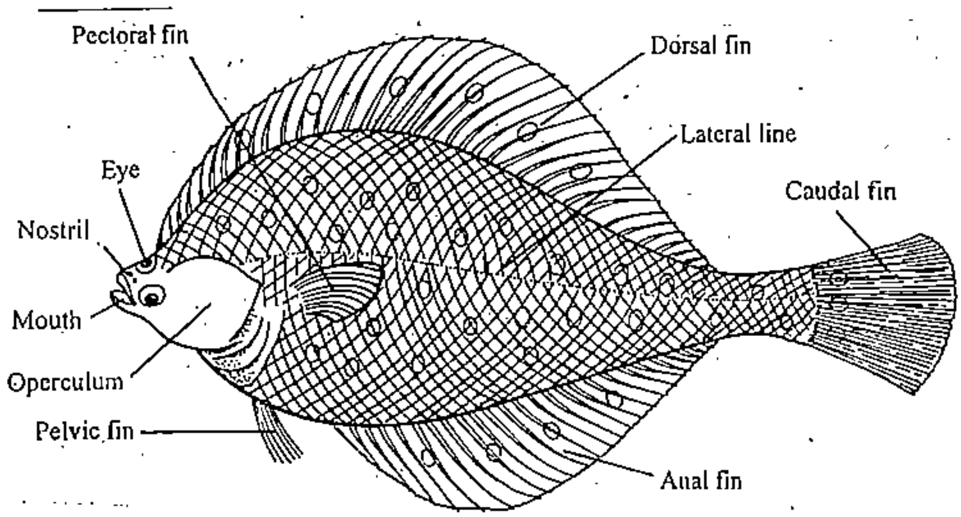

Fig. 27.11: *Synaptura.*

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Osteichthyes**	Endoskeleton bony, gill slits covered by operculum
Subclass	**Actinopterygii**	Single external gill opening on each side of the head. Paired fins are supported by fin rays.
Order	**Pleuronectiformes**	Body flat; skull twisted and both eyes lie on the same side; anal and dorsal fins extend all along the trunk.
Genus	***Synaptura***	
Common name	**Flat fish**	

27.4.12 *Antennarias* (Angler fish)

Characters

i) *Antennarias* (Fig. 27.12) is commonly known as Angler fish.
ii) Body dorso-ventrally flattened. Head and anterior part of the body without scales.
iii) Mouth large, containing recurved teeth.
iv) Large eyes, lateral in position, small nostrils.
v) Gill opening is in the lower axis of pectoral fin. Pseudobranchiae are present.
vi) First dorsal fin is greatly modified. The first three fin rays are spiny and free. The first spine is rod-like and bears a fleshy mass at its tip called *illicium* which serves as a bait for other fishes.
vii) The next three spines are united by a skin fold, while the rest of the dorsal fin is supported by soft rays.
viii) Pectoral and caudal fins present.
ix) The male is small in size and attached to the body of the female as ectoparasite.

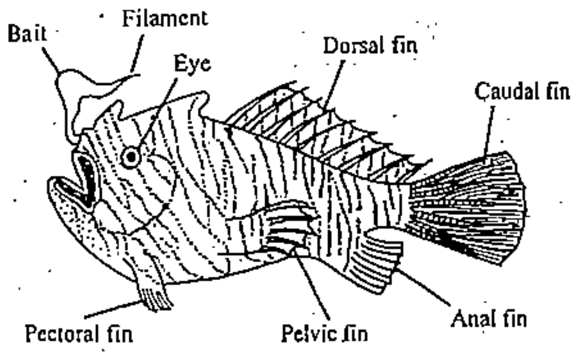

Fig. 27.12: *Antennarias.*

Habit and Habitat

It is found in the deep seas. It is a poor swimmer.

Geographical Distribution

Found in Indian, Atlantic, Pacific Oceans.

Classification and its Justification

Kingdom	Animalia	Animals, multicellular organisms with cells that lack a cell wall; many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	Vertebrata (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	Gnathostomata	Jaws and paired appendages are present.
Class	Osteichthyes	Endoskeleton bony, gill slits covered by operculum
Subclass	Actinopterygii	Single external gill opening on each side of the head. Paired fins are supported by fin rays.
Order	Lophiformes	Spinous dorsal fin modified into an *illicium*. Air bladder absent.
Genus	*Antennarias*	
Common name	Angler fish	

27.5 TERMINAL QUESTIONS

1. Give one example each of the bony fishes showing catadromous and anadromous migration.

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2. Write three important characteristics of bony fishes.

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3. Describe habit, habitat, size and feeding behaviours of *Labeo*, *Wallago*, *Anabas* and *Hippocampus*.

   i) *Labeo*

   ....

   ....

   ....

   ii) *Wallago*

   ....

   ....

   ....

   iii) *Anabas*

   ....

   ....

   ....

   iv) *Hippocampus*

   ....

   ....

   ....

Table 27.1: Differences between Cyclostomata, Cartilaginous and Bony Fishes

Characteristic	Cyclostomata (Lampreys and Hagfishes)	Cartilaginous Fishes (Chondrichthyes)	Bony Fishes (Osteichthyes)
Habit	*Lampreys* are semiparasitic on aquatic vertebrates and *hagfishes* are scavengers.	Carnivorous and predaceous, feeds on crabs, lobsters, worms and fishes; it is a fast swimmer.	It is chiefly herbivorous, feeds on algae and aquatic plants. It is a bottom feeder.
Habitat	Both marine and freshwater but parasitic. Hagfishes produce immense amount of slime when disturbed.	Mostly marine	Both marine and fresh water, common in freshwater ponds, rivers, lakes.
Shape	Body is elongated, cylindrical and eel-like.	Usually elongated, fusiform dorso-ventrally flattened, highly streamlined.	Usually bilaterally flattened.
Caudal fin	Present which continues with the posterior part of the dorsal fin. It is supported by cartilaginous fin-rays.	Heterocercal, posterior end is turned upward.	Homocercal or diphycercal, deeply notched into two similar lobes.
Pelvis fins	Absent	Usually posterior. In males – claspers for transferring sperms.	Usually anterior, sometimes posterior. Claspers absent, whenever present not formed by pelvic fins.
Mouth	In *lampreys* cup-like structure called funnel is a downwardly directed depression. The mouth of *hagfish* is lined with tentacles and supported by cartilages.	Mouth opening is ventral on head, it is large, transverse, crescentic with upper and lower jaws, each bearing 1 or 2 rows of sharply pointed and backwardly directed teeth for holding and tearing prey, not for chewing.	Mouth opening is terminal on head. Teeth are lacking on jaws.
Gill openings	In *lampreys*, seven pairs of round gill slits are present on postero-lateral sides of the head. Hagfishes have a single, external branchial aperture.	Usually five pairs of naked gill slits. No operculum.	Five pairs of gill-slits covered by a lateral flap of skin called operculum so that a single gill opening on either side.
Spiracles	Absent	Usually first gill slits become spiracles which open just behind eyes.	Spiracles are lacking.
Nares	The olfactory sac opens into the nasal canal, the latter continuing as the hypophyseal sac beneath the floor of the brain.	Two, cresentic, present ventrally and anterior to mouth. Only olfactory having no respiratory function.	Snout bears dorsally a pair of small nostrils.

Caudal pits	Absent	At the base of caudal fin, the tail bears two shallow depressions, characteristic of genus *Scoliodon*.	Absent
Cloaca	Anus and urinogenital aperture open separately into a cloacal pit, otherwise a true cloaca is absent.	Between two pelvic fins lies midventrally cloacal opening for alimentary, urinary and genital products.	Cloaca absent. Anus, urinary and genital apertures open separately.
Exoskeleton	Absent	Separate dermal placoid scales or odontoids.	Overlapping dermal, cosmoid, ganoid, cycloid or ctenoid scales.
Endoskeleton	Cartilaginous, composed of large cells embedded in a matrix of *chondrin*.	Wholly cartilaginous, no true bones apart from the basal plates of placoid scales.	Mostly bony.

EXERCISE 28 AMPHIBIA: OBSERVATION AND CLASSIFICATION OF THE SPECIMENS

Structure

28.1 INTRODUCTION

The class Amphibia (Gr. *amphi* = dual; *bios* = life) as you will recall from Unit 2, Block 1, of the LSE-10 course includes animals that are able to live in water as well as on land, hence they are amphibious and are called amphibians. Their skin is soft, slimy and naked. The exoskeletal structures are absent in them. The body is differentiated into head, trunk and tail regions. Paired appendages in the form of pentadactyle limbs are present. However, forelimbs are with four and hind limbs are with five digits. Hind limbs are longer than forelimbs. In some forms the limbs are absent and cannot be visualised. The digits are without claws. The skull is autostylic with two occipital condyles; cranium is cartilaginous and later replaced by bony elements. The respiratory organs are gills, lungs and also the integument. Gills are present only during development or may be permanently present in the adult. The heart is three chambered and there are both systemic arches. Both the hepatic portal and the renal portal systems are present. The external ear is absent and the middle ear has a rod-like structure – the columella. Kidneys are provided with persistent nephrostomes. The eggs are with a gelatinous covering, usually laid in water. The larva is aquatic and herbivorous in nature.

In the present exercise you will study some selected specimens of amphibians in order to know their characteristics, identification, habit and habitat and their geographical distribution.

Objectives

After completing this exercise, you will be able to:

- identity the given specimens and give their scientific/common name,
- classify the identified specimens up to level of order and list the characters justifying their classification,
- mention the habit, habitat and geographical distribution and special features, if any of the identified genera,
- draw well labelled diagram of the genera,

28.2 MATERIAL REQUIRED

1. The museum specimens of the following animals:

   i) *Ambystoma* (Spotted salamander or tiger salamander)
   ii) Axolotl larva of *Ambystoma*
   iii) *Necturus* (Mud puppy)

iv) *Ichthyophis*
v) *Hyla* (Tree frog)
vi) *Bufo* (Toad)
vii) *Rana* (Green frog)

28.3 OBSERVATION OF AMPHIBIANS

Amphibians as you know are adapted to live in water as well as on land. Study the general characters of the given specimens so as to understand the adaptations for amphibious life.

28.3.1 *Ambystoma*

Examine the specimen of *Ambystoma* (Spotted salamander or Tiger salamander) carefully and observe with help of Figure 28.1 the head, the trunk and the tail regions. Study carefully the limbs and the digits.

General characters

i) *Ambystoma* is lizard-like with yellow spots on the black background of the body.
ii) It is, therefore, called as Tiger salamander or spotted salamander.
iii) Head is depressed with a wide mouth.
iv) Eyes distinct with movable eye lids.
v) Neck with a prominent gular fold.
vi) Intercostal grooves present on both sides of the trunk.
vii) A pair of large parotid glands present which produce poisonous secretion.
viii) Gills and gill slits are absent in the adult. Respiration by lungs.
ix) Limbs stout and are of equal size; fore limbs with four digits and hind limbs with five digits, without claws or web.
x) Tail is compressed without tail fin.
xi) The adult returns to water for laying eggs.
xii) Larval life is prolonged and the larva is known as Axolotl larva. The larva becomes sexually mature and reproduces: a phenomenon known as Neoteny.

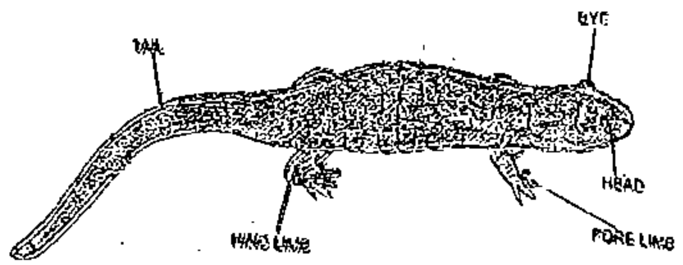

Fig. 28.1: *Ambystoma*.

Habit and Habitat

Fresh water animal usually found in ponds, lakes and rivers.

General Distribution

Ambystoma is found in North America from Southern Alaska to Mexico.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.

Phylum	Chordata	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	Vertebrata (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	Gnathostomata	Jaws and paired appendages are present.
Class	Amphibia	Can live in water and on land. The fore limbs and hind limbs are of equal size. Limbs with digits. Skin soft and glandular.
Order	Urodela/Caudata	The tail persists throughout life. The external gills of larva may or may not persist.
Genus	*Ambystoma*	
Common name	Spotted Salamander or Tiger salamander	

28.3.2 Axolotl larva of *Ambystoma*.

Study the specimen carefully and note the details from all the angles.

General Characters

i) The body of axolotl larva (Fig. 28.2) is lizard-like and stout, and tail is with tail fin (without fin rays) extending up to the back of the body.
ii) External gills in three pairs and gill slits four pairs.
iii) Forelimbs with four digits and hindlimb with five digits and are of equal size.
iv) The larva develops gonads and reproduces like adult. The phenomenon is known as neoteny.
v) The metamorphosis occurs when there is scarcity of water and food or there is an increased concentration of iodine in water. During metamorphosis it sheds off gills and tail fin and develops lungs.

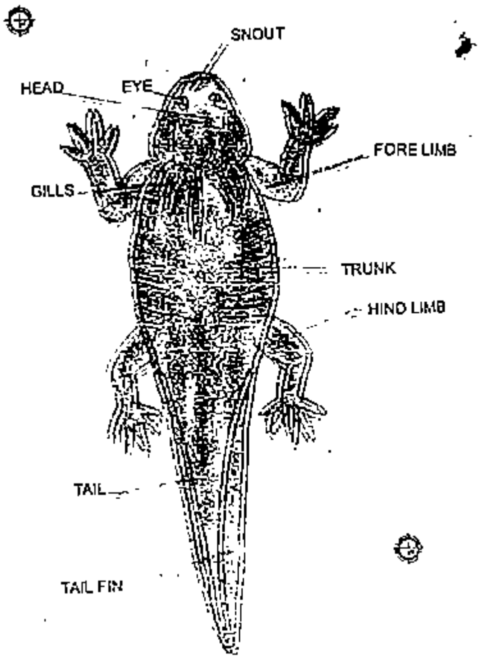

Fig. 28.2: Axolotl larva of *Ambystoma*.

Habit and Habitat

Lives in fresh water rivers, ponds and lakes.

General Distribution

It is found in mountain regions of Mexico.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Amphibia**	Can live in water and on land. The fore limbs and hind limbs are of equal size. Limbs with digits. Skin soft and glandular.
Order	**Urodela/Caudata**	The tail persists throughout life. The external gills of larva may or may not persist.
Genus	***Ambystoma larva* (Axolotl larva)**	

28.3.3 *Necturus*

Observe the specimen of *Necturus* (Mud puppy) from all angles and study the details

General Characters

i) *Necturus* (Mud puppy or Water newt) (Fig. 28.3) has a stout body with rusty brown colour and black spots.
ii) Head is flattened and marked off from the trunk by a constriction.
iii) Eyes covered by transparent fold of integument.
iv) Limbs weak, short and with four digits, adapted for crawling.
v) Skull cartilagenous.
vi) Tympanum and eye lids absent.
vii) It has three pairs of bushy red coloured external gill slits.
viii) Tail laterally compressed with tail fin.
ix) Lateral line system present.
x) Larval circulatory system present.

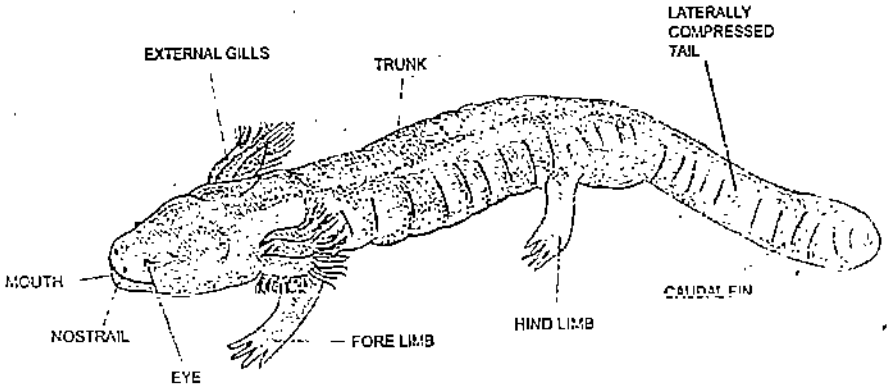

Fig. 28.3: *Necturus* (Mud puppy).

Habit and Habitat

It is an aquatic salamander. Lives in fresh water.

General Distribution

It is found in North America, Yugoslavia.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Amphibia**	Can live in water and on land. The fore limbs and hind limbs are of equal size. Limbs with digits. Skin soft and glandular.
Order	**Urodela/Caudata**	The tail persists throughout life. The external gills of larva may or may not persist.
Genus	***Necturus***	
Common name	**Mud puppy or Water newt**	

28.3.4 *Ichthyophis*

Study the specimen of *Ichthyophis* from all the angles and observe the details.

General characters

i) The body of *Ichthyophis* (Fig. 28.4) is elongated and 'Worm like'.
ii) Minute scales are present which are concealed in the wrinkled skin.
iii) Slime glands and squirt glands are present in the skin. Squirt glands produce irritating fluid.
iv) Limbs and limb girdles absent.

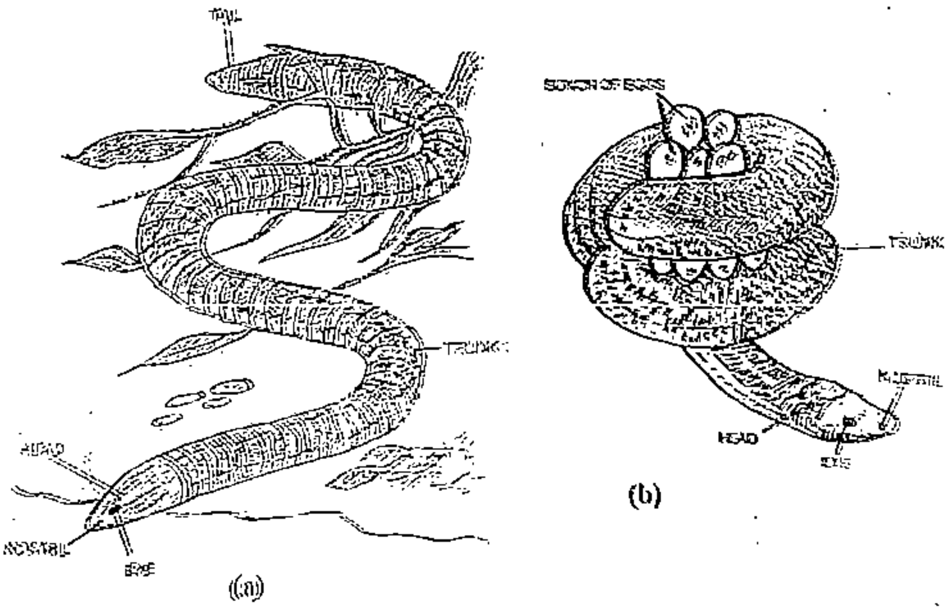

Fig. 28.4: *Ichthyophis*. a) Male. b) Female.

v) Tail vestigial and anus is subterminal.
vi) Head conical with a pair of nostrils, eyes and sensory tentacular apparatus.
vii) Eyes rudimentary and buried deep in the skin.
viii) Tympanic membrane, tympanic cavity and columella absent.
ix) Vertebrae many and amphicoelous.
x) It can be identified as a limbless amphibian with a vestigial tail and has calcified scales.

Habit and Habitat

Burrowing type in muddy areas. Exhibits parental care. The female coils around the eggs and carry them till they are hatched (Fig. 28.4 b). The larva possesses three pairs of finely branched external gills.

General Distribution

Found in tropical regions of India, Sri Lanka, Borneo, Java, Philippines and Malaysia.

Classification with its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Amphibia**	Can live in water and on land. The fore limbs and hind limbs are of equal size. Limbs with digits. Skin soft and glandular.
Order	**Apoda/Gymnophiona**	Limbless, burrowing, body worm-like and without tail; body surface wrinkled and with minute scales that form the exoskeletal structures.
Genus	***Ichthyophis***	

28.3.5 *Hyla*

Study the specimen of *Hyla* (Tree frog) animal in the jar from all the directions and note the details.

General Characters

i) *Hyla* (Tree frog) (Fig. 28.5) has a slender body adapted for arboreal life.
ii) Skin smooth on the dorsal side and papillated on the ventral side, with hygroscopic glands on the belly and throat regions.
iii) The digits have terminal adhesive discs. These stick to the surface and are used in climbing on trees.
iv) Web between the toes of hind limbs extensively developed and is useful in leaping from one branch to another.
v) Teeth present only in the upper jaw; lower jaw is edentulous.
vi) Vocal sacs present in male *Hyla*. These are very large and produce loud noise.
vii) Exhibit protective coloration; can change its colour according to the environment.
viii) Eggs are laid in water but in *Hyla goedii*, the eggs are carried on the back of the female. Thus, it exhibits parental care.
ix) It can be identified by the presence of adhesive discs on the tips of digits.

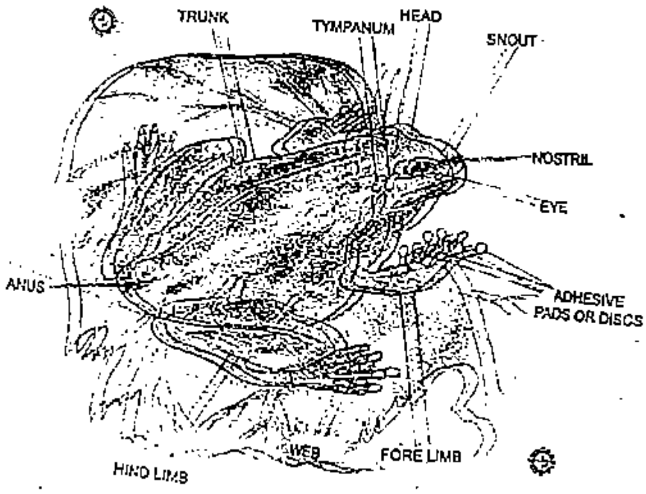

Fig. 28.5: *Hyla*.

Habit and Habitat

Found in damp forests and can climb trees.

General Distribution

It is cosmopolitan; found in India, China, Java, United States of America, Africa, Canada.

Classification and its Justification

Kingdom	Animalia	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	Vertebrata (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	Gnathostomata	Jaws and paired appendages are present.
Class	Amphibia	Can live in water and on land. The fore limbs and hind limbs are of equal size. Limbs with digits. Skin soft and glandular.
Order	Anura	Adults without tail; External gill slits absent; body broad and hind limbs strong and powerful.
Genus	*Hyla*	
Common name	Tree frog	

28.3.6 *Bufo*

Observe the specimen of *Bufo* (Toad) from all angles to study the details.

General Characters

i) *Bufo* (Toad) (Fig. 28.6) is a true toad.
ii) Skin dry, rough, warty and with poison glands. Skin is protective in function and non-respiratory.

iii) Eyes are large and behind the eyes are present a pair of parotid glands.
iv) Forelimbs without web and hindlimbs with poorly developed web and with horny tips.
v) The tongue is pear shaped and thicker in front, and free behind but not bifid.
vi) Vertebrae procoelous; and both the jaws are edentulous.
vii) Epicoracoids of the pectoral girdle overlap (arciferous) and omosternum absent.
viii) Eggs are pigmented and laid in water forming gelatinous string.
ix) The secretion of parotid gland is poisonous. It contains two toxic substances bufotalous and bufogus. These toxins if swallowed cause nausea, respiratory and muscular disorders and heart malfunctioning.

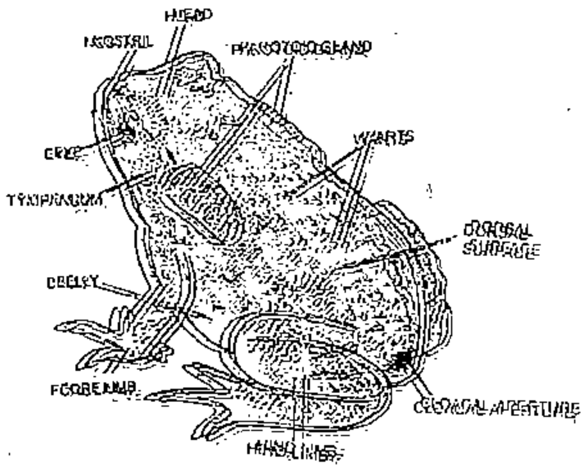

Fig. 28.6: *Bufo*.

Habit and Habitat

Nocturnal, lives in shady area. Carnivorous, feeds on worms, insects and snails.

General Distribution

Found all over the world except Australia and Madagascar.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata** (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Amphibia**	Can live in water and on land. The fore limbs and hind limbs are of equal size. Limbs with digits. Skin soft and glandular.
Order	**Anura**	Adults without tail; External gill slits absent; body broad and hind limbs strong and powerful.
Genus	***Bufo***	
Common name	**Toad**	

28.3.7 *Rana*

Observe the details of the specimen of *Rana* (Green frog) from all the angles.

General Characters

i) *Rana* (Green frog) (Fig. 28.7) has a slender, elongated body.
ii) Digits are webbed and end in feeble claws.
iii) Eyes large with eyelids.
iv) Head broad and nearly conical.
v) Females are larger than the males.

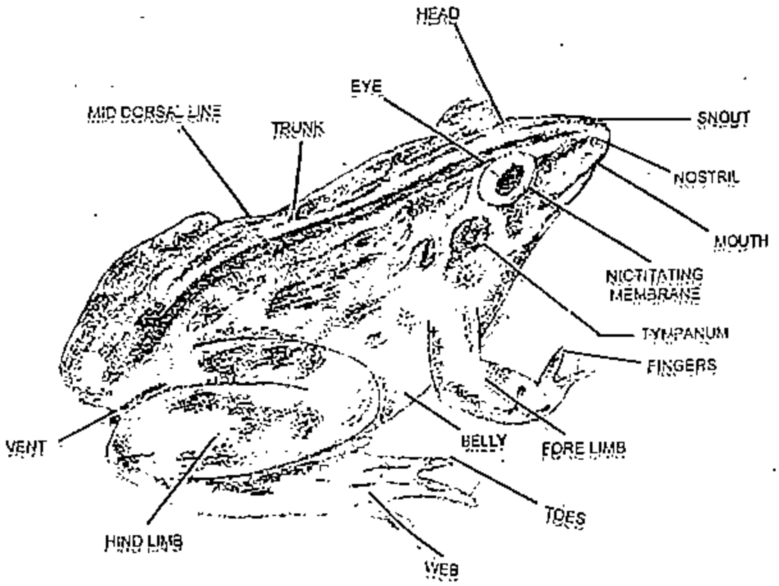

Fig. 28.7: *Rana.*

Habit and Habitat

Found in moist places, freshwater ponds and streams. The adults are carnivorous.

General Distribution

Distributed all over the world.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	Vertebrata (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	Gnathostomata	Jaws and paired appendages are present.
Class	Amphibia	Can live in water and on land. The fore limbs and hind limbs are of equal size. Limbs with digits. Skin soft and glandular.

Order	Anura	Adults without tail; External gill slits absent; body broad and hind limbs strong and powerful.
Genus	*Rana*	
Common name	Green frog	

28.4 TERMINAL QUESTIONS

1. In what ways do you think that the amphibians are better evolved than fishes?

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2. Define neoteny. Explain this phenomenon with an example studied by you.

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3. In what ways have the living amphibians adapted themselves for a life on land?

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EXERCISE 29 REPTILIA I : OBSERVATION AND CLASSIFICATION OF SELECTED SPECIMENS

Structure

29.1 INTRODUCTION

This lab course is based on Unit 3 Block 2 of LSE-10. You will recall that reptiles are the first group of vertebrates to evolve from amphibians as true land dwellers. They first appeared in the Upper Carboniferous and gradually conquered all habitats on the earth to herald the **Golden Age of Reptiles** in the Mesozoic which lasted for more than 170 million years. There was a great radiation of reptiles into a bewildering array of terrestrial and aquatic lineages. This included herbivorous and carnivorous dinosaurs, many of which were huge and of awesome appearance and dominated the animal life on land. By the end of Mesozoic era, during the mass extinction, they suddenly declined. Among the few reptilian lineages to escape the Mesozoic extinction are today's reptiles. The tuatara (*Sphendon*) of New Zealand is the sole survivor of the group which otherwise disappeared 100 million years ago and is known as a living fossil as it exhibits many primitive characterisitics. Others, especially lizards and snakes, have radiated since the Mesozoic extinction into diverse and abundant groups. Reptiles have undergone widespread convergent and parallel evolution among the many lineages. The living reptiles are mostly small to medium sized lizards and snakes in addition to a few species of turtles, crocodiles, etc. and they are a mixture of primitive and highly evolved animals. Therefore, a study of the living reptiles could give an insight into the evolution of this group of animals.

In this exercise and the next one (Exercise 30) you will examine a few examples of reptiles in order to familiarize yourself with some of the common ones which we often come across. The enormous variability in the animals of this class should be noted along with the primitive as well as advanced characteristics exhibited by some of them.

Objectives

After performing this exercise you will be able to:

- identify and give the scientific and common names of the specimens - *Kachuga, Trionyx, Hemidactylus, Chamaeleo, Draco and Mabuya* belonging to the Class Reptilia.
- classify the identified reptiles up to the level of order.

- list the characters justifying the classification of the identified reptile specimens and mention special features, if any,
- mention the habit, habitat and geographical location of each museum specimen.
- draw well labelled diagrams of each of the identified specimen.
- mention economic importance, if any, of the listed reptile.

29.2 MATERIAL REQUIRED

1. Selected museum specimens of the following reptiles:
   i) *Kachuga* (Roofed terrapin)
   ii) *Trionyx* (Soft shelled fresh water terrapin)
   iii) *Hemidactylus* (Common wall/house uzord)
   iv) *Chamaeleon* (Chamaeleon)
   v) *Draco* (Flying lizard or Dragon)
   vi) *Mabuya* (Keeled Indian Skink)
2. Laboratory manual
3. Laboratory Practical file
4. Pen, pencil, eraser and ruler

29.3 THE CHARACTERISTICS AND GENERAL CLASSIFICATION OF THE CLASS REPTILIA

Reptiles are scaly-skinned creatures and include the tortoises, lizards, snakes and crocodiles. Their main features are as follows:

29.3.1 Characteristics of Reptilia

1). Body is covered with horny epidermal scales. Skin is dry and with few glands.
2) Two paired limbs are generally present (except in amphisbaenians, legless lizards and snakes).
3) Skull with one occipital condyle, skeleton is well ossified and ribs are with sternum.
4) Respiration is by lungs.
5) Heart is three chambered, being four chambered in crocodiles.
6) Kidneys are metanephric and uric acid is the main excretory product.
7) There are twelve pairs of cranial nerves.
8) Sexes are separate and fertilization is internal.
9) Eggs are laid on land and covered with calcareous or leathery shell.
10) Amnion, chorion and allantois are present during embryonic life. No larval stages.

29.3.2 General Scheme of Classification of Reptila

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata** (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.

Class	Reptilia	Cold blooded, terrestrial or aquatic vertebrates; single occipital condyle; vertebrae gastrocentrous; respiration by lungs; heart with two auricles and incompletely divided ventricle; right and left aortic arches complete and functional, cranial nerves 12 pairs and embryo with amnion and allantois.

29.3.3 Outline of Classification of extant classes of Reptilia

The outline of class Reptilia is given in Fig. 29.1. In this scheme only those genera (specimens) are listed which will be studied in this lab exercise and in the next lab exercise.

- Class Reptilia
  - Subclass: Anapsida
    - Order: Testudines (Chelonia)
      - Genera: *Kachuga*, *Trionynx*
  - Subclass: Diapsida
    - Superorders: Lepidosauria
      - Orders: Sphenodonta
      - Squamata
        - Suborders: Lacertilia (Lizards)
          - Genera: *Hemidactylus*, *Chamaeleo*, *Draco*, *Mabuya* (*Mabuia*)
        - Serpentes (Ophidia) (Snakes)
          - *Eryx*, *Xenochrophis*, *Ptyas*, *Bungarus*, *Naja*, *Vipera*, *Hydrophis* — To be studied in Exercise 30
        - Amphisbaenia (Worm lizard)
    - Archosauria
      - Crocodilia

Fig. 29.1: Classification scheme of extant Reptiles.

29.3.4 Characters of Extant Subclasses

Among the more than 13 orders of reptiles found in the Mesozoic era only members of four orders – Testidunes, Sphenodonta, Squamata and Crocodilia are found today (extant) and belong to the two extant subclass – Anapsida and Diapsida whose main features are given in Table 29.1.

Table 29.1: Main differentiating features of the extant subclasses – Anapsida and Diapsida.

Subclass Anapsida	Subclass Diapsida
1. Skull has no temporal openings behind the orbits – skull behind the orbits is completely roofed over with dermal bone	1. Skull has two temporal openings – one pair located low on the cheeks and bordered by a long arch, and one pair positioned above the lower pair and separated from them by a bony arch.

2. Body enclosed in carapace and plastron 3. Single order Testudines (Chelonia). Quadrate connected to otic bones	Post-orbital and squamosal meet between the temporal vacuities 2. (a) Super Order: Lepidosauria (i) Lacertilia (ii) Serpentes (iii) Amphisbaenia (b) Super Order: Archosauria

29.4 SPECIMENS OF ORDER TESTUDINES (CHELONIA)

In this exercise you will study the specimens belonging to Order Testudines of Subclass Anapsida which include turtles and tortoises. You will also study specimens of Lizards which belong to subclass Diapsida. Lizards come under Suborder Lacertilia of Order Squamata. Order squamata also includes the Suborder Serpentes (Ophidia) that contains snakes which will be studied in the next exercise.

Characters of order Testudines

1. Body is enclosed in shell consisting of a dorsal carapace and a ventral plastron
2. Thoracic vertebrae and ribs are fused with the shell
3. Shell is made up of an outer horny layer of keratin and an inner layer of bone
4. Jaws have no teeth but have tough horny plates
5. Tail always present
6. Unpaired copulatory organ present
7. Fertilization internal
8. Female lay their shelled amniotic eggs burrowed in the ground

29.4.1 *Kachuga*

Kachuga tectum (Fig. 29.2) is commonly known as roofed terrapin. It is one of the turtles.

Examine the specimen of *Kachuga* and note the following features:

i) Body is about 23 cms long, 17 cms broad and 10.5 cms deep.
ii) Top of the head is black, temporal region is yellow, neck is black with fine yellow longitudinal lines.
iii) Body is enclosed in a shell comprising the dorsal carapace and ventral plastron.
iv) The body shell forms chambers for lungs.
v) The first three central (Fig. 29.2 b) plates of the carapace are produced into backwardly directed **dorsal median spines**.
vi) Eyes are provided with eyelids and nictitating membrane (Fig. 29.2 c).
vii) Jaws without teeth but with horny sheath.
viii) Fore and hind-limbs have five clawed digits.
ix) Digits are half webbed.
x) Skin on the hinder part of the head divided into shields.
xi) Tail is short.
xii) Head, limbs and tail are retractable into the carapace.

Habit and Habitat

It lives in deep warm waters and feeds almost exclusively on water plants. It leaves water only to lay eggs or to sun itself. Copulation is usually preceeded by strenuous courtship on the part of male.

Geographical Distribution

It is found in deep warm water in India, in areas around Indus and Ganges and Myanmar.

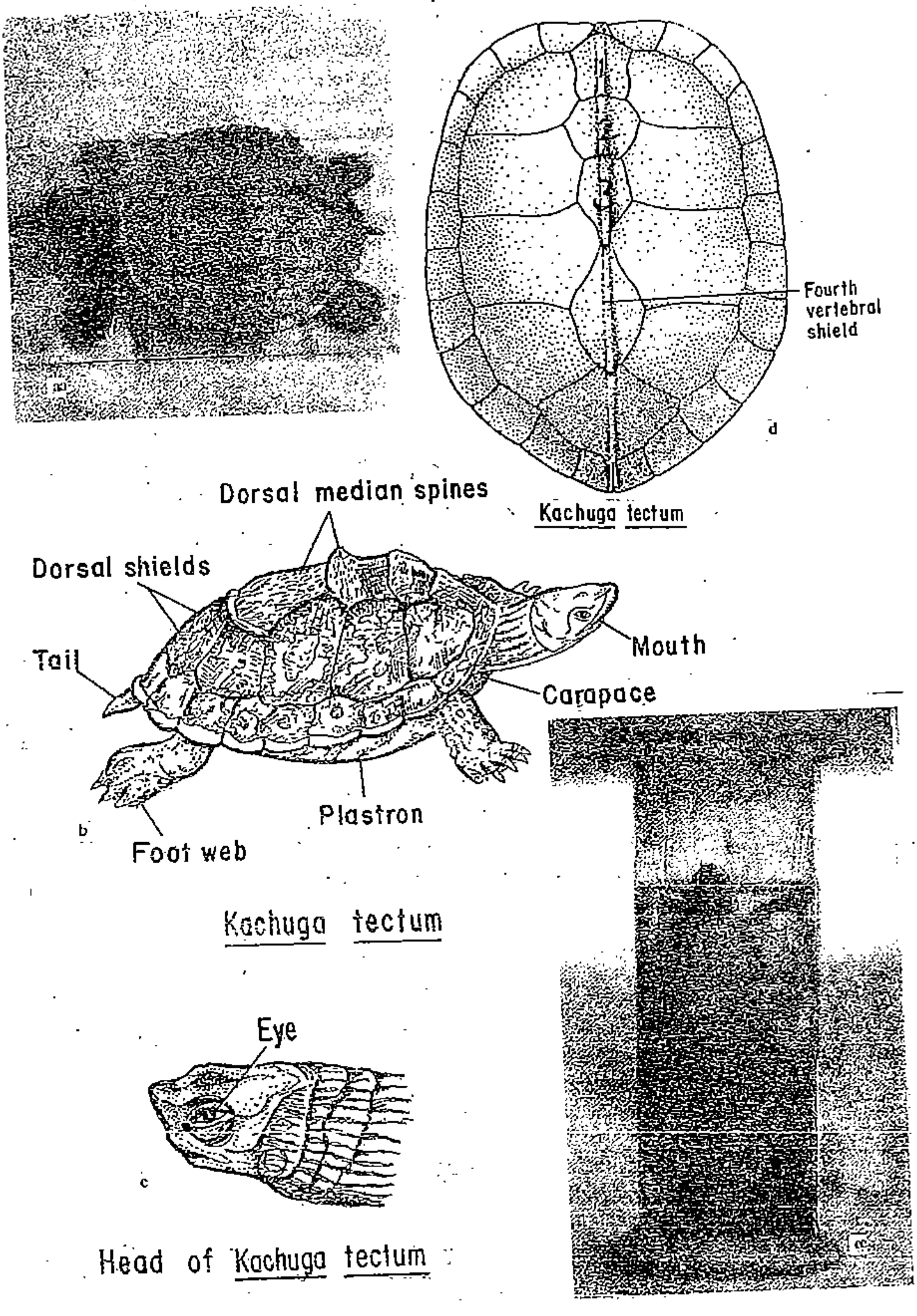

Fig. 29.2: *Kachuga tectum*: a) Photograph of a specimen. b) Drawing as interpreted from specimen. c) Lateral view of head. d) Dorsal view of shell. e) Photograph of ventral view.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Reptilia**	Cold blooded, terrestrial or aquatic vertebrates; single occipital condyle; vertebrae gastrocentrous; respiration by lungs; heart with two auricles and incompletely divided ventricle; right and left aortic arches complete and functional, cranial nerves 12 pairs and embryo with amnion and allantois.
Subclass	**Anapsida**	Skull having solid roof without temporal fossae; body enclosed in the carapace and plastron.
Order	**Testudines (Chelonia)**	Jaws without teeth but with horny sheaths; thoracic vertebrae and ribs usually fused with shell.
Genus	***Kachuga***	
Species	***tectum***	
Common Name	**Roofed terrapin**	

29.4.2 *Trionyx*

Trionyx gangeticus (Fig. 29.3) is commonly known as tortoise or soft-shelled Freshwater (or river) Terrapin.

Trionyx is one of the soft-shelled turtles.

Examine the specimen and note the following features:

i) Body is enclosed in a shell comprising the dorsal carapace and ventral plastron.
ii) The bony shell is very much regressed, has no horny scale and so it is covered with a thick skin which extends far beyond its edges.
iii) Shell of this species is more than 60 cm in length. Colour of the shell is olive green above and yellowish beneath. These turtles have striking 'eyespots' on the carapace, consisting of concentric dark and light rings. As the turtle grows older these rings become fainter and may disappear altogether.
iv) Carapace has two nuchal shields which are not jointed with the plastron. The bony marginal plates are lost except for vestiges, and the plastron has become simply an arrangement of bony struts.
v) Head is triangular and elongated and ends in a proboscis.
vi) Head has fleshy lips, beneath which the horny jaws lie hidden.
vii) On each of the long flattened, forelegs as well as on the shorter, flat hindlegs-one can see five pointed claws.
viii) One of the very popular turtles as a food item.

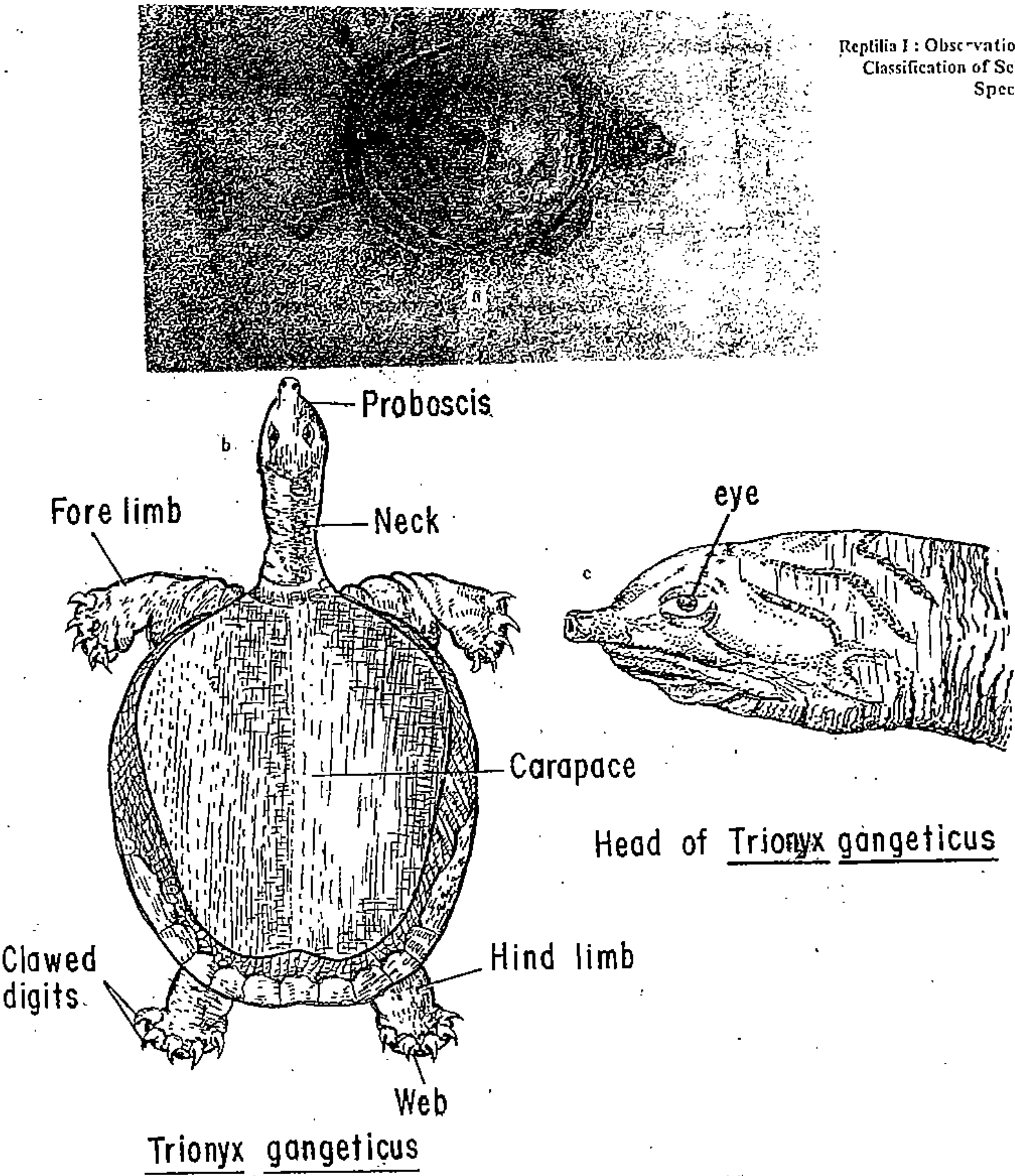

Fig. 29.3: *Trionyx*: a) Photograph of complete specimen. b) Drawing of *Trionyx* as interpreted from specimen. c) Lateral view of head.

Habit and Habitat

Very active and quite ready to bite since they can easily stretch their long necks back over the carapace in order to bite. Food essentially other animals like fish, frogs and molluscs. Occasionally they eat plants as well. They leave the waters to lay eggs or to bask in the sun. The covering of the shell, the oesophageal villi with their rich supply of blood and the structure of the cloaca make effective respiration possible through the skin. All the species lay spherical eggs.

Geographical Distribution

Found in ponds and rivers in Asia, Africa and North America. *Trionyx gangeticus* is found in the rivers of North India.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Reptilia**	Cold blooded, terrestrial or aquatic vertebrates; single occipital condyle; vertebrae gastrocentrous; respiration by lungs; heart with two auricles and incompletely divided ventricle; right and left aortic arches complete and functional, cranial nerves 12 pairs and embryo with amnion and allantois.
Subclass	**Anapsida**	Skull having solid roof without temporal fossae; body enclosed in the carapace and plastron.
Order	**Testudines (Chelonia)**	Jaws without teeth but with horny sheaths; thoracic vertebrae and ribs usually fused with shell.
Genus	***Trionyx***	
Common name	**Soft shelled fresh water Terrapin**	

29.5 SPECIMENS OF ORDER SQUAMATA

In this section you will study the lizards which belong to suborder Lacertilia of order Squamata.

Characters of Order Squamata

1. Quadrate is movably articulated with the skull
2. Joints in the palate and across the roof of the skull allow the snout to be tilted up
3. Lizards have one temporal vacuity (the supra or upper temporal fossa) while snakes have neither the upper nor the lower fossa
4. Body covered with horny epidermal scales
5. Cloacal opening is transverse
6. Vertebrae are generally procoelous

Characters of suborder Lacertilia:

1. Extremely diversified group adapted for terrestrial, arboreal or burrowing life
2. Movable eyelids
3. Generally have four limbs and relatively short bodies
4. Most lizards have external ears
5. Produce semisolid urine with a high concentration of crystalline uric acid
6. The two rami of mandibles are firmly united by symphyses
7. Sternum is present.

29.5.1 *Hemidactylus*

Hemidactylus flaviviridis is commonly known as **wall lizard** or **house lizard** or **Gecko** (Fig. 29.4).

Examine the specimen and note the following featucs:

i) Body is depressed and is about 25 cm. long and pale green or dust-coloured with head being broad and flat.
ii) Body is covered with minute scales which are smooth.
iii) Eyes with vertical pupil, without movable eyelids and are covered by transparent scale.
iv) Ear opening is vertical.
v) Tongue is short, sticky, slightly notched and protrusible.
vi) Digits are clawed more or less strongly dilated with a double series of ridged lamellae beneath for movement on ceilings and smooth surfaces.

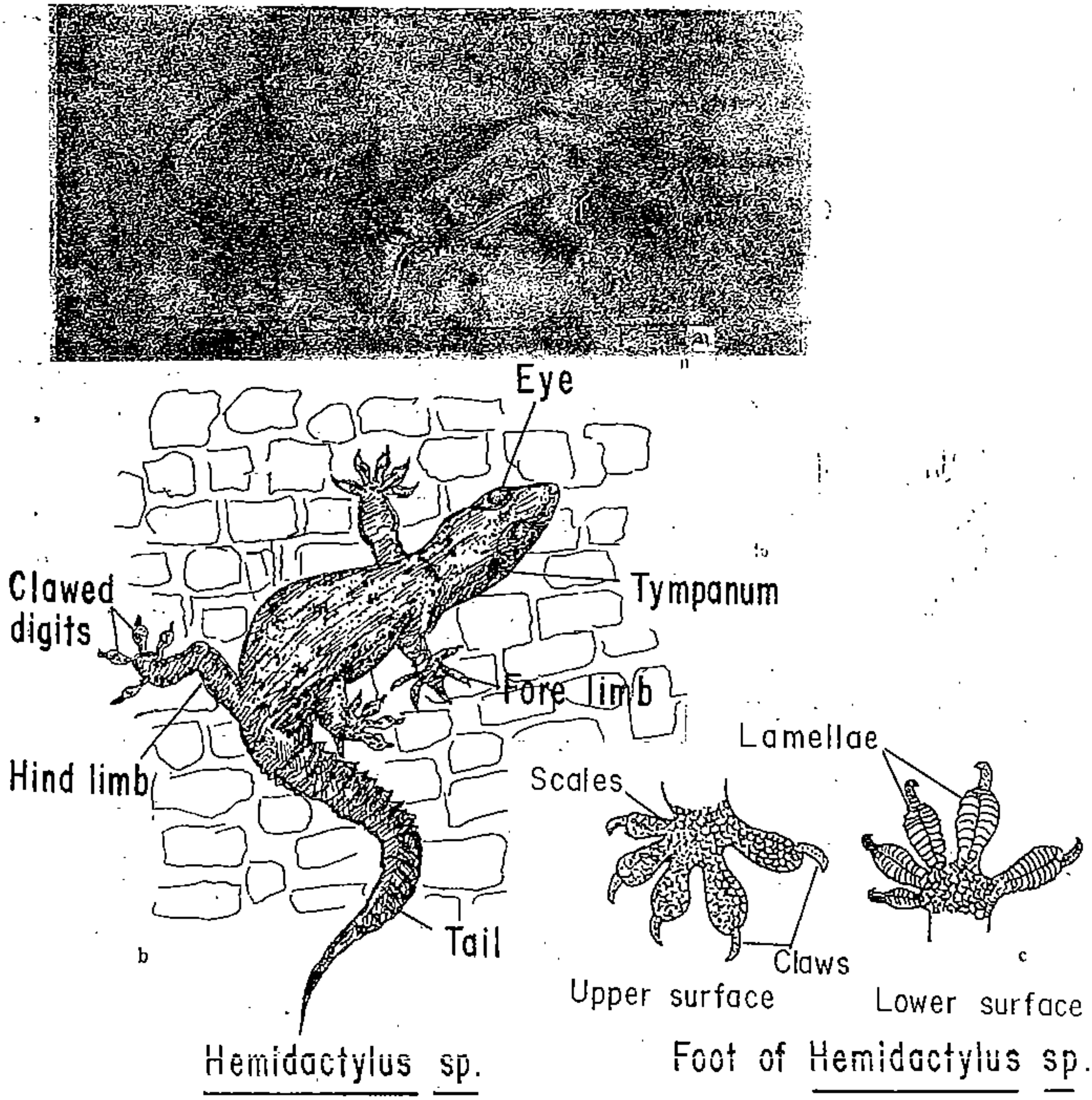

Fig. 29.4: *Hemidactylus flaviviridis*. a) Photograph of museum specimen. b) Drawing as interpreted from specimen.. c) View of upper surface of foot. d) View of lower surface of foot.

vii) Terminal phalanges are long, slender, clawed, free, rising angularly from within the expansion. This also enables them to move around over vertical surfaces and ceilings.
viii) Tail is moderately long and thick at the base and tapers posteriorly. (It can break off at the unossified part of the caudal vertebrae. This is a defence mechanism whereby the tail is broken off and the animal flees leaving the

broken tail behind. This process is known as **autotomy.** The tail regenerates but does not develop the vertebrae.)

ix) Only one supra-temporal arch is present.

x) Parietal organ is absent.

xi) Vertebrae are amphicoelous.

xii) The males have several femoral pores on the thighs. (Females are oviparous and lay almost spherical and hard shelled eggs.)

Habit and Habitat

Hemidactylus is nocturnal and insectivorous.

Geographical Distribution

Hemidactylus is generally found in warmer climatic regions of India, Sri Lanka and Southern Asia, Africa, China, Southern Europe.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Reptilia**	Cold blooded, terrestrial or aquatic vertebrates; single occipital condyle; vertebrae gastrocentrous; respiration by lungs; heart with two auricles and incompletely divided ventricle; right and left aortic arches complete and functional, cranial nerves 12 pairs and embryo with amnion and allantois.
Subclass	**Diapsida**	Two temporal vacuities on each side; post-orbital and squamosal usually meet between termporal vacuities.
Super Order	**Lepidosauria**	Two temporal vacuities present, anterior orbital vacuities absent; post temporal fenestrae usually present; humerus with two foramina.
Order	**Squamata**	Body covered with horny epidermal scales; single supra-temporal vacuity in lizards and none in snakes; teeth pleurodont; quadrate movable; quadratojugal absent; vertebrae procoelous; limbs present or absent; cloacal opening transverse; male possesses a pair of eversible copulatory organ.
Suborder	**Lacertilia**	Terrestrial, arboreal or burrowing forms; single supra-temporal vacuity; limbs pentadactyle and usually present; rami of mandibles fused in front; sternum present; eye-lids movable; typmpanum present.
Genus	***Hemidactylus***	
Species	***flaviviridis***	
Common Name	**Wall lizard/house lizard**	

Common Name   Wall lizard/house lizard

29.5.2 *Chamaeleo*

Examine the specimen and note the following features:

i) Head and body of *Chamaeleo chamaeleon* (Fig. 29.5) are laterally compressed and covered with flat minute tubercles or granules.

ii) Scales on head are larger and flatter than those on the rest of the body.

iii) Head is angular and forms a casque or helmet with prominent crests and turberocities which are formed by the processes of squamosal and occipital bones, which project backwards on the neck.

iv) Eyes are on the sides of the head. They are large, covered with a thick granular lid, pierced by a pore.

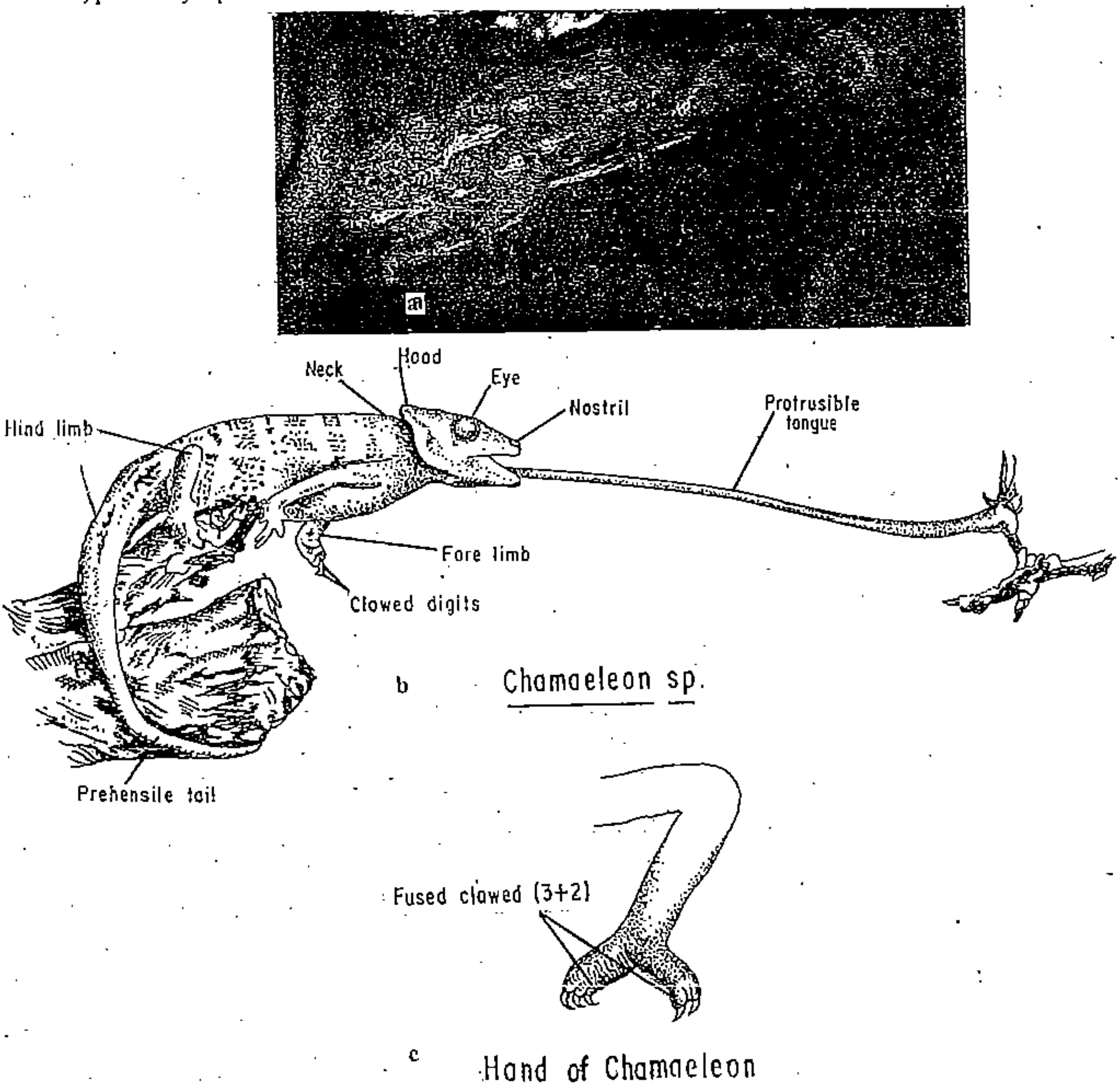

Fig. 29.5: *Chamaeleo.* a) *Chamaeleo chamaeleon* in its natural habitat. b) Drawing as interpreted from specimen. c) View of hand showing fused claws (3+2).

v) The left and right eye are movable independently.

vi) Tympanum and tympanic cavity are absent.

vii) Tongue is long, sticky and with a thickened, club-like (spoon shaped) tip. It is extremely protrusible and catches insects with great precision even upto a distance about 20 cm.
viii) Lungs have air sacs and the animal can inflate the body on seeing an enemy.
ix) Tail is long (as long as body and head) and prehensile.
x) Limbs are long and slender.
xi) Feet are modified by fusion of five toes into two groups – two in one group and three in other – which are opposable to each other and are good in grasping twigs, etc. The group having 3 toes is on the inside of the fore-foot and on outside of the hind-foot.
xii) The animal is capable of changing colour to some extent. The dermis contains melanophores which are controlled by the autonomic nervous system.
xiii) Teeth are acrodont.
xiv) Vertebrae are procoelous.
xv) Clavicles and interclavicles are absent.
xvi) Costal sternum is present.
(They are oviparous and lay 30-40 parchment-shelled eggs which are burried in the ground.)

Habit and Habitat

Chamaeleon is arboreal though it may be found in low bushes and undergrowth as well as trees. It is insectivorous.

Geographical Distribution

Chamaeleon is found in India, parts of South Western Asia, South Arabia, Africa, Madagascar and Southern Europe.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Reptilia**	Cold blooded, terrestrial or aquatic vertebrates; single occipital condyle; vertebrae gastrocentrous; respiration by lungs; heart with two auricles and incompletely divided ventricle; right and left aortic arches complete and functional, cranial nerves 12 pairs and embryo with amnion and allantois.
Subclass	**Diapsida**	Two temporal vacuities on each side; post-orbital and squamosal usually meet between temporal vacuities.
Super Order	**Lepidosauria**	Two temporal vacuities present, anterior orbital vacuities absent; post temporal fenestrae usually present; humerus with two foramina.
Order	**Squamata**	Body covered with horny epidermal scales;

single supra-temporal vacuity in lizards and none in snakes; teeth pleurodont; quadrate movable; quadratojugal absent; vertebrae procoelous; limbs present or absent; cloacal opening transverse; male possesses a pair of eversible copulatory organ.

Suborder	Lacertilia	Terrestrial, arboreal or burrowing forms; single supra-temporal vacuity; limbs pentadactyle and usually present; rami of mandibles fused in front; sternum present; eye-lids movable; tympanum present.
Genus	*Chamaeleo*	
Species	*chamaeleon*	
Common name	Chamaeleon	

29.5.3 *Draco*

Draco volans (Fig. 29.6) is commonly known as Flying Lizard or Flying Dragon.

Examine the specimen and note the following features:

i) Body is about 25 cm in length of which 12 cms is taken by tail.
ii) Body is compressed dorsoventrally and has a gular appendage and a lateral flap or wattle on either side of the throat.

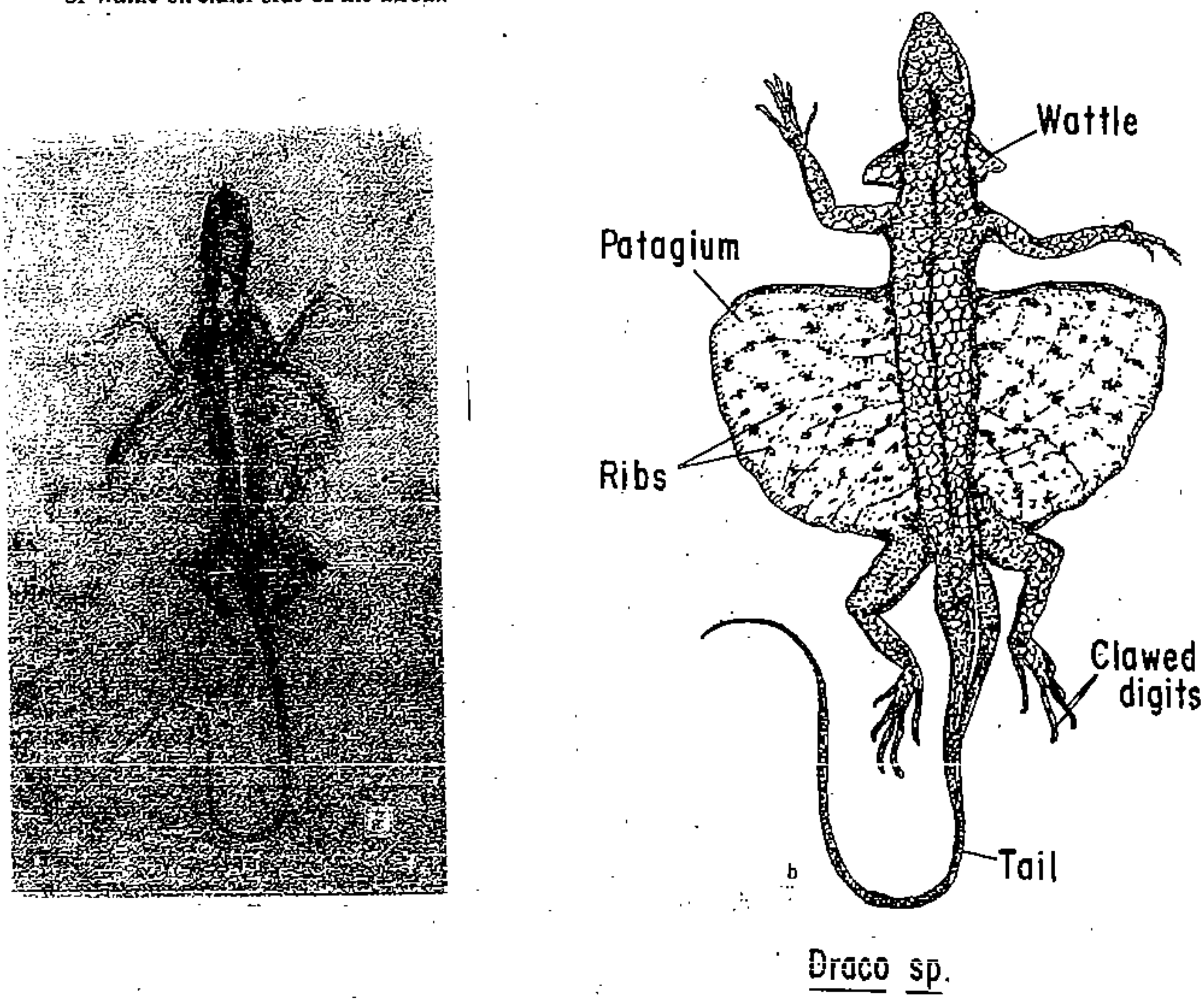

Fig. 29.6: *Draco* sp. a) Photograph of specimen. b) Drawing as intepreted from specimen.

iii) Gular pouch is present in both sexes but is larger in males. It is orange in males and blue in females.

iv) The sides of the body, between the fore-limbs and hind-limbs have a pair of large, wing-like expansions of skin, the **patagia**, supported by 5 or 6 greatly elongated ribs. When the ribs are raised the skin is stretched to form wing-like parachutes which enable the lizard to glide downwards from branch to branch, but the *Draco* does not fly.

v) The throat has three pointed hooks, a short one on either side and a long in the middle. The hooks on the neck help in alighting on branches. When at rest or climbing trees they are folded back along the sides of the body and are hardly distinguishable from it.

vi) Eyes are small with rounded pupil and complete eyelids. Vision is sharp.

vii) Tympanum is circular and is present a little behind and below the eye.

viii) Tail is very long, slender and tapering.

ix) Teeth are acrodont.

x) Vertebrae are procoelous.

xi) Females lays 2-5 eggs burried in the ground.

Habit and Habitat

It is arboreal. It lives in trees and feeds on insects, grubs, etc.

Geographical Distribution

Draco is found in India, Malaysia, Philippines, Myanmar (Burma).

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Reptilia**	Cold blooded, terrestrial or aquatic vertebrates: single occipital condyle; vertebrae gastrocentrous; respiration by lungs; heart with two auricles and incompletely divided ventricle; right and left aortic arches complete and functional, cranial nerves 12 pairs and embryo with amnion and allantois.
Subclass	**Diapsida**	Two temporal vacuities on each side; post-orbital and squamosal usually meet between temporal vacuities.
Super Order	**Lepidosauria**	Two temporal vacuities present, anterior orbital vacuities absent; post temporal fenestrae usually present; humerus with two foramina.
Order	**Squamata**	Body covered with horny epidermal scales; single supra-temporal vacuity in lizards and none in snakes; teeth pleurodont; quadrate movable; quadratojugal absent; vertebrae procoelous; limbs present or absent; cloacal

		opening transverse; male possesses a pair of eversible copulatory organ.
Suborder	Lacertilia	Terrestrial, arboreal or burrowing forms; single supra-temporal vacuity; limbs pentadactyle and usually present; rami of mandibles fused in front; sternum present; eye-lids movable; typmpanum present.
Genus	*Draco*	
Species	*volans*	
Common Name	**Flying Lizard or Flying Dragon**	

29.5.4 *Mabuya/Mabuia*

Mabuya (Fig. 29.7) is commonly known as skink.

Examine the specimen and note the following features.

i) Snout is obtusely pointed brown on top and yellow-brown on the underside.
ii) Body is covered with cycloid, imbricate scales, with osteodermal plates, each provided with a regular system of channels – a transverse one anastomosing with longitudinal one.
iii) Head with symmetrical shields above, no femoral or preanal pores.
iv) Teeth are pleurodont.
v) Tongue is covered with imbricate, scale-like papillae and is feebly nicked anteriorly.
vi) Eyelids are movable, ear is distinct, tympanum more or less deeply sunk.
vii) Limbs are weak and slender and pentadactyle.
viii) Digits are moderately long, with smooth or obtusely keeled lamellae. Palms of hands and soles of feet with flattish or subconical tubercles, the heels often with larger ones.

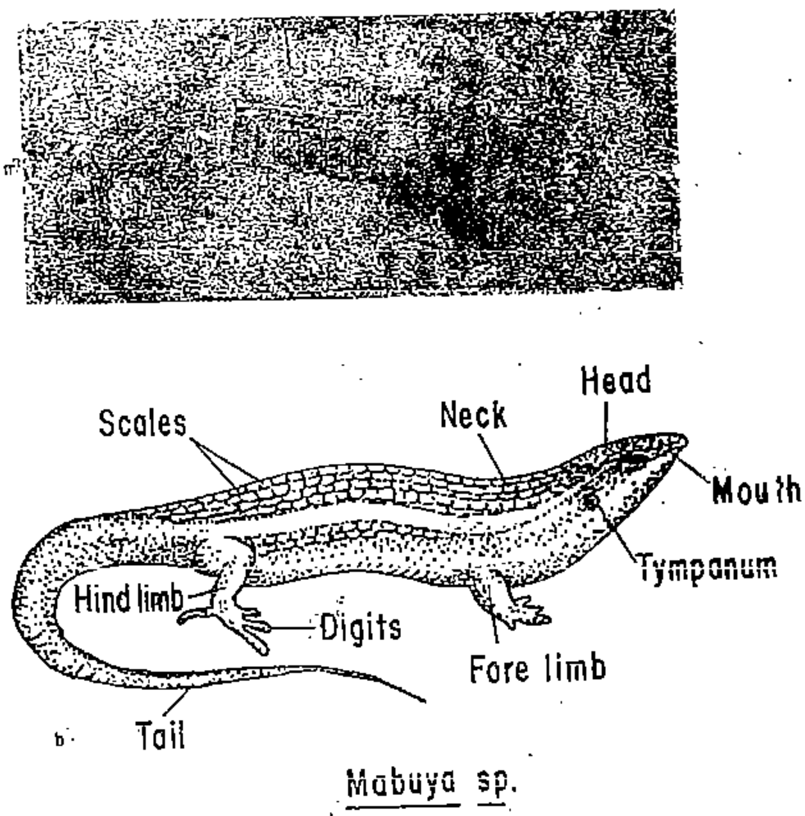

Fig. 29.7: *Mabuya*. a) In its natural habitat. b) Drawing of skink from specimen.

Habit and Habitat

Mabuya lives on ground and suns itself on warm blocks of stone in forests. It can hide in narrow rocky crevices. It hunts insects in the undergrowth. Female lays 2-3 eggs which she buries in soil.

Geographical Distribution

They are found in Africa, Madagascar, Southern Asia, Indonesia, the Carribbean Islands, Central and South America. It is also found in South India.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Reptilia**	Cold blooded, terrestrial or aquatic vertebrates; single occipital condyle; vertebrae gastrocentrous; respiration by lungs; heart with two auricles and incompletely divided ventricle; right and left aortic arches complete and functional, cranial nerves 12 pairs and embryo with amnion and allantois.
Subclass	**Diapsida**	Two temporal vacuities on each side; post-orbital and squamosal usually meet between termporal vacuities.
Super Order	**Lepidosauria**	Two temporal vacuities present, anterior orbital vacuities absent; post temporal fenestrae usually present; humerus with two foramina.
Order	**Squamata**	Body covered with horny epidermal scales; single supra-temporal vacuity in lizards and none in snakes; teeth pleurodont; quadrate movable; quadratojugal absent; vertebrae procoelous; limbs present or absent; cloacal opening transverse; male possesses a pair of eversible copulatory organ.
Suborder	**Lacertilia**	Terrestrial, arboreal or burrowing forms; single supra-temporal vacuity; limbs pentadactyle and usually present; rami of mandibles fused in front; sternum present; eye-lids movable; typmpanum present.
Genus	***Mabuya* or *Mabuia***	
Common Name	**Skink**	

29.6 TERMINAL QUESTIONS

1. What is the economic importance of turtles?

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2. How are lizards different from snakes?

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3. Compare the wing-like patagia of *Draco* with the wings of a bird.

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4. Describe the more advanced features of reptiles as compared to amphibians.

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5. Animals are adapted to the mode of life they lead. Discuss this with reference to the reptiles you have studied.

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Acknowledgement :

All drawings are original and have been drawn by Dr. H.C. Agarwal.

EXERCISE 30 REPTILIA II : SNAKES – OBSERVATION AND CLASSIFICATION OF SPECIMENS

Structure

30.1 INTRODUCTION

Every body, young or old, recognizes a snake. Snakes are perhaps the only creatures that evoke a mixed response of fear and fascination. They have contributed richly to folklore, fantasies, facts and falsehoods – all F's as you might see! The worst in fact is fear that has led to the mindless slaughter of these poor creatures, most of which are harmless or non-poisonous. In reality, snakes play a very vital role in keeping the rodent pest population in check. Without snakes, nature would lose much of its beauty and bounty.

Of the 2000 and odd species of snakes found in the world, India has only around 200 of them. Sadly, many are wantonly killed for their skins while others are confused with poisonous varieties and killed out of fear. Do your little bit to save wildlife.

The study of snakes belongs to the wide field of Herpetology that includes other reptiles and amphibians as well. In your practical class you will be able to study all or most of the seven specimens listed in this exercise.

Snakes share the Order Squamata with lizards and differ from them in the absence of limbs, moveable eyelids and middle ear including tympanum. In both snakes and lizards, the fork-like tongue is flipped in and out more to smell than to taste. Snakes shed their skins several times as they grow. Unlike lizards, the skin does not peel off in patches. A moulting snake rubs its chin and jaws on a bush to crack the skin and then crawls out of it. The loosened skin comes off like socks turned inside out.

Objectives

After performing this exercise, you should be able to:

- explain the uniqueness in body plan of snakes,
- identify the different types of scales,
- highlight the differences between poisonous and non-poisonous snakes,

- identify, classify and state the zoological names along with the vernacular names of the given museum specimens of snakes,
- list the salient features justifying the classification of the identified snake genera and mention special features if any,
- mention the habit, habitat and geographical location of each museum specimen,
- draw well labelled diagrams of each of the identified specimen,
- mention economic importance, if any, of the identified snakes.

30.2 MATERIAL REQUIRED

1. Museum specimens of the following snakes:
   i) Red sand boa (*Eryx johnii*)
   ii) Checkered keel back (*Xenochorphis piscator*)
   iii) Rat snake (*Ptyas mucosus*)
   iv) Common krait (*Bungarus caerulus*)
   v) Indian spectacled snakes (*Naja naja*)
   vi) Russell's viper (*Vipera russelli*)
   vii) Annulated sea snakes (*Hydrophis cyanocinctus*)
2. Magnifying glass/hand lens

30.3 CHARACTERISTICS OF SUBORDER SERPENTES

You will recall from the previous laboratory exercise that both lizards (Suborder Lacertilia) and snakes (Suborder Serpentes) belong to the Order Squamata. You have in that exercise studied the characteristic features of suborder Lacertilia with the help of selected museum specimens of that suborder. In this exercise too you will study the characteristics of Suborder Serpentes with the help of some selected museum specimens of non poisonous and poisonous snakes.

Characteristics of Serpentes (Ophidia) of Order Squamata

Snakes are found in terrestrial or aquatic habitats. They may be arboreal or burrowing in nature. Their main features are as follows:

- Body elongate, limbs and sternum absent.
- Temporal vacuities are absent.
- Ear openings, tympanum and middle ear absent.
- Rami of mandibles are bound anteriorly by ligaments.
- Eyelids immovable, fused into transparent spectacle.
- Tongue forked (bifid) and protrusible.
- Zygosphene and zygantra are present in the vertebra (Fig. 30.1).

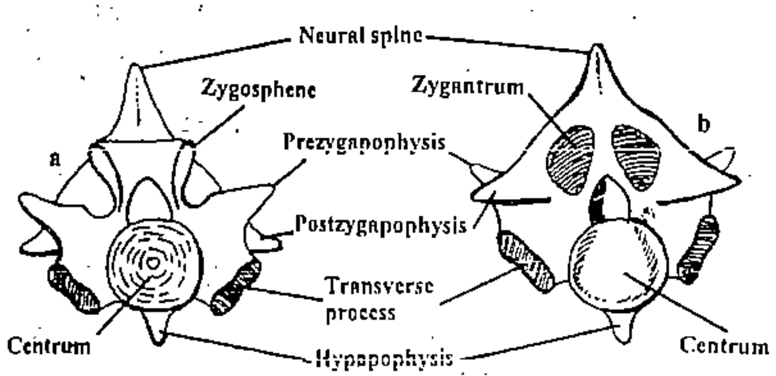


Fig. 30.1: Vertebrae of snake. In the vertebrae of snakes and some lizards in addition to zygopophyses there is a special pair of apophyses called zygosphenes which fit into concavities called zygantra. (a) Anterior view. (b) Posterior view.

30.4 GENERAL INSTRUCTIONS ON HOW TO IDENTIFY SNAKES

As all snake bodies are basically divisible into head, trunk and tail, the main way to identify them is to note the form and proportion of these body parts such as broad or small head, robust or slender body, short or long, blunt or tapering tail. The colour patterns are definitely striking features for instant recognition. Sometimes, colour patterns may be misleading as some non-poisonous snakes mimic or copy the colour patterns of poisonous varieties (Refer Unit 16 of LSE-10).

Please Note: There are some drawbacks in the study of bottled specimens of snakes.

1. the colour patterns, bandings and markings that are very diagnostic often fade with long preservation in formalin.
2. most bottled specimens are juveniles and very young. They may not therefore, have developed all the characteristic features.

It is thus essential to know the scale patterns which are technically the most diagnostic features.

30.4.1 Colour Patterns and Other Field Characters for Instant Recognition of Snakes

(1) *Eryx johnii* : Red Sand Boa (Fig. 30.6 a)

Medium sized, stout and robust body; blunt bulbous head-like tail; uniformly dull muddy red or pale chocolate brown in colour, sometimes with irregular patches of dark-brown and dull-white.

(2) *Xenochrophis piscator* : Checkered Keelback or Water Snake (Fig. 30.7 a)

Body scales rough in appearance as they are strongly keeled; a striking checker-board pattern of five rows of black spots alternating with background colour spots of creamish-brown. In some cases, the spots may be bright scarlet red alternating with greenish-brown.

(3) *Ptyas mucosus* : Rat Snake (Fig. 30.8 a)

Long slender body, very glossy with large black, shiny eyes; background colour yellowish-brown or greenish-yellow; black cross-bars of broken net-like markings; two black streaks behind the eyes; black margins on the ventral scales.

(4) *Bungarus caeruleus* : Common Krait (Fig. 30.9 a)

Shiny deep blue-black or jet-black body with pairs of white bead-like cross-stripes; large spots of white in a single row on the back.

(5) *Naja naja* : Indian Spectacled Cobra (Fig. 30.10 a and b)

Wheatish to deep brown coloured medium sized snake; neck inflatable into an oval hood; the dorsal side of the hood bears a characteristic spectacle or binocellate mark – two black circles connected by a U-bordered white and then black; the ventral side of hood with two pairs of black spots and two or three black bands below.

(6) *Vipera russelli* : Russell's Viper (Fig. 30.11 a)

Broad triangular head with a deep neck; background colour wheatish with three rows of almond-shaped patches, one middle and two on the sides; the patches are deep brown bordered white with an island of light brown in the middle; at some places, small spots scattered between the side row of patches. One dark stripe below the eye and another over and behind it, give it an angry look. Two white stripes starting from the jaws pass over the head meeting at the snout to form a V.

(7) *Hydrophis cyanocinctus* : Annulated or Banded Sea Snake (Fig. 30.12 a)

Broad rounded head with the upper half of the body cylindrical and the rest flattened. Tail broad, extremely flattened and paddle-like. Background colour pale bluish or greenish grey; ventral side cream; 60 to 70 broad black cross-bands; each band gets narrower and fainter down the sides.

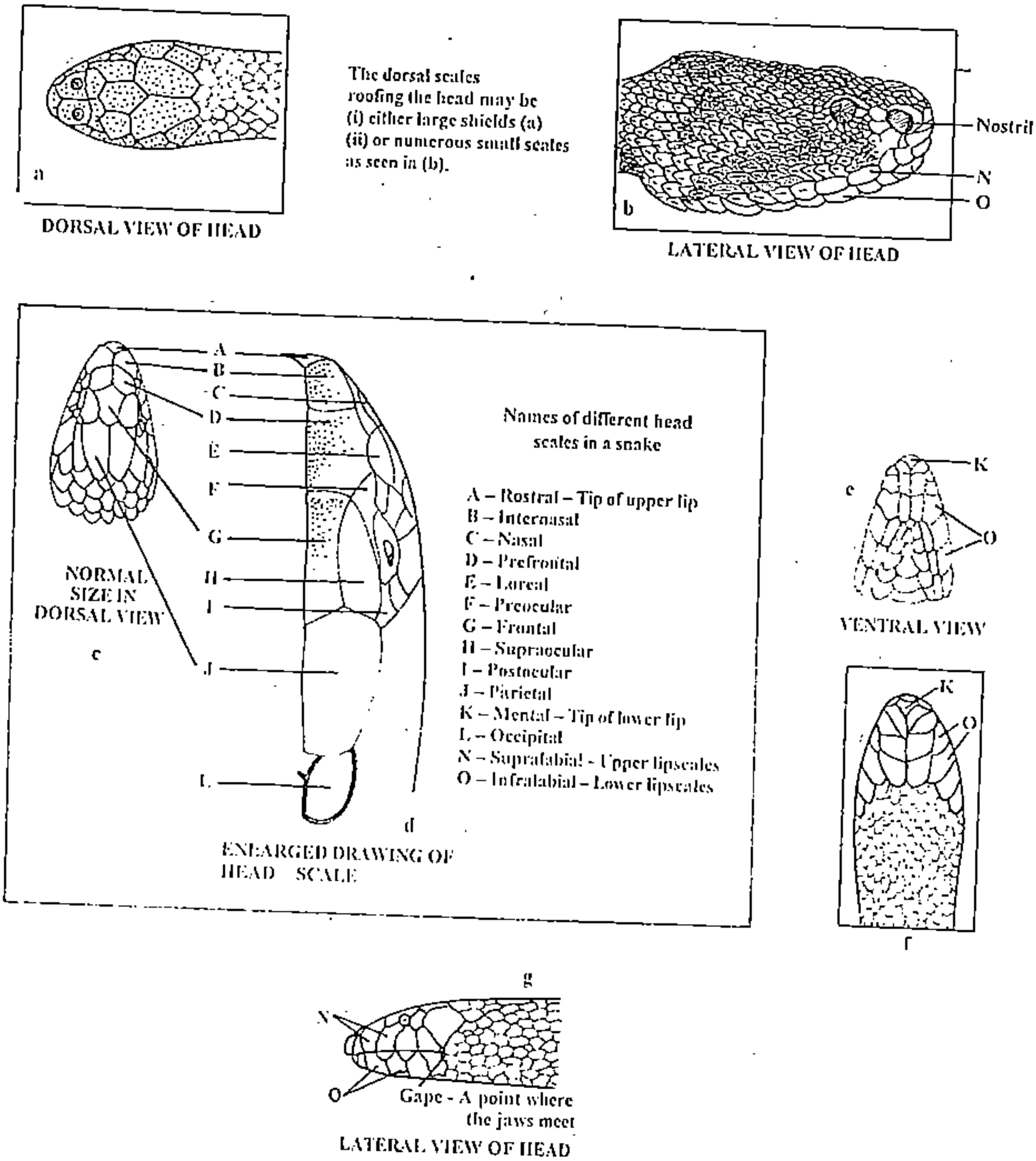


Fig. 30.2: Head scales. a) and b) View of head showing that the dorsal scales roofing the head may be (a) either few and large or (b) numerous and small. c) Dorsal view of head showing the head scales in normal size and d) in enlarged size so that the different head scales (shields) may be identified, e and f) ventral view of head region showing (e) the infra labials (lower lip scales) clearly since ventral view of head gives a better study of infralabials. g) Lateral view of head clearly shows both the supralabials and infra labials and enables one to count their number upto the gape and also to see which suprabials touches the eye.

Note: It is not necessary to memorise all the name of the head scales given in fig. c. You should however learn the names of the upper and lower lip scales. The shape and size of shields vary in different snakes.

30.4.2 Scale Patterns

The form, size and arrangement of scales must be observed in a methodical way in order to identify the differences between poisonous and non-poisonous snakes. You can use a hand-lens or a magnifying glass for closer scrutiny. We go about the study of (I) head, (II) trunk and (III) tail systematically as follows:

I) Head scales : See Fig. 30.2

1. Dorsal side :
   a) Small, numerous, uniform-sized scales or
   b) Large, fewer, varied-sized scales called shields
2. Lateral side :
   a) Upper-lip scales or supra labials; these are noted for making contact with eye or nasal scale. The number of supra labials are 7 to 9.
   b) Lower-lip scales or infra labials; 8 to 9 in number; noted for some diagnostic feature.

II) Trunk scales : See Fig. 30.3.

1. Dorsal side :
   a) Middlemost or median row called vertebrals may be the same size or larger than the side scales.
   b) The side scales called costals can be of different shapes and form.
      Shapes: Imbricate or semicircular; elliptical; oblong; rhomboidal.
      Form: Smooth or rough; roughness due to a ridge in the middle of the scale giving it a boat-shaped form – this is referred to as a keeled scale.

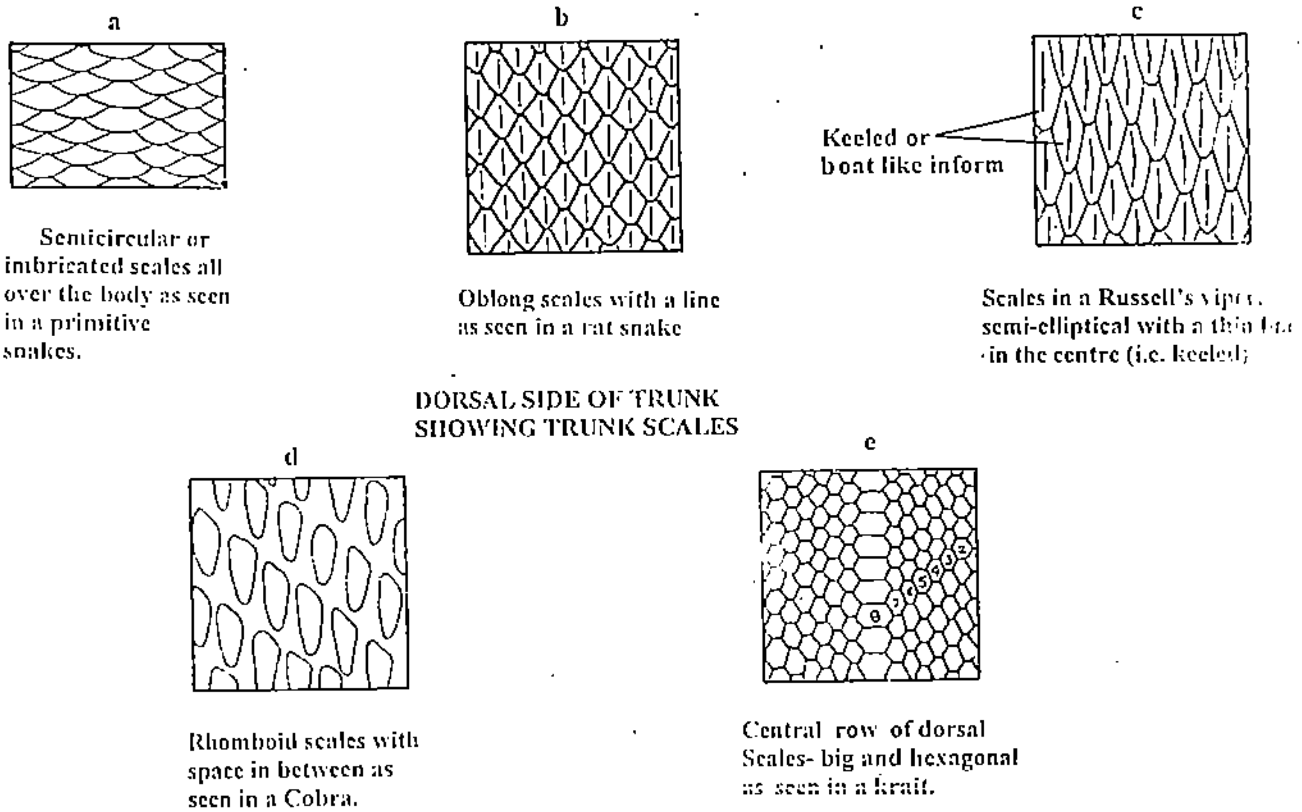


Fig. 30.3: Dorsal scales of the trunk region. (a, b, c) dorsal view of trunk showing scales which may be all uniform in size and shape or (e) the central row of vertebrals may be enlarged and distinct.

2. Ventral side : (Fig. 30.4)
   a) Middlemost row called ventrals may be the same size or larger than the costals.
   b) Shape and form: The enlarged vertebrals may form a median ridge or a row of narrow rectangular shields or large rectangular shields running across the belly.

VENTRAL SIDE OF TRUNK

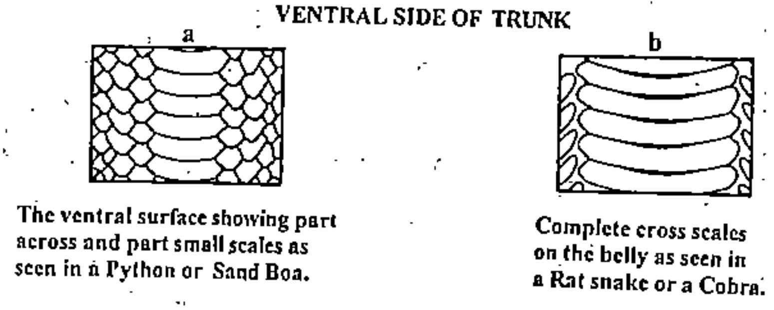


Fig. 30.4: Ventral view of trunk showing different types of belly scales in Sand boa and Rat snake or Cobra respectively.

III) Tail : See Fig. 30.5.

The tail is not distinctly demarcated from the trunk and so, you have to look at the ventral side and locate the cloacal aperture or vent. Remember that the tail is a post anal appendage. The length of the tail in proportion to the overall length of the body can be ascertained.

1. Shape of Tail: a) Long, cylindrical and tapering.
   b) Short, stumpy and conical.
   c) Stout, blunt and bulbous.
   d) Long, extremely flattened and paddle-like.
2. Scales of Tail: a) The scales behind the vent are referred to as subcaudals.
   b) They can be in a single row or a double row.

TAIL SCALES OR SUBCAUDALS

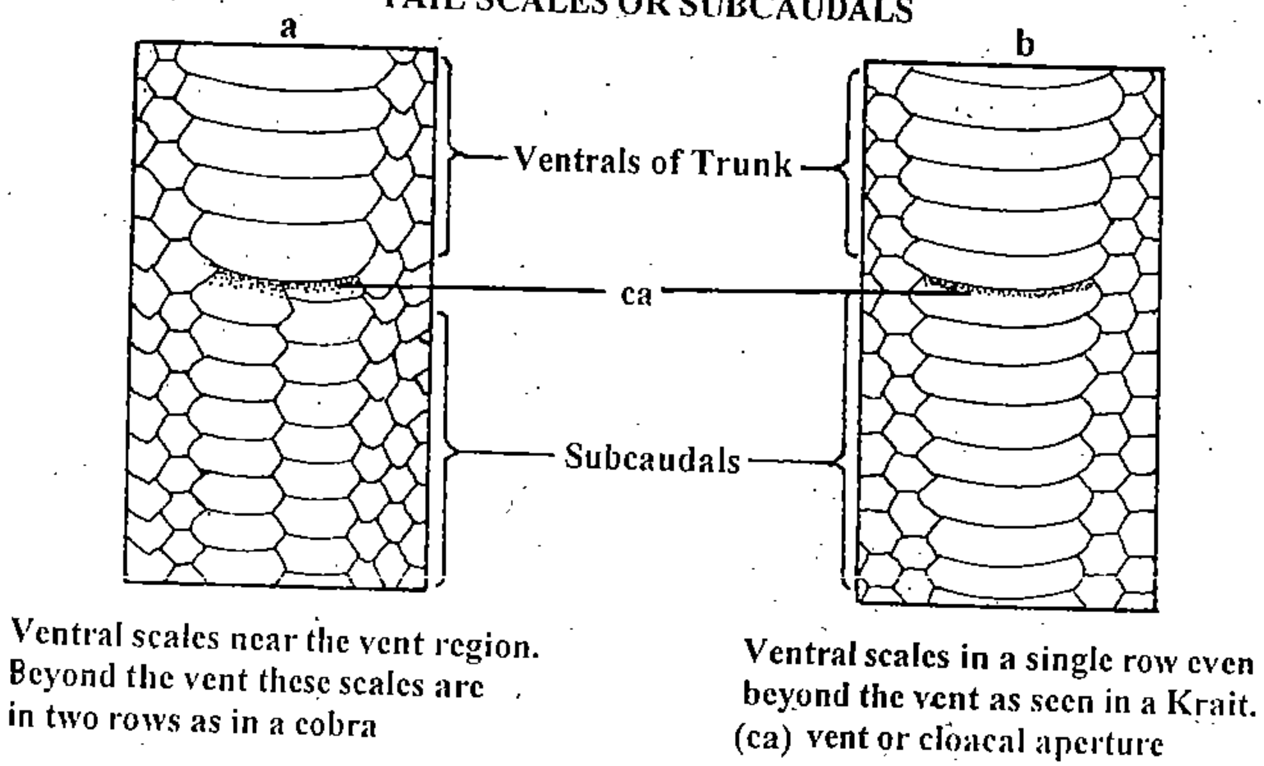


Fig. 30.5: Tail scales or subcaudals (a) ventral scales near the vent regions as in Cobra (b) ventral scales beyond the vent as seen in Krait.

30.4.3 Key for identification of Non-poisonous and Poisonous Snakes

In describing a snake we start with the head and move on from the trunk to the tail; whereas in an identification process we go in the reverse order from the tail to the trunk.

A. Tail :
- i) Elongate, flattened, paddle-like .... Sea snakes (poisonous) e.g. *Hydrophis*.
- ii) Cylindrical; either short and conical or blunt and bulbous .... Burrowing land snakes (non-poisonous) e.g. *Eryx*.
- iii) Cylindrical; long and gradually tapered .... Land snakes (poisonous/non-poisonous)

B. Trunk scales (Ventral) :
- i) Uniform sized scales .... Worm snakes (non-poisonous)
- ii) The median row of ventrals raised to form a ridge .... Sea snakes (poisonous).
- iii) A median row of slightly enlarged rectangular scales .... All non-poisonous land snakes.
- iv) Broad rectangular shields greatly enlarged covering entire belly .... Poisonous/non-poisonous.

C. Trunk scales (dorsal):
- i) Uniform dimension of rhomboid scales in oblique rows with space in between .... Cobras (poisonous) e.g. *Naja*.
- ii) Central row of vertebrals enlarged and hexagonal .... kraits (poisonous) e.g. *Bungarus*.
- iii) Uniform dimension of closely places scales, oblong or elliptical; smooth or keeled .... Majority of snakes (poisonous/non-poisonous).

D. Neck :
- i) A deep neck constriction demarcating head from trunk .... Vipers (poisonous) e.g. *Vipera*.
- ii) An expansible hood formed by dilating the neck .... Cobras (poisonous).
- iii) Slight or no constriction at neck .... All other snakes (poisonous/non-poisonous).

E. Head (shape) :
- i) A broad triangular head .... Vipers (poisonous).
- ii) Ovate or elliptical head .... All other snakes (poisonous/non-poisonous)

F. Dorsal Head scales :
- i) Numerous small scales + a broad triangular head .... Vipers (Poisonous).
- ii) Large shields arranged symmetrically .... (Poisonous/ non-poisonous)

G. Supra Labial scales :
- i) 3rd and 4th touch eye .... Krait and Cobra (Poisonous).
- ii) 3rd enlarged and also touches nasal scale .... Only Cobras (poisonous).
- iii) 4th and 5th touch eye .... Rat snake and Water snake (non-poisonous).

iv) 3rd, 4th and 5th touch eye .... Sea snake (Poisonous).

v) No supra labial scale touches eye as several small scales come in between .... Viper (Poisonous) and Sand Boa (non-poisonous).

H. Infra Labial scales :

i) 4th is the largest .... Krait (Poisonous)

ii) A small triangular cuneate scale sandwiched between 4th and 5th .... Cobra (Poisonous).

30.5 CLASSIFICATION

All snakes belong to the same order as lizards (i.e. squamata) and are separated at the suborder level. In this lab exercise all the snakes to be studied have to be classified upto the level of Suborder. Since all the snakes to be studied in this exercise belong to the same Suborder Ophidia therefore the classification given in this section will be the same for all of them.

Classification and its justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Reptilia**	Cold blooded, terrestrial or aquatic vertebrates; single occipital condyle; vertebrae gastrocentrous; respiration by lungs; heart with two auricles and incompletely divided ventricle; right and left aortic arches complete and functional, cranial nerves 12 pairs and embryo with amnion and allantois.
Subclass	**Diapsida**	Amniotes having a skull with two temporal vacuities on each side; post-orbital and squamosal usually meet between temporal vacuities.
Superorder	**Lepidosauria**	Characterised by sprawling posture, no bipedal specialisations; diapsida skull with two temporal vacuities present; anterior orbital vacuities absent; post temporal fenestrae usually present; humerus with two foramina.
Order	**Squamata**	Body covered with horny epidermal scales; single supra-temporal vacuity in lizards and none in snakes; teeth pleurodont; quadrate movable; quadrato-jugal absent; vertebrae procoelous (concave in front); limbs present or absent; anus (cloacal opening) transverse in form of slit; male possesses a pair of eversible copulatory organs.

Suborder	Serpentes (Ophidia)	Snakes; elongate body with no limbs; terrestrial or aquatic, arboreal or burrowing; temporal vacuities entirely absent; limbs absent; rami of mandibles united by a ligament, sternum absent; eye-lids immovable; tympanum absent; tongue bifid and protrusible, zygosphene and zygantra present in the vertebra.

30.6 SPECIMEN STUDY OF SOME COMMON HARMLESS OR NON-POISONOUS SNAKES

Snakes that are marked non-poisonous are actually harmless to man but do have poison that kills small creatures. Their bite however, can be quite painful. Death does not always occur from the bite of a poisonous snake; it depends on the amount of poison injected. All cases however, must be treated with antivenin. Let us study some non poisonous snakes.

30.6.1 *Eryx johnii*

Examine the specimen Red Sand Boa or John's Earth Boa (*Eryx johnii*) (Refer to Fig. 30.5) and note the following characteristics:

i) **Head:** Rounded and blunt; shovel-shaped snout with a prominent ridge adapted for digging; eyes very small, barely noticeable; nostrils slit-like and high on the snout; only a few scales enlarged as shields, rest small and numerous separating the supralabials from the eye; ventrally, the chin bears a groove; neck hardly distinguishable.
ii) **Trunk:** The stout muscular trunk has uniform diameter all the way upto the tail; scales numerous, minute, elliptical and keeled; mid-body has 55 rows of scales; the ventral scales form a narrow row of rectangular plates.
iii) **Tail:** Very short, stumpy and rounded, it appears as if it has been chopped off at the end; the tail scales more strongly keeled and rough, perhaps to be irritating and unpalatable to the predator; sub-caudal scales in one row.
iv) **Length:** Usually less than a metre, 75 to 90 cm.
v) **Field characters:** Stout and heavy body, very blunt and bulbous tail resembling head. Sometimes moves backwards when coming out of a burrow, hence mistaken to be double-headed. Uniform chocolate-brown or pale brick-red in colour (See Fig. 30.6).

Habitat and Habitat

It is nocturnal; unlike its cousin, the Common Sand Boa, it is gentle and docile. If confronted by a predator such as a mongoose or a peacock, it hides its head under the body coils and waves its tail as if it is the head to distract attention. Its movement on land is slow and sluggish but it burrows with a terrific speed. Prefers dry sandy areas and inhabits rodent burrows.

Food

Prefers rats, lizards and small birds, occasionally eats other snakes; kills its prey by constricting with its heavy body.

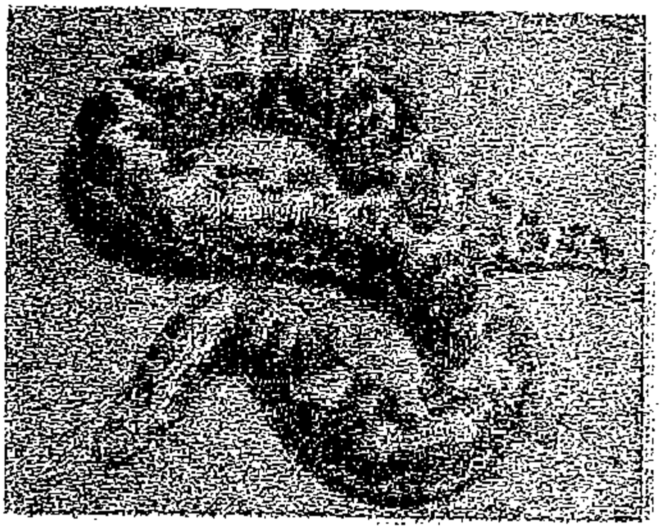
Breeding

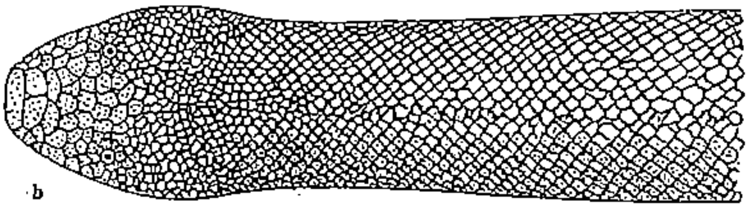
Not much known. The female is viviparous and bears 6-8 live young in the summer months.

Bite

It is a shy snake and never bites even when tormented.

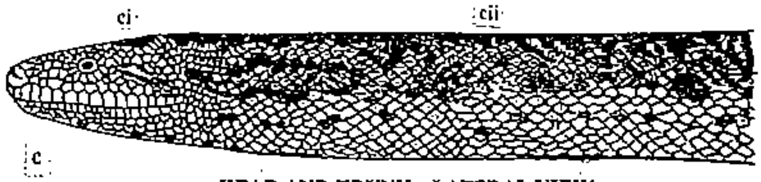
a.





- Note the ovate head with a blunt shovel-shaped snout; the small eyes and slit-like nostrils.
- The stout trunk has numerous, small and elliptical scales; the scales are keeled especially in the posterior region.

- The usually uniform colour may have occasional blotches of darker brown and white
- The lateral view of the head show absence of a neck constriction
- Note that the supralabial scales are separated from touching the eye due to numerous small scales in-between



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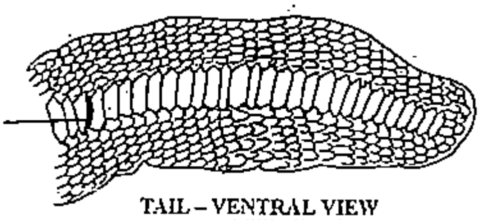


- Note the blunt bulbous end of the tail
- The narrow rectangular ventrals continue as single row of sub-caudals beyond the vent

Fig. 30.6: Non poisonous (Harmless) snake, Red Sand Boa (*Eryx johnii*) (a) Photograph of the snake showings its natural colouration. (b) Dorsal view of head and trunk showing (b i) ovate head with a blunt shaped snout, small eyes, slit like nostrils and (b ii) stout trunk with numerous, small, elliptical scales which are keeled especially in the posterior region. (c) lateral view of head and trunk showing (c i) the absence of neck constriction between head and trunk and that of the supralabial scales are separated from touching the eye due to numerous small scales in between and the (c ii) the usually uniform colour of the snake may have occasional blotches of darker brown and white (d) ventral view of tail showing the blunt bulbous end of the tail and the narrow rectangular ventrals that continue as a single row of subcaudals beyond the vent.

Status

The myth surrounding the snake that it is double-headed, has made it a favourite with snake-charmers who even try to make eye-like marks to befool gullible people for money. Luckily, it is not slaughtered for its skin.

Geographical Distribution

Widely distributed in the plains, more common in the drier parts of South India.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Reptilia**	Cold blooded, terrestrial or aquatic vertebrates; single occipital condyle; vertebrae gastrocentrous; respiration by lungs; heart with two auricles and incompletely divided ventricle; right and left aortic arches complete and functional, cranial nerves 12 pairs and embryo with amnion and allantois.
Subclass	**Diapsida**	Amniotes having a skull with two temporal vacuities on each side; post-orbital and squamosal usually meet between temporal vacuities.
Superorder	**Lepidosauria**	Characterised by sprawling posture, no bipedal specialisations; diapsida skull with two temporal vacuities present; anterior orbital vacuities absent; post temporal fenestrae usually present; humerus with two foramina.
Order	**Squamata**	Body covered with horny epidermal scales; single supra-temporal vacuity in lizards and none in snakes; teeth pleurodont; quadrate movable; quadrato-jugal absent; vertebrae procoelous (concave in front); limbs present or absent; anus (cloacal opening) transverse in form of slit; male possesses a pair of eversible copulatory organs.
Suborder	**Serpentes (Ophidia)**	Snakes; elongate body with no limbs; terrestrial or aquatic, arboreal or burrowing; temporal vacuities entirely absent; limbs absent; rami of mandibles united by a ligament, sternum absent; eye-lids immovable; tympanum absent; tongue bifid and protrusible, zygosphene and zygantra present in the vertebra.
Genus	*Eryx*	
Species	*johnii*	
Common name	**Red Sand Boa**	

Vernacular or local names:

Hindi :	Do Muha
Gujrati :	Chakalan
Marathi :	Do Tondya
Malayalam:	Mandalli
Oriya :	Do Mundia
Tamil :	Iruthalai Paambu

30.6.2 *Xenochrophis piscator*

Examine the specimen of *Xenochrophis piscator* (Checkered Keelback or Water Snake) (Refer to Fig. 30.7) and note the following characteristics.

i) **Head:** Elongated oval head, obtusely pointed; eyes fairly large with a white circle and two black lines distinct; nostrils small and slit-like; head-shields large; the 4th and 5th supralabials touch eye.
ii) **Trunk:** A fairly robust body; shiny oblong and very strongly keeled scales, about 19 rows in mid-body; ventral side pale with scales broad and rectangular covering the entire belly.
iii) **Tail:** Long, almost 1/3rd of total body length; sub-caudal scales in one row.
iv) **Length:** About a metre, females average length is longer than males.
v) **Field characters:** Shiny, with distinct black and cream checker-board pattern; the black spots run in 5 rows with spots in adjacent rows alternating in position; eyes surrounded by white circles with two black lines, one below and the other behind the eye. Some rare forms have bright-red spots alternating with greenish-brown in a checker-board pattern (Fig. 30.7).

Habit and Habitat

Active, both by night and day. Generally hunts by day in the water for fishes and frogs. At night, it is mostly on land. It is a swift diver and swimmer. It can move in leaps if pursued. When excited, it erects its forebody in a cobra-fashion, flattens its neck and darts forward to strike. If attacked by a predator, it pretends to be dead turning its belly-side up and writhing its body slowly. In summer, during drought, it aestivates. Common in most fresh-water bodies like lakes, ponds, wells, rivers and even flooded paddy fields during rains.

Food

Tadpoles, frogs and fish. The prey is swallowed live.

Breeding

Oviparous; the female lays a large number of eggs. About 40-50 eggs are laid in a rat-tunnel, tank-bund or a hole in a well. The female incubates them until they hatch, 60-70 days later.

Bite

It bites quite viciously when caught or stepped upon. Although its poison-gland secretion is not fatal to man, it does kill the small creatures.

Status

A favourite snake for skin traders, as a result, the snake has been wiped out completely from certain areas.

Geographical Distribution

Throughout India, from the plains upto 3000 mts. in the hill-streams of the Himalayas.

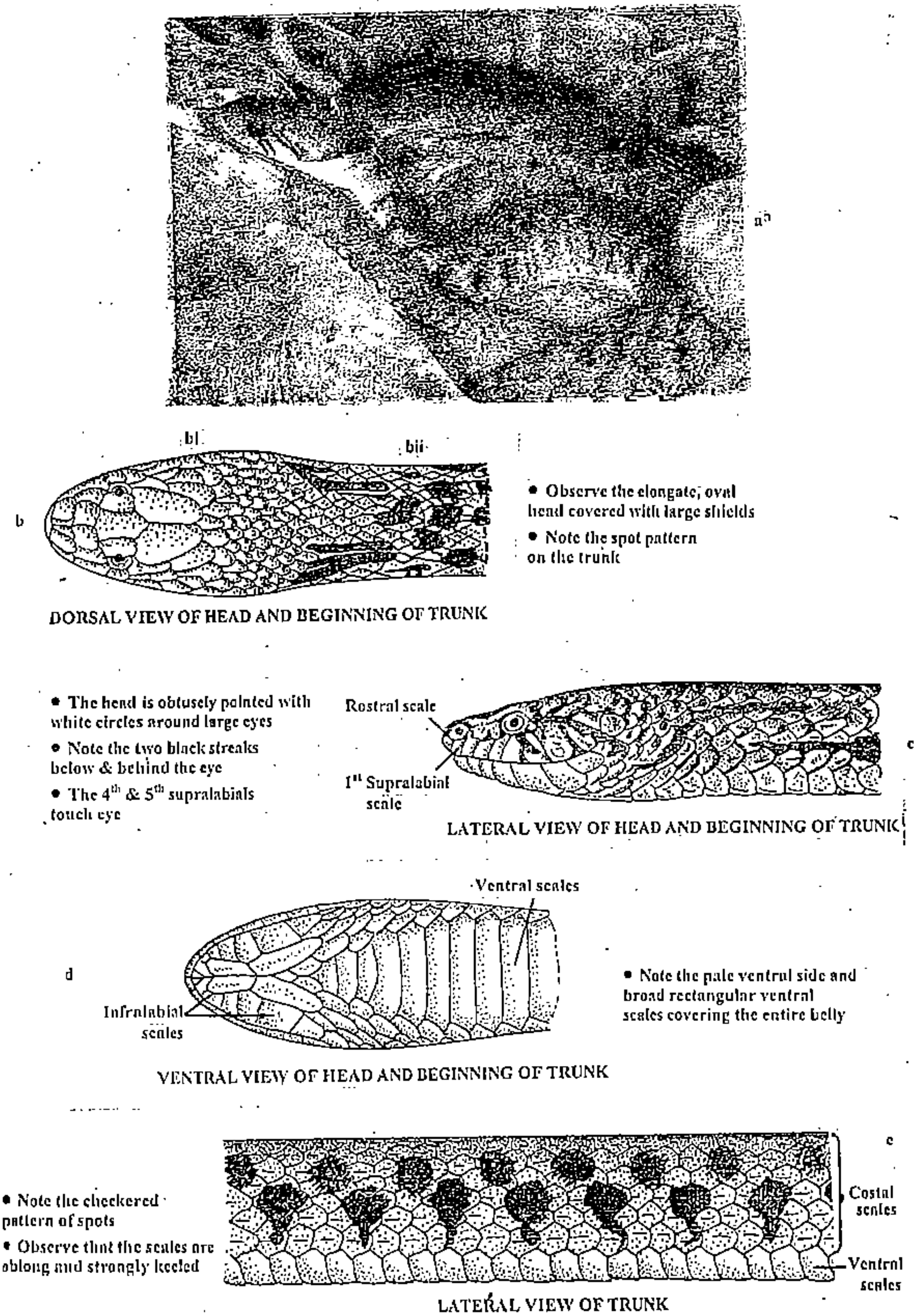


Fig. 30.7: Non poisonous (harmless) snake, checkered keel back or water snake (a) photograph of the snake showing its natural colouration (*Xenochrophis piscator*) (b) Dorsal view of head and beginning of trunk showing (b i) elongate, oval head covered with large shields and (b ii) spot pattern on trunk (c) Lateral view of head and beginning of trunk showing the obtusely pointed head with white circles around large eyes and two black streaks below and behind eye. The 4th and 5th supralabial can be observed touching the eye. (d) Ventral view of head and beginning of trunk, showing the pale ventral side and the broad rectangular ventral scales covering the entire belly. (e) Lateral view of trunk showing checkered pattern of spots and the oblong, strongly keeled scales.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Reptilia**	Cold blooded, terrestrial or aquatic vertebrates; single occipital condyle; vertebrae gastrocentrous; respiration by lungs; heart with two auricles and incompletely divided ventricle; right and left aortic arches complete and functional, cranial nerves 12 pairs and embryo with amnion and allantois.
Subclass	**Diapsida**	Amniotes having a skull with two temporal vacuities on each side; post-orbital and squamosal usually meet between temporal vacuities.
Superorder	**Lepidosauria**	Characterised by sprawling posture, no bipedal specialisations; diapsid skull with two temporal vacuities present; anterior orbital vacuities absent; post temporal fenestrae usually present; humerus with two foramina.
Order	**Squamata**	Body covered with horny epidermal scales; single supra-temporal vacuity in lizards and none in snakes; teeth pleurodont; quadrate movable; quadrato-jugal absent; vertebrae procoelous (concave in front); limbs present or absent; anus (cloacal opening) transverse in form of slit; male possesses a pair of eversible copulatory organs.
Suborder	**Serpentes (Ophidia)**	Snakes; elongate body with no limbs; terrestrial or aquatic, arboreal or burrowing; temporal vacuities entirely absent; limbs absent; rami of mandibles united by a ligament, sternum absent; eye-lids immovable; tympanum absent; tongue bifid and protrusible, zygosphene and zygantra present in the vertebra.
Genus	***Xenochrophis***	
Species	***piscator***	
Common name	**Checkered keel back or water snake**	

Vernacular or Local Names:

Hindi :	**Pani Saamp**
Bengali :	**Jol Dhorna**
Gujarati:	**Dendu**
Malayalam:	**Neer Kolee**
Marathi:	**Pan Divad**
Tamil :	**Thanni Paambu**

30.6.3 *Ptyas mucosus*

Examine the specimen *Ptyas mucosus* (Rat snake) (Refer Fig. 30.7) and note the following characteristics.

i) **Head:** Elongated oval head, rather small in proportion to the body, pointed snout; prominent bright eyes large with round pupils; ridge-like scales over the eyes; nostrils large forming vertical oval slits; head-shields large; the 4^{th} and 5^{th} supralabials touch eye; neck constriction fairly visible.
ii) **Trunk:** A well-build body, long, slender and somewhat compressed, tapering gradually; the dorsal scales uniformly oblong, with some being keeled; about 16-19 rows in mid-body; ventral scales broad and rectangular covering the entire belly.
iii) **Tail:** Long, cylindrical and tapering; tail is prehensile and almost $1/4^{th}$ of total body length; sub-caudal scales in two rows.
iv) **Length:** 1.6-2.2 mts; males longer than females.
v) **Field characters:** Head rather elongated with large black shiny eyes. The slender long body is glossy with a background colour of cream-yellow or mustard. The notable feature is the black irregular pattern of cross-bars forming reticulations like a broken net. The lip-scales and ventral-scales have black margins (Fig. 30.8).

Habit and Habitat

Generally active by day but hunts at night where there is dense human population. It can dive and swim well. It is very adept at climbing trees and can even leap down a height of 6 mts. from the tree-top. It knots up its long tail on a tree branch and suspends its body down as it sights a prey. When provoked, it raises its head and body into as S, puffs up its throat and strikes upwards. It also hisses and produces a peculiar sound. As a result, it is mistaken for a Cobra. To ward off an enemy, it emits a foul-smelling black secretion from the anal glands. An unusual behaviour mistaken for a mating ritual is the combat dance which is actually between two males fighting over a female. The fighting pair coil around each other and sway in a semi-erect position.

It is essentially a plains dweller, but is also seen upto 2000 mts. altitude. Prefers to live in rat holes and termite mounds. Common near granaries, rice-fields and godowns where rats are known to breed.

Food

Mainly prefers rats, but eats almost any small creature like frogs, toads, lizards, birds and even small snakes. The prey is swallowed live and whole. Sometimes, a frog may even be heard croaking in its throat. An actively struggling prey is crushed by pressing the throat or belly firmly to the ground.

Breeding

Mating occurs in May-June. It is oviparous and eggs are laid in August or September. About 8-16 eggs are laid and the female coils around them until hatching 60 days later. The young mature in 3 years.

Bite

Though the snake is non-venomous, its bite can be quite painful.

Status

The Rat Snake is eaten descaled in some parts of Kerala. Some mistaken beliefs that it sucks the teats of cows for milk and that it is the male Cobra have lead to its extensive slaughter. It is also killed for its skin. Sadly, this has lead to an explosion of the rodent pest population.

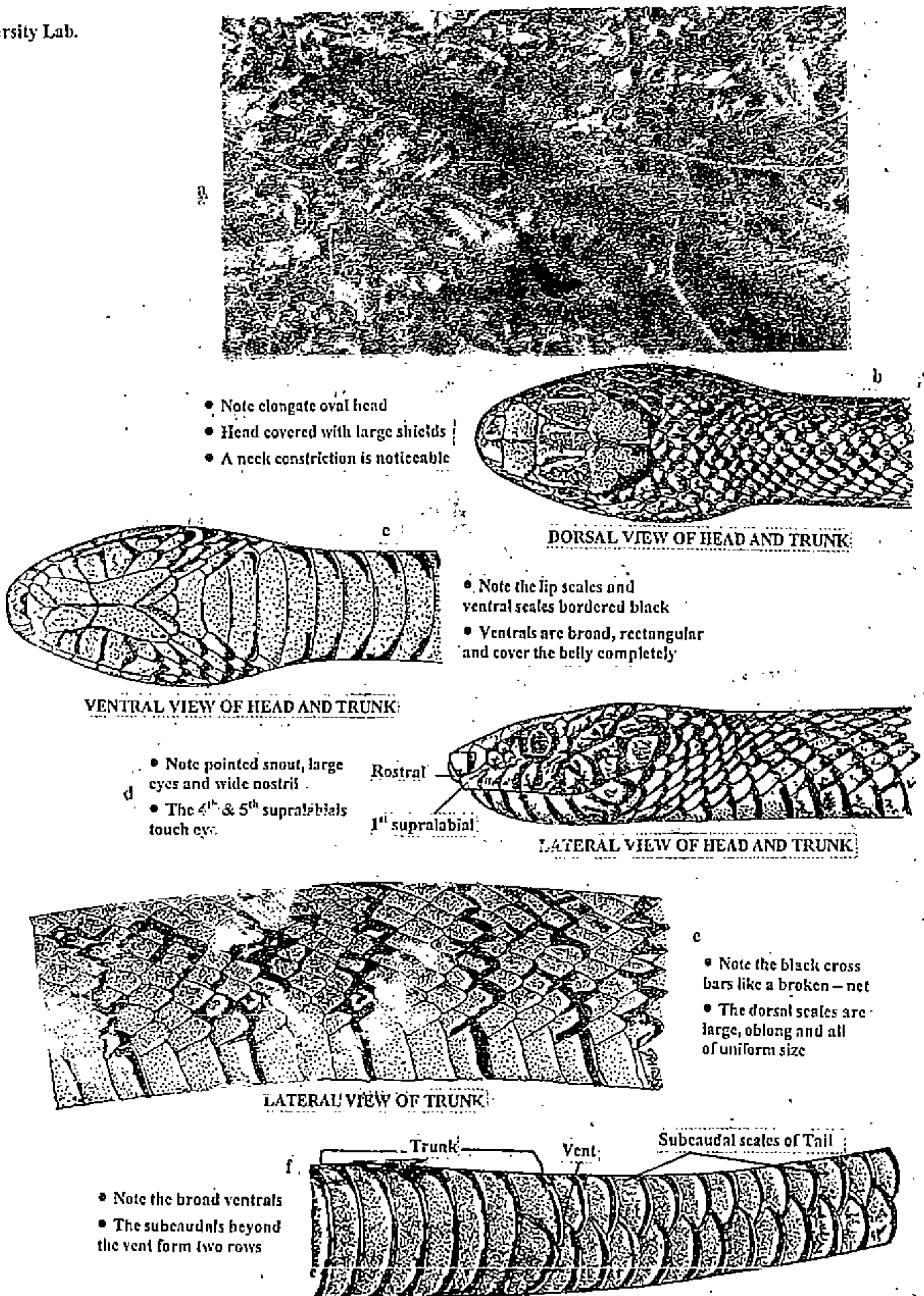


Fig. 30.8: Non poisonous (harmless) rat snake (*Ptyas mucosus*), (a) Photograph of the snake in its habitat showing its natural colouration. (b) Dorsal view of head and beginning of trunk showing neck constriction between neck and trunk as well as the elongate, oval head which is covered with large shields (c) ventral view of head and beginning of trunk showing lip scales and ventral scales which are bordered black. Also seen are broad, rectangular ventrals which covers the belly fully. (d) Lateral view of head and beginning of trunk showing pointed snout, large eyes wide nostrils and the 4^{th} and 5^{th} supralabials touching the eye (e) lateral view of main trunk showing black coloured cross bars similar to a broken net and large oblong, dorsal scales all of uniform size. (f) ventral view of end trunk and tail showing the broad ventrals and the subcaudals forming two rows, beyond the vent.

Geographical Distribution

Found throughout the Indian subcontinent including the Andaman and Nicobar Islands. It extends upto Afghanistan, S. China and Indonesia.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle: heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Reptilia**	Cold blooded, terrestrial or aquatic vertebrates; single occipital condyle; vertebrae gastrocentrous; respiration by lungs; heart with two auricles and incompletely divided ventricle; right and left aortic arches complete and functional, cranial nerves 12 pairs and embryo with amnion and allantois.
Subclass	**Diapsida**	Amniotes having a skull with two temporal vacuities on each side; post-orbital and squamosal usually meet between temporal vacuities.
Superorder	**Lepidosauria**	Characterised by sprawling posture, no bipedal specialisations; diapsid skull with two temporal vacuities present; anterior orbital vacuities absent; post temporal fenestrae usually present: humerus with two foramina.
Order	**Squamata**	Body covered with horny epidermal scales; single supra-temporal vacuity in lizards and none in snakes; teeth pleurodont; quadrate movable; quadrato-jugal absent; vertebrae procoelous (concave in front); limbs present or absent; anus (cloacal opening) transverse in form of slit; male possesses a pair of eversible copulatory organs.
Suborder	**Serpentes (Ophidia)**	Snakes; elongate body with no limbs; terrestrial or aquatic, arboreal or burrowing; temporal vacuities entirely absent; limbs absent; rami of mandibles united by a ligament, sternum absent; eye-lids immovable; tympanum absent; tongue bifid and protrusible, zygosphene and zygantra present in the vertebra.
Genus	***Ptyas***	
Species	***mucosus***	

Vernacular or Local Names

Hindi :	**Dhaman**
Bengali :	**Dharas**
Assamese:	**Gola Saamp**
Malayalam:	**Chera**
Marathi:	**Dhaman**
Tamil :	**Sarai Paambu**

30.7 SPECIMEN STUDY OF SOME VENOMOUS OR POISONOUS SNAKES

Poisonous or venomous snakes are divided into four families on based on the type of fangs. The four families are: Viperidae, Elapidae, Hydrophiidae, Colubridae. In this exercise we will study only a few commonly known poisonous snakes.

30.7.1 *Bungarus caeruleus*

Examine the specimen of Common krait (*Bungarus caeruleus*) (Refer Fig. 30.9) and note the following characteristics.

i) **Head:** Small and elongated head, no neck visible; eyes medium-sized. Large shields on the head; the 3rd and 4th supralabials touch eye.
ii) **Trunk:** Long and cylindrical; smooth and polished scales in about 15-17 rows around the mid-body. **The dorsal-most row or vertebrals are enlarged and hexagonal. This is the unique feature of Kraits.** Ventral scales are broad and cover the belly.
iii) **Tail:** Short, about 1/6th to 1/11 the total body length; sub-caudal scales in a single row.
iv) **Length:** About a metre; males longer than females.
v) **Field characters: A deep blue-black or jet-black snake; smooth and glossy. The body is marked by rows of paired narrow-white cross-bars. Each bar appears like a string of beads being made of a chain of white dots.** The white dots are largest in the middle of the back. Ventral side is a dull grayish-white (Fig. 30.9).

Habit and Habitat

It is a nocturnal snake hiding by day. It is common near human habitation but bites only when stepped upon. Its favourite hiding places are under piles of stones, rubble or bricks. It may be found inside houses where there are cracks in damp walls.

The snake is essentially a plains dweller, commoner in the sandy soils of coastal areas. Also inhabits termite mounds and rodent burrows near fields and scrub jungles.

Food

Mainly snakes, but also eats small creatures like lizards and rodents. Cannibalistic feeding is not uncommon. In captivity, larger Kraits often feed upon the younger ones.

Breeding

Mating season is in February or March. A foul-smelling anal-gland secretion serves in mate recognition. It is oviparous and eggs are laid in May to July. About 6-12 eggs are laid which the female guards until hatching two months later. The young are only about 15-20 cm. long at hatching.

Bite and Venom

The bite is not painful initially but the venom is highly neurotoxic i.e., it paralyses the nervous system. Initially the victim feels drowsy and death occurs due to respiratory paralysis. Urgent treatment with antivenin within 6-12 hrs. alone can save the life of the victim. **Krait venom is 10-15 times more poisonous than Cobra venom.**

Status

Due to its nocturnal habits, this snake has escaped hunting by man and therefore is fairly common. It is the similar-looking Wolf Snake that is mistaken for the Krait and unfortunately killed although it is non-poisonous and is useful to man.

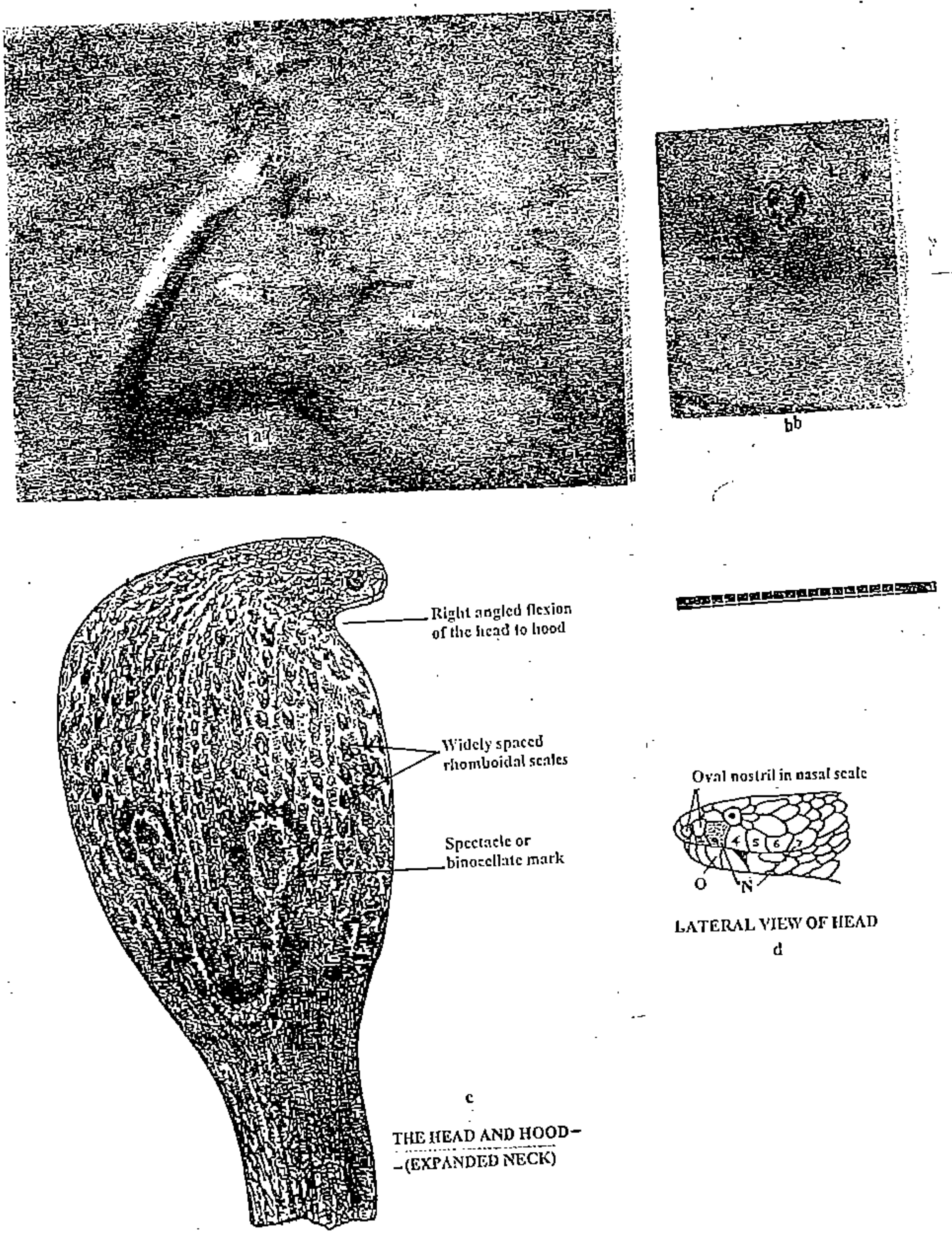


Fig. 30.8: Poisonous (venomous) snake, common krait (*Bungarus caeruleus*) (a) Photograph of the snake showing its natural colouration. (b) Dorsal view of head in which the large shields are not clear as the snake is deep blue-black or black in colour (c) lateral view of head showing the 3rd and 4th supralabials touching the eye and that 4th infrabial is enlarged (d) ventral view of head showing the 1-6 infralabials of which the 4th is the largest (e) dorsal view of trunk showing the hexagonal shaped enlarged vertebrals which are the most diagnostic in kraits (f and g) Lateral view of trunks in two races showing that in most cases (f) the paired white bars are narrow appearing as strings of beads and in some races (g) the paired white bars are broad.

Geographical Distribution

Most of India; less common in the North-eastern states where its cousin, the Banded Krait is found.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Reptilia**	Cold blooded, terrestrial or aquatic vertebrates; single occipital condyle; vertebrae gastrocentrous; respiration by lungs; heart with two auricles and incompletely divided ventricle; right and left aortic arches complete and functional, cranial nerves 12 pairs and embryo with amnion and allantois.
Subclass	**Diapsida**	Amniotes having a skull with two temporal vacuities on each side; post-orbital and squamosal usually meet between temporal vacuities.
Superorder	**Lepidosauria**	Characterised by sprawling posture, no bipedal specialisations; diapsid skull with two temporal vacuities present; anterior orbital vacuities absent; post temporal fenestrae usually present; humerus with two foramina.
Order	**Squamata**	Body covered with horny epidermal scales; single supra-temporal vacuity in lizards and none in snakes; teeth pleurodont; quadrate movable; quadrato-jugal absent; vertebrae procoelous (concave in front); limbs present or absent; anus (cloacal opening) transverse in form of slit; male possesses a pair of eversible copulatory organs.
Suborder	**Serpentes (Ophidia)**	Snakes; elongate body with no limbs; terrestrial or aquatic, arboreal or burrowing; temporal vacuities entirely absent; limbs absent; rami of mandibles united by a ligament, sternum absent; eye-lids immovable; tympanum absent; tongue bifid and protrusible, zygosphene and zygantra present in the vertebra.
Genus	***Bungarus***	
Species	***caeruleus***	

Vernacular or Local Names

Hindi :	**Karayat**
Bengali :	**Domna Chitti**
Gujarati:	**Kala Taro**
Malayalm:	**Valla Paambu**
Marathi :	**Maniyar**
Tamil :	**Kattu Viriyan**

30.7.2 *Naja naja*

Examine the specimen of Indian Spectacled Cobra (*Naja naja*) (Refer Fig. 30.10) and note the following characteristics.

i) **Head:** Moderate in size, appears like a peg when bent at right angles to the expanded hood. When not expanded, the neck region is not noticeable. Head oval and flat; eyes round and piercingly black; nostrils large and oval; large shields on the head; like in krait, **the 3rd and 4th supralabials touch the eye but unlike in krait, the 3rd supralabial is enlarged and also touches the nasal scale. Another unique feature is a small triangular cuneate scale sandwiched between the 4th and 5th infralabials.**

ii) **Trunk:** Body cylindrical; narrowing rapidly down in diameter; scales are unique, they are uniformly rhomboidal with gaps in between. Also, they form oblique rows: There are around 21-25 rows around the mid-body.

iii) **Tail:** Short and tapered, about 1/5th of the total body length; the sub-caudal scales in two rows.

iv) **Length:** 1.2-1.6 m.; males being longer than females.

v) **Field characters:** A shiny body, varying in colour from yellow to golden-brown to deep blackish-brown. **Dilatable neck region forms an oval hood. When expanded, the hood reveals on the dorsal side, the strikingly familiar spectacle or binocellate mark. Ventrally the hood has two black spots on the sides bordered below by 2 or 3 black bars** (Fig. 30.10).

Habit and Habitat

The snake is most active in the monsoon season and is a good swimmer. It generally hunts during early morning and the twilight hours of late evening. Everyone is familiar with this snake's erect posture. When excited, it erects 1/3rd the length of its body to assume a striking posture. It expands its hood, sways backwards and forwards and ejects air violently as a hiss. When provoked further, it goes beyond this aggressive posture to strike forward and bite.

It is commonly found near breeding areas of rats such as granaries or fields. Favourite hideouts are beneath tangled roots of old trees, anthills, ratholes and wherever else it is cool and dark.

Food

Feeds mainly on rats, frogs, toads, lizards and birds. It often steals eggs from bird's nests which it swallows whole.

Breeding

Mating occurs in January and this is often preceded by rival fights between males. Combating males coil around each other and sway back and forth aggressively till one of them accepts defeat. It is an oviparous snake and eggs are laid normally in a rat hole. Around 12-30 eggs are laid and both parents guard them until they hatch 60 days later. The young start mimicking the aggressive posture of their parents soon after birth.

Bite and venom

The bite is not painful initially but later, a stinging or burning pain ensues followed by haemorrhage and paralysis. The venom is highly neurotoxic i.e., it paralyses the nervous system. Death occurs if not treated with antivenin. Sometimes, a swaying snake may miss biting the victim. It then spits the venom as a spray.

Status

Cobra skins are the most valued of all the snake skins. Despite the ban on export, killing still continues. It is a strong religious sentiment that protects them in certain places of worship.

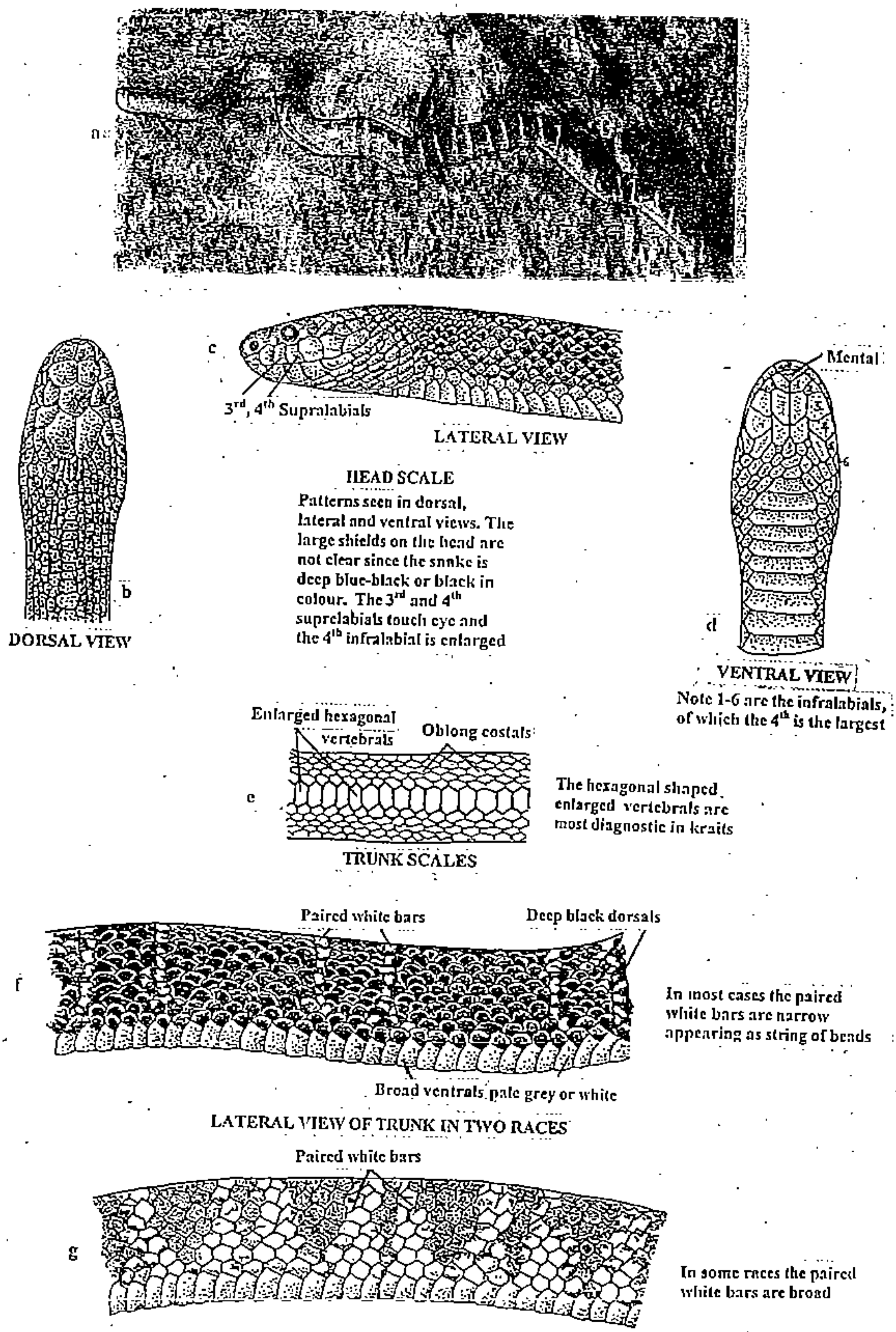


Fig. 30.10: Poisonous (venomous snake), the Indian spectacled cobra (*Naja naja*) (a and b) Photograph of the snake showing its natural colouration. (c) Head view of cobra with expanded neck (hood) which is the striking posture of this animal and most characteristic features of it. The dilated or expanded neck forms an oval hood making the spectacle mark distinctly visible. The gaps between the rhomboidal scales are also made prominent by the dilation. The piercing eyes appear focused on the victim before striking. (d) Lateral view of head showing the labial scales which are technically the most diagnostic features of the cobra. The 3rd and 4th supralabials touch the eye and the 3rd supralabial being the largest also touches the nasal scale. A small triangular cuneate scale (shaded black in the figure) can be seen between the 4th and 5th infralabials.

Geographical Distribution

Found throughout India; from the plains upto 2000 m. in the hills. Also found in China, Sri Lanka and the Phillipines.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Reptilia**	Cold blooded, terrestrial or aquatic vertebrates; single occipital condyle; vertebrae gastrocentrous; respiration by lungs; heart with two auricles and incompletely divided ventricle; right and left aortic arches complete and functional, cranial nerves 12 pairs and embryo with amnion and allantois.
Subclass	**Diapsida**	Amniotes having a skull with two temporal vacuities on each side; post-orbital and squamosal usually meet between temporal vacuities.
Superorder	**Lepidosauria**	Characterised by sprawling posture, no bipedal specialisations; diapsid skull with two temporal vacuities present; anterior orbital vacuities absent; post temporal fenestrae usually present; humerus with two foramina.
Order	**Squamata**	Body covered with horny epidermal scales; single supra-temporal vacuity in lizards and none in snakes; teeth pleurodont; quadrate movable; quadrato-jugal absent; vertebrae procoelous (concave in front); limbs present or absent; anus (cloacal opening) transverse in form of slit; male possesses a pair of eversible copulatory organs.
Suborder	**Serpentes (Ophidia)**	Snakes; elongate body with no limbs; terrestrial or aquatic, arboreal or burrowing; temporal vacuities entirely absent; limbs absent; rami of mandibles united by a ligament, sternum absent; eye-lids immovable; tympanum absent; tongue bifid and protrusible, zygosphene and zygantra present in the vertebra.
Genus	***Naja***	
Species	***naja***	
Common name	**Indian Spectacled Cobra**	

Vernacular or Local Names

Hindi :	**Nag**
Bengali :	**Gokhura**
Gujarati:	**Nag**
Malayalam:	**Sarpam**
Marathi:	**Nag**
Tamil :	**Naga Paambu or Nalla Paambu**

30.7.3 *Vipera russelli*

Examine the specimen of Russell's viper (*Vipera russelli*) (Refer to Fig. 30.11) and note the following characteristics.

i) **Head:** Small in proportion to the body, narrow at the snout but broadens greatly at the jaw angle giving it a typical triangular shape; eyes large with a golden glow and sharp vertical pupils; wide-open nostrils; **only the scales bearing the nostril and scales over the eye on each side are enlarged shields; all other scales on the head are very small, numerous and uniformly elliptical (only Vipers possess this unique feature); a prominent deep neck constriction is yet another special feature; no supralabials touch the eye as several small scales come in between.**

ii) **Trunk:** Massive and strongly muscular; trunk scales like the head scales are uniformly elliptical and very strongly keeled; 27-33 rows of scales around the mid-body; broad ventral scales covering the entire belly.

iii) **Tail:** Quite abruptly narrow and distinct from the trunk; short, only $1/7^{th}$ the total body length; subcaudal scales in 2 rows.

iv) **Length:** 1.0-1.2 m. males larger than females.

v) **Field characters:** A stout-bodied, wheatish-brown snake. **The three rows of large almond-shaped dark brown spots are strikingly unique.** Each spot is bordered white with a central island of light brown. **Large triangular head;** shiny eyes; two pinkish-white streaks running over the eyes and meeting on the snout to form a V gives it a rather angry expression (Fig. 30.11).

Habit and Habitat

It is usually quite sluggish, but moves rapidly in a wriggling fashion if provoked. It does not move rapidly for long and soon enough comes to rest. Normally if annoyed, it doesn't move, but hisses so loudly (it is the loudest of all snakes) that it frightens away the intruder. If irritated further, it can leap off the ground and bite quite viciously. Generally avoids human contact and is timid and nocturnal in habit. Bites occur in plantations, farmlands or estates if someone steps on it or puts his hand near it.

It prefers open hilly countryside. Also found in scrub jungles, dense jungles, plantations and farmlands. Fond of hiding in rat holes, rock crevices, thorny bushes, cacti, clumps and under a thick mat of leaves.

Food

It feeds on rats, mice, squirrels, shrews, lizards, frogs and even crabs and scorpions. This snake is known to go without food for several weeks.

Breeding

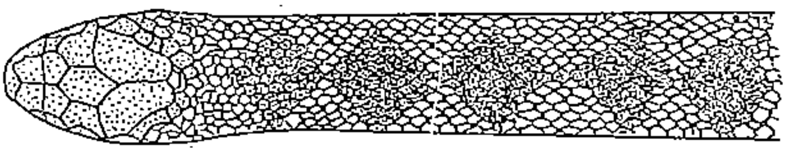
Is viviparous and highly fecund, producing 30-40 young ones at a time. It breeds at any time of the year and the peak period is in June.

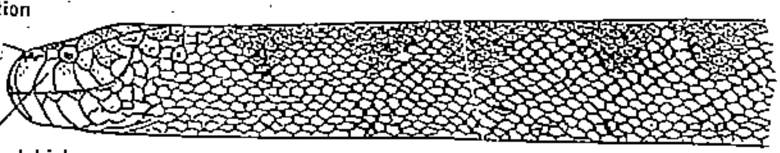
Bite and Venom

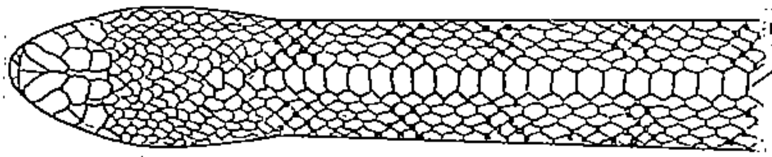
The bite runs quite deep and occasionally the snake may hang on to the victim for sometime before withdrawing its fangs. Thus a large quantity of venom gets injected. The venom is highly haemotoxic i.e. it destroys the blood vessels, red blood corpuscles, affects clotting and weakens the heart. The victim haemorrhages severely, bleeds through his mouth, nose and ears and dies due to cardiac failure. Antivenim treatment is the only remedy.

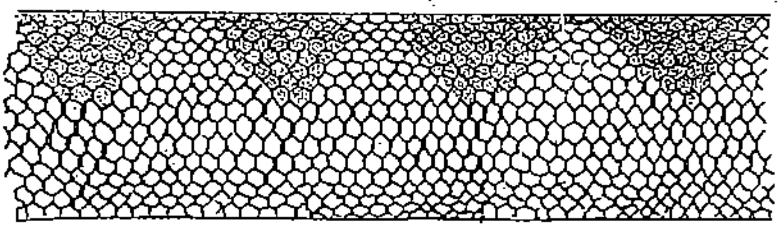
Status

Extensive capturing and slaughter for skins have wiped out entire populations of these snakes from certain places.









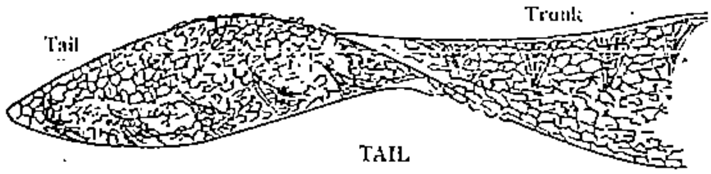


Fig. 30.11: Poisonous (venomous) snake, Russel's viper (*Vipera russelli*) (a) Photograph of the snake showings its natural colouration. (b) A broad, triangular head and beginning of trunk with deep neck constriction showing white streak from gape over eye and snout bordered by black below which gives the snake an angry expression. (c) Lateral view of head showing distinct small sized and numerous scales on head (None of the supralabial touch the eye as many small scales come in between). (d and e) dorsal view of trunk showing the three rows of almond spots which are diagnostic for this snake. The median row of spots are larger. Note the strongly keeled elliptical scales (e) (f) Lateral view of trunk showing the broad ventrals, reaching upto the sides. Smaller spots can be seen on the sid-

Geographical Distribution

It is found widely distributed in India, from the plains upto 3000 m. height. Commoner in the North-west than in the North-east. Also seen in China, Far East countries, Sri Lanka and Indonesia.

Classification and its Justification

Kingdom	**Animalia**	Animals, multicellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Group	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Reptilia**	Cold blooded, terrestrial or aquatic vertebrates; single occipital condyle; vertebrae gastrocentrous; respiration by lungs; heart with two auricles and incompletely divided ventricle; right and left aortic arches complete and functional, cranial nerves 12 pairs and embryo with amnion and allantois.
Subclass	**Diapsida**	Amniotes having a skull with two temporal vacuities on each side; post-orbital and squamosal usually meet between temporal vacuities.
Superorder	**Lepidosauria**	Characterised by sprawling posture, no bipedal specialisations; diapsid skull with two temporal vacuities present; anterior orbital vacuities absent; post temporal fenestrae usually present; humerus with two foramina.
Order	**Squamata**	Body covered with horny epidermal scales; single supra-temporal vacuity in lizards and none in snakes; teeth pleurodont; quadrate movable; quadrato-jugal absent; vertebrae procoelous (concave in front); limbs present or absent; anus (cloacal opening) transverse in form of slit; male possesses a pair of eversible copulatory organs.
Suborder	**Serpentes (Ophidia)**	Snakes; elongate body with no limbs; terrestrial or aquatic, arboreal or burrowing; temporal vacuities entirely absent; limbs absent; rami of mandibles united by a ligament, sternum absent; eye-lids immovable; tympanum absent; tongue bifid and protrusible, zygosphene and zygantra present in the vertebra.
Genus	*Vipera*	
Species	*russelli*	
Common name	Russell's viper	

Vernacular or Local Names

Hindi :	**Kander/Daboia**
Bengali :	**Chandra Bora**
Gujarati:	**Khad Chitalo**
Malayalam:	**Ruthramandali**

Marathi : Ghonas
Tamil : Kannadi Viriyan

30.7.4 *Hydrophis cyanocinctus*

Examine the specimen of Annulated or Banded Sea Snake (*Hydrophis cyanocinctus*) (Refer to Fig. 30.12) and note the following characteristics.

i) **Head:** Broad and oval with a rounded snout; small eyes, anteriorly placed; nostrils placed high on the head and can be closed off by lid-like pads of tissue; head covered by large shields with the 3rd, 4th and 5th supralabials touching the eye. The neck constriction is very slight.
ii) **Trunk:** The upper two-fifths of the body is cylindrical, while the rest is flattened laterally. Scales are numerous, small and uniformly oblong. The largest part of the trunk has 50 rows of scales. The ventral side bears a row of slightly enlarged median scales. **The unique feature is a median ridge formed by the enlarged ventrals.**
iii) **Tail:** The broad, thick and extremely flattened oar-like shape is very characteristic. The male has a thicker tail.
iv) **Length:** 1.2-1.5 m., the longest recorded being about 2 m.
v) **Field characters:** Broad head, anterior part of the body is cylindrical while rest of the body is abruptly compressed. **Tail extremely flattened and paddle-like.** Bluish-grey background colour on the back marked by **60-70 broad black cross-bands.** The ventral side is pale yellow and the black bands get narrower and fainter down the sides (Fig. 30.12).

Habit and Habitat

The Sea Snake is fully adapted for aquatic life. Its body muscles have degenerated and therefore it can hardly move on land. It is an excellent swimmer using its strongly compressed tail as a paddle for propulsion. Although air-breathing, the snake can remain underwater for about 2 hrs. shutting off its nostrils with the lid-like pads.

It is found in Coastal waters.

Food

Feeds on fish mainly. May also feed on mollusks and annelid worms.

Breeding

Viviparous; the female bears 2-6 live young.

Bite and Venom

Many fishermen get bitten as the snakes sometimes get caught in their nets. The bitten part gets inflamed and painful. The poison is extremely neurotoxic and paralyses the nervous system.

Status

Sea Snakes are mostly unexploited. Some species are hunted for their meat and skin in Hong Kong and Singapore.

Geographical Distribution

They are abundant in the Persian Gulf and along the coast upto Karachi. Not found on the West Coast of Peninsular India but common on the East Coast.

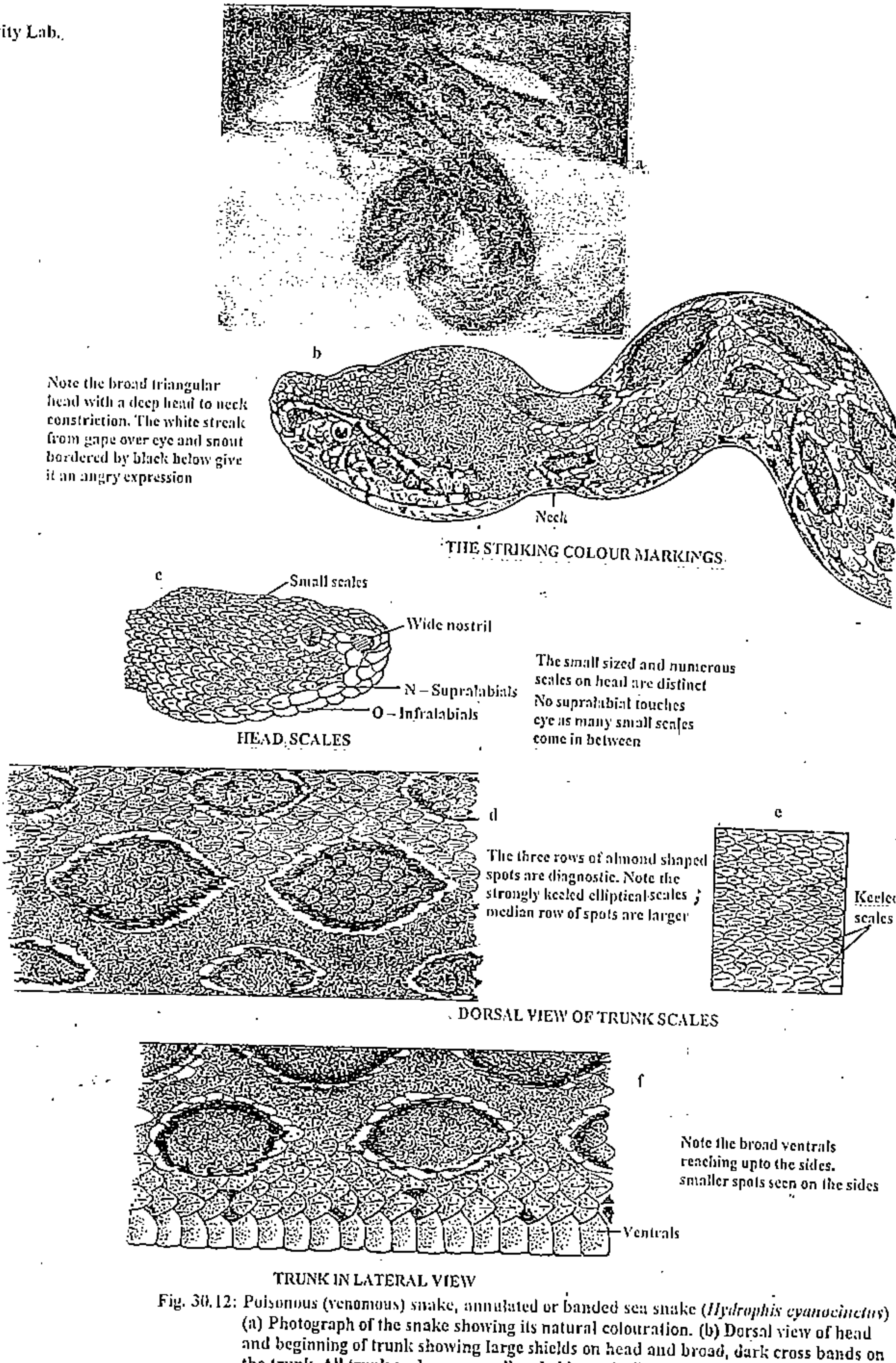


Fig. 30.12: Poisonous (venomous) snake, annulated or banded sea snake (*Hydrophis cyanocinctus*) (a) Photograph of the snake showing its natural colouration. (b) Dorsal view of head and beginning of trunk showing large shields on head and broad, dark cross bands on the trunk. All trunk scales are small and oblong. (c) Lateral view of head and trunk showing the high position of nostril and 3rd, 4th and 5th supralabials touching the eye. Also the cross bars on the trunk narrow side wards. (d) Ventral view of head and beginning of trunk showing the streaks of cross bars and pale undersides. The narrow ventrals (slightly enlarged) can be seen forming a raised median ridge (e) An enlarged lateral view of trunk showing the banding pattern clearly. The oblong trunk scales are small and are in several rows. (f) View of end of trunk and tail.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Subphylum	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood ~~red~~ containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Reptilia**	Cold blooded, terrestrial or aquatic vertebrates; single occipital condyle; vertebrae gastrocentrous; respiration by lungs; heart with two auricles and incompletely divided ventricle; right and left aortic arches complete and functional, cranial nerves 12 pairs and embryo with amnion and allantois.
Subclass	**Diapsida**	Amniotes having a skull with two temporal vacuities on each side; post-orbital and squamosal usually meet between temporal vacuities.
Superorder	**Lepidosauria**	Characterised by spreading posture, no bipedal specialisations; diapsid skull; two temporal vacuities present; anterior orbital vacuities absent; post temporal fenestrae usually present; humerus with two foramina.
Order	**Squamata**	Body covered with horny epidermal scales; single supra-temporal vacuity in lizards and none in snakes; teeth pleurodont; quadrate movable; quadrato-jugal absent; vertebrae procoelous (concave in front); limbs present or absent; anus (cloacal opening) transverse in form of slit; male possesses a pair of eversible copulatory organs.
Suborder	**Ophidia**	Snakes; elongate body with no limbs; terrestrial or aquatic, arboreal or burrowing; temporal vacuities entirely absent; limbs absent; rami of mandibles united by a ligament, sternum absent; eye-lids immovable; tympanum absent; tongue bifid and protrusible, zygosphene and zygantra present in the vertebra.
Genus	***Hydrophis***	
Species	***cyanocinctus***	
Common name	**Banded or Annulated Sea Snake**	

Vernacular or Local Names

Hindi :	**Samudra Saamp**
Bengali :	**Chittul**
Gujarati:	**Samudra Sarp**
Marathi:	**Samudra Sarp**
Tamil :	**Kadal Paambu**

30.8 TERMINAL QUESTIONS

1. Fill in the blanks:

   i) Snakes differ from lizards in not having ...., ... and ....
   ii) In Cobras, the .... scale is largest and touches both the eye and ....
   iii) Vipers have .... shaped head covered with .... scales.
   iv) Some Rat Snakes are mistaken to be .... and killed.
   v) The tail can be demarcated from the trunk by looking for .... on the ventral side.

2. Indicate the name of the snake against the diagnostic featues:

   i) Rhomboid scales ....
   ii) Large hexagonal vertebrals ....
   iii) Small scales on the head ....
   iv) Median ventrals ridge-like ....
   v) Strongly keeled scales with 3 rows of spots ....
   vi) Strongly keeled scales with 5 rows of spots ....

3. Complete the following statements

   i) The flat paddle-like tail in Sea Snakes is adapted for ....
   ii) The long and prehensile tail in Rat Snakes is adapted for ....
   iii) The short and blunt head-like tail in Sand Boas is adapted for ....

4. State whether the following statements are True or False.

   i) Some land snakes can swim. True/False
   ii) Broad ventrals are seen only in poisonous snakes. True/False
   iii) The 3rd infralabial is the largest in Cobras. True/False
   iv) The Rat Snake can also inflate its neck like the Cobra. True/False
   v) The venom of Vipers is neurotoxic. True/False

Acknowledgement:

The drawings in this Exercise have been redrawn from figures provided by Dr. Rama Sinha.

EXERCISE 31 AVES I: OBSERVATIONS AND CLASSIFICATION OF SPECIMENS

Structure

31.1 INTRODUCTION

Birds occupy all continents, oceans and islands, penetrating the Arctic and the Antarctic and live from sea level to above timberline on the Everest. They have well adapted migratory habits. They are the best known and most easily recognised animals being unique in having feathers for flying which also cover and insulate their bodies and provide them with distinctive colouration. The body weight is reduced for flight by elimination of some bones and fusion of others and by presence of some air filled cavities and spaces in many bones. High metabolic rate,and raised body temperature,strong flight muscles and advanced respiratory mechanism with air sacs and lungs provide necessary strength for flight. They have highly developed voice,sight and hearing but poor sense of smell.

Class Aves is made up of 28 orders of living birds and a few fossil orders. More than 9600 species have been named so far and only a few species remain to be discovered. Of the 28 orders, four or five (depending on the classification system) are ratitae or flightless birds, the remaining orders are carinate birds with keeled sternum.In this exercise you will observe and classify some representative specimens of class Aves.

We would advise you to come prepared for this exercise by reading Unit 3 of Block I, LSE-10 again as you would find it useful to refer to Fig.3.39 of that unit for identifying the orders of this class.

Objectives

After completing this exercise you will be able to:

- identify and give scientific and common names of some of the avian species,
- classify the identified genera upto the level of order,
- list the characters justifying the classification of the identified specimens and mention special features if any,
- mention the habitat and geographical distribution,
- draw labeled diagram of each of the identified genera,
- mention the economic importance if any, of each of the given genera.

31.2 MATERIAL REQUIRED

1. Stuffed specimens of:

   Kite
   Owl
   Common crow
   Drongo
   Blue rock pigeon
   Fowl
   Woodpecker
   Koel
   Large Indian parakeet
   Ostrich
2. Hand lens

In absence of stuffed specimens good large sized photographs may be provided.

31.3 GENERAL CHARACTERS OF CLASS AVES

Let us recall the general characters that distinguish class Aves from all other classes.

1. Endothermic tetrapod vertebrates with **feathers**.
2. Forelimbs modified into **wings** each bearing three clawless digits and feathers for flight.
3. The hindlimbs are modified for walking, perching or swimming and bear four toes.
4. No glands in the skin except for **oil gland in the tail**.
5. Bones are strong fully ossified though light, provided with **air cavities**.
6. Skull bones fused, bearing **single occipital condyle** as in reptiles. This makes it possible for birds to rotate their heads almost 180°.
7. Modern birds have no teeth, only horny beak present.
8. Pelvis fused to many vertebrae but open ventrally, small ribs with strengthening processes; **sternum** is broad, well developed usually with median keel or reduced with no keel; flight muscles attached to keel.
9. The sacral vertebrae are fused with lumber, last thoracic and last caudal vertebrae to form **synsacrum**.
10. Posterior caudal vertebrae fused to form **pygostyle**.
11. Gullet has **crop** to store food, **muscular gizzard** in the stomach to masticate food.
12. Lungs spongy attached to **air** sacs that extend into various parts of the body.
13. Voice produced by **syrinx** situated at the junction of the trachea and the bronchioles.
14. Heart four chambered.

31.4 OBSERVATION OF SPECIMENS

Look at the given specimens of birds carefully, use the hand lens wherever you need to see any details and note down all the characters. Compare your observations with the characters given in the text as you draw the given specimen.

31.4.1 *Milvus migrans*

Special Characters

i) Pariah kite or *Milvus* is a large bird about 45-60 cm in length.
ii) The plumage is reddish brown streaked with dark brown in both the sexes.
iii) It is distinguished from all similar bird by its forked tail.
iv) The toes are elongated bearing sharp pointed claws for grasping and capturing.

Fig.31.1: *Milvus migrans.*

v) The beak is sharp pointed and hooked, very well adapted for tearing the flesh of the prey.

Habit and Habitat

Milvus is largely a scavenger bird feeding on rodent pests, reptiles, small birds, earthworms and garbage etc. It can be seen soaring around villages and towns at all times. Avoiding only dense forests. It boldly swoops down to snatch food from the busiest street or market.

Geographical Distribution

Milvus is found throughout India, Pakistan, Bangladesh, Sri Lanka and Myanmar.

Classification and its Justification

Kingdom	Animalia	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve chord; notochord and paired gill slits present.
Group	Vertebrata (Craniata)	Notochord is replaced by vertebral column; 2 pairs of appendages; circulatory system closed; hepatic portal system present; RBC present in blood.
Class	Aves	Endothermic with feathers; forelimbs modified into wings, claws absent; hind limbs adapted for climbing perching or swimming; skull with single occipital condyle; beak present; sternum well developed; amniotic; oviparous.
Subclass	Neornithes	Tail short, ends in pygostyle; metcarpal fused with distal carpals to form carpometacarpals; sternum well developed with keel.
Superorder	Neognathae	Skull neognathus; feathers with interlocking mechanism; wings well developed.
Order	Falconiformes	Beak short and curved at the tip; mandibles sharp-edged; feet with sharp curved claws; diurnal strong flier.
Genus	*Milvus*	
Species	*migrans*	
Common name	Pariah Kite	

31.4.2 *Bubo bubo*

Special Characters

i) Barn owl is a large and robust bird, measuring upto 60cm in length.
ii) The colour is dark brown streaked with tawny buff and black.
iii) The head is large and has two black ear tufts or horns.
iv) The eyes are large, round and directed forwards.
v) The legs are fully feathered.

Habit and Habitat

Barn owl is nocturnal but can be seen frequently during the day time. It spends the day resting on the ground under the shelter of a bush or on some shady projection of a rock near a river.Its food consists of small mammals, birds, lizards, and other reptiles; also feeds on small insects as well as on fish or crabs. Best known for its deep double hoot.

Geographical Distribution

Barn owl is found throughout India, Pakistan and Myanmar.

Fig. 31.2: *Bubo bubo.*

Economic Importance

The barn owl is a farmer's friend, for it kills a large number of crop pests like rodents and other vermin. It deserve the strictest protection.

Classification with Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve chord; notochord and pharyngeal gill slits present.
Subphylum	**Vertebrata**	Notochord is replaced by vertebral column; 2 pairs of appendages; circulatory system closed; hepatic portal system present; RBC present in blood.
Class	**Aves**	Endothermic with feathers; forelimbs modified into wings, claws absent; hind limbs adapted for climbing perching or swimming; skull with single occipital condyle; beak present; sternum well developed; amniotic; oviparous.
Subclass	**Neornithes**	Tail short, ends in pygostyle; metcarpal fused with distal carpals to form carpometacarpals; sternum well developed with keel.
Superorder	**Neognathae**	Skull neognathus; feathers with interlocking mechanism; wings well developed.

Order	**Strigiformes**	Eyes large, directed forwards;
Genus	***Bubo***	
Species	***bubo***	
Common name	**Barn owl**	

31.4.3 *Corvus splendens*

Characters

i) The adult grows to 32 to 42cm in length.
ii) The body is covered with glossy black plumage while the neck and breast are grey.
iii) Both sexes are similar.
iv) Tail feathers are elongated.
v) Eyes are large, beak elongated with a broad base, gradually tapering.
vi) Feet are well adapted for perching, three toes in front and one behind

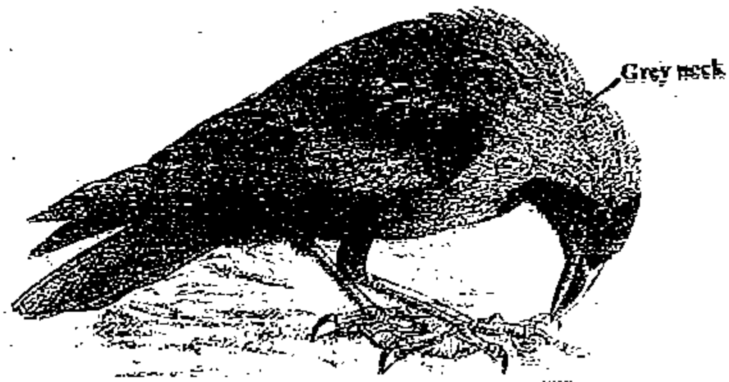


Fig. 31.3: *Corvus splendens.*

Habit and Habitat

Omnivorous and scavenger in feeding habit as they eat any thing from dead sewer rats to kitchen refuge, insects, fruits, grains, eggs, etc., therefore, is responsible for the cleanliness of the surroundings. It is almost totally dependent on human presence. It makes a large stick nest placed in a tree and is frequently parasitised by the koel.

Geographical Distribution

It is abundantly found throughout the peninsula of India and therefore is the most familiar bird of our towns and villages.

Classification with Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve chord; notochord and pharyngeal gill slits present.
Subphylum	Vertebrata	Notochord is replaced by vertebral column; 2 pairs of appendages; circulatory system closed; hepatic portal system present; RBC present in blood.
Class	Aves	Endothermic with feathers; forelimbs modified into wings, claws absent; hind limbs adapted for climbing perching or swimming; skull with single occipital condyle; beak present; sternum well developed; amniotic; oviparous.

Subclass	**Neornithes**	Tail short, ends in pygostyle; metcarpal fused with distal carpals to form carpometacarpals; sternum well developed with keel.
Superorder	**Neognathae**	Skull neognathus; feathers with interlocking mechanism; wings well developed.
Order	**Passeriformes**	Because feet adapted for perching on trees and stones, highly developed syrinx.
Genus	*Corvus*	
Species	*splendens*	
Common name	**kowa, kag, crow**	

Fig.31.4: Black drongo, *Dicrurus adsimilis.*

31.4.4 *Dicrurus adsimilis*

Characters

i) Drongo is smaller and slimmer than the crow, about 28cm in size.
ii) The body is covered with shining jet black feathers.
iii) The long tail is so deeply forked that the two ends point in different directions.
iv) The bill is small but sharply hooked and the eyes are red.

Habit and Habitat

Drongo is commonly seen in the open country side around cultivation, perched on telegraph wires, fence posts, bush tops. The bird is very bold in defense of its nest, attacking and driving off birds as big as kites and crows.Its only food is insects, therefore plays a very important role in keeping down the insect pest population.

Geographical Distribution

It is quite common in the Indian peninsula, China, Java etc.

Classification and Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve chord; notochord and pharyngeal gill slits present.
Subphylum	**Vertebrata**	Notochord is replaced by vertebral column; 2 pairs of appendages; circulatory system closed; hepatic portal system present; RBC present in blood.
Class	**Aves**	Endothermic with feathers; forelimbs modified into wings, claws absent; hind limbs adapted for climbing perching or swimming; skull with single occipital condyle; beak present; sternum well developed; amniotic; oviparous.
Subclass	**Neornithes**	Tail short, ends in pygostyle; metcarpal fused with distal carpals to form carpometacarpals; sternum well developed with keel.
Superorder	**Neognathae**	Skull neognathus; feathers with interlocking mechanism; wings well developed.
Order	**Passeriformes**	Because feet adapted for perching on this trees and stones, highly developed syrinx.
Genus	*Dicrurus*	
Species	*adsimilis*	
Common name	**Bhujanga, kotwal, Black drongo**	

31.4.5 *Columba livia*

Characters

i) The compact fusiform or boat shaped streamlined body measures about 32.5 cm.
ii) It is a slate grey bird with glistening metallic green, purple and magenta sheen on the neck and upper breast.
iii) Eyes amd feet are pink.
iv) Wings are well developed and suitable for rapid flight, feathers with interlocking system.
v) Two dark bars are present on the wings and a broader one across the end of the tail.
vi) Feet are modified for bipedal locomotion on the ground and for perching having three digits directed forwards and one backwards.
vii) Feet are covered with epidermal scoots formed by the fusion of several epidermal scales.
viii) A short and slender beak is present , at the base of the beak there is a white patch of skin called cere

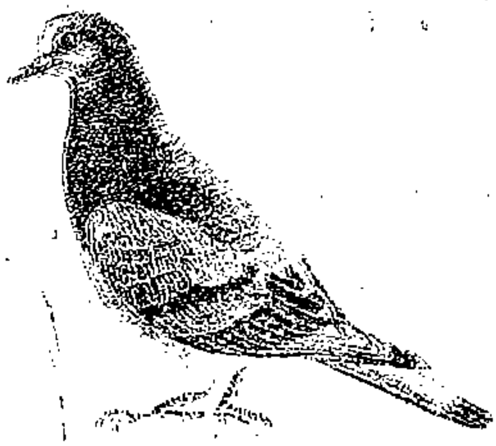


Fig. 31.5: Blue rock pigeon – *Columba livia.*

Habit and Habitat

The wild forms like to live in open country with cliffs and rocky hills avoiding dense forest. In semi- domesticated conditions it is a commensal of man living in wharehouses, factory sheds other buildings , railway yards etc.

Being grain eaters they cause destruction in newly sown or harvested fields of cereals and pulses and groundnuts etc.

Geographical Distribution

Columba is found in the Indian sub-continent, forested zone of the Pacific coast and United States.

Classification with Justification

Kingdom	**Animalia**	Animals, multi-celluiar organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve chord; notochord and pharyngeal gill slits present.
Subphylum	**Vertebrata**	Notochord is replaced by vertebral column; 2 pairs of appendages; circulatory system closed; hepatic portal system present; RBC present in blood.

Class	Aves	Endothermic with feathers; forelimbs modified into wings, claws absent; hind limbs adapted for climbing perching or swimming; skull with single occipital condyle; beak present; sternum well developed; amniotic; oviparous.
Subclass	Neornithes	Tail short, ends in pygostyle; metcarpal fused with distal carpals to form carpometacarpals; sternum well developed with keel.
Superorder	Neognathae	Skull neognathus; feathers with interlocking mechanism; wings well developed.
Order	Passeriformes	Because feet adapted for perching on this trees and stones, highly developed syrinx.
Genus	*Columba*	
Species	*livia*	
Common name	Pigeon, kabutar	

31.4.6 *Dendrocopus mehrattensis*

Characters

i) *Dendrocopus* is a small woodpecker about the size of a bulbul (15 cm).
ii) The upper plumage is irregularly spotted black and white with brownish yellow forecrown and scarlet crest.
iii) The under parts are whitish, streaked with brown on the breast and flanks with a scarlet crimson patch on the abdomen and under the tail. The female lacks the scarlet on the crown.
iv) The tail is stiff and wedge shaped and the tail feathers are pointed at the tips.
v) The feet are zygodactylus, that is, two of the toes are directed forwards and two directed backwards, well developed for climbing on tree trunks.
vi) A highly specialized chisel like bill for boring into wood to extract insects and excavate nest hole.
vii) Tongue is protrusible and roughened with barbs near the tip to extract insects and grubs from cracks and bark of the tree trunks.

Fig. 31.6: *Dendrocopus* male and female.

Habit and Habitat

Dendrocopus lives in pairs; inhabiting light scrub in country side , thin forest, mango orchards and other leafy trees. It bores neat nest holes often quite low down on a tree – trunk or branch.

Geographical Distribution

Dendrocopus is widely distributed in the Indian peninsula.

Classification and its Justification

Kingdom	Animalia	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve chord; notochord and pharyngeal gill slits present.
Subphylum	Vertebrata	Notochord is replaced by vertebral column; 2 pairs of appendages; circulatory system closed; hepatic portal system present; RBC present in blood.
Class	Aves	Endothermic with feathers; forelimbs modified into wings, claws absent; hind limbs adapted for climbing perching or swimming; skull with single occipital condyle; beak present; sternum well developed; amniotic; oviparous.
Subclass	Neornithes	Tail short, ends in pygostyle; metcarpal fused with distal carpals to form carpometacarpals; sternum well developed with keel.
Superorder	Neognathae	Skull neognathus; feathers with interlocking mechanism; wings well developed.
Order	Piciformes	because of the highly specialized beak and two toes facing forward and two toes facing backwards.
Genus	*Dendrocopus*	
Species	*mehrattensis*	
Common name	woodpecker, kathphurwa	

Fig. 31.7: Indian parakeet male and female.

31.4.7 *Psittacula eupatria*

Characters

i) The large Indian parakeet is about the size of a pigeon (approximately 33 cm), with a slender body and long pointed tail.
ii) The body is covered with a brilliant grass green plumage with some bluish colour in the wing and tail feathers.
iii) The female is green all over but the male has a rose pink collar and a black throat.
iv) Wings are well developed and feathers have interlocking mechanism.
v) The beak is short stout, broad at the base, sharply hooked and coral red in colour, well adapted for fructivorous habit.
vi) The feet are zygodactylus having two digits (II and III) directed forewards and the other two (I and IV) directed backwards, well adapted for climbing on tree truks, grasping and holding.

Habit and Habitat

Indian parakeet is a popular cage bird, and can mimic the human voice and speak words like humans.It lives in flocks and is commonly found near fruit trees,ripe crops and in thin forests.It is a serious agricultural pest especially for fruit trees as it eats little and destroys enormous amounts.

Geographical Distribution

The large indian parakeet is commonly found all over the Indian sub-continent except in Pakistan where it is scarce.

Classification and Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve chord; notochord and pharyngeal gill slits present.
Subphylum	**Vertebrata**	Notochord is replaced by vertebral column; 2 pairs of appendages; circulatory system closed; hepatic portal system present; RBC present in blood.
Class	**Aves**	Endothermic with feathers; forelimbs modified into wings, claws absent; hind limbs adapted for climbing perching or swimming; skull with single occipital condyle; beak present; sternum well developed; amniotic; oviparous.
Subclass	**Neornithes**	Tail short, ends in pygostyle; metcarpal fused with distal carpals to form carpometacarpals; sternum well developed with keel.
Superorder	**Neognathae**	Skull neognathus; feathers with interlocking mechanism; wings well developed.
Order	**Psittasiformes**	because of hinged upper beak, fleshy tongue.
Genus	***Psittacula***	
Species	***eupatria***	
Common name	**Tota, Suwa, Parakeet**	

31.4.8. *Gallus domesticus*

Characters

i) The fowl differs from other pheasants in having a comb and wattles about the head and having a tail more arched and curved.
ii) The cock is about 75 cm in length.
iii) The male and female are very different from each other in many features.
iv) The male is larger and has bright plumage except in the tail and neck region; tail is very long and curved like a sickle. Wattles are present only in the males.
v) The female is smaller lighter and shows less brighter plumage; tail feathers are much shorter and straight
vi) Fowls have massive scratching feet with long bony spur only in males.
vii) The wings are less developed capable of only short but powerful flight (except jungle fowl).
viii) The fowl is graminivorous in feeding habit, therefore bears a short pointed and strong bill.

Habit and Habitat

The bird is commonly kept in poultry farms and even in the houses for obtaining meat, eggs and as a game bird for cock fighting.The wild form (jungle fowl-*Gallus gallus*) lives in bushes in thin forested areas and bamboo jungles.

Geographical Distribution

The fowl is commonly found all over the Indian sub-continent, and their distribution is seen eastwards to Indo china and Java.

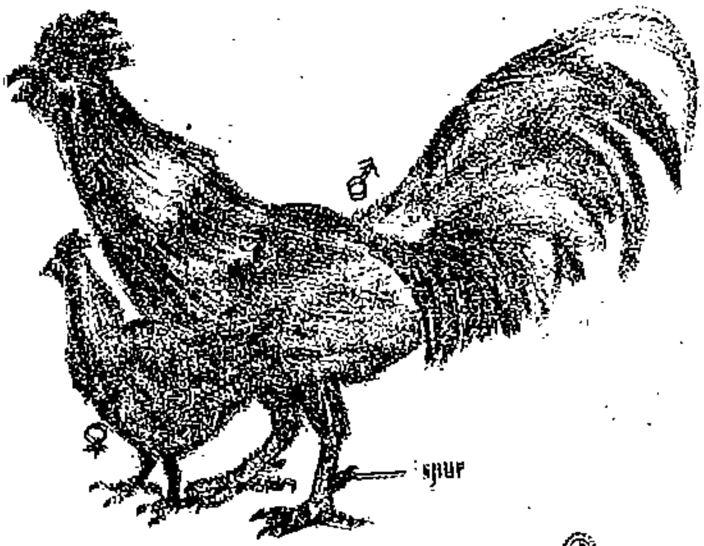


Fig. 31.8: Domestic fowl. Male and female.

Classification and Justification

Kingdom	Animalia	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve chord; notochord and pharyngeal gill slits present.
Subphylum	Vertebrata	Notochord is replaced by vertebral column; 2 pairs of appendages; circulatory system closed; hepatic portal system present; RBC present in blood.
Class	Aves	Endothermic with feathers; forelimbs modified into wings, claws absent; hind limbs adapted for climbing perching or swimming; skull with single occipital condyle; beak present; sternum well developed; amniotic; oviparous.
Subclass	Neornithes	Tail short, ends in pygostyle; metcarpal fused with distal carpals to form carpometacarpals; sternum well developed with keel.
Superorder	Neognathae	Skull neognathus; feathers with interlocking mechanism; wings well developed.
Order	Galliformes	because herbivorous with strong beaks and heavy feet. Ground nesting.
Genus	*Gallus*	
Species	*domesticus*	
Common name	fowl, murga	

31.4.9 *Eudynamys scolopacea*

Characters

i) The body of *Eudynamys* is slender with a long tail, measuring upto 42cm in length.

ii) Sexual dimorphism is well marked. The male is shining metallic black all over with a striking yellowish green beak and crimson eyes. The female is brown, spotted and barred with white. Only the male sings.

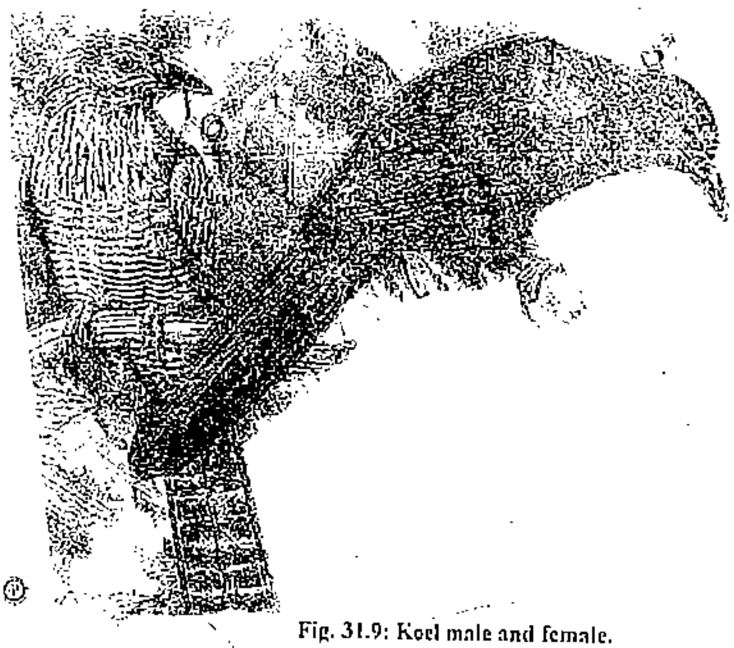


Fig. 31.9: Koel male and female.

Habit and Habitat

The koel mostly parasitises the nests of crows. The koel stealthly lays its egg in the crow's nest. The chick on hatching pushes the crow chicks out of the nest and the crow rears the young koel chick feeding it and even teaching it to fly!

Eudynamys commonly known as koel, is an example of a parasitic bird. It bu[illegible] nest of its own but lays eggs in crow's nest leaving them to be hatched, and th[illegible]g to be reared by the foster parents(see margin remark). Its food consists of ban[illegible]d peepal figs, various berries and hairy caterpillars.

It is completely arboreal, never descending to the ground. Though it is a ve[illegible]mon and well-known bird of leafy gardens and grooves it is better known for its fluty double call than its appearance. During winter it is silent and thus overlooked, and presumed to have migrated. It again starts to sing in spring and remains noisy during the hot summer.

Geographical Distribution

Koel is distributed throughout India Pakistan Sri Lanka and Myanmar.

Classification and Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve chord; notochord and pharyngeal gill slits present.
Subphylum	**Vertebrata**	Notochord is replaced by vertebral column; 2 pairs of appendages; circulatory system closed; hepatic portal system present; RBC present in blood.
Class	**Aves**	Endothermic with feathers; forelimbs modified into wings, claws absent; hind limbs adapted for climbing perching or swimming; skull with single occipital condyle; beak present; sternum well developed; amniotic; oviparous.
Subclass	**Neornithes**	Tail short, ends in pygostyle; metcarpal fused with distal carpals to form carpometacarpals; sternum well developed with keel.

Superorder	**Neognathae**	Skull neognathus; feathers with interlocking mechanism; wings well developed.
Order	**Cuculiformes**	Toes two in front and two behind, outer hind toe reversible; feet not adapted for grasping; tail long.
Genus	***Eudynamys***	
Species	***scolopacea***	
Common name	**Cuckoo, koel, kokila**	

31.4.10 *Struthio camelus*

Characters

i) Largest of all living birds reaching a length of 180 cm, height 2.60 m, weight 136 kg.
ii) Almost half of the height is due to its long neck.
iii) Flightless bird, strong runner with long strong legs, toes reduced to two almost like hooves.
iv) Males black and white; female brown. Aftershafts, down and filaplumes absent.
v) Largest eggs, weight almost 16 kg.
vi) Head small, beak short rather wide. Eyes large brown with thick lashes.

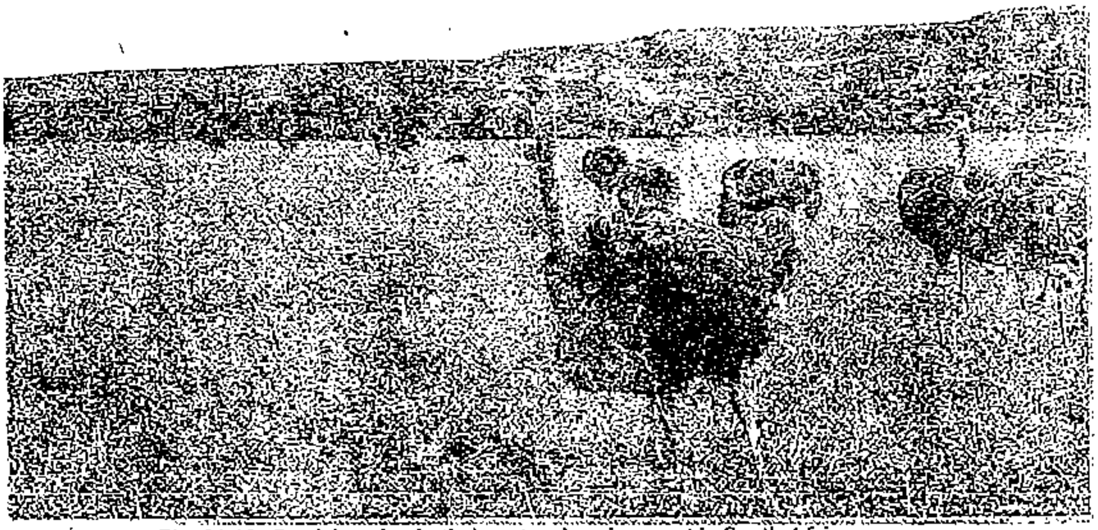


Fig. 31.10: Ostrich males, in their natural environment in South Africa.

Habit and Habitat

Lives mostly on plant matter, but takes animal food, can go without water for long periods. Lives in groups of 5-50.

Geographical Distribution

Found widely in Southern Africa.

Economic Importance

Bred for their meat and feathers that are used in hats.

Classification and justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.

Phylum	Chordata	Dorsal tubular nerve chord; notochord and pharyngeal gill slits present.
Subphylum	Vertebrata	Notochord is replaced by vertebral column; 2 pairs of appendages; circulatory system closed; hepatic portal system present; RBC present in blood.
Class	Aves	Endothermic with feathers; forelimbs modified into wings, claws absent; hind limbs adapted for climbing perching or swimming; skull with single occipital condyle; beak present; sternum well developed; amniotic; oviparous.
Subclass	Neornithes	Tail short; ends in pygostyle; metcarpal fused with distal carpals to form carpometacarpals; sternum well developed with keel.
Superorder	Paleognathae	Modern birds with primitive Archrosaurian palate; Ratites with unkeeled sternum and tinamous (keeled sternum).
Order	Struthinioformes	flightless, 2 toed running birds
Genus	*Struthio*	
Species	*camelus*	
Common name	Ostrich	

31.5 TERMINAL QUESTIONS

1. How are Ratitae and Carniate birds different from each other?

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   ....

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2. Distinguish between Passariformes and Cuculiformes species.

   ....

   ....

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3. Name atleast three Passariformes birds other than those described here, that you have seen in your surroundings.

   ....

   ....

   ....

4. What are the distinguishing feature of Falconiformes and Strigiformes?

   ....

   ....

   ....

Acknowledgment :

Fig. No. 31.8 is an original figure drawn by Dr. Anjum Ara.

EXERCISE 32 AVES II : BEAKS AND FEET

Structure

32.1 INTRODUTION

Birds are very well adapted to their environment according to their needs and various modes of life. Since the forelimbs are modified for flying, the mouth is modified into beak which serves the need of mouth and hand. The beaks are used for preening (=cleaning) the feathers, gathering and arranging the nest material and also for offence and defense purposes. The shape of the beak , therefore, gives an idea of the food and feeding habits of the bird.

Like their beaks, the feet of the birds serve different functions, depending on their habit and habitat Besides helping in locomotion and feeding these are also used by the bird in offence and defense and in collecting the nest material. The feet are generally covered with horny epidermal scales and have typically four toes ending in horny claws, but the structure of feet differs in different birds, as these are adaptively specialized.

Objectives

After completing this exercise you will be able to:

- Identify, classify and draw labeled diagrams of the beak of birds adapted to seed-eating, fruit cutting, insectivorous, mud and water straining and fish catching habits
- Identify, classify and draw labeled diagrams of different types of bird feet/claws that have been adapted to their habit, habitat and manner of locomotion.

32.2 MATERIAL REQUIRED

1. Models of beaks or stuffed specimens of sparrow/finch, parrot. flycatcher/hoopoe, duck/teal and kingfisher.
2. Models of feet or stuffed specimens of sparrow, parakeet/woodpecker, kite/owl, fowl, lapwing, duck/teal and hummingbird.

32.3 STUDY OF VARIOUS TYPES OF BEAKS

You will be provided with models or stuffed specimens of birds that show how their beaks have adapted to different foods eaten by these birds and their manner of feeding.

32.3.1 Seed-Eating Beaks

- Graminivorous or seed eating birds like sparrow, finches, cardinals etc., have short, stout, conical or peg shaped beaks (32.1 A).
- These beaks facilitate the husking and crushing of the grains.
- Weaker beaks are used for piecing up small seeds, while more powerful beaks are meant for crushing large and hard shelled seeds and fruit stones.

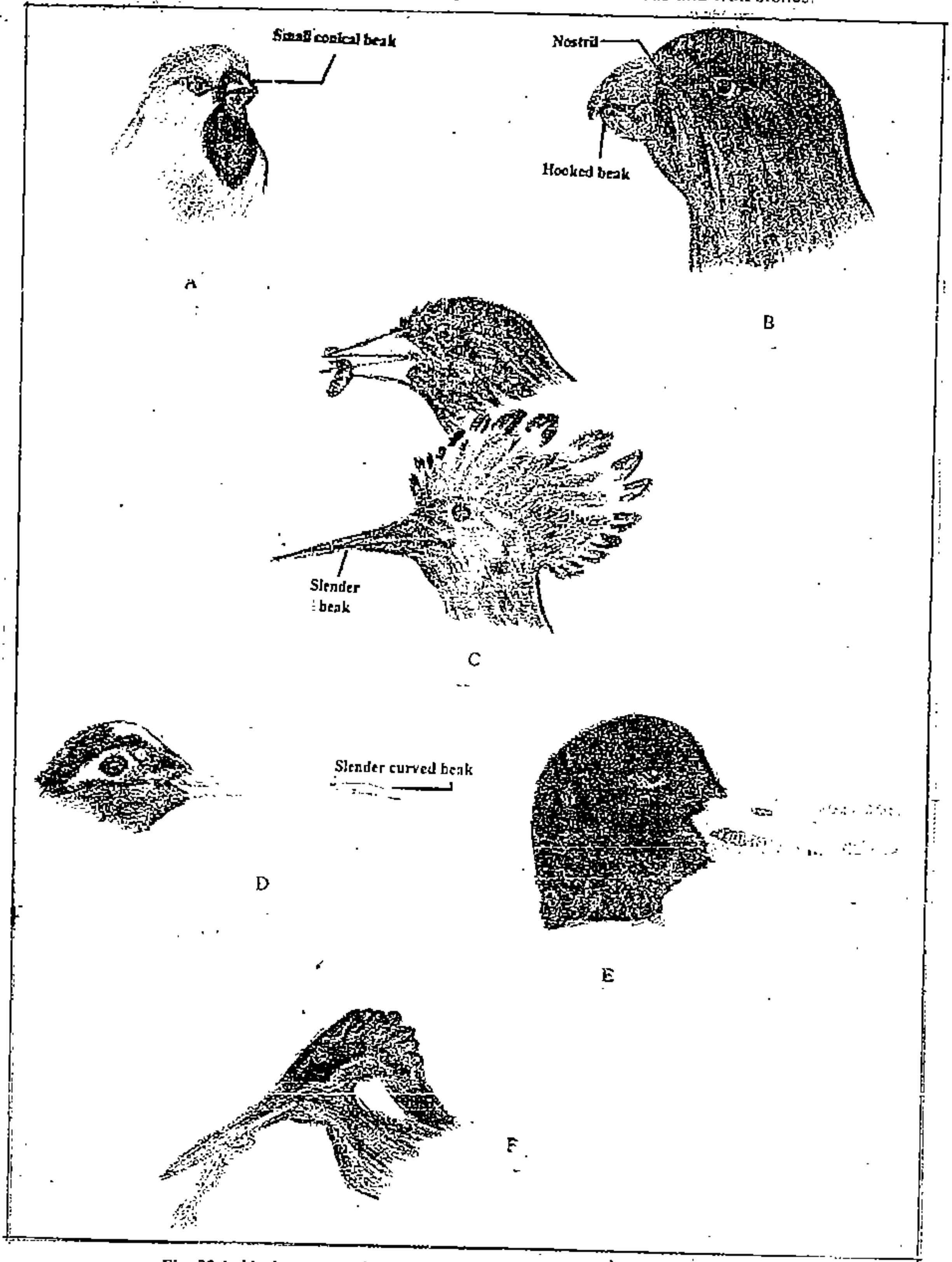


Fig. 32.1: Various types of beaks. A) Seed eating beak of sparrow. B) Fruit eating beak of parrot. C) Insectivorous beak of hoopoe. D) Mud probing beak of snipe. E) Beak of duck. F) Fish catching beak of kingfisher.

32.3.2 Fruit Eating Beak

- These are short, hooked movable and extremely strong beaks (Fig. 32.1 B).
- Such bills or beaks are well adapted for breaking, tearing and gnawing hard nuts and big hard seeds.
- These are found in all fructivorous birds like parrots, parakeets, cross bills etc.

32.3.3 Insectivorous Beaks

- In insectivorous birds like swallows and swifts the beak is small, wide and delicate to scoop up their living insect preys while on wing.
- In flycatcher the beak is short but strong with mandibles notched at the tip and beset with numerous rectal bristles at the base.
- In hoopoe the beak is long, slender and slightly curved and meant for turning the leaves or probing into the soil for searching insects, worms, insect larvae, pupae and mites etc. (Fig. 32.1 C).

32.3.4 Mud Probing Beak

- Generally such beaks are sufficiently long and slender (Fig. 32.1 D) and are used as a probe for thrusting far down into water and mud in search of worms, mollusks, insects and seeds of certain water plants.
- Birds like snipe, stilt, sand piper, jacana and lapwing etc. bear such beaks.

32.3.5 Water and Mud Straining Beak

- The mud straining beak is broad and flat (Fig. 32.1 E).
- The edges of the jaws are furnished with horny serrations or transverse lamellae.
- These lamellae act as a sieve or strainer letting the water and mud pass out while retaining the food in the mouth.
- Such a beak enables the bird to avail itself of the rich store of food in the form of insect larvae, other small aquatic organism and seeds of water plants.
- Such beaks are found in ducks, teals and geese.

32.3.6 Fish Catching Beaks

- Such beaks are long powerful and sharply pointed spearing beaks (Fig. 32.1 F) to capture fish, frogs, tadpoles and other small aquatic animals.
- Storks, herons and kingfishers have such simple fish catching beaks.
- Cormorants have long and narrow fish catching beaks, the edges of which are armed with sharp backwardly pointed tooth like processes restricting the escaping of prey.

32.4 STUDY OF TYPES OF FEET AND CLAWS

You would recall from Unit 3, Block 1, LSE-10 that a bird's legs are designed for walking as well as for perching, scratching, food gathering and occasionally for swimming. When a bird perches on a branch an ingenious toe locking mechanism is activated which prevents the bird from falling of its perch even when asleep (Fig. 32.2). The same mechanism causes the tendons of a hawk or owl to automatically sink deep into the victim's flesh. Thus it has a powerful grip that is not easy to be released from. In this exercise you will observe and note how the feet/claws of birds have adapted to suit their varied habits.

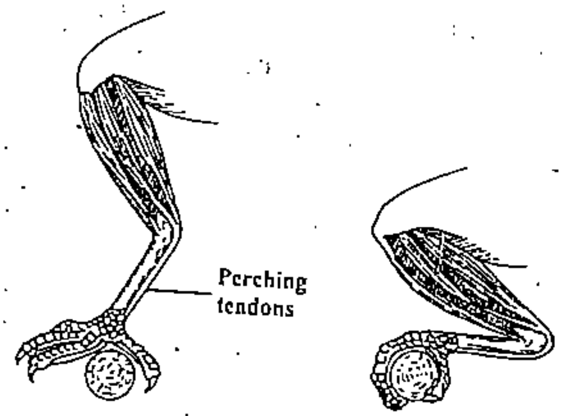


Fig. 32.2: Perching mechanism in birds.

32.4.1 Perching Feet

- The majority of birds are perching or passer type, such as sparrow, robin, pigeon, crow, finch etc. and have perching type of feet.
- In this type of feet the toes are slender and anterior in position except the one (hallux) which is quite long and posterior in position (Fig. 32.3 A).
- The toes are strongly built and apposable so that they can securely fasten the foot to a branch or a perch.

32.4.2 Raptorial Feet

- These are present in birds of prey like kite, eagle, owl etc.
- Such feet are strongly taloned feet meant for striking and grasping the prey.
- The toes have strongly developed sharp and curved claws.
- Large and fleshy bulbs called tylari are found on the under surface of the toes (Fig. 32.3 B), especially developed in the sparrow hawk.
- In some of the carnivorous birds instead of tylari horny spines are present, which help in gripping slippery prey such as fish.

32.4.3 Climbing Feet

- In certain birds like parrot and woodpeckers climbing feet are present (Fig. 32.3 C).
- These feet are used as grasping organs and are especially adapted for climbing vertical surfaces.
- The II and III toes are directed infront while I and IV directed backwards (zygodactylus condition).

32.4.4 Clinging Feet

- In this type of feet all the toes are forwardly directed.
- This property serves to cling the bird to steep faces of cliffs or under caves or ledges of houses etc.
- Clinging feet are seen in small birds like swifts, martinets, humming birds etc.

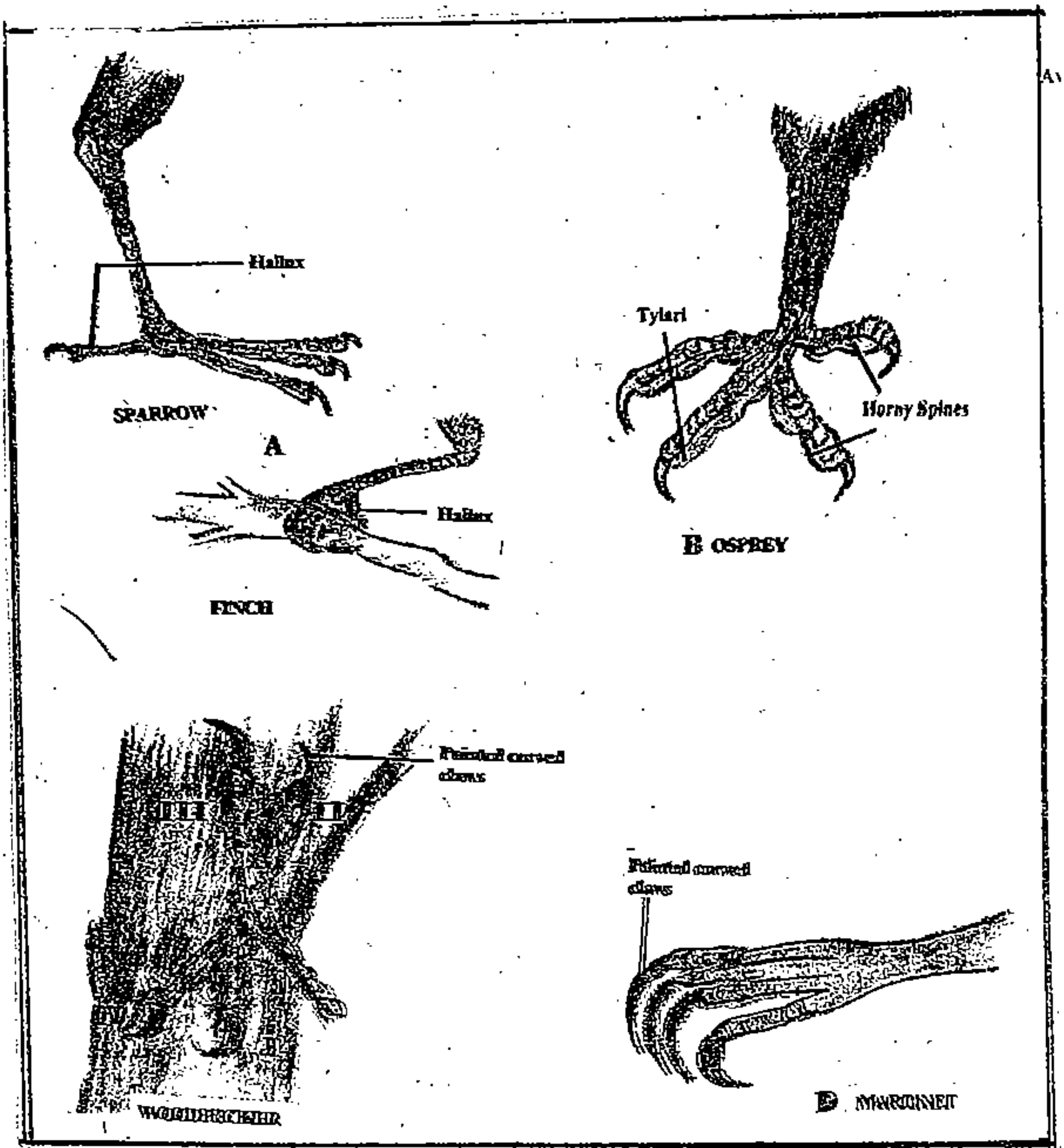


Fig. 32.3: Feet of birds. A) Perching feet. B) Raptorial feet. C) Climbing feet and D) Clinging feet.

32.4.5 Scratching Feet

- The scratching feet are stout, with strongly developed claws (Fig. 32.4 A).
- These are well adapted for running and scratching the earth.
- The feet of male birds are usually provided with a pointed bony spur for offence and defence.
- Such feet are found in fowls, pheasants, quails etc.

32.4.6 Wading Feet

- The marshy birds like jacana, lapwing, snipe, herons etc. have wading feet.
- This type shows exceptionally long legs and toes (Fig. 32.4 B).
- The long toes enable the birds to walk over aquatic vegetation or marshes.
- The web is absent or sometimes feebly developed.

32.4.7 Swimming Feet

- In all swimming birds the toes are webbed partially or completely.
- In swimming and padding birds such as ducks and teals, only the anterior three toes are united in a web, the hallux is free (Fig. 32.4 C).
- In pelicans and cormorants all the four toes are enclosed in the web.

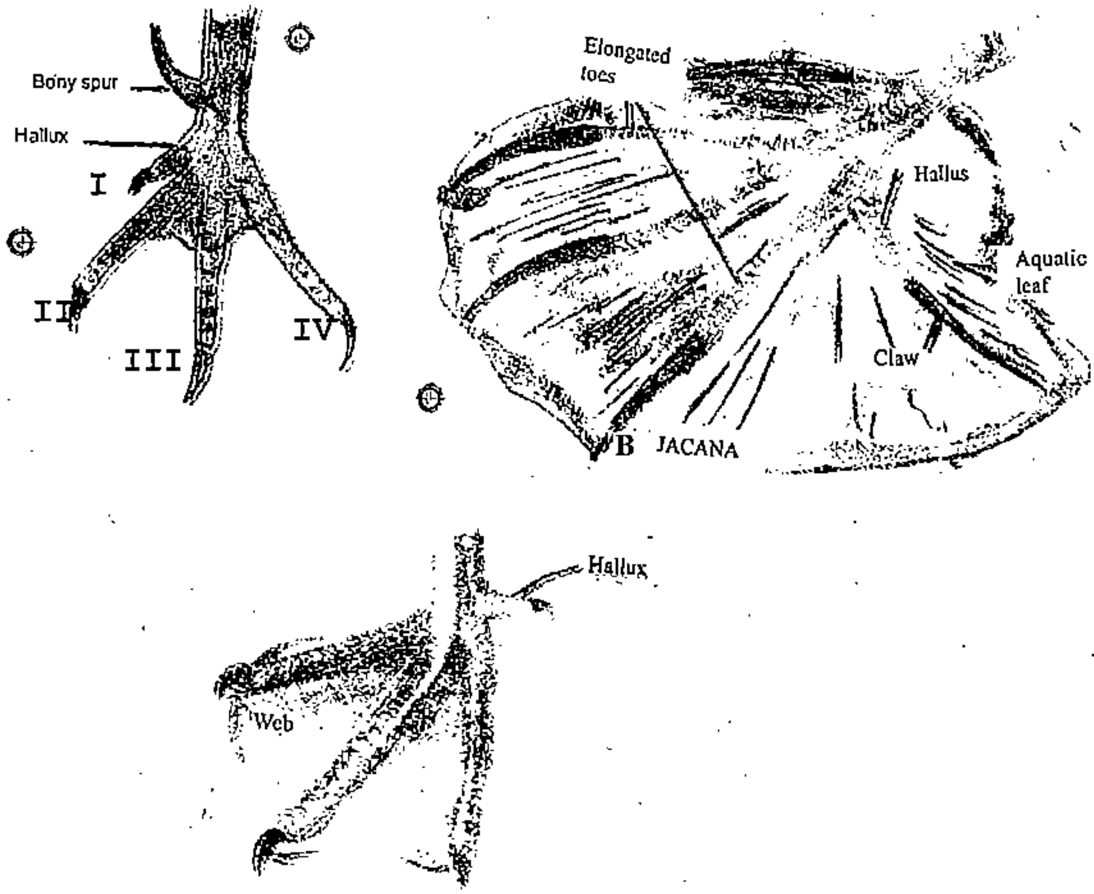


Fig. 32.4: Feet of birds specialized for A) Scratching, B) Wading, C) Swimming.

32.5 ACTIVITY

Obtain a field guide to the birds of your area. Using binoculars:

a) Identify as many birds of your area as possible.

b) Observe the populations of common birds of your area in different seasons (winter and summer) and draw a histogram to show relative frequencies of these populations in different seasons in an area of about 5 kilometer.

   i) Do the birds show similar population frequencies in different seasons?

   ii) Have you observed some uncommon birds in some particular season? If yes, can you suggest a reason for their presence?

Acknowledgement:

Fig. Nos.: 32.1, 32.3, 32.4 are original figures drawn by Dr. Anjum Ara.

EXERCISE 33 OSTEOLOGY OF FROG AND FOWL

Structure

33.1 INTRODUCTION

The skeleton is the frame-work of the animal body, and is so important that on the basis of it, two distinct divisions of the animal kingdom have been recognised – **Chordata** (having an axial supporting skeleton) and **Non Chordata**. The internal frame-work of bones and cartilages of the chordatés is called endoskeleton is divisible into two main categories:

1. **THE AXIAL SET**, includes skull, vertebral column, ribs and sternum (constituting the long axis of the body).
2. **THE APPENDICULAR SET,** consists of girdles and limb bones.

In this unit you will study the skelcton of two chordates – the frog and fowl.

The endoskeleton of frog is made partly of cartilage and partly of bones. In tadpole, the skeleton is solely **cartilaginous**, but in adult frog it is largely replaced by the bones called **cartilage bones**. In some parts of the body where no cartilage was present in the larval stage, certain bones develop from the dermis, called **membrane bones**.

The bird's skeleton presents characteristic and indeed unique features. Almost the entire skeleton in birds is so highly specialized that there is hardly a bone except the phalanges of the toes and the free caudal vertebrae, which could possibly be typically similar to that of any other vertebrate class. A further peculiarity in bird skeleton is that many of the bones are light and contain no bone marrow. Such bones are filled with air cavities and are called pneumatic bones, further, there are internally strutted to give them strength.

Objectives

After completing this exercise you will be able to

- identify, distinguish and draw labelled diagrams of the skull of frog and fowl

- identify, distinguish and draw labelled diagrams of bones of axial and appendicular skeleton of frog and fowl
- describe and mention special features of each bone
- explain the interrelationship of bones of girdles and limbs
- explain the interrelationships of fore and hind-limb bones in frog and fowl.

33.2 MATERIAL REQUIRED

1. Complete articulated skeletons of frog and fowl
2. Skull of frog and fowl .
3. Disarticulated bones of axial sets of the skeleton of frog and fowl
4. Disarticulated bones of appendicular sets of both frog and fowl
5. Pencil and eraser
6. Laboratory manual and note book

33.3 OSTEOLOGY OF FROG

Skeleton system of frog comprises axial and appendicular skeletons.

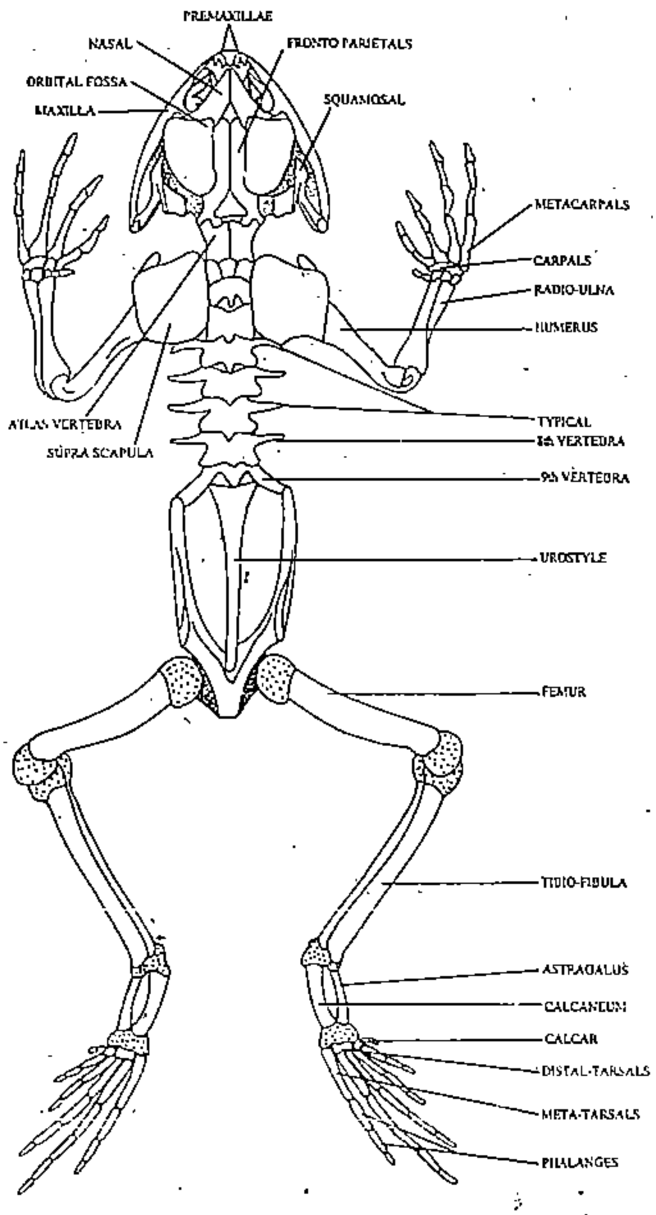


Fig. 33.1: Complete Skeleton of frog (Dorsal view)

33.3.1 The Two Sets-Axial and Appendicular Skeleton

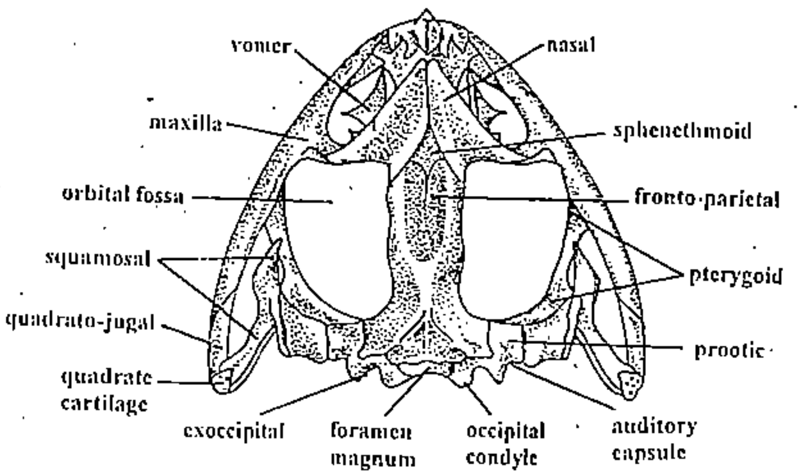
Observe the articulated skeleton of frog and make out the two sets, namely the axial skeleton and appendicular skeleton with the help of figure 33.1 which shows a complete skeleton of frog with the various components. List the parts in sequence, which you can make out in the axial skeleton and similarly, those that constitute the appendicular skeleton.

Next, make detailed observations on the individual parts as listed under subsections 33.3.2 to 33.3.8.

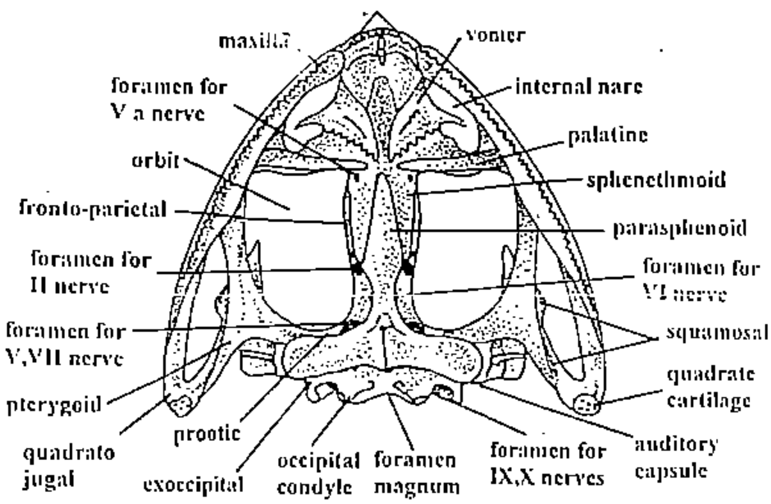
33.3.2 Skull

Observe the skull bones carefully by comparing them with those shown in Fig. 33.2.

(i) In frog the skull is triangular in shape, broad and dorsoventrally flattened.
(ii) It includes three regions i.e. **cranium** (brain box), sense capsules and jaws.
(iii) The cranium or brain box is smaller due to the smaller size of brain.
(iv) Floor of cranium is formed by **paraphenoid** and roof by **frontoparecital** bones.



Skull (Dorsal view)



Skull (Ventral view)

Fig. 33.2: Skull of Frog.

(v) Posterior-most part of the cranium is the occipital segment, mainly made of **exoccipitals** because supra and basioccipitals are absent.

(vi) There are two occipital condyles projecting backwardly to articulate with the anterior concavities of atlas vertebra.

(vii) The interorbital septum is absent so the cranium extends beyond eye orbits,

(viii) The orbits are dorsally placed and optic capsule is not fused with the skull.

(ix) A pair of olfactory capsules is made up of the **nasal** dorsally, **vomers** ventrally and **sphenethmoid** posteriorly.

(x) The anterior wall and partly the roof and floor of each auditory capsule are formed by the irregular cartilage bone called **pro-otic** and **squamosal**.

(xi) Each half of upper jaw is formed by **premaxilla, maxilla** and **quadratojugal** bones.

(xii) The maxilla is provided along its whole length with numerous sharp, pointed and backwardly directed conical teeth (homodont dentition).

(xiii) The lower jaw or mandible is devoid of teeth.

(xiv) Each half of lower jaw consists of a core of **Meckel's cartilage** surrounded by three bones i.e. **Mentomeckelian, angulosplenial** and **dentary**.

(xv) Jaw suspensorium is autostylic in which lower jaw is attached to skull through a rod like cartilaginous **quadrate** bone.

33.3.3 Vertebral Column

The vertebral column of frog is remarkable for its extreme shortness due to its inflexibility and the absence of tail. It consists of only nine **vertebrae**, the last one followed by a slender bony rod, the **urostyle**. The 2nd to 7th vertebrae (Fig. 33.3) have similar characters hence are called as typical vertebrae. The Ist, 8th and 9th vertebrae are not typical and also differ from each other. Let us first study the typical vertebrae. (any one out of 2nd to 7th).

Hold the vertebra in hand one by one and verify the features as described below.

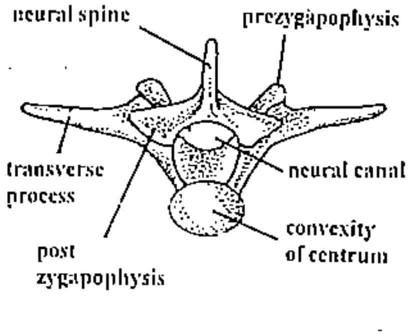
(A) TYPICAL VERTEBRAE (2ND TO 7TH) (Fig. 33.3)

(i) In frog 2nd to 7th vertebrae are typical in structure.

(ii) Each has a ring-like form with a large passage called **neural canal** through which the spinal cord passes.

(iii) The **centrum** is procoelus (*pro*: front, *coelous*: cavity) in all typical vertebrae, its anterior side is concave and posterior face is convex (to fit into the concavity of the centrum of the next vertebra).

(iv) Neural arch bears a small and blunt middorsal **neural spine** which is obliquely directed backward.



Typical vertebra (Posterior view)

Fig. 33.3: A typical vertebra of frog.

(v) Anteriorly at the base of neural spine on either side the neural arch bears upwardly and inwardly directed articular surfaces called **prezygapophyses**.

(vi) The postzygapophyses present at the posterior margins of neural arch are directed downwards and upwards (to fit into the prezygapophyses on the next vertebra).

(vii) Sideward prominent tapering processes directed sidewards arise from the neural arches, these are called the **transverse processes.**

(viii) Now look at the second and fourth vertebra in particular.

(ix) The second vertebra is like other typical vertebrae except that its **neural spine is short and conical** and **transverse processes are broad and flat.**

(x) The fourth vertebra is also typical in structure except that the **transverse processes are broader.**

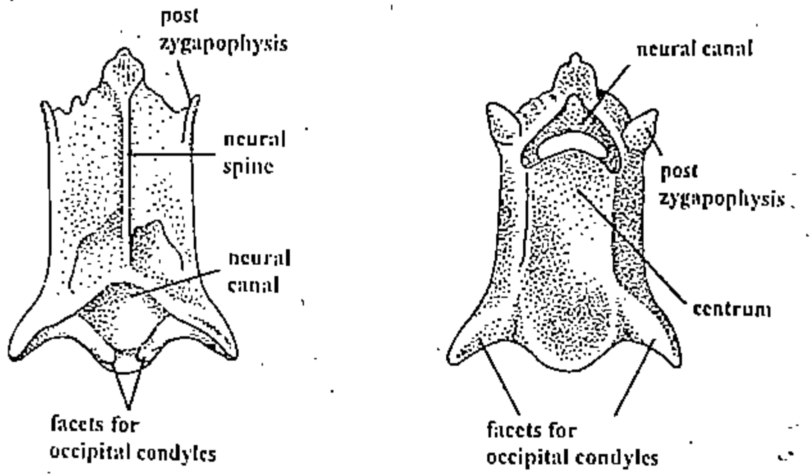
(B) ATLAS – THE FIRST VERTEBRA (Fig. 33.4)

(i) This vertebra is simply in the form of a bony ring with reduced centrum and neural spines.

(ii) The transverse processes and prezygapophyses are absent.

(iii) Anteriorly the centrum carries a pair of large concave facets to articulate with the occipital condyles of the skull.

(iv) Postzygapophyses are present on the posterior margins of the neural arch.



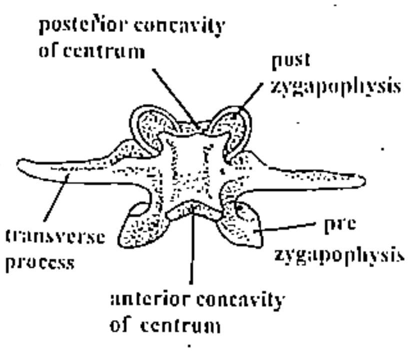
Atlas (Dorsal view) Atlas (Ventral view)

Fig. 33.4: Atlas Vertebra.

(C) EIGHTH VERTEBRA (Fig. 33.5)

(i) It resembles a typical vertebra very much but its centrum is amphicoelus or biconcave.

(ii) The anterior concavity receives the posterior convexity of 7^{th} vertebra while its posterior concavity receives the anterior convexity of the 9^{th} vertebra.



Eighth vertebra (Ventral view)

Fig. 33.5: Eighth Vertebra of frog.

(D) NINTH VERTEBRA (Fig. 33.6)

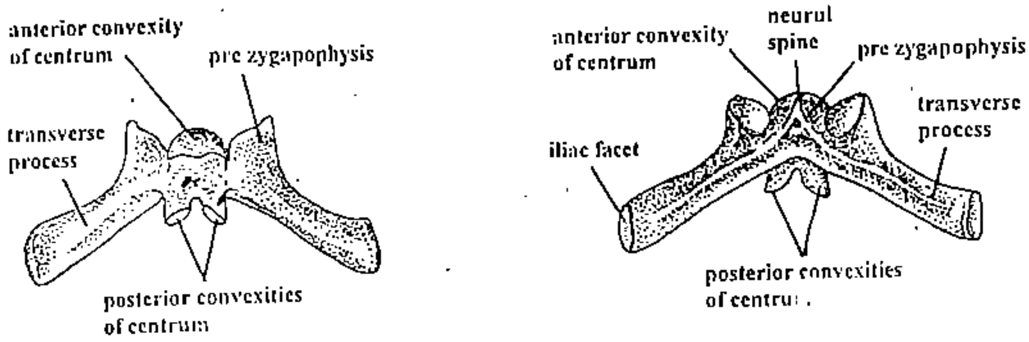
(i) This is also called **sacral vertebra** and is different in many respect from the typical structure.

(ii) Its centrum is biconvex, bearing one anterior and two posterior convexities.

(iii) The two posterior convexities fit into the corresponding two anterior concavities of urostyle.

(iv) Large cylindrical and stout transverse processes are directed backwards.

(v) The distal ends of these transverse process support the iliac bones of the pelvic girdle.



Ninth vertebra (Dorsal view) Ninth vertebra (Ventral view)

Fig. 33.6: Ninth vertebra of frog.

(E) UROSTYLE (Fig. 33.7)

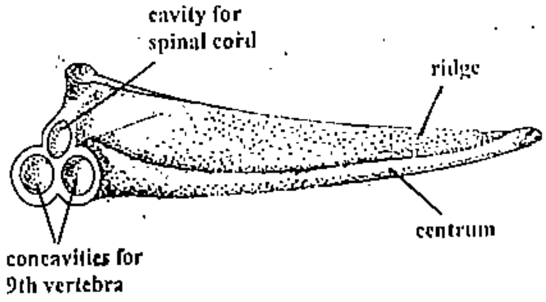
(i) It is the posterior unsegmented part of vertebral column which constitutes approximately half of the total length of vertebral column in frog.

(ii) It is somewhat triangular in outline with the pointed apex directed backwards.

(iii) Its centrum is rod-like with a broad anterior face bearing two concavities for articulation with the ninth vertebra.

(iv) The dorsal surface is raised up in the form of a vertical ridge gradually tapering posteriorly.

(v) Anteriorly the ridge contains a short narrow neural canal which encloses the terminal part of spinal cord.



Urostyle (Lateral view)

Fig. 33.7: Urostyle of frog.

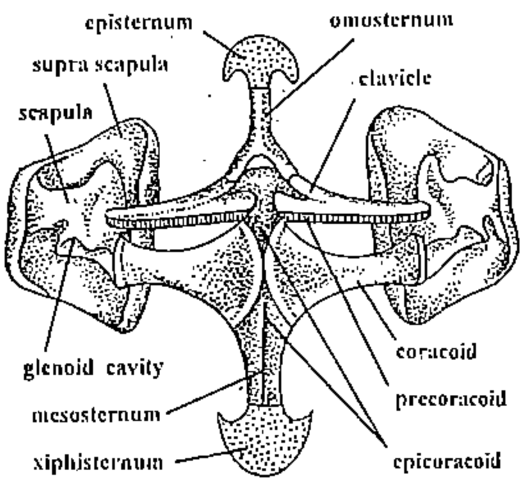
33.3.4 Sternum

(i) The sternum (Fig. 33.8) lies in the midventral line intimately connected between the two halves of the pectoral girdles.

(ii) It includes four parts i.e. the (a) episternum, (b) omosternum, (c) mesosternum and (d) xiphisternum:

(a) Episternum is a flat circular and cartilaginous disc, anteriormost in position.

(b) **Omosternum** is a bony rod connecting the episternum with the clavicles.
(c) **Mesosternum** is a cartilaginous rod projecting behind the epicoracoid.
(d) **Xiphisternum** is the terminal broad cartilaginous plate.



Pectoral girdle and sternum (Ventral view)

Fig. 33.8: Pectoral girdle of frog.

33.3.5 Pectoral Girdle

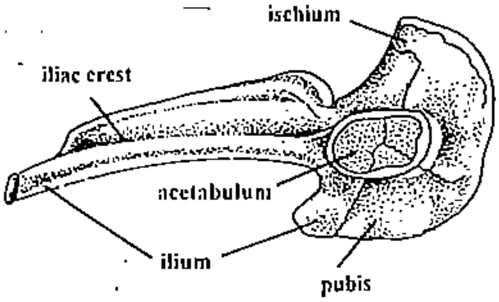
(i) The pectoral girdle (Fig. 33.8) protects the inner softer parts of the chest region as there are no ribs.
(ii) The pectoral girdle also provides support and attachment to the forelimb bones and muscles.
(iii) It is formed by the bones and cartilages both.
(iv) The two similar halves of pectoral girdle are united midventrally with the sternum but are separated dorsally.
(v) Each half is made up of four bones – (a) supra-scapula, (b) scapula, (c) coracoid and (d) clavicle bones:
  (a) **Supra-scapula** is broad, flat, almost rectangular bone whose upper margin is made of calcified cartilage.
  (b) **Scapula** is a stout fat bone broader towards the ends and constricted in the middle. Posteriorly the scapula forms the upper half of glenoid **cavity**.
  (c) **Clavicles and coracoids** of both sides unite midventrally with each other and with sternum through a cartilaginous strip called **epicoracoid**.
  (d) The **clavicle** is a slender rod-like bone separated from the coracoid by a wide gap called **coracoid foramen**.
(vi) A narrow strip of cartilage called **precoracoid**, lies attached to each clavicle posteriorly.
(vii) The **coracoid** is a dumb-bell shaped bone with its inner end broader than outer.
(viii) The outer end of coracoid forms the lower half of the **glenoid** cavity which receives the head of humerus bone of the forelimb.

33.3.6 Pelvic Girdle

(i) In frog pelvic girdle (Fig. 33.9) is a 'V' shaped structure in the posterior region of the body providing support to pelvic region and hind limbs
(ii) Each half of the pelvic girdle called **innominatum** is composed of – (a) *ilium*, (b) *ischium* and (c) *pubis*:
  (a) The long ilium meets with the transverse processes of ninth vertebra. Two ilia meet posteriorly at an iliac symphysis.

(b) Pubis, the reduced calcified cartilage forms the part of acetabulum (The cavity which lodges the head of femur of the hind limb). Pubic cartilages of both sides are completely fused together.

(c) The two ischia give rise to one third of disc and completely fused together at an ischial symphysis.



Pelvic girdle (Lateral view)

Fig. 33.9: Pelvic girdle of frog.

33.3.7 Forelimb Bones

Humerus, radio-ulna and hand bones constitute the bones of forelimb (Fig. 33.10).

(A) HUMERUS (Fig. 33.10)

(i) It is a short cylindrical bone of the upper arm.
(ii) The shaft of humerus is slightly curved.
(iii) The round head formed at the proximal end fits into the glenoid cavity of the pectoral girdle.
(iv) The head is covered by calcified cartilage and below the head is present the deltoid ridge for the attachment of muscles.
(v) The distal end has a well prominent trochlea or capitulum and a condylar ridge for articulation with radio-ulna.

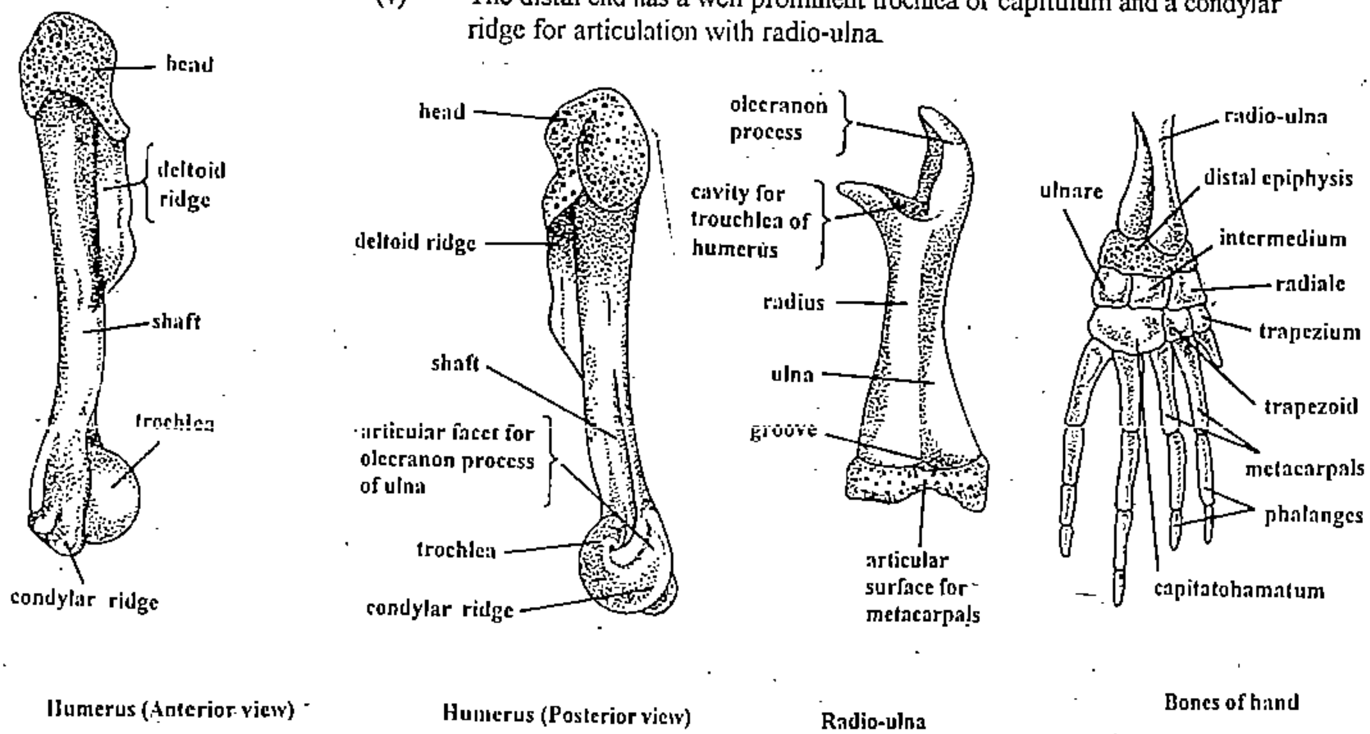


Fig. 33.10: Forelimb bones of frog.

(B) RADIO-ULNA (Fig. 33.10)

(i) It is the compound bone of the lower arm, formed by the fusion of two bones i.e **radius** and **ulna**.
(ii) At the proximal end of this bones a concavity is present to receive the rounded capitulum of humerus.
(iii) An **olecranon process** is also found at the same end.
(iv) Distally the division of radio-ulna into radius and ulna is well marked due to the presence of a groove.
(v) Each of these bones terminates distally into a facet to articulate with the carpal bones.

(C) BONES OF THE HAND (Fig. 33.10)

(i) **Carpals** or wrist bones are 6 in number, arranged in two rows
(ii) The proximal row bears the three bones – **radiale, intermedium and ulnare.**
(iii) Distal row bears the other three bones called **trapezium, trapezoid** and **capitohematum** which articulate with the metacarpals.
(iv) The hand of frog is supported by five slender, rod-like bones the metacarpals, the first one is rudimentary.
(v) There are only four digits in the hand of frog, (pollex or thumb is absent).
(vi) All the digits are internally supported by short rod-like bones called phalanges.
(vii) Two phalanges occur in each of the I and II digit and three in each of III and IV digit.

33.3.8 Hind Limb Bones

Femur, tibio-fibula, astragalus-calcaneum and foot bones constitute the hind limb of the frog (Fig. 33.11).

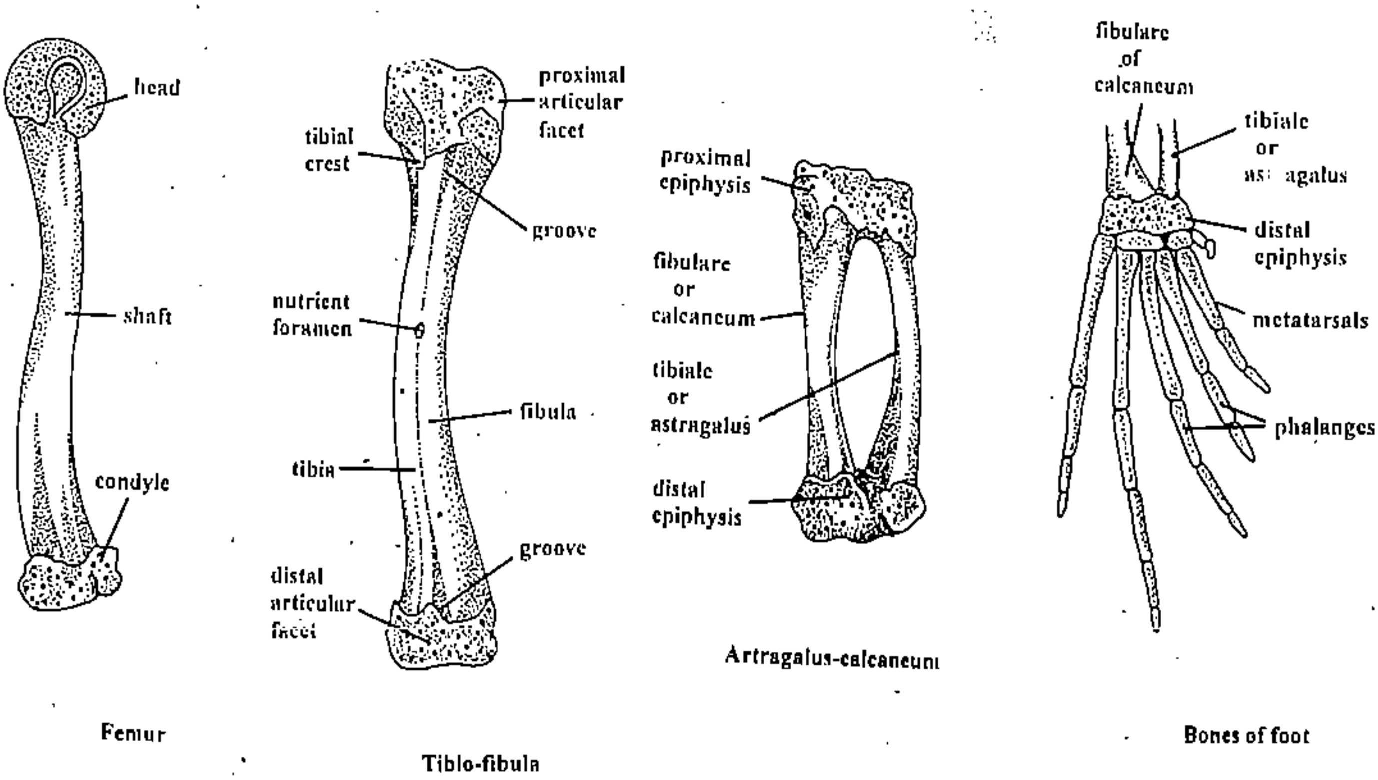


Fig. 33.11: Hind limb bones of frog.

(A) FEMUR (Fig. 33.11)

(i) Femur or the thigh bone has a slightly curved shaft.

(ii) Both expanded ends of the bone are covered by calcified cartilage.
(iii) Proximal end has rounded head which articulates with acetabular cavity of pelvic girdle and distal end with tibio-fibula.

(B) TIBIO-FIBULA (Fig. 33.11)

(i) This is a large compound bone of shank, and its longest in frog's skeleton.
(ii) Its shaft is slightly curved while two ends are expanded and are covered by cartilage.
(iii) As indicated by the median longitudinal groove, this bone is made up of two bones i.e. inner tibia and outer fibula.
(iv) Proximal end of tibia contains a tibia crest.
(v) This bone articulates proximally with femur and distally with astragalus-calcaneum.

(C) ASTGRAGALUS-CALCANEUM (Fig. 33.11)

(i) Astragalus and calcaneum together constitute compound bone.
(ii) These are greatly elongated tarsal bones which represent two rows of tarsals that are fused together at proximal and distal ends but have a wide gap at the middle.
(iii) The outer thicker and straight bone is **calcaneum** while the inner, thinner and slightly curved bone is **astragalus** (or tibiale.)
(iv) Both ends are covered by epiphysis or calcified cartilage.
(v) The distal row of tarsals bears two very small bones.

(D) BONES OF FOOT (Fig. 33.11)

(i) Frog's foot is supported by five long slender metartarsals.
(ii) These metartarsals have 5 true digits (toes) and in addition a very small pre-axial sixth toe, present on the inner side of Ist toe or hallux.
(iii) This supplementary toe called calcar or prehallux is made of 2-3 small bones and does not project from the foot.
(iv) The true toes have 2,2,3,4 and 3 phalanges respectively.

33.4 OSTEOLOGY OF FOWL

A complete skeleton of fowl is shown in Figure 33.12 to give you a general idea of a skeleton of bird. Similar to frogs in birds as well the skeleton is composed of two sets – axial skeleton and appendicular skeleton. The former set consists of the skull, vertebral column, the rib cage and the sternum, whereas the latter set consists of the girdles and limb-bones.

33.4.1 Skull

(i) The compact skull (Fig. 33.13) is very light due to pneumatic bones (see also Fig. 33.12 & 33.13).
(ii) Sutures disappear in skull of adult birds as most of the bones become firmly fused together.
(iii) The skull broadly consists of the same usual three parts i.e. the jaws, sense capsules and cranium.
(iv) A toothless beak is formed by the jaw bones.
(v) Each half of the upper jaw is made up of four bones i.e. **premaxilla, maxilla, jugal and quadratojugal.**
(vi) Similarly each half of lower jaw is made up of five bones i.e. **articular, angular, supra-angular sphenoid** and **dentary.**
(vii) All these bones develop around Meckel's cartilage.
(viii) Jaw suspensorium is autostylic.

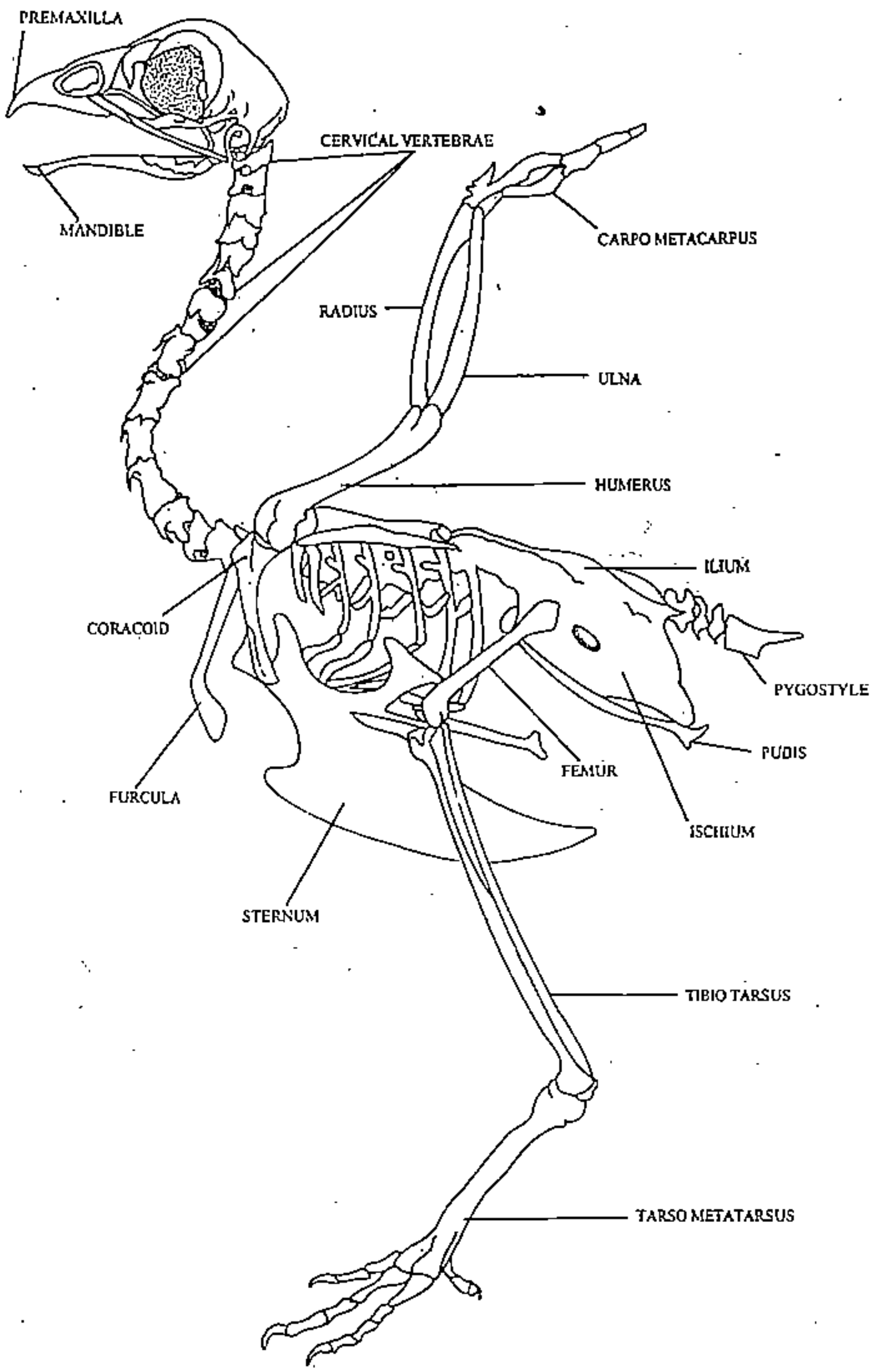


Fig. 33.12: Complete Skeleton of Fowl in Lateral View.

(ix) Palate is formed by vomers, palatines, pterygoid and palatal prolongations of maxillae and is schizognathous i.e. with short vomers allowing palatines to meet.

(x) Large eye orbits are separated from one another by a narrow longitudinal interorbital partition formed by mesethmoid together with orbito-, pre-, and parasphenoids.

(xi) Each orbit is bounded by frontal anteriorly, alisphenoid and postorbital process of frontal posteriorly.

(xii) The auditory capsule mainly formed by pro-otic bone has large cup-like hemispherical tympanic cavity.

(xiii) Three bones are associated with each reduced olfactory capsule, these are nasals, vomers and a small median bone at the base of nasal chamber.

(xiv) Cranium is large and rounded to accommodate the well developed brain.

(xv) Occiptal segment is made up of supra-,basi-and exoccipitals enclosing a downwardly directed foramen magnum.

(xvi) Single occipital condyle is present formed mostly by basioccipitals.

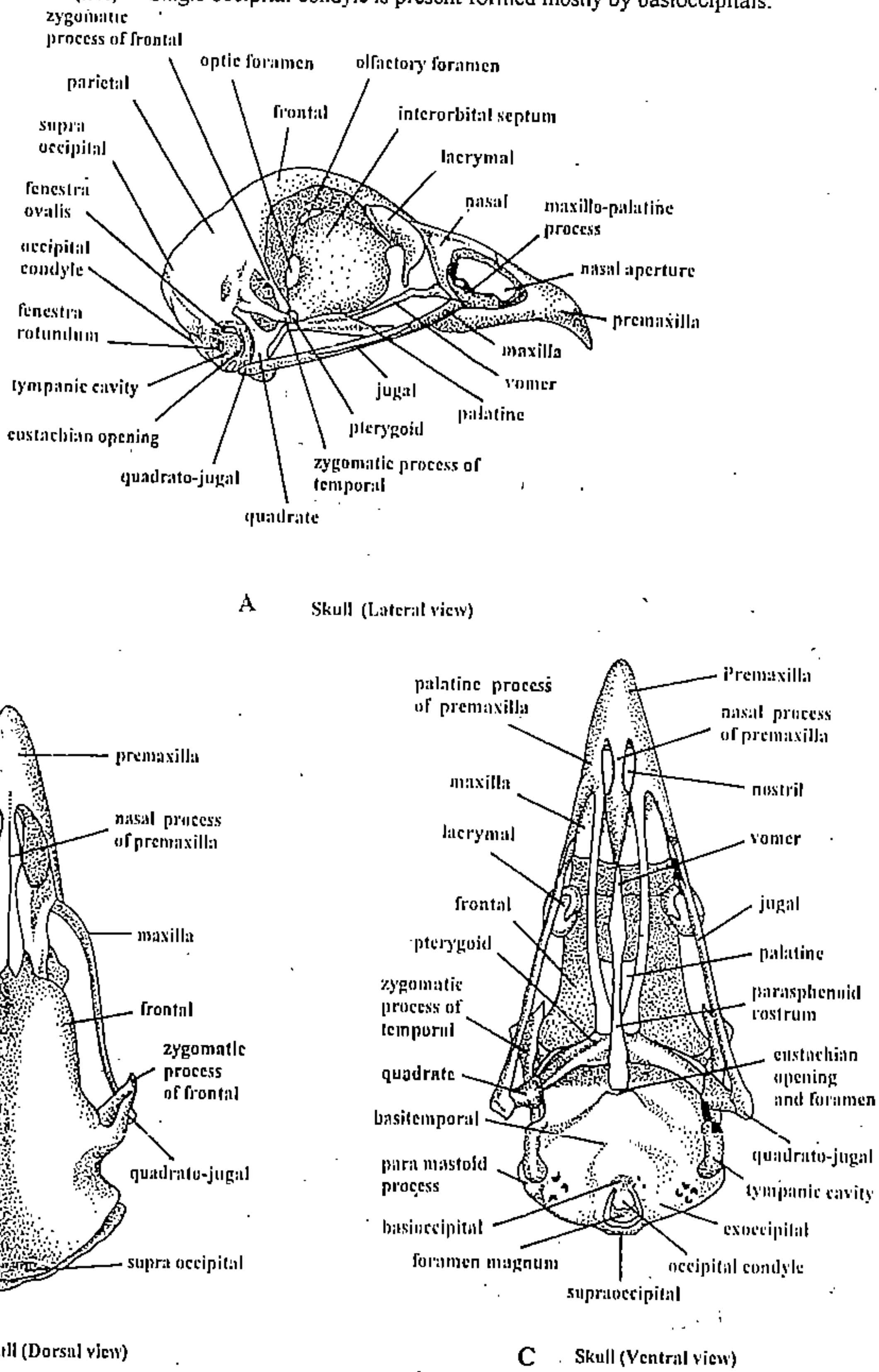


Fig. 33.13: Skull of Fowl. A) Lateral View, B) Dorsal and C) Ventral View.

33.4.2 Vertebral Column

The vertebral column is distinguished by the great length and extreme mobility of the neck, the rigidity of trunk region and shortness of the tail. These features are very advantageous for flight (Fig. 33.12).

The vertebral column of fowl is differentiated into following regions:

(1) Cervical (2) Thoracic (3) Synsacral and (4) Caudal.

(1) CERVICAL VERTEBRAE

Approximately half of the total length of vertebral column in fowl is occupied by 14-16 cervical vertebrae. The cervical vertebrae consist of (a) Atlas vertebra (b) Axis vertebra (c) Typical vertebrae (from 6 – 33 vertebrae) (d) Posterior cervical vertebrae. Special structure and articulation of cervical vertebrae allow greather freedom of movement of the long neck and head. All of these are not similar in structure. The first two vertebrae differ from others.

(a) ATLAS VERTEBRA (Fig. 33.14)

(i) This is first cervical vertebra which is quite small in size and ring-like or roughly triangular in shape.
(ii) The centrum, neural spines, transverse processes, ribs and prezygapophyses are all absent.
(iii) A transverse ligament divides the broad neural canal into two halves.
(iv) The upper half of the neural canal is spinal canal through which spinal cord passes.
(v) The lower one is a notch to receive the odontoid process of axis vertebra.
(vi) Thick ventral portion anteriorly carries a deep concavity to receive the single occipital condyle of skull.
(vii) Small postzygapophyses are present on the posterior side of neural arch to join with the prezygapophyses of axis vertebra.

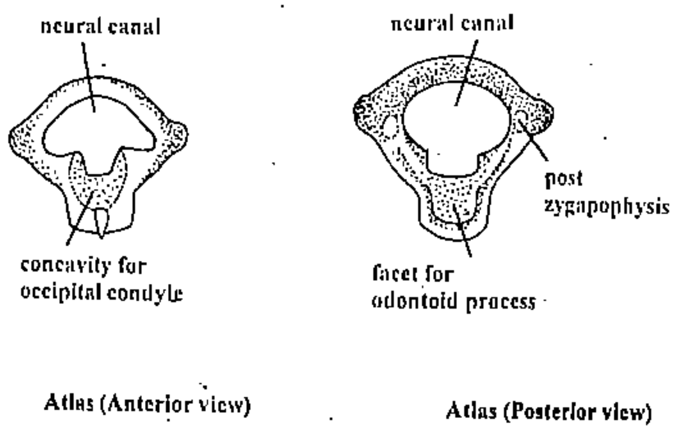
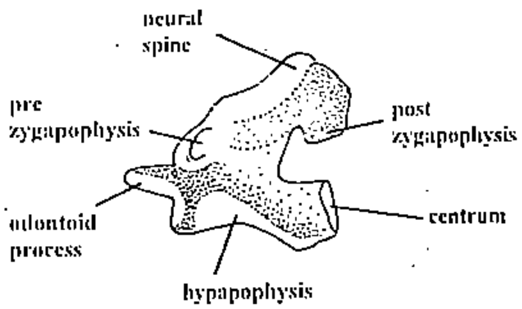


Fig. 33.14: Atlas Vertebrae of Fowl.

(b) AXIS VERTEBRA (Fig. 33.15)

(i) Axis is the second cervical vertebra slightly bigger than atlas.
(ii) Axis also lacks transverse processes, ribs and vertebral canal.
(iii) Centrum is heterocoelus and gives rise to an anterior peg-like odontoid process.
(iv) A small and blunt neural spine is present on the dorsal side of neural arch.
(v) Post and prezygapophyses are present.
(vi) Axis forms the pivot on which the atlas vertebra and in turn the head rotates.

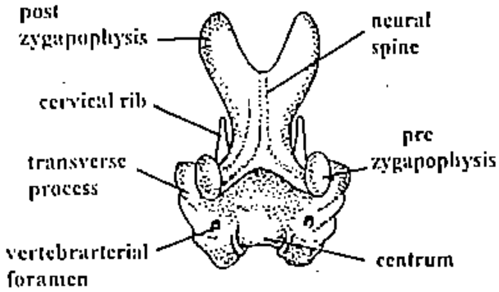


Axis vertebra (Lateral view)

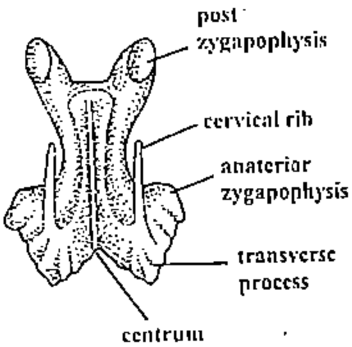
Fig. 33.15: Axis Vertebra.

(c) TYPICAL CERVICAL VERTEBRA (Fig.: 33.16)

(i) From 6^{th} to 33^{th} cervical vertebrae all are typical in structure.
(ii) The body of a typical vertebra is long but neural arch and neural spine are short.
(iii) Centrum is heterocoelous having saddle-shaped articular surfaces.
(iv) Short transverse processes arise laterally at the anterior end.
(v) Each process is fused with a backwardly directed thin, spicular rudimentary cervical rib of its side.
(vi) Anterior articulating surfaces called prezygapophyses are flat and oval facing upwards and inwards.
(vii) Post zygapophyses are projecting backwards from the posterior side of the neural arh.



Typical cervical vertebra (Dorsal view)



Typical cervical vertebra (Ventral view)

Fig. 33.16: Typical Cervical Vertebra.

(d) POSTERIOR CERVICAL VERTEBRAE

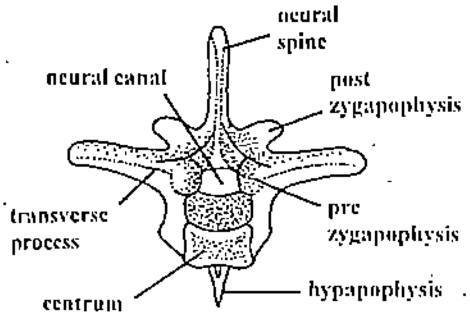
(i) Four vertebrae (11^{th} to 14^{th}) are included in this category. These are similar in structure to the typical cervical vertebrae differing only slightly in size.
(ii) These are shorter but more massive.
(iii) The neural arch and spine are well developed.
(iv) Transverse processes bear the large double headed ribs in last one or two cervical vertebrae.
(v) Centrum is heterocoelus and bears at its ventral surface a prominent spine like **hypapophyses**.
(vi) Pre and post zygapophyses are present on anterior and posterior surfaces respectively.

(2) THORACIC VERTEBRAE (Fig. 33.12)

(i) There are 7 short thoracic (free and fused thoracic) vertebrae present in fowl.
(ii) Second to fifth vertebrae are fused together into a common mass.
(iii) The Ist and 6^{th} vertebrae remain free while the 7^{th} fuses with synsacrum.

(a) FREE THORACIC VERTEBRAE (Fig. 33.17)

(i) The 1^{st} and 6^{th} thoracic vertebrae are slightly smaller than the cervical vertebrae.
(ii) The centrum in free thoracic vertebra is heterocoelus.
(iii) Neural arch well developed and neural spine is long and pointed.
(iv) Long transverse processes are outwardly directed.
(v) Pre and postzygapophyses are present on the anterior and posterior surfaces respectively.
(vi) The centrum at its ventral surface gives rise a well developed hypapophysis for the attachment of flexor muscles of neck.
(vii) The transverse processes and centrum also bear the articular facets for the attachment of tuberculum and capitulum of thoracic ribs.

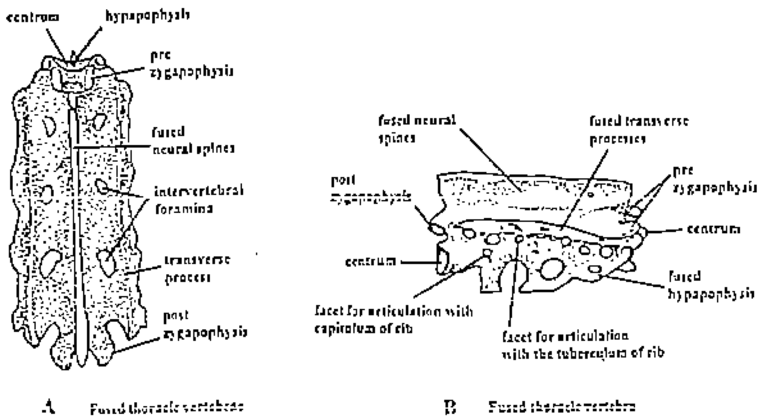


Free thoracic vertebra

Fig. 33.17: Free Thoracic Vertebra.

(b) FUSED THORACIC VERTEBRAE (Fig. 33.18)

(i) Most of the structures of four thoracic vertebrae (2^{nd} to 5^{th}) are fused together to make almost a common continuous structure (Fig. 33.18).
(ii) The neural arches and transverse processes of these vertebrae are fused with each other to form continuous dorsolateral ridges.
(iii) The neural spines and hypapophyses are fused to form a dorsal and ventral crest respectively.
(iv) All heterocoelus centra are also fused together.
(v) The fused transverse processes and centra possess the tubercular and capitular facets for the thoracic ribs.



A Fused thoracic vertebrae (Dorsal view)
B Fused thoracic vertebra (Lateral view)

Fig. 33.18: Fused Thoracic Vertebrae. A) Dorsal view, B) Lateral View.

(3) SYNSACRUM (33.19)

(i) It is a compound structure formed by 16 fused vertebrae to support the pelvic region.
(ii) Among these 16 are included the last thoracic, six lumbars, two sacrals and about 7 caudal vertebrae.
(iii) Anteriormost vertebra of synsacrum is the last thoracic vertebra bearing a pair of free thoracic ribs.
(iv) Lumbar vertebrae are firmly fused together with free transverse processes and without hypapophyses.

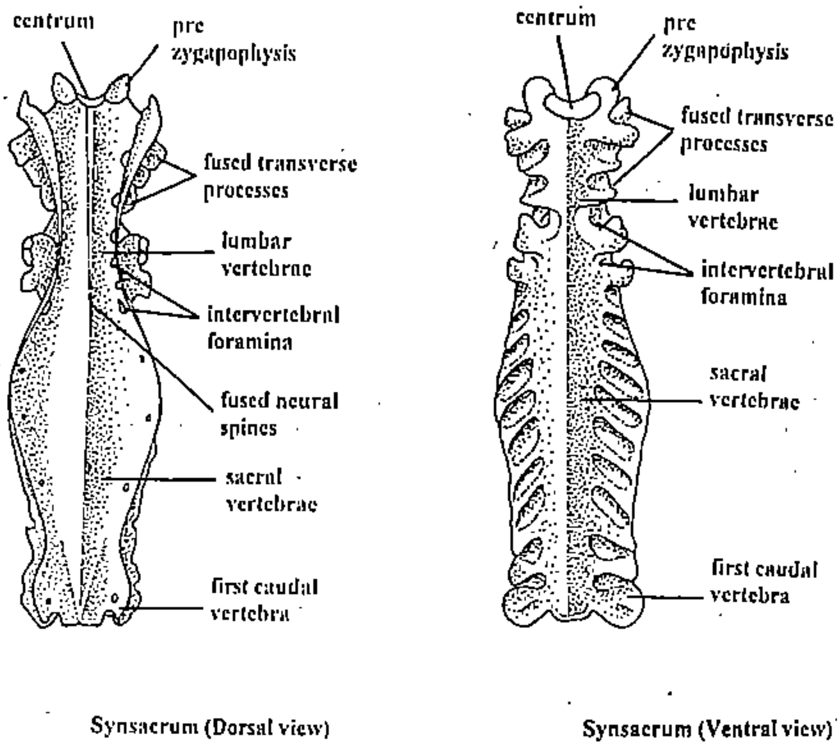


Fig. 33.19: Synsacrum of fowl.

(v) The two sacral vertebrae fuse with the lumbar region and their transverse processes are fused to form bony plates.
(vi) Sacral ribs are fused with the transverse processes of these vertebrae.
(vii) Remaining seven vertebrae in synsacrum are anterior caudal vertebrae.
(viii) Their transverse processes except in the last, bifurcated into dorsal and ventral processes.
(ix) The dorsal processes unite to form bony plates.
(x) Free ventral processes represent the ribs, which are rod-like in first 4-5 vertebrae but are smaller in the rest.
(xi) All the components of synsacrum are so intimately fused that it is difficult to distinguish them separately.

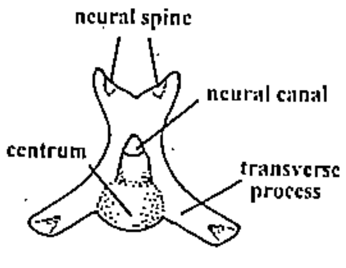
(4) CAUDAL REGION

It is a short portion of the bird's vertebral column. In fowl it includes 4 or 5 free vertebrae and a pygostyle (Fig. 33.20).

(a) FREE CAUDAL VERTEBRAE (Fig. 33.20)

(i) A free caudal vertebra is quite small and rudimentary.
(ii) The centrum is heterocoelous and transverse processes are directed downwards and outwards.
(iii) The small neural spine is bifid.
(iv) Pre- and post-zygapophyses are absent.

(v) Free caudal vertebrae make the movement of tail and tail feathers possible.



Free caudal vertebra

Fig. 33.20: Free Caudal Vertebra and Pygostyle of Fowl.

(b) **PYGOSTYLE**

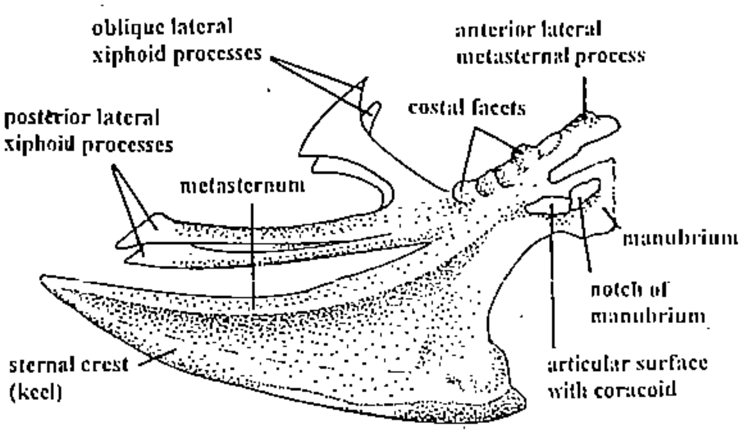
(i) The last part of caudal region is formed by the fusion of four or more posterior most caudal vertebrae and is called pygostyle (Fig. 33.21).
(ii) It is a large vertical plough-shaped like compound bone.
(iii) It looks like a vertical triangular and laterally compressed plate.
(iv) Centra, neural spines, pre and post zygapophyses, all are absent.
(v) It supports the muscles and large tail feathers.

Pygostyle

Fig. 33.21: Pygostyle.

33.4.3 Sternum

(i) The sternum of most flying birds is a broad plate, concave dorsally from side to side and produced anteriorly into an anteroposterior keel (Fig. 33.22).
(ii) The sternum of fowl is well developed and is called breast bone.
(iii) The boat-shaped sternum is composed of 4-5 components.



Sternum (Lateral view)

Fig. 33.22: Sternum of fowl.

(iv) Metasternum is the main component which is concave dorsally and convex ventrally.
(v) Another part called manubrium is the anteroventral vertical process of metasternum, perforated by foramen of manubrium.
(vi) A median sagittal ridge arising from the ventral surface of metasternum is called keel. It provides the attachment surfaces for the pectoral muscles.
(vii) Metasternum gives out from its anterior region, on either side a small anterior costal process and a large posterior metastea or xiphoid process.
(viii) For the attachment of lower ends of sternal ribs, 4-5 costal facets are present in the dorsolateral margins of metasternum.
(ix) At the base of manubrium on either side a groove is present to articulate with the lower end of coracoid bone.

33.4.4 Ribs

(i) Seven pairs of thoracic ribs (Fig. 33.23) are present in fowl.
(ii) One pair of rib articulates with each thoracic vertebra.
(iii) Two distinct parts are present in each thoracic rib.
(iv) A dorsal flat and curved vertebral part remains attached to the vertebral surface.
(v) The other rod-like part is attached to the sternum.
(vi) The 1st and 2nd and sometimes the 7th rib lacks the sternal part and do not reach the sternum.
(vii) The vertebral end of each rib in turn has two parts, a lower capitulum attached to centrum and upper tuberculum attached to transverse process of vertebra.
(viii) On the vertebral side, each rib (except the first and last pair) carries a backwardly directed uncinate process which overlaps the next rib behind, to provide sufficient strength and rigidity to the thoracic wall.

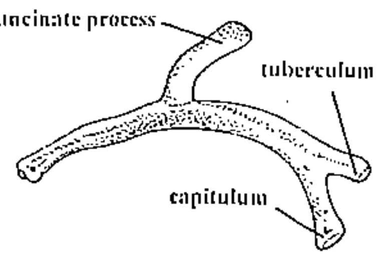
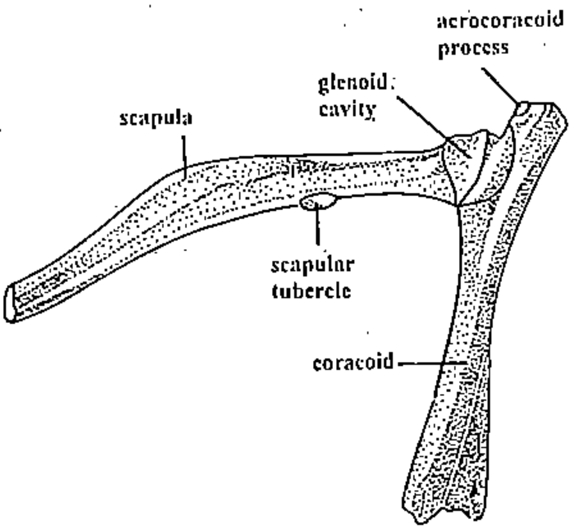


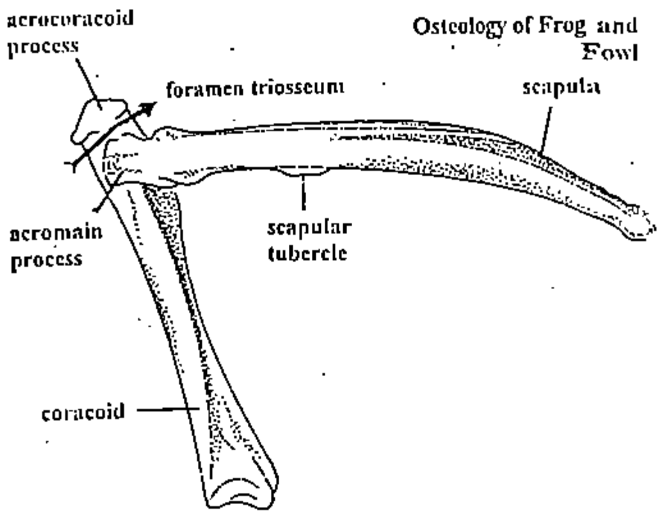
Fig. 33.23: Thoracic ribs of fowl.

33.4.5 Pectoral Girdle

(i) Pectoral girdle (Fig.33.24) is made of the usual three bones i.e., **Coracoid; Scapula and Clavicle.**
(ii) All these bones are elongated and constitute the two similar halves of pectoral girdle.
(iii) Each half is peculiarly like the inverted "L" in shape.
(iv) Coracoid is a large, stout and rod-shaped bone, its inner surface articulates with scapula and outer surface contains the cup shaped glenoid cavity. The head of humerus bone fits into this cavity.
(v) Scapula is also a narrow , elongated sabre like bone.
(vi) A depression is present in the anterior part of scapula contributing in the formation of glenoid, cavity and on inner side it has an acromian process.
(vii) The rod shaped clavicles of both sides fuse to form a 'V' shaped furcula or wishbone.
(viii) Ventrally the furcula bears the interclavicle at the region of fusion.



Pectoral girdle (Outer view)



Pectoral girdle (Inner view)

Fig. 33.24: Pectoral girdle of fowl.

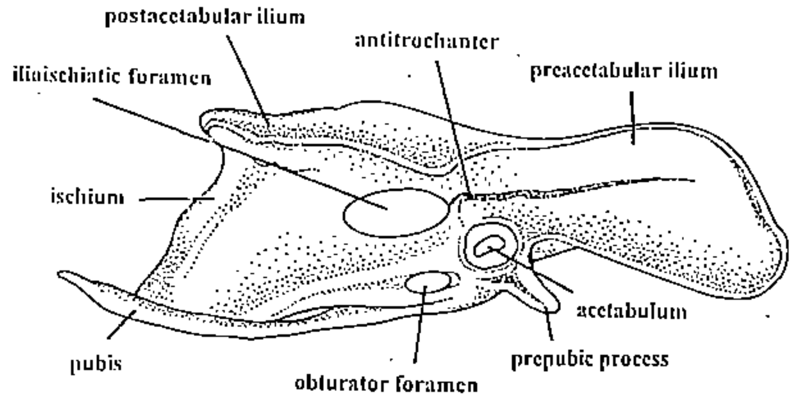
33.4.6 Pelvic Girdle

(i) The pelvic girdle of fowl is made up of usual three bones i.e. the **Ilium, Ischium** and **Pubis** (Fig.33.25).

(ii) The flat and lamellar **ilium** bone forms the dorsal part of the acetabulum.

(iii) The outer surface of preacetabular part of ilium is concave while that of postacetabular part is convex.

(iv) **Ischium** is a broad and lamellar bone which extends behind the acetabalum. It fuses with ilium posteriorly and remains separated from it in the anterior region by its ischiatic foramen.



Pelvic girdle (Right half)

Fig. 33.25: Pelvic girdle of fowl.

(v) Pubis forms the ventral part of the acetabulum.

(vi) Just behind the acetabulum the pubis is separated from ischium by an obturator foramen.

(vii) Ventral symphysis is absent in accordance with the laying of relatively large sized eggs.

(viii) Firm and extensive fusion of pelvic girdle with synsacrum provides sufficient strength to the pelvic region in the absence of ventral symphysis.

33.4.7 Forelimb Bones

(i) In birds because the forelimb is adapted for flight and has to support the wings, certain changes have occurred in the number and arrangement of the fore limb bones (Fig. 33.26).

(ii) Forelimb of fowl. like those of other birds is composed of the usual bones : **humerus, radius, ulna, carpals, carpometacarpus and phalanges.**

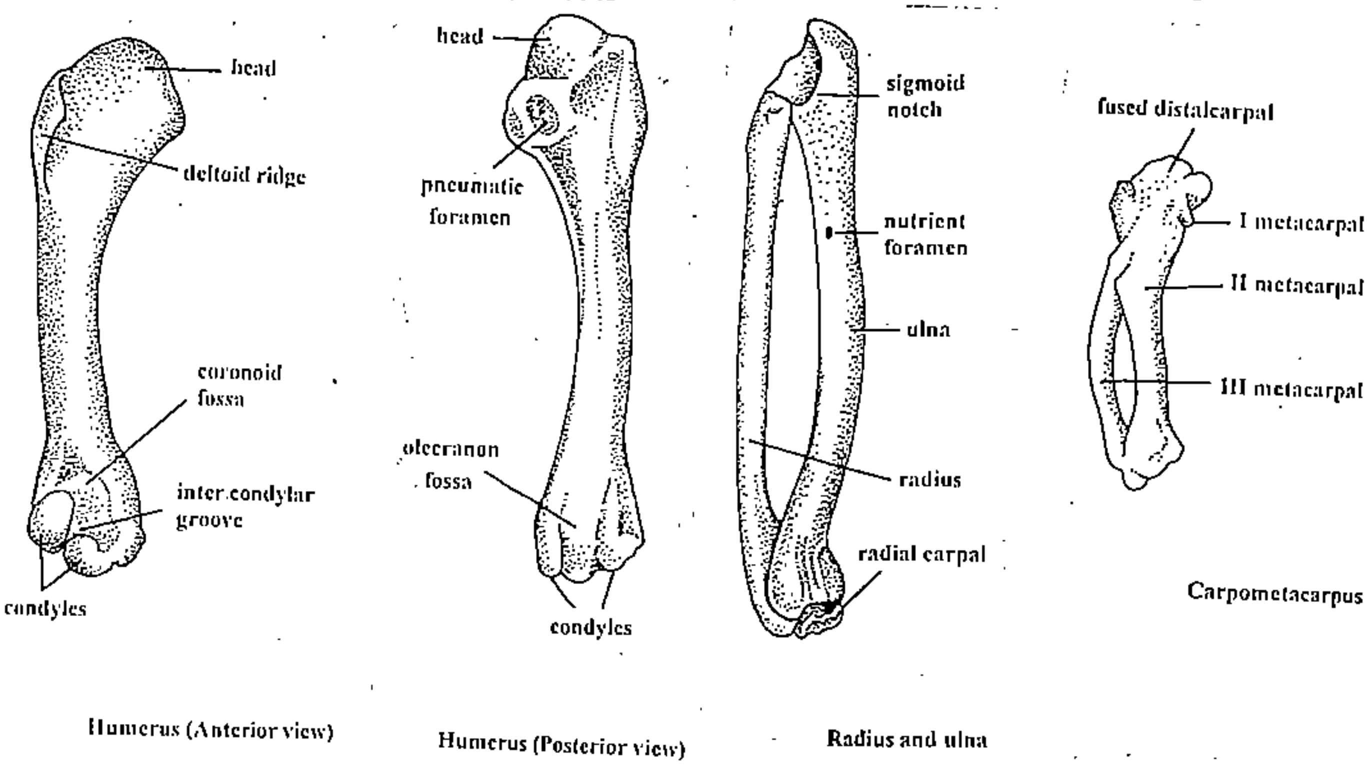


Fig. 33.26: Fore-limb bones of fowl.

(iii) Distal carpal bones fuse with the metacarpals forming carpometacarpus.

(iv) Instead of five only three digits are present in the forelimbs.

(A) HUMERUS

(i) The upper arm bone is stout, elongated, slightly curved and expanded at both ends (Fig.33.26)

(ii) Proximal expanded end bears a head which articulates with the glenoid cavity of pectoral girdle.

(iii) The head bears a small preaxial tubercle with a prominent deltoid ridge for the attachment of pectoral and deltoid muscles.

(iv) A greater tuberosity with a large pneumatic foramen is present on the post-axial side of the head.

(v) The distal end of humerus bears two trochlear articular surface or condyles for radius and ulna.

(B) RADIUS AND ULNA

(i) The forearm has two separate bones i.e. radius and ulna (Fig. 33.26) which in birds do not move upon each other.

(ii) Radius is a short, slender and almost straight bone. Its proximal end has a cup-like depression to receive and articulate with the outer condyle of humerus. A distal knob-like end fits into the radiale carpal.

(iii) Ulna is longer, stouter and more curved than radius. Its proximal end contains a facet for inner condyle of humerus and it further projects into small olecranon process.

(iv) Distal end articulates partly with carpals and partly with radius.

(C) CARPALS

(i) There are only two carpal bones present in adult birds (Fig. 33.26).
(ii) The smaller one is called radiale, and articulates with radius and is proximal in position.
(iii) The large, ulnare articulates with distal end of ulna and is post-axial in position.
(iv) These two represent the proximal row of carpals, because all the distal carpals fuse with the metacarpals in adult.

(D) CARPOMETACARPUS

(i) Three metacarpals fuse with distal carpals to form a single elongated compound bone, called **carpometacarpus** (Fig. 33.26).
(ii) **First metacarpal** is in the form of a small stumpy projection at the proximal end of **carpometacarpus**.
(iii) **Second carpometacarpus** is the strongest and straight bone.
(iv) The **third metacarpal** is slightly curved and slender than the second with which it is fused at both ends.

(E) PHALANGES (Fig. 33.26)

(i) The three metacarpals bear three clawless fingers.
(ii) First and the third digit consists of single phalanx each.
(iii) The second digit or index finger has three phalanges.

33.4.8 Hind-Limb Bones

(i) Hind-limbs in birds are modified for bipedal locomotion.
(ii) These are homologous with forelimbs in general structural plan.
(iii) Each hind-limb comprises femur, tibio-tarsus, fibula, tarsals, tarsometatarsal and phalanges (Fig. 33.27).

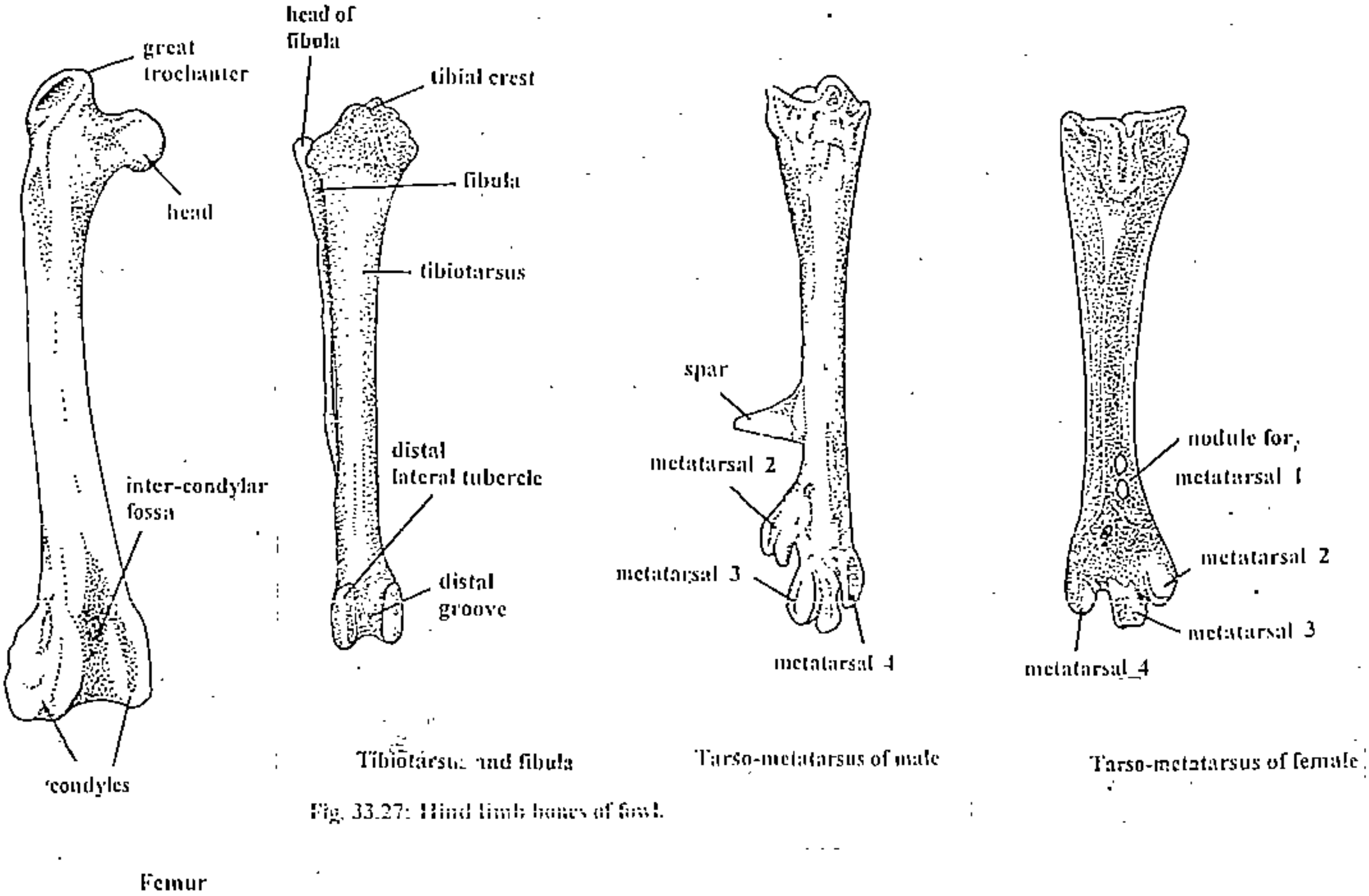


Fig. 33.27: Hind limb bones of fowl.

(A) FEMUR

(i) It is a single, cylindrical, stout and slightly curved bone with flattened ends (Fig. 33.27).
(ii) On the inner side of the proximal end a rounded head is present which fits into acetabulum of pelvic girdle.
(iii) On the outer side of this end is present a prominent but irregular process called a greater trochanter.
(iv) Distal end of femur has a pulley like structure, consisting of an anterior deep intercondyler groove or fossa.
(v) Two prominent condyles are present on the lateral sides of fossa for the articulation with tibio-tarsus.
(vi) Outer condyle is deeply grooved to articulate with the upper end of fibula.
(vii) In front of femur tibiotarsal joint, a sesamoid bone or patella is found in order to provide sufficient protection to the joint.

(B) TIBIO-TARSUS AND FIBULA

(i) These are the bones of the shank region.
(ii) Tibio-tarsus is the longest bone in the body, even longer than femur (Fig. 33.27).
(iii) It is a stout nearly straight bone formed by the fusion of tibia with proximal tarsals (astragalus and calcaneum).
(iv) The broad proximal end shows two articular facets to receive two distal condyles of femur
(v) The same end also contains a prominent cnemial crest in front.
(vi) Distal end contains a smooth groove bounded by two condyles to articulate with the tarso-metatarsus.

(C) FIBULA

(i) It is markedly reduced to a small slender bone (Fig. 33.27).
(ii) It is attached to the outer surface of tibio-tarsus.
(iii) The proximal end bears a head to articulate with the outer condyle of femur.
(iv) The distal end tapers gradually to a sharp point and does not reach the ankle.

(D) TARSALS

(i) No free tarsals are present in adult fowl.
(ii) The proximal row of these fuses with tibia to form a compound tibio-tarsus bone.
(iii) Their distal row fuses with metatarsals.
(iv) An intertarsal ankle joint is present between the two rows.

(E) TARSO-METATARSUS

(i) It is a single, stout and straight compound bone present in the foot region (Fig. 33.27).
(ii) Second, third and fourth metatarsals fuse with the distal row of tarsals to form this compound bone.
(iii) At the distal end the three metatarsals become free, each forming a pulley like articular surface for the corresponding toe.
(iv) In male fowl the tarsometatarsus bears a stout, conical and slightly curved bony projection ending into a pointed horny fighting spur.

(F) PHALANGES

(i) There are four toes in the foot (Fig. 33.27).
(ii) Only the first toe (hallux) is directed backwards while the remaining three, are directed forwards.

(iii) Each one is made up of small slender bones, the phalanges, whose number varies in the four toes.

(iv) There are 2,3,4 and 5 phalanges in hallux, second third, and fourth toe respectively.

(v) Each toe ends in a horny claw making the feet raptorial.

33.5 TERMINAL QUESTIONS

1. Give two major difference between vertebrae of frog and fowl.

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2. How can you identify the bone of frog from that of fowl.

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3. What is the difference between Urostyle and Pygostyle.

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4. What is very peculiar in the following?

   i) Ninth vertebra of frog:

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   ii) Ribs of fowl:

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iii) First vertebra of fowl:

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5. Campare the bones of lower jaw of frog with those of the lower jaw of fowl.

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EXERCISE 34 MAMMALS : OBSERVATION AND CLASSIFICATION OF SPECIMENS

Structure

34.1 INTRODUCTION

Mammals are one of the most familiar groups of animals that we see around us. These belong to class Mammalia of back-boned animals (vertebrates). Mammals as you will recall from Unit 4, Block 1 LSE-10 course are a group of more than 4000 species which share intricate adaptations, extraordinary behavioral patterns and very complex societies i.e. they exhibit a vast range of complexity and diversity. Technically you can describe a mammal as:

'A group of animals with backbone whose bodies are covered with hair and who nurse the infants with milk secreted by special glands'.

Mammals are found all over the world and in almost all types of habitat. They have a big range of size from the largest blue whale to the very small hog-nosed bat. They can be found on the cold frozen arctic upto the hot equator, in snow clad mountains rising high on land to the very deep bottom of the ocean. This indeed is a remarkable group of animals. All these varying habitat that these animals inhabit call for a very large range of adaptations. These include besides the terrestrial life, adaptations for a life under water, for flying in the air, and for living in the trees. These diverse habitats have brought about many changes in the body form and function during evolution. In the present exercise you will study some important representatives of class Mammalia.

Objectives

After completing this exercise, you should be able to:

- identify and give the scientific as well as common names of specimens of **Duck bill platypus, Mole, Hedge hog, Shrew, Bat, Squirrel, Mongoose, Slender loris,**
- classify the identified genera upto the level of order .
- list characters justifying the classification of identified specimen and mention special features, if any
- mention habitat and geographical distribution of each genus
- draw a . labelled diagram of each identified mammal.

34.2 MATERIALS REQUIRED

1. Museum specimens of the following mammals:
   Ornithorhynchus (Duck bill platypus)
   Talpa (Mole)

Erinaceus (Hedge hog)
Sunchus murinus (Shrew)
Pteropus/Cynopterus (Bat)
Funambulus (Squirrel)
Herpestes (Mongoose)
Loris (Slender loris)

2. Laboratory manual
3. Laboratory record book
4. Pencil and eraser

34.3 GENERAL CHARACTERISTICS OF CLASS MAMMALIA

Some salient features of the class mammalia are given below:

i) Body is covered with hair.
ii) External ears or pinnae present with three ear ossicles (malleus, incus & stapes) in the middle ear.
iii) Two sets of teeth (milk teeth and permanent teeth).
iv) Exoskeleton includes horny spines, scales, claws, hoofs, nails, horns, dermal plates, etc.
v) Skin having oil glands, sweat glands and scent glands.
vi) Young are nourished on milk secreted by mammary glands.
vii) Enucleated and biconcave red blood corpuscles (RBC).
viii) Movable eyelids.
ix) A diaphragm separating abdominal and thoracic cavity.
x) Pelvic bones are fused.
xi) Lower jaw compound and with single bone dentary.
xii) Seven cervical vertebrae present.
xiii) Kidneys metanephric, ureters open into a urinary bladder.
xiv) Most animals viviparous giving birth to young ones.
xv) Endothermic and homeothermic.

34.4 CLASSIFICATION OF MAMMALIA

Mammalians are classified into three major sub-classes Prototheria, Metatheria and Eutheria. Eutheria has 19 orders which are listed below:

Class	-	Mammalia
Subclass	-	Prototheria (=Monotremata) (*Echidna*)
Subclass	-	Metatheria (=Marsupialia) (Platypus and other marsupialia)
Subclass	-	Eutheria (=Placentalia)
Order	-	Insectivora (shrews & moles)
Order	-	Macroscelidea (elephant shrews)
Order	-	Dermoptera (flying lemurs)
Order	-	Chiroptera (bats)
Order	-	Edentata (armadillo)
Order	-	Pholidota (pangolins)
Order	-	Tubulidentata (aardvark)
Order	-	Lagomorpha (hares & rabbits)
Order	-	Rodentia (rats & squirrels)
Order	-	Cetacea (whales, dolphins, porpoises)
Order	-	Proboscidea (elephants)
Order	-	Sirenia (sea cows, dugongs, manatees)
Order	-	Hyracoidea (hyracoids)
Order	-	Carnivora (cats, dogs, lions, bears, weasels)
Order	-	Artiodactyla (hoofed mammals, cattle, deer, goat etc.)
Order	-	Perissodactyla (horses, Zebra, rhinoceros, donkeys)
Order	-	Primates (monkeys, man)

34.5 STUDY OF SOME REPRESENTATIVE TYPES OF MAMMALS

In this exercise as you are already aware we have selected some examples of class mammalia for you in order to identify them and to know their special features, habit and habitat and geographical distribution. You are required to draw well labelled line diagram of each specimen.

34.5.1 *Ornithorhynchus*

Examine the specimen of *Ornithorhynchus* (Duck bill platypus) and observe the following features with the help of Fig. 34.1.

i) Dark brown back, light brown underside and rusty brown midline.
ii) Short, dense and waterproof fur covers the whole body except feet and bill.
iii) Light patch below eye/ear groove.
iv) Bill like that of a duck but soft. Used for locating food and finding way underwater. Richly supplied with nerves.
v) Cheek pouches having ridges.
vi) Fore feet with large webs and hind feet with small webs.
vii) Rear ankle has a spur which is hollow and is connected to a poison gland in the thigh.
viii) Tail broad and fat.
ix) Lays eggs (generally two in number).
x) Small eyes with nictitating membrane.
xi) Mammary glands without nipple.
xii) Cloaca present.

[Duck bill platypus is so called because of its bill which resembles that of duck. It is an egg-laying mammal. This animal has features that are borrowed from different groups like reptiles and mammals, etc.]

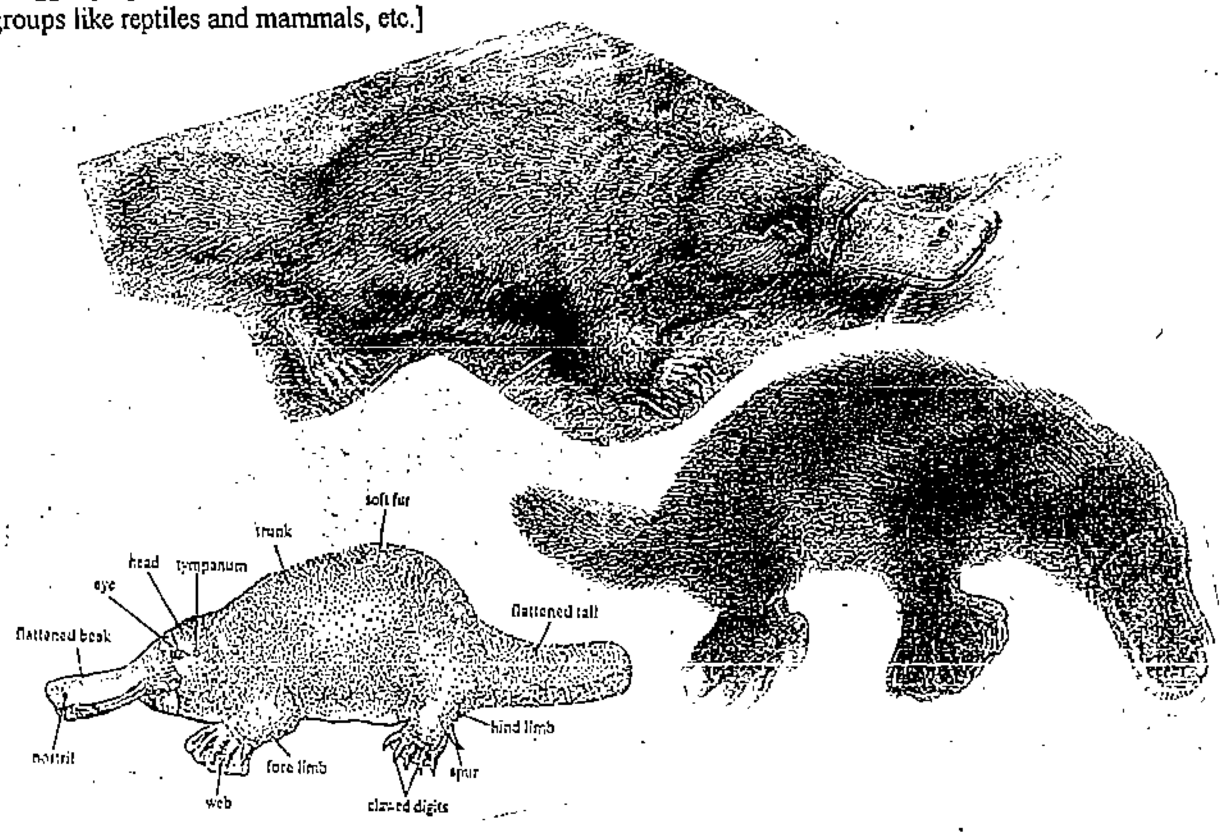

Fig. 34.1: *Ornithorhynchus* (Duck bill platypus).

Habit and Habitat

It lives in streams, rivers, and some lakes. Found in areas where banks are suitable for burrowing. Feeds mainly on bottom-dwelling invertebrates.

Geographical Distribution

East Australia, Tasmania

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Subphylum	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Mammalia**	Hairy skin, milkgland.
Subclass	**Theria**	Monotremata, egg-laying mammal.
Genus	***Ornithorhynchus***	
Common name	**Duck bill platypus**	

34.5.2 *Talpa*

Examine the specimen of Talpa (Mole) and note the following features with help of Fig. 34.2.

i) Head wedge-shaped with pre-nasal bone in the snout which extends beyond the lower lip.
ii) Eyes are rudimentary and pinnae are absent.
iii) Body covered with thick velvety fur.
iv) Tail sensory and devoid of hair.
v) Forelimbs characterised by short humerus embedded in the body.
vi) Extra sickle-shaped bone of carpus called radial seasamoid or falciform bone.
vii) Muzzle endowed with projections called 'Eimer's organs' which are probably sensory in nature.

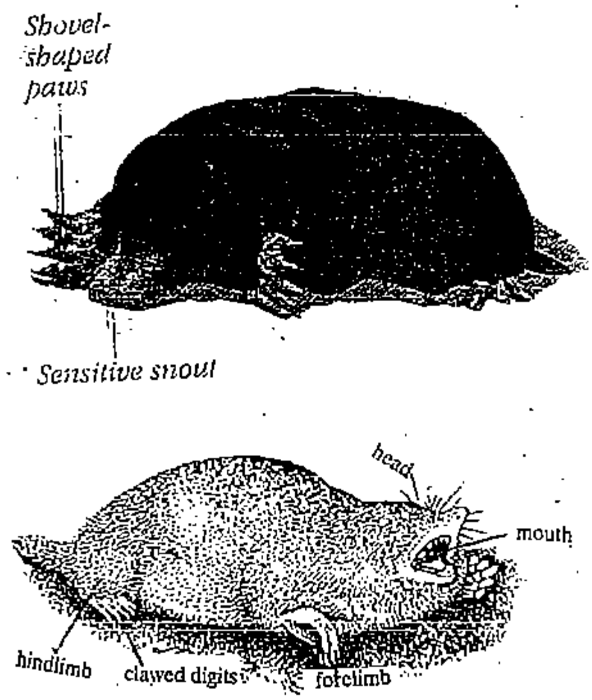

Fig. 34.2: *Talpa* (Mole)

Habit and Habitat

It lives in tunnels and is adapted for living under the ground.

Geographical Distribution

It is found in western Himalayas and eastern part of India.

Classification and its Justification

Kingdom	Animalia	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Subphylum	Vertebrata (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	Gnathostomata	Jaws and paired appendages are present.
Class	Mammalia	Hairy skin, milkgland
Subclass	Eutheria	Viviparous mammals
Order	Insectivora	Small cranial cavity and low grade brain
Genus	*Talpa*	
Common name	Mole	

34.5.3 *Erinaceus*

Examine the specimen of Erinaceus (Hedge hog) and note the following features with help of Fig. 34.3.

i) Body is covered with spines.
ii) Ventral side has fur.
iii) Band of muscle passes along the side and over the neck and base of tail for moving the spiny area in order to cover the whole body in a defensive posture.
iv) Head is small with a pointed snout and the tail is small.
v) Eyes are small and pinnae are short.
vi) There are five toes on each foot.
vii) Number of teeth varies from 36 to 44.
viii) Upper and lower first incisors larger than others. Lower incisors fit in the gap between upper incisors.

[The most special feature of hedgehog is that it curls into a ball of spine when threatened thus succeding in thwarting efforts of predators.]

Habit and Habitat

It is a nocturnal (active during the night) animals and is found hiding in bushes and dark holes during the day. It is omnivorous. Food consists of insects, fruits, worms, slugs and other small animals. When disturbed it rolls into a tight ball covered with spines. It lives in burrows. Each individual hedgehog has its own burrow. It hibernates in winters. Hibernation is dictated by climatic conditions and food availability. Young ones are born naked with the spines being under the skin.

Geographical Distribution

Found widely in northern hemisphere, Africa, India and West Indies.

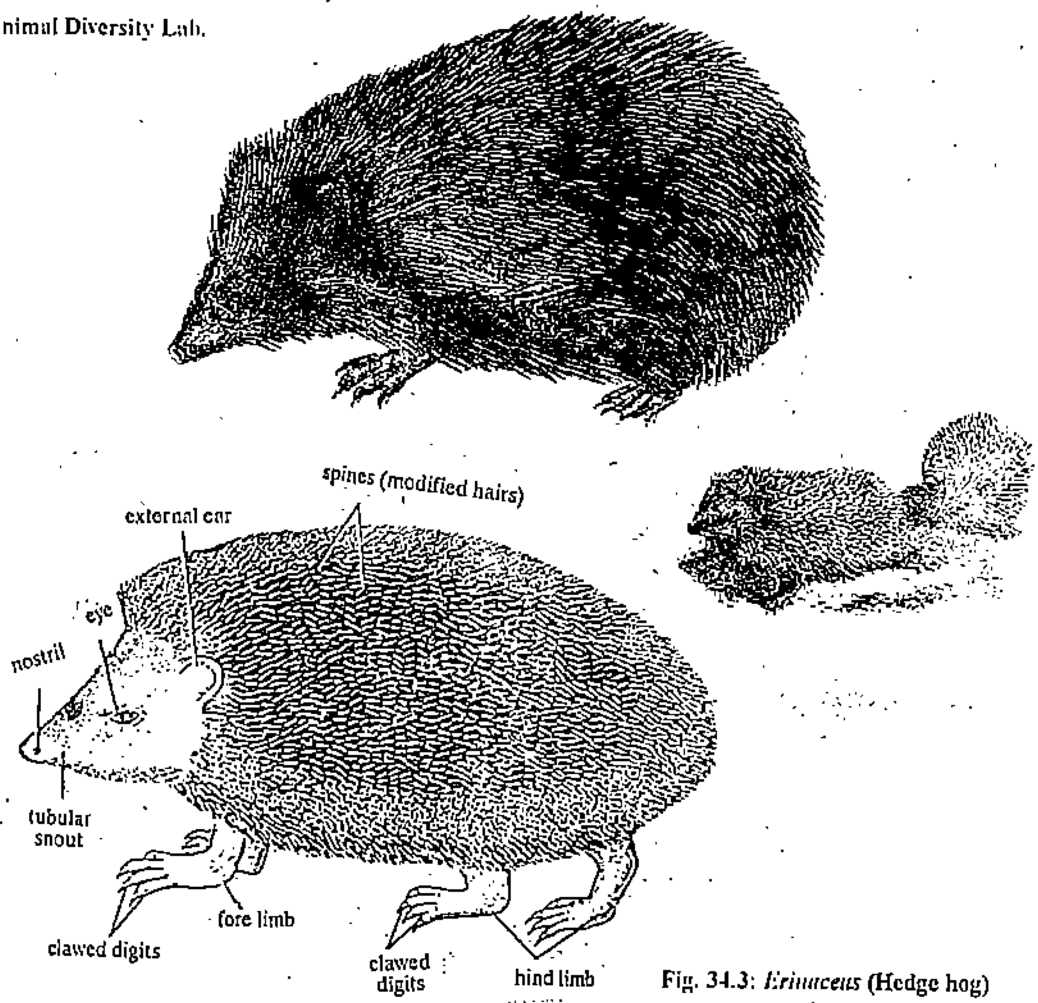

Fig. 34.3: *Erinaceus* (Hedge hog)

Classification and its Justification

Kingdom	Animalia	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Subphylum	Vertebrata (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	Gnathostomata	Jaws and paired appendages are present.
Class	Mammalia	Hairy skin, milkgland
Subclass	Eutheria	Viviparous mammals
Order	Insectivora	Small cranial cavity & lowgrade brain
Genus	*Erinaceus*	
Common name	Hedge hog	

34.5.4 *Sunchus murinus*

Examine the specimen of *Sunchus murinus* (Shrew) and note the following features with help of figure 34.4.

i) Body is covered with fur and has an elongated snout and tail.
ii) Small eyes and ears.
iii) First pair of incisor teeth is very long.
iv) Limbs with five claws.

v) Teeth are not replaced and hence wearing down of teeth leads to starvation and even death in some shrews.

vi) Most of the shrews show refection i.e. licking the anus. By this they are supposed to obtain trace elements and vitamin B & K.

vii) They show territorial behaviour.

[Pigmy shrew is the smallest mammal.]

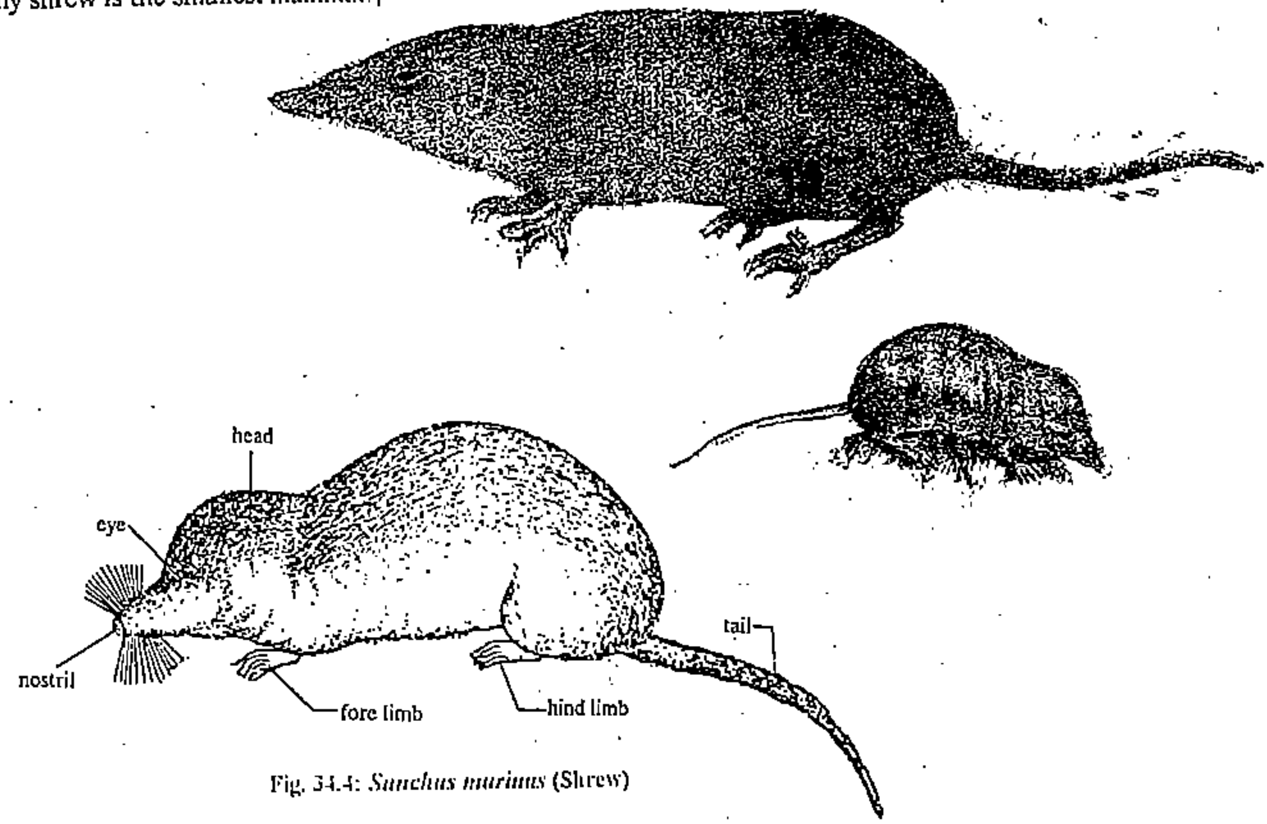

Fig. 34.4: *Sunchus murinus* (Shrew)

Habit & Habiat

It lives in burrows in gardens. It is found in places with human settlements. It is a carnivore and is active during night time. Feeds on insects and worms.

Geographical Distribution

Widely distributed common in Indian subcontinent but absent from Australia and parts of USA.

Classification and its Justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Subphylum	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Mammalia**	Hairy skin, milkgland
Subclass	**Eutheria**	Viviparous mammals
Order	**Insectivora**	Small cranial cavity & low grade brain
Genus	***Sunchus***	

Species *murinus*
Common name **Shrew**

34.5.5 *Pteropus*

Malayan flying fox *Pteropus vampyrus*, or large fruit bat is the world's largest bat which can attain a wing span of over 6 feet (1.8 m) and weigh well over two and a half pounds (1000 g). There are 7 subspecies of large fruit bat, and the most threatened being *Pteropus vampyrus lanensis* of philippines. The large fruit bat has a gestation period of approximately 180 days and gives birth to a single pup (two on rare occasion).

Examine the specimen of *Pteropus* (Bat) and note the following features with help of figure 34.5.

(i) Large sized animals. May have a wing span as large as 5 feet.
(ii) Body covered with soft fur.
(iii) Snout long and without nose leaf.
(iv) Ears are oval and widely separated.
(v) Tail absent.
(vi) Thumb and second digit clawed.
(vii) Tail membrane (Uropatagium) absent.

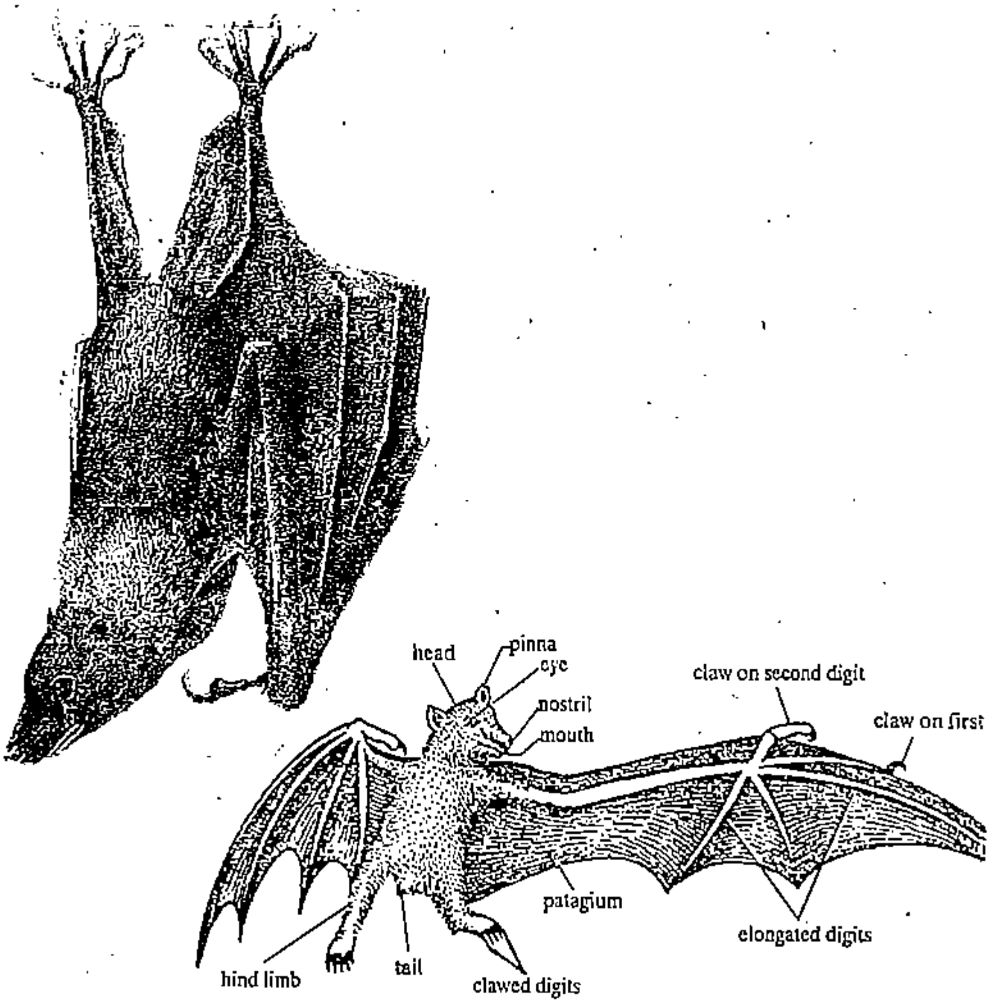

Fig. 34.5: *Pteropus* (Fruit bat)

[Bats exhibit the unique feature of echolocation in which they use high frequency waves emitted by them to find food and avoid obstacles in the dark. This system works like a sonar.]

Habit and Habitat

This animal is adapted to an arboreal mode of life. It is found hanging upside down on large trees during daytime and becomes active at night. Lives in groups.

Geographical Distribution

It is found in tropics and subtropics, Africa to East Asia and Australia.

Classification and its justification

Kingdom	Animalia	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Subphylum	Vertebrata (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	Gnathostomata	Jaws and paired appendages are present.
Class	Mammalia	Hairy skin, milkgland
Subclass	Eutheria	Viviparous mammals
Order	Chiroptera	Large fruit-eating bats; fore-limbs modified for flight; second and fifth digits greatly elongated, supporting the wing or flight membrane; hind-limbs weak, have five clawed digits; eyes small and vision weak; ears with large pinnae, teeth sharp; sternum has a keel; nocturnal.
Genus	*Pteropus*	
Common name	Bat	

34.5.6 *Funambulus*

Examine the specimen of *Funambulus* (Squirrel) and note the following features with the help of figure 34.6.

(i) Body bears three stripes of white and grey coat on dorsal side.
(ii) The ventral side and limbs have grey coat.
(iii) Eyes large and pinnae well developed.
(iv) Large chisel-like exposed incisors, canines absent.
(v) Limbs have five claws on digits and the elbow joint is capable of rotating.
(vi) Tail elongated and bushy.

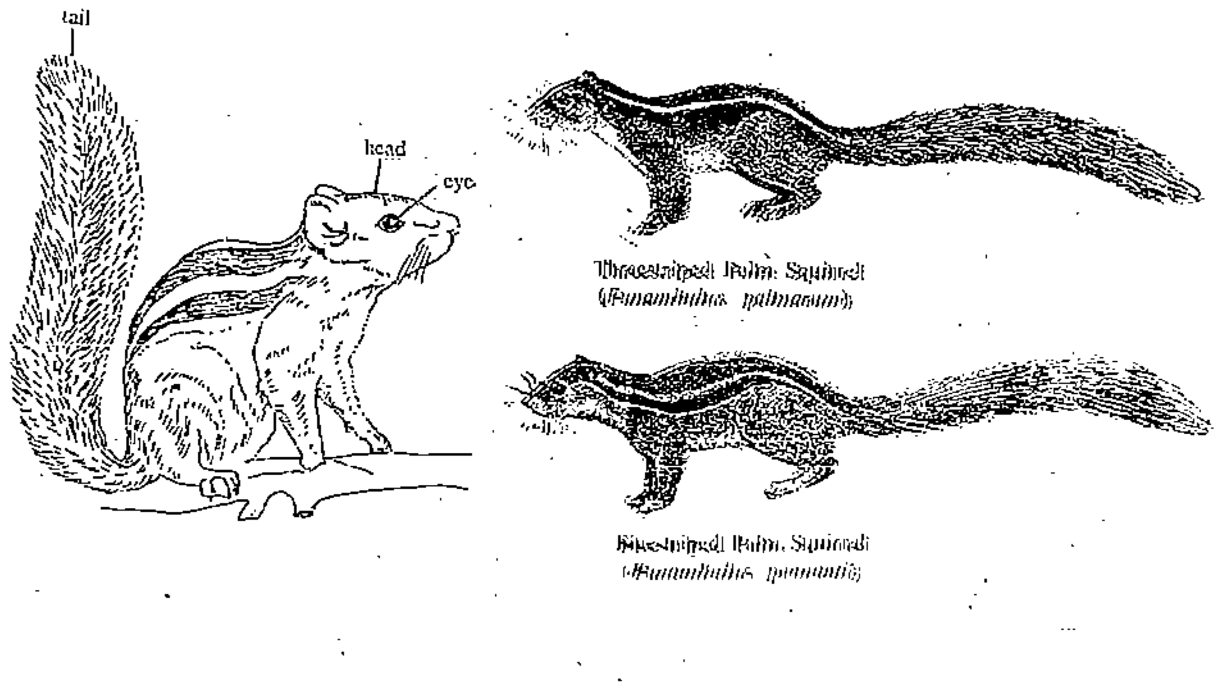

Fig. 34.6: *Funambulus* (Squirrel)

Habit & Habitat

It lives in trees and on ground. It is a diurnal animal feeding on fruits and seeds.

Geographical Distribution

Worldwide.

Classification and its justification

Kingdom	Animalia	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Subphylum	Vertebrata (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	Gnathostomata	Jaws and paired appendages are present.
Class	Mammalia	Hairy skin, milkgland
Subclass	Eutheria	Viviparous mammals
Order	Rodentia	*Chisel* like incisors, canines absent
Genus	*Funambulus*	
Common name	Squirrel	

34.5.7 *Herpestes*

Examine the specimen of *Herpestes* (Mongoose) and note the following features with help of figure 34.7.

(i) Body covered with short fur, blackish brown to gray in colour.
(ii) Feet darker than head and body.
(iii) Carnivore, feeds on snakes, small vertebrates, insects and occasionally fruits.
(iv) Teeth 34 to 40 in number.
(v) Well developed carnassial teeth to shear flesh.
(vi) Digits tipped by long non retractable claws adopted for digging.
(vii) Large anal sac with two glandular openings used for scent marking.

[In India, mongoose has long been associated with the folklore involving snakes as it is known to often attack and kill snakes. Some species stand in a group when threatened by snakes who due to their poor eyesight interpret them as one single large animal and thus avoid them.]

Habit and Habitat

It lives in burrows and is mainly nocturnal. It is mainly carnivorous and feeds on snakes, small vertebrates, insects and occasionally fruits.

Geographical Distribution

Africa, Arabia, India and Sri Lanka

Classification and its justification

Kingdom	Animalia	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	Chordata	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Subphylum	Vertebrata (Craniata)	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed;

		hepatic portal system present; blood containing R.B.C.
Superclass	Gnathostomata	Jaws and paired appendages are present.
Class	Mammalia	Hairy skin, milkgland
Subclass	Eutheria	Viviparous mammals
Order	Carnivora	Powerful canines, carnassial both to shear flesh
Genus	*Herpestes*	
Common name	Mongoose	

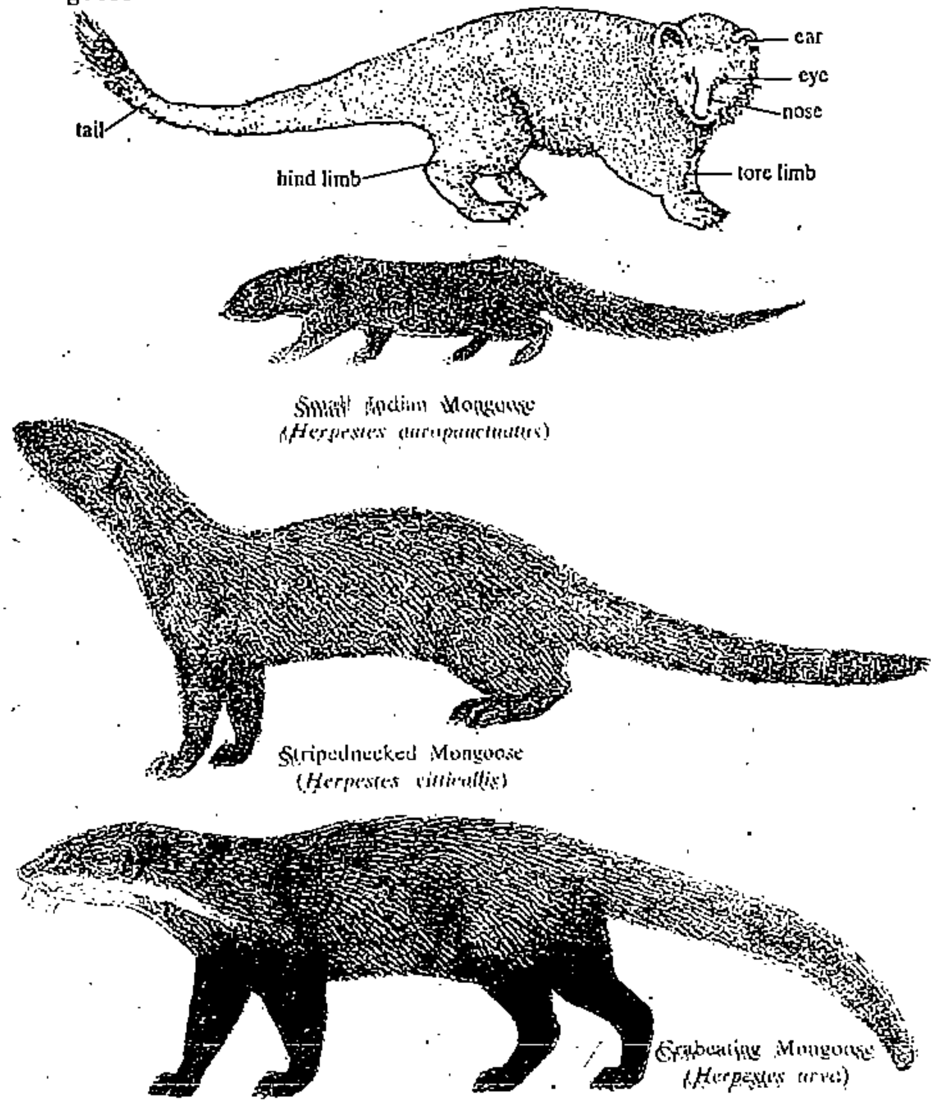

Fig. 34.7: *Herpestes* (Mongoose)

34.5.8 *Loris*

Examine the specimen of *Loris* (Slender loris) and note the following features with help of figure 24.8.

(i) Body is covered with grey reddish coat of hair.
(ii) Moist snout (as different from higher primates).
(iii) Face covered with hair.
(iv) Dental formula; I 2/2, C 1/1, Pm 3/3, M 3/3 = 36.
(v) External sexual organs visible.
(vi) Much reduced tail.
(vii) Short fingers having soft pads on the tips.
(viii) Eyes surrounded by black spots separated by narrow white line down to nose.

[These animals have some of the features which may be considered primitive like a transverse fold of skin on the abdomen of the female that might be a representation of marsupium.]

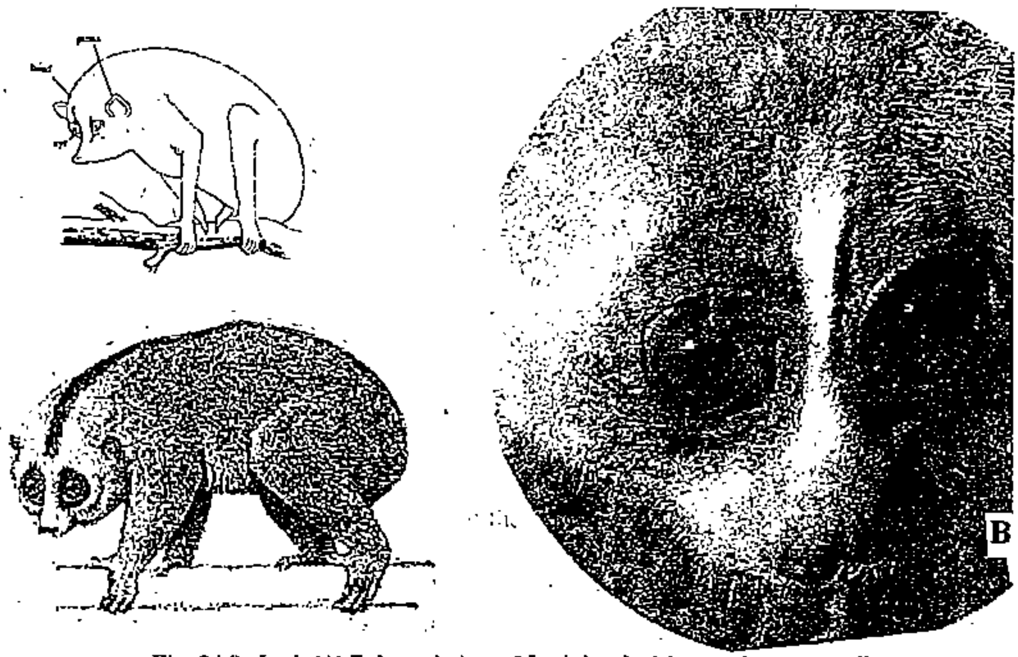

Fig. 34.8: *Loris* (A) Enlarged view of *Loris* head with prominent eyes (B).

Habit and Habitat

These animals are nocturnal and live on the trees.

Geographical Distribution

Found in Africa and Asia.

Classification and its justification

Kingdom	**Animalia**	Animals, multi-cellular organisms with cells that lack a cell wall, many capable of movement or movement of some of their body parts or capable of movement at some time of their life cycle; heterotrophic nutrition.
Phylum	**Chordata**	Dorsal tubular nerve cord, notochord and paired gill-slits are present.
Subphylum	**Vertebrata (Craniata)**	Notochord is replaced by vertebral column; two pairs of appendages; circulatory system closed; hepatic portal system present; blood containing R.B.C.
Superclass	**Gnathostomata**	Jaws and paired appendages are present.
Class	**Mammalia**	Hairy skin, milkgland
Subclass	**Eutheria**	Viviparous mammals
Order	**Primates**	Opposable thumb
Genus	***Loris***	
Common name	**Slender loris**	

34.6 TERMINAL QUESTION

1. Match animals given in column-I with their respective orders (given in column-II)

	Column-I Animal	Column-II Order
(i)	*Erinaceus*	*Chiroptera*
(ii)	*Herpestes*	*Insectivora*
(iii)	*Pteropus*	*Rodentia*
(iv)	*Funambulus*	*Carnivora*

2. Give two salient features of the following mammals.

   (i) *Ornithorhynchus* (iii) *Loris*

   (ii) *Talpa* (iv) *Pteropus*

EXERCISE 35 *RATTUS RATTUS* (Common Rat)-I : EXTERNAL FEATURES, GENERAL ANATOMY AND DIGESTIVE SYSTEM

Structure

35.1 INTRODUCTION

The common house rat, *Rattus rattus*, is the preferred animal type to understand the organization of the major systems in a mammal. The reasons: 1) easy availability, as it is common near human dwellings. 2) needs no maintenance for breeding since it breeds prolifically in the wild. 3) relatively easy to procure by fumigating the burrows. 4) cost effective and 5) being small it is easy to handle and dissect.

There is no need to fear contacting any infection, as you can be safe by washing your hands and nails well with soap and water followed by any suitable antiseptic.

You may initially feel a bit of aversion to handle a not too attractive animal like the rat. But soon, however, you will get over the feeling once you learn to appreciate its structural organisation.

Objectives

After completing this exercise you should be able to:

- describe the field characters of the common house rat
- distinguish between a male and a female,
- highlight those features that are exclusively mammalian,
- reason out why the rat is dissected from the ventral side,
- demonstrate your skill and neatness in pinning, dissecting and displaying – flag labelling the system concerned,
- describe the viscera and differentiate between the various organs by their form, colour, size and texture;
- identify the major subdivisions of the alimentary canal by comparing their appearance and size,
- identify and state briefly the functions of the various subdivisions of the digestive tract and the digestive glands,
- infer how many times longer the alimentary canal is with respect to the length of the body.

35.2 MATERIAL REQUIRED

1. Mature rats
2. Chloroform
3. Killing jar with lid
4. Dissection tray
5. Pins
6. Large beakers with water
7. Petridishes to collect discarded tissues
8. Cotton wool
9. Blotting sheets
10. Napkins
11. Dissection instruments
12. Any antiseptic solution
13. White paper
14. Black paper
15. Laboratory manual
16. Pencil and eraser

Note 1: You will be provided with a chloroformed rat that should be dead. If you find that it is still breathing, you can put some chloroform moistened cotton on its nostrils till the breathing stops.
Note 2: After the dissection is complete flag label the structures to be displayed. For this cut small pieces of white paper, write the name of the structure/organ and with the help of a pin insert it along its side in the dissection tray.
Note 3: After the dissection is over you must leave the area clean and place your instruments in neat order by the side of the tray. Being tidy in work will help you score better.

35.3 FIELD CHARACTERS OF RAT

Let us look at a rat first from its natural condition. See Fig. 35.1 where the labelling helps you with a gross description.

Form: elongate body, low placed i.e. a somewhat depressed head, pointed snout. The barrel-shaped body is carried by short legs; a long tapering tail covered with scales and scanty hair.

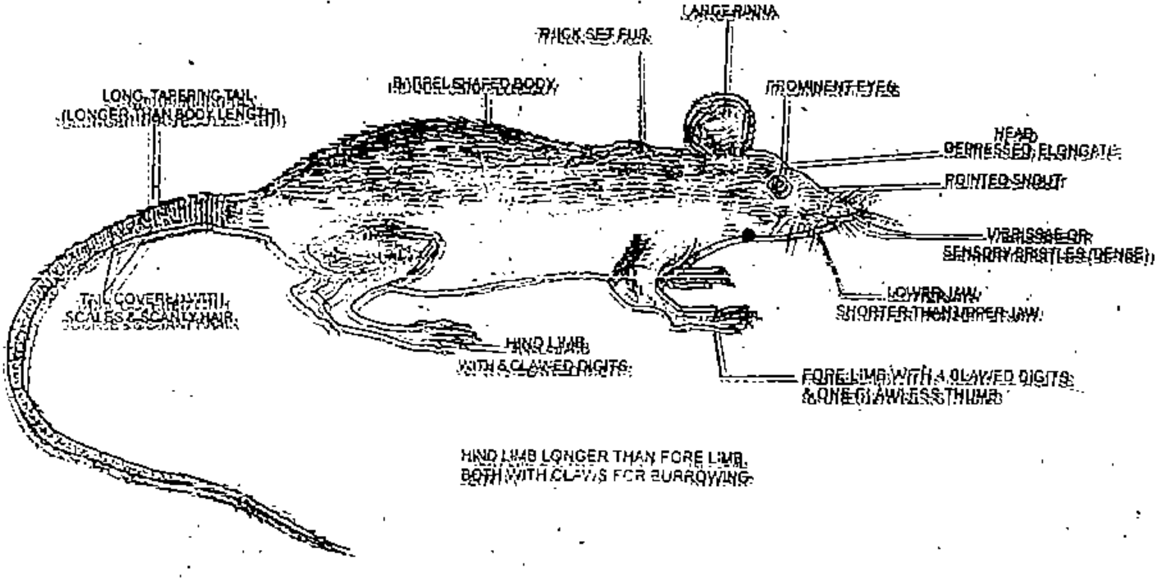

Fig. 35.1: Field characters of *Rattus rattus.*

Pelage (Hairy covering): the hair is a typical mammalian feature. The general body hair is thick set, somewhat coarse dorsally but soft ventrally. The hair on the snout or muzzle, called vibrissae, are specialised tactile organs.
Colour: the rat is a dirty ditch grey above (dorsal side) and a dull dirty white below (ventral side).
Size: it measures 18 to 21 cm from the tip of the snout to the base of the tail. The tail is longer than the body by one or two cm.

35.4 EXTERNAL FEATURES OF *Rattus rattus*

You have studied the external features of the rat from its dorsal side. Now turn the rat over to the ventral side. Lay it in the dissection tray. Straighten its limbs well out and pin down the palms and soles. Stretch the neck and straighten the head. Put two pins through the upper lip; this pinning is important as otherwise the neck of the rat tends to sag while you are working at its jaw region. With the help of Fig. 35.2 study the external features of the ventral side as described below.

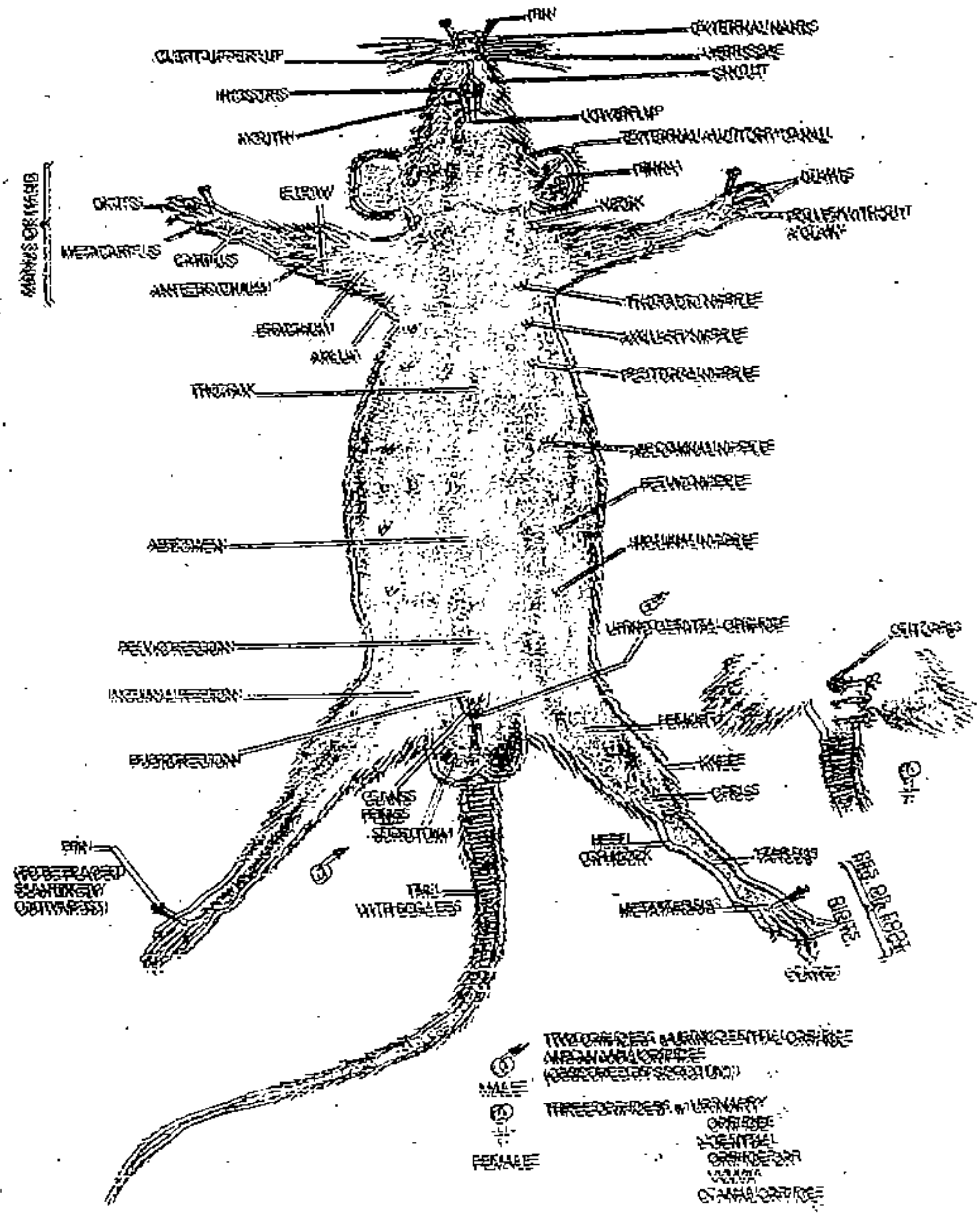

Fig. 35.2: External characters of *Rattus rattus* (Ventral view).

There are four basic divisions of the body – head, neck, trunk and tail.

35.4.1 Head

The low pointed head is a primitive mammalian feature. Let us observe in detail its structure along with the sense organs.

a) **Snout or muzzle**: as mentioned earlier it is pointed and bears the following structures –

   1. **External nares** – a pair of apertures shaped like commas in reverse and situated ventrally on a small rounded protrusion of the snout.
   2. **Mouth, jaws and lips** – the mouth opening lies ventral and is rhomboidal in outline due to the projections of the upper and lower incisors. The upper jaw is longer than the lower jaw. The lips do not cover the teeth and therefore the mouth remains open even when the jaws are closed. The upper lip is cleft.
   3. **Vibrissae or whiskers** – the snout is highly mobile and the rat feels the sides of burrows and holes with its whiskers. The **vibrissae** are long stiff sensory bristles highly sensitive to touch. They are arranged in four groups around the muzzle and jaws, beneath the chin, over the eyes and on the cheeks.

b) **Organs of special senses**: these are the eyes and ears for sight and hearing respectively.

   1. Eyes – situated dorsolaterally midway between the nostrils and the ears: guarded by eyelids and eyelashes. The position of the eyes provides for a wide-angle lateral vision.
   2. **External ears** – these are extensions of the auditory apparatus, functioning to concentrate and funnel in the sounds. They are unique mammalian features. Each ear consists of a semicircular lobe or **pinna** leading into a funnel or the **external auditory meatus**. The ear is placed at the top end of the head.

35.4.2 Neck

A short but extensible structure between the head and shoulders. It provides for free mobility of the head that is essential for it, to survey the environment.

35.4.3 Trunk

It is barrel-shaped and forms the main part of the body between the forelimbs and hind limbs. It is divisible into an upper **thorax** and a lower **abdomen**. Laterally, there are two mammary lines, each having a row of six teats or **mammae**.

a) **Thorax**: a narrow pyramidal structure, which feels hard on touching. The hardness is due to the ribs. It bears three pairs of teats – **thoracic, axillary** and **pectoral** named on basis of their location.

b) **Abdomen**: a broad portion soft to touch. It also bears three pairs of teats – **abdominal, pelvic** and **inguinal**.
   The teats, nipples or **mammae** are papilla-like small projections barely 2 or 3 mm long. They are similar in appearance in both the sexes, only slightly enlarged in a pregnant or lactating female. Their total number corresponds to the maximum number of young born in a litter.

c) **Limbs**: the limbs are relatively short in proportion to the body; the forelimbs are shorter than the hind limbs. Both limbs have a five-digit plan, i.e. they are **pentadactyl**. The tips of the fingers and toes, as well as the palms and soles, have thick cushioned pads or **plantar pads**. These avoid friction while running. The digits have long curved and sharp claws for clinging and burrowing.

   1. **Fore limbs**: there are three parts – the proximal part called upper arm or **brachium** (directed downwards from the shoulder); the middle part called fore arm or **antebrachium** (bent forwards at the elbow); a distal part called fore paw or **manus** in line with the fore arm and linked with it at the wrist or

carpus. The first digit, thumb or **pollex**, is highly reduced and clawless; the rest are long and well clawed.

2. **Hind limbs**: this also has three parts, a proximal part called thigh or **femur** (directed downwards from the hip); a middle part called shank or **crus** (bent backward from the knee); a distal part, hind paw or **pes** (directed forwards from the ankle, instep or **tarsus**). All the five toes are clawed.

d) **Pelvis, pubis and perineum**: **Pelvis**: the region below the abdomen and below the hips. **Pubis**: the region below the pelvis lodging the urinary and genital apertures. **Perineum**: the area between the genital aperture and the anus. The anus lies just in front of the base of the tail. The other two apertures differ in the male and female forming the parts of the **external genitalia**. The external genitalia are the only sexually dimorphic character.

1. **Female external genitalia**: there are the three apertures, urinary, genital and anal seen in that order. A small pinkish conical projection, the **glans clitoris**, overlies the urinary aperture. The genital aperture in the middle is not open, but appears as a pit or depression in an immature rat. In a mature rat the opening is wide. The distance between the genital and anal opening is very short.
2. **Male external genitalia**: there are only two apertures, a common urinogenital aperture and the anal aperture. The perineal skin forms a pouch or scrotum with scanty hair and wrinkled appearance. It lodges the male gonad or **testis**. Above the scrotum lies a small projection, the **glans penis**, at the base of which is a combined urinogenital opening. The penis or male intromittent organ is a tube-like structure withdrawn as an S into a sheath and therefore not immediately visible. The ano-genital distance is longer in the male.

35.4.4 Tail

It is an extension of the body beyond the anus. It is abruptly narrow, long and tapered. Close observation reveals neat transverse rows of small overlapping scales. The hair is scanty and seen here and there between the scales. The scales speak of the reptilian descent of mammals.

35.5 GENERAL ANATOMY OF *Rattus rattus*

The study of the general anatomy concerns knowing the layout plan of the various organs and organ systems in their natural or *in situ* position. It helps you to understand the organisation and the interrelationships of the visceral organs.

Note 1: The rat is dissected from the ventral side as most vertebrates are. The reasons a) the bony and hard backbone or vertebral column is a major hindrance and difficult to cut through; b) the major blood vessels (aorta and posterior vena cava) are situated dorsally and they are quite likely to get punctured if the rat is opened from the dorsal side; c) the heart and lungs are likely to get damaged before the digestive system is reached; d) most visceral organs are held by mesenteries (the visceral or peritoneal membrane) to the dorsal wall of the body cavity.
Note 2: As the rat is pinned with the ventral side up, there is a lateral reversion of the left and right sides between you and the animal. **Remember, when we say left or right side, we refer to the animal's left or right and not ours.**

35.5.1 Procedure for Dissection and Display

You have already pinned the rat to the dissection tray to study the external features. Now we will have to make incisions in the skin and muscle and pin them up so as to expose the viscera.

SKIN

a) Incision

1. Hold the skin up in the pubic region and make a small V cut in the middle. From this point proceed to cut straight forward medially right up to the lower lip.

2. The skin is held to the muscle by a whitish layer of adipose tissue or fascia. Releasing the skin from the muscle requires no use of the scalpel, as mere pulling suffices.
3. Repeat this procedure with the flaps of skin on the jaws, neck, arms and legs.

b) Pinning

1. Pin the edges of the skin flaps firmly down at the points indicated in the figure. **Note that the pins always be driven deep and tilted outwards.**

MUSCLES

a) Incision

1. Give a median straight cut from the pubic area upto the upper part of the abdomen.
2. As you reach the rib-cage, hold it up with a pair of blunt forceps and cut along the sternum medially. You can thus be sure that you do not puncture the heart and mess up your work. For this you must insert the blunt ended blade of your large scissors under the sternum and then make the incision.
3. Progress further with the median incision up to the jaw muscles to expose the trachea.
4. Cut the muscles along the length of the arms and legs.

b) Pinning

1. The muscle flaps on either sides of the body can be pinned along with the skin.
2. Remove and readjust the pins on the skin to do so.
3. The muscles of the jaws, neck, arms and legs do not need any pinning as most of them can be teased or removed.

RIB CAGE

Procedure to expose the thoracic viscera

1. Look below the last rib. You will be able to see a thin transparent and dome-like membrane stretching across the body cavity. This is the diaphragm that separates the thorax from the abdomen and facilitates breathing. It is a structure special to mammals.
2. Make slight cuts on the sides of the membrane to release it from the ribs. **Do not remove the diaphragm.**
3. Trim the left and the right set of ribs as close to the dorsal side as possible and discard the pieces. This leaves you free to work into the thorax. Be careful as you near the clavicle and the first rib. Do not cut too close here as the jugular veins pass just below.

There is nothing much by way of display as we are to understand the general layout plan of the organs in their natural positions.

35.5.2. Description of the Viscera

Let us now look at the plan of the visceral organs with minimal shifting and disturbance to the structures. You must have the diagram as shown in Fig. 35.3 by the side to match the labelled parts with the description below.

Jaw and Neck Region: Look at the region over and below the strong jaw muscles and note the following structures –

1. **Salivary glands**: there are three of them, creamish and spongy in appearance
   a) sub-maxillary gland-largest and close to the mid-line,
   b) sub-lingual – smaller and anterolateral to sub-maxillary,
   c) parotid – smaller and somewhat flat, lying ventrolaterally lower to the other two.

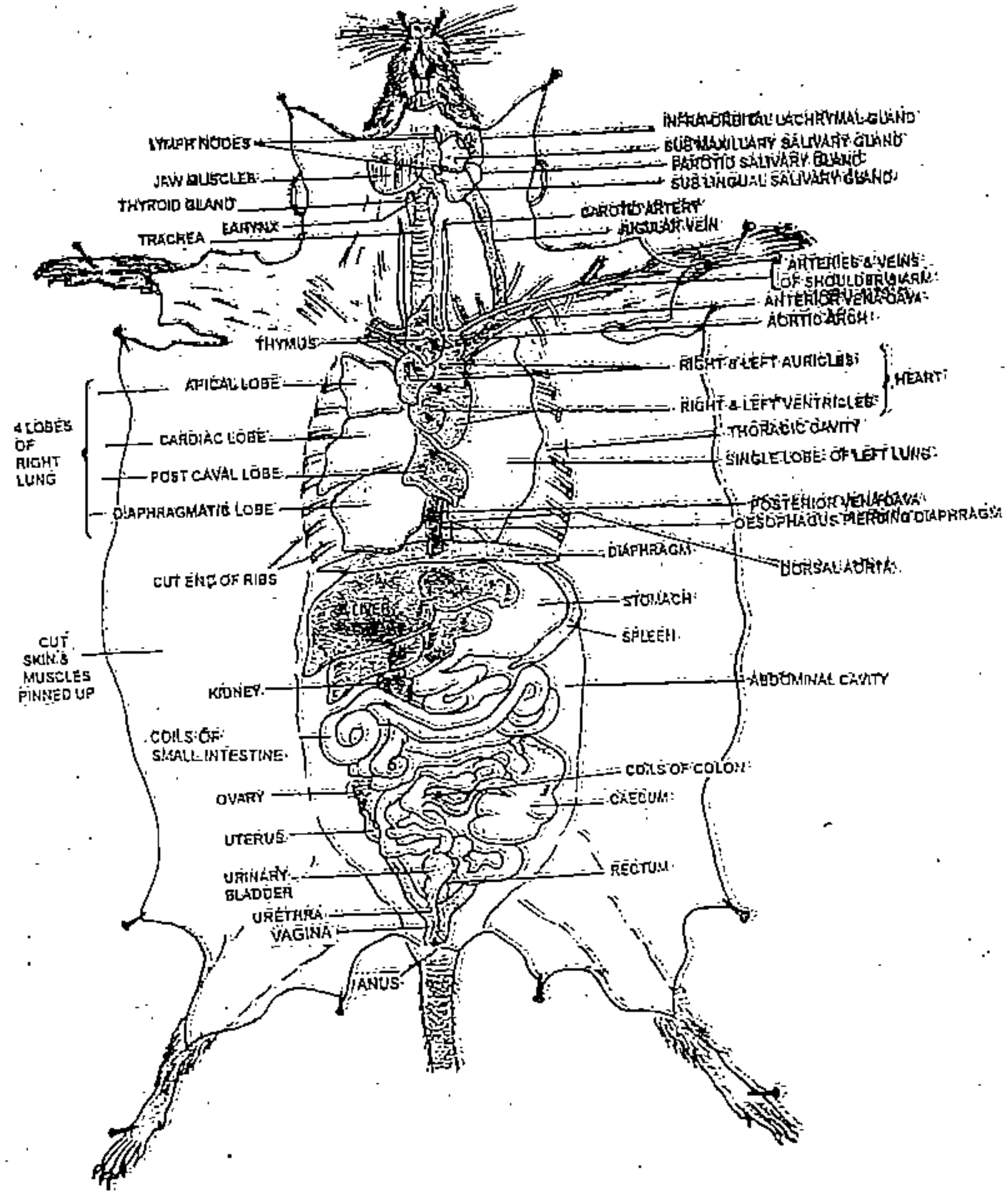

Fig. 35.3: General anatomy of *Rattus rattus*.

2. **Lymph nodes**: there are three to four of them scattered between or laying over the salivary glands. They are small, smooth, ovoidal and muddy-coloured structures quite different from the salivary glands.
3. **Lachrymal gland**: An elongate, flat smooth walled structure anterior to the sub-maxillary salivary gland is the infra-orbital lachrymal gland.
4. **Trachea**: it is a thin-walled tube marked by rings of cartilage. It runs through the entire length of the neck, at the end of which it divides into two very short primary bronchi.
5. **Larynx**: seen at the beginning of the trachea, it is a widened cartilage covered structure masked by the thyroid gland.
6. **Thyroid gland**: this is an H-shaped, brick-red coloured gland.
7. **Oesophagus**: this is not immediately visible; therefore shift the trachea slightly to the side. It is seen as a long, thin and smooth-walled tube.

Thoracic Viscera: The two prominent structures are the heart and lungs. The oesophagus also lies in the thoracic cavity but can be seen only when the lungs are removed.

1. **Heart:** lies in the middle of the thoracic cavity; the ventricles are large, conical and tilted with the apex pointing to the left side (not yours but the rat's!). The two ear-like flaps above the ventricles are the auricles or atria (singular: atrium). The heart is covered over by a thin-walled, transparent pericardium. An oblique groove running over the ventricle demarcates the left from the right ventricle.
2. **Thymus gland:** Look above the auricles – the thymus gland is seen as a shiny, translucent, white flap. You can miss if you have ruptured some blood-vessels.
3. **Aortic arch and anterior vena cava** (plural: venae cavae). You have to remove the thymus gland and the pericardial membrane. Be careful not to puncture the heart. With a finger gently pull the heart down. The aortic arch is seen as a greyish prominent vessel rising up and looping down to the left. This is the major artery. On either sides of the auricles you can see two large vessels, purplish-red in colour. These are the left and right anterior venae cavae or major veins.
4. **Lungs:** Lie one on each side of the heart. Each lung is a very bright, flesh-pink coloured structure with a rather cheesy texture; a) left lung – this is a single undivided organ; b) right lung – this has four lobes: anterior, middle, posterior and post-caval lobes, also called apical, cardiac, diaphragmatic and post-caval lobes respectively.

Abdominal viscera: Mainly consists of the alimentary canal and associated structures. Start looking for the following structures from below the diaphragm.

1. **Liver:** Large, deep-brick coloured and made of several flap-like lobes. It occupies most of the upper and right part of the abdominal cavity covering the stomach like a hood.
2. **Stomach:** The liver lobes have to be lifted and pushed up to see the stomach below. It can be seen as a large, curved sac-like structure occupying most of the upper and left part of the abdominal cavity.
3. **Spleen:** Gently lift the wide outer curvature of the stomach. You can see a dark brick-red coloured long structure embracing the outer curvature of the stomach. It is of the same colour and texture as the liver.
4. **Intestines:** The coils of the duodenum and the small intestines occupy all of the middle part of the abdominal cavity. You will learn more about the subdivisions of the small intestines while dissecting the digestive system.
5. **Pancreas:** It is a curdy, white diffuse structure not immediately visible until the coils of the intestines are unwound. It occupies most of the mesenteries, the membranes holding the coils together.

Pelvic Viscera: The pelvic area lies below the abdominal cavity and corresponds to the hip region. It harbours the following structures:

1. **Caecum:** This is a large blind pouch at the terminal end of the small intestines. It takes prominence in the pelvic hiding other structures below it.
2. **Colon:** Emerging from the caecum is a long, narrow and coiled structure. It is a part of the large intestines.
3. **Rectum:** It is a short straight tube which is the terminal part of the large intestines. It opens out at the anus.
4. **Kidneys:** These are completely hidden by the loops of the alimentary tract. You have to shift the tract to the left to see them. Each kidney is bean-shaped and coloured like the liver. The right kidney is higher in position by 1.5 to 2 cm from the left kidney.
5. **Gonads:** The female gonads or ovaries and the gonoducts (fallopian tubes and uterus) lie immediately below the kidneys. The male gonads or testes are not seen in a corresponding position as they are extra-abdominal and lying in a scrotal pouch. The male reproductive glands, however, are seen in the pelvic/pubic area.

You will learn more about this in detail while dissecting the male and female urinogenital systems.

35.6 DIGESTIVE SYSTEM OF *Rattus rattus*

The digestive system consists of two divisions: the alimentary canal or tract, which moves and processes the food and the digestive glands, which provide the enzymes.

35.6.1 Procedure for Dissection and Display

By the time you finish the exercise on the general anatomy, the blood in the heart and vessels would have somewhat clotted. This is just as well for we need to remove the heart, lungs and trachea and this can thus be done with minimal bleeding. Follow the steps given below and compare with the Fig. 35.4 as you go on.

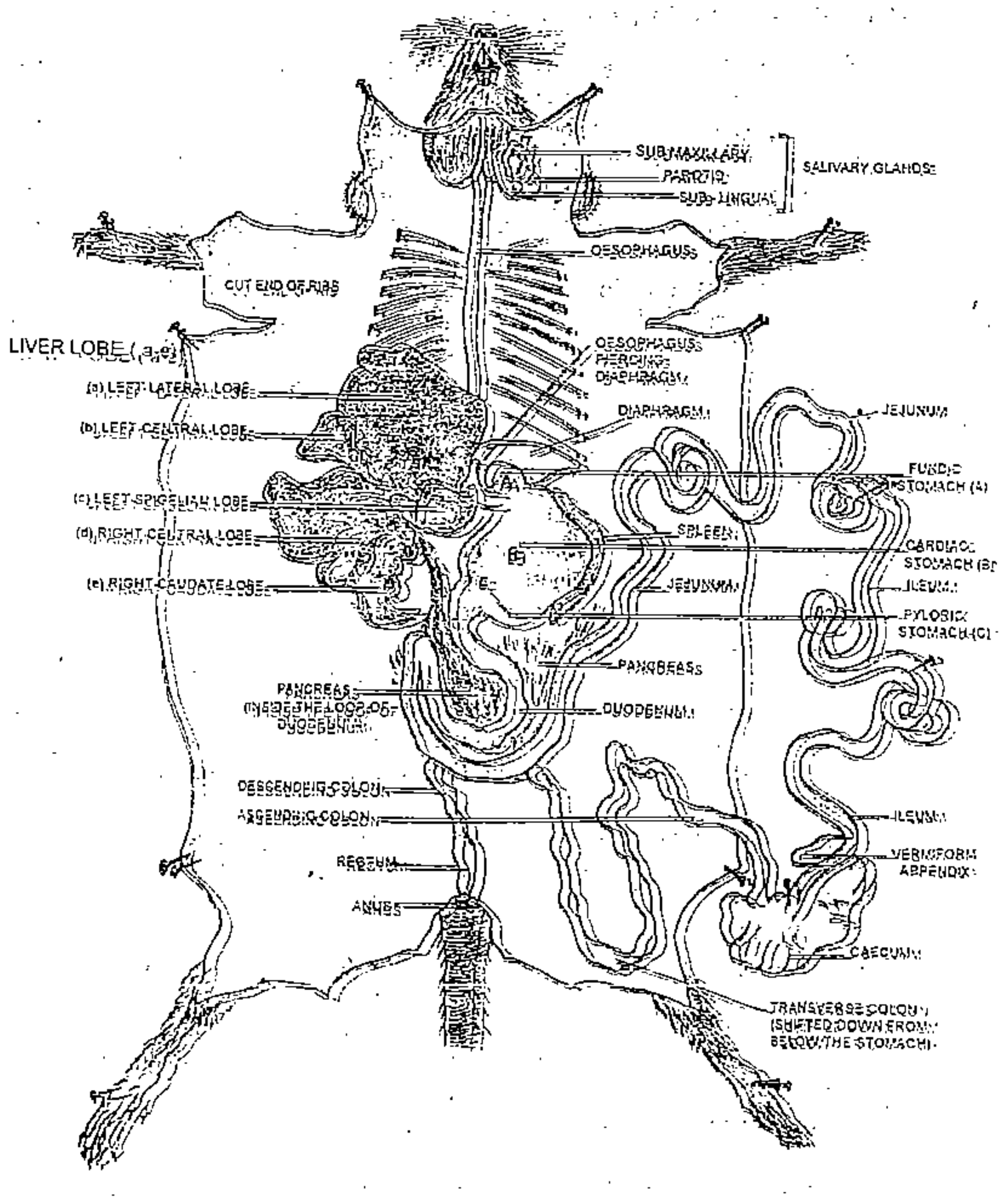

Fig. 35.4: Digestive system of *Rattus rattus*.

NECK AND THORACIC CAVITY

The dissection in this region mainly concerns the display of the **oesophagus**. The oesophagus functions to lubricate and transport the food from the mouth to the stomach.

1. Recall that the heart, lungs and trachea hide the oesophagus. Therefore, they all need to be removed. With the fingers of one hand (DO NOT USE ANY FORCEPS), hold up the lungs and heart in a single bunch and cut away. Cut the trachea as well and discard them all. DO NOT CUT THE DIAPHRAGM. This step exposes the long, narrow oesophagus.
2. Some bleeding is bound to occur as the clotting is only partial. To clear this mess, do the following – drain out all the water; put a dry wad of cotton or cloth to mop up the blood; repeat with fresh cotton/cloth until the bleeding is controlled; take the tray to the tap, letting the water run over the bleeding point. Fill the tray with fresh water and settle down.
3. You have already located the oesophagus in the neck below the trachea. You can now see it continuing all through the thoracic cavity and piercing the diaphragm.

ABDOMINAL AND PELVIC CAVITIES

1. As the oesophagus emerges from the diaphragm in the abdominal cavity, it seems to insert itself into the large bag of the stomach.
2. Most of what lies in the abdominal and pelvic cavities have been described in the section on general anatomy. Since you are familiar with the description, our next step is to proceed to uncoil the loops of the alimentary tract. This will help you to know the various subdivisions of the intestines, as well as their lengths and limits.
3. Display of the liver: You already know that the liver occupies most of the upper and right part of the abdominal cavity. Lift the flaps of the liver lobes and spread them on the upper right side. They basically fall into a left and a right subdivision. Arrange the lobes as indicated in the figure. You can see that the smaller lobes are held together by peritoneal membrane. Separate them and note the following structures: right side → two lobes, a medium-sized **central lobe** and a somewhat curved smaller **caudate lobe**; left side→ three lobes, a small **central lobe**, a large **lateral lobe** and a very small caudate or **spigelian lobe**.
   There is no gall bladder in rats.
4. Display of the **stomach**: The stomach functions in grinding the food to a paste or chyme and begins with the digestion of proteins. It has a high acid content. Having shifted the liver, the stomach reveals itself in full shape. You can see it as a huge, C-shaped sac with a wide curvature at the outer and left side. Look at the point of entry of the oesophagus and above it. A small peg-like projection above is the fundus or upper part of the stomach. The large pear-shaped body with a wide outer curvature and a shallow inner curvature is the **cardiac** part of the stomach. The narrow funnel-like terminal part is the **pyloric** end of the stomach, which leads to the intestines.
5. Display of the **small intestines** and **pancreas**: The small intestines function in further digestion and absorption of the food. The pancreas provides the alkaline medium and enzymes for the same. They also secrete hormones to facilitate the liver function.
   The small intestine begins as an abruptly narrow tube from the stomach. It is the longest part of the alimentary tract and divisible into three parts – duodenum, jejunum and ileum. The limits of these parts are not so well demarcated. They are histologically more different than externally so. You have learnt about it in LSE-10 on Animal Diversity.
   a) **Duodenum**: The first part of the small intestines, it forms a long U-shaped loop; it lodges within its curve the pancreas which will be described later.
   b) **Jejunum**: The middle part of the small intestines, it begins at the end of the U-turn of the duodenum as a slightly wider tube. It is long and coiled; the coils are held together by large sheets of folded mesenteries (the thin peritoneal membranes attaching the alimentary canal dorsally to the body wall) which need to be gently separated. As you do so, you can begin to see the pancreas.

c) **Ileum**: The last part of the small intestines, it begins at some point where the jejunum very slightly narrows down. This demarcation is not exact. The ileum too is very complexly coiled. Uncoil the loops gently. USE ONLY YOUR FINGERS TO RELEASE THE MESENTERIES. Having dissected open the small intestines, spread them out of the body cavity to the left and pin to display.

d) **Pancreas**: it is the most diffuse (widespread) organ in the body. Curdy white in appearance, it begins at the duodenal loop and spreads its dendritic branches extensively in the mesenteries. AS YOU UNCOIL THE LOOPS OF THE INTESTINES, THE PANCREAS SEEMS TO TEAR APART AND LOSE ITS IDENTITY. OBSERVE IT IN THE PROCESS OF UNCOILING AND GATHER WHAT IS LEFT OF IT CLOSE TO THE DUODENUM. You will also notice that there are several branches of blood vessels in the mesenteries; some of them may rupture and bleed. Mop up the blood with cotton or cloth.

6. Display of the **large intestines**: The large intestines function to absorb water from the undigested contents and transport the faecal matter outside. It has three distinct parts – the caecum, colon and the rectum.

   a) **Caecum**: It is a blind large pouch at the junction of the end of the ileum and the beginning of the colon. It looks like a huge wrinkled bean seed or a swollen worm. Its pointed conical end is the **vermiform appendix**.

   b) **Colon**: It is a long, narrow and coiled tube; about half the length of the ileum but wider. It looks knotted at intervals because of the pellets of faecal matter. The colon has three subdivisions. The first or **ascending colon** moves anteriorly forward from the caecum up to the liver, here it bends at right angles to the left to form the second portion or **transverse colon**. Near about the stomach, it bends downwards to form the **descending colon**. THE UNCOILING OF THE COLON SHOULD BE DONE GRADUALLY SO AS TO NOTE THE ARRANGEMENT OF THE THREE PORTIONS. AFTER TOTAL UNCOILING, THESE PORTIONS GET DISLODGED AND YOU CANNOT IDENTIFY THEM.

      Display the colon along with the caecum as you have done with the small intestines.

   c) **Rectum**: It is a dark grey short and straight tube lying in the lowest portion of the pelvic cavity. It opens outside by way of the **anus** to void the faecal matter.

   FINAL DISPLAY

   For the final display, change the water, remove the pins holding the intestines and the colon and layer a long strip of black paper below them. Repin. Also line the oesophagus and stomach below with black paper. Flag label these organs.

35.6.2 Length of Alimentary Canal

Given below is the measurements taken of each region of the alimentary tract from one rat. This rat measured 21 cm from the snout to the base of its tail. These measurements are not absolute values; they only serve the purpose of understanding the relative proportions of the parts concerned.

Oesophagus	-	8.5 cm
Stomach (Outer curvature)	-	7.0 cm
Duodenum	-	8.5 cm
Jejunum	-	33.5 cm
Ileum	-	58.0 cm
Colon	-	27.0 cm
Rectum	-	2.5 cm
Total length	-	145.0 cm

* The small intestines i.e. the duodenum, jejunum and the ileum together measure 100.0 cm or 1.0 metre! This is longest portion of the alimentary tract.
* The total length of 145.0 cm is approximately 7 times as long as the total body length of 21.0 cm. This helps us appreciate how compactly packaged a long structure is within a small space.

35.7 TERMINAL QUESTIONS

1. What are the following structures adapted for?
   i) Vibrissae..
   ii) Claws...
   iii) Plantar pads...

2. Fill in the blanks.
   i) The pollex lacks a ....
   ii) The ano-genital distance in the females is .... than in males.
   iii) The nature and arrangement of hairs on the body is called ....

3. State whether the following structures in the rat are mammalian or reptilian.
   i) Hair ....
   ii) Claws ....
   iii) Scrotum ....
   iv) Pinna ....
   v) Scales ....
   vi) Mammae...................................

4. Make a neat labelled drawing of your dissection of digestive system.

5. Mention the location of the following.
   i) Pyloric end ....
   ii) Vermiform appendix ....
   iii) Lymph nodes ....
   iv) Trachea ....

EXERCISE 36 *RATTUS RATTUS* – II : THE CIRCULATORY SYSTEM

Structure

36.1 INTRODUCTION

The circulatory system as you will recall from Unit 8, Block 2, LSE-10 begins at the heart with the aorta or the main trunk artery and ends at the heart with the anterior and posterior caval veins or the major veins. The arterial system is constituted of the aorta and all its major and minor branches carrying oxygenated blood away from the heart and supplying it to various organs and tissues. The venous system is constituted of small veins collecting deoxygenated blood from all the organs and tissues; these veins unite to form larger veins, all of which ultimately drain into the caval veins returning the blood to the heart.

The blood in the veins is physicochemically different from that in the arteries. Basically, it is low in O_2 and high in CO_2. Thus the veins appear deep purplish-red in colour as compared to the bright scarlet-red colour of the arteries. Other differences are tabulated below. It should help you to distinguish easily between the arteries and veins.

VEINS	ARTERIES
1. Are generally larger in diameter. For example, the jugulars in the neck.	1. Are generally narrower in diameter. For example, the carotids in the neck.
2. Being thin-walled, they are collapsible. If you press a vein for some time, it blanches, because the blood moves away and gets dammed elsewhere.	2. Being thick-walled, they are not collapsible. Pressing an artery does not blanch it as the blood in it flows rapidly and under great pressure.
3. Many large veins are quite superficial and most of them require a minimal clearing of tissues to expose them.	3. Almost all arteries are deep-seated. It is necessary to remove most of the veins as they mask the arteries.
4. Since the blood in veins moves towards the heart, smaller or contributory veins unite to form larger veins.	4. Since the blood in arteries moves towards the heart, a large artery is said to branch into smaller arteries.

In the present unit you will be expected to dissect a rat in order to display and flag label its venous and arterial systems. The dissection of these two systems will help you to know the basic plan and names of the components of circulatory system of the rat, as well as most mammals.

Objectives

After completing this exercise you should be able to:

- dissect and flag label both the arterial and the venous systems,
- distinguish between arteries and veins by their colour, texture and appearance,
- demonstrate the similarities and differences in the organisation of the two systems,
- relate the names of arteries/veins to their respective organs of supply/drainage,
- draw a well-labelled diagram of both the system.

36.2 MATERIAL REQUIRED

1. Mature rats (*Rattus rattus*)
2. Chloroform
3. Killing jar with lid
4. Dissection tray
5. Pins
6. Large beakers with water
7. Petri dishes to collect discarded tissues
8. Cotton wool
9. Blotting sheets
10. Napkins
11. Dissection instruments
12. Any antiseptic solution
13. White and black paper
14. Flag labels
15. Hand lens
16. Laboratory manual
17. Pencil and eraser

36.3 THE VENOUS SYSTEM OF *Rattus rattus*

Points to Remember

1. In your first attempt at dissection, the venous system must be attempted prior to the arterial system. The reason – veins are more superficial and are visible without the need to remove the arteries.
2. DO NOT PERFORM THE DISSECTION OF VEINS UNDER WATER. If you do, you will soon lose sight of some of them as they blanch (lose colour). This dissection can easily be done without water. DO KEEP WET COTTON WADS OVER THE EXPOSED VEINS.
3. For display flag label the major veins.

36.3.1 Procedure for Dissection and Display

For your convenience, the procedure has been divided part-wise such that each part when completed can be covered with wet cotton. You can also take a short break between completing one part and beginning the next. Don't take too long as the rat is drying up! Take the guidance from Fig. 36.1.

36.3.2 Veins of Jaws and Neck

1. Just after cutting open the skin (Refer to subsection 35.5.1) and pinning it, you can see a prominent vein bulging on either side of the neck. This is the **external jugular vein**. We expose this vein and its contributories first. Select any one side for your work.
2. With a pair of fine forceps, tease the muscles and membranes carefully over the veins. Follow the course of the vein from the figure as you do so.

3. Remove the lachrymal gland, salivary glands and lymph nodes in the jaws to see the four contributory veins (two of the **anterior facial** and two of the **posterior facial**) uniting to form the external jugular.
4. At the outer margin down the neck, the external jugular receives an **anterior jugular vein.**
5. Clear the external jugular down upto the point where it is seen to enter the rib cage.

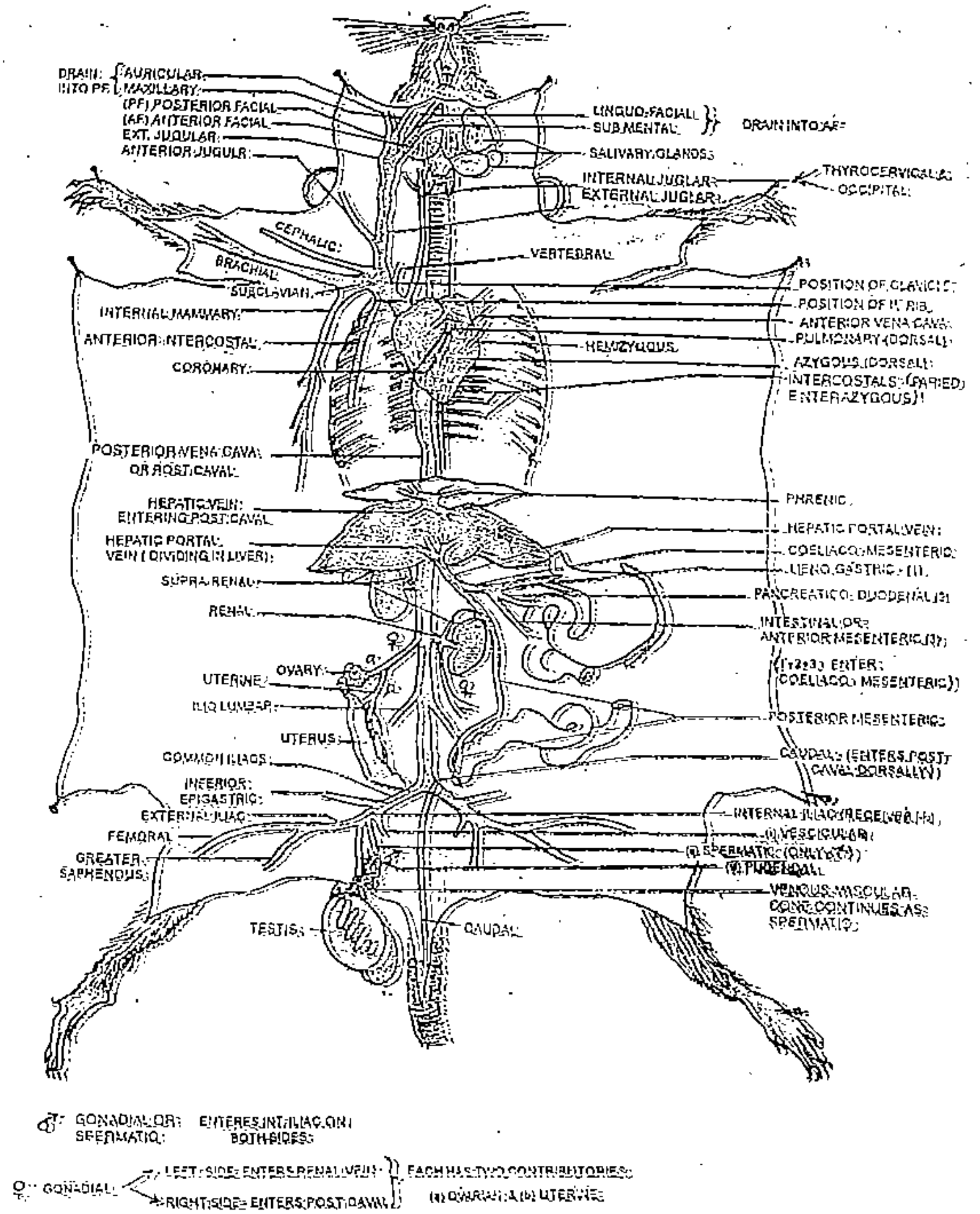

Fig. 36.1: Venous system of *Rattus rattus.*

36.3.3 Veins of Shoulder and Arm

1. A slight incision in the muscle along the length of the arm is enough to expose the **brachial vein** and another one parallel and above it, the **cephalic vein.**

2. Clear these veins towards the heart to reach the rib cage

36.3.4 Veins of Thorax

1. Make a medial incision in the muscle in the abdominal region upto the diaphragm. DO NOT MAKE A MEDIAL INCISION IN THE RIB CAGE. If you do, you will lose the veins in the chest wall – the **anterior intercostal vein**.
2. The anterior intercostal veins of both sides run close to the midline in the chest wall; to retain one, you cannot avoid cutting the other. If you need the vein on the right side, then cut the rib cage to the left of the midline and vice versa.
3. Take the incision up to the upper part of the thorax and into the neck to expose the trachea.
4. Trim the rib cage laterally on either side and close to the body wall. TAKE CARE WHEN REACHING THE CLAVICLE AND RIBS. Now, the ribs will lift up as two flaps; one of them will have the anterior intercostal vein running along its underside; retain this and cut the other flap off.
5. Trim the retained rib flap to a very narrow strip just wide enough for the display of the anterior intercostal vein.
6. Look for the **internal mammary** along the flanks running in the skin below the row of teats. You will need to remove a layer of fascia to expose this.
7. Cut and remove the pericardium to expose the heart, aorta and the caval veins.
8. Focus your attention closely on the groove over the ventricles. You may notice a small vessel curling upwards and disappearing into the heart; this is the **coronary** vessel indistinguishable as artery or vein due to its extremely small size.
9. Clear the membranes beneath the aortic arch and release it from the surrounding structures. Slip a piece of thread with a fine forceps beneath the aortic arch and tie it tightly. This aortic ligature will help you retain the blood in the heart as you cut away the rest of the aortic trunk. Cut the aorta distal to the ligature taking care not to damage any veins. Mop up the blood, wash and fill the tray with fresh clean water.
10. Pull the heart slightly down to expose the **left and the right anterior** venae cavae. Look for a thin **internal jugular** vein running down by the side of the trachea and entering the anterior vena cava close to the heart.
11. You can also see a short **vertebral** vein entering the caval vein outer to the internal jugular.
12. The cephalic and brachial veins from the arm and the internal mammary and anterior intercostal from the thorax converge near the first two ribs to form the **subclavian vein**. The jugulars and the subclavian converge to drain into the anterior vena cava. Clearing this junction is a crucial step requiring skill and concentration. Carefully trim the stumps of the clavicle and the first rib and separate. DO NOT APPLY TOO MUCH PRESSURE HERE AS YOU MAY PUNCTURE THE ANTERIOR VENA CAVA. With a minimal clearing of membranes, you can see all the veins draining into the anterior vena cava.
13. Dislodge the lungs and push them sidewards. Lift and turn the ventricles up to expose the **posterior vena cava**. It is the broadest vein.
14. You can see a small and narrow vein to the left of the posterior vena cava. This is the **azygous vein** that curves up to enter the left anterior vena cava. It receives 7-8 pairs of veins transversely; these are the **paired intercostal veins** from the ribs and thoracic muscles.
15. The azygous also receives at the top a short unpaired **hemizygous vein** collecting blood from the anterior few ribs and muscles.
16. Lift the heart now to the right side and locate the **pulmonary veins** emerging from the lungs and entering the left auricle of the heart. It may be a little difficult to see it due to the large postcaval vein close to it.

36.3.5 Veins of Abdominal Region

1. Shift the alimentary canal outside the body cavity to the left. There are two types of veins in this region –

a. Paired veins draining into the posterior vena cava and
b. Unpaired veins from the alimentary canal alone draining into the liver.

Paired veins – Move down below the diaphragm where the posterior vena cava is seen to pierce through. Here it receives a pair of **phrenic veins** from the diaphragm. Further down, it receives a pair of **hepatic veins** from the left and the right liver lobes. The other paired veins include **renal veins** from the two kidneys situated at two different levels; **suprarenal veins** from the adrenl glands located above the kidneys; the **gonadial** or **genital veins** from the ovaries (therefore only in the female) – the right gonadial vein enters the postcaval directly, while the left gonadial vein joins the low-placed renal vein.

Unpaired veins – As stated earlier, the veins from the alimentary tract do not enter the postcaval but instead collect into one main vessel or the portal vein, which enters the liver. This is the hepatic **portal vein**. (You have learnt about the significance of the hepatic portal system in LSE-10, Block 2, Unit 8) The contributory veins of the hepatic portal vein are –

i) **Coeliacomesenteric** vein formed of **lienogastric vein** (from spleen and stomach) and **pancreatico-duodenal vein** (from pancreas and duodenum)
ii) **Anterior mesenteric vein** from the small intestines
iii) **Posterior mesenteric vein** from the large intestines

36.3.6 Veins of Pelvic – Pubic – Inguinal Area and Legs

1. The beginning of the pelvic area is marked by the entry point of a pair of **ilio-lumbar veins** entering the posterior vena cava. All the veins in this area and legs are paired veins.
2. Look below the ilio-lumbars; you will not miss the fork. The two veins forming the fork and uniting to form the posterior vena cava are the paired **common iliac** veins.
3. Proceed to the inguinal region and further down to the legs clearing the muscles along the way. Several veins seem to enter the common iliac vein. The first such vein is the **inferior** epigastric vein coming from the hip joint. It enters the common iliac from its superior side.
4. From the inferior side, the common iliac receives two veins, viz., the **internal** iliac (innermost in position) and the **external** iliac (outermost in position). The external iliac comes from the thigh while the internal iliac comes from the inguinal-pubic region.
5. Look medially to trace the veins draining into the internal iliac. Two very short veins (three in the male) enter it interiorly. These are the – **vesicular vein** (from the urinary bladder), the **pudendal vein** (from the external genitalia) and the **spermatic vein** (from the testis) in the male only.
6. The external iliac receives two veins; they are the **femoral vein** (from the outer border of the thigh) and the saphenous vein (from the inner border of the thigh). The saphenous vein is commonly and erroneously referred to as the sciatic vein.
7. A single median vein coming from the tail enters the post caval vein just above the fork. This is the caudal vein; to locate this, tease the tail muscles as it is deep seated.

36.4 THE ARTERIAL SYSTEM OF *Rattus rattus*

Points to remember

1. **This dissection has to be performed completely under water.**
2. As most arteries are deep-seated, the superficial veins masking them have to be removed; it is advisable to ligate all the three venae cavae before cutting the veins.
3. When you remove the veins to expose the arteries, it will be worthwhile to racall and revise the names of the veins, which you remove.
4. Flag label the major arteries for displaying.

36.4.1 Procedure for Dissection and Display

The procedure is quite similar to that of the venous system. Minor differences are there in the order in which you begin and progress. Normally, we begin with the thoracic cavity and then proceed to the neck, shoulder and arms. The posterior arteries below the diaphragm are exposed last. Refer to Figure 36.2.

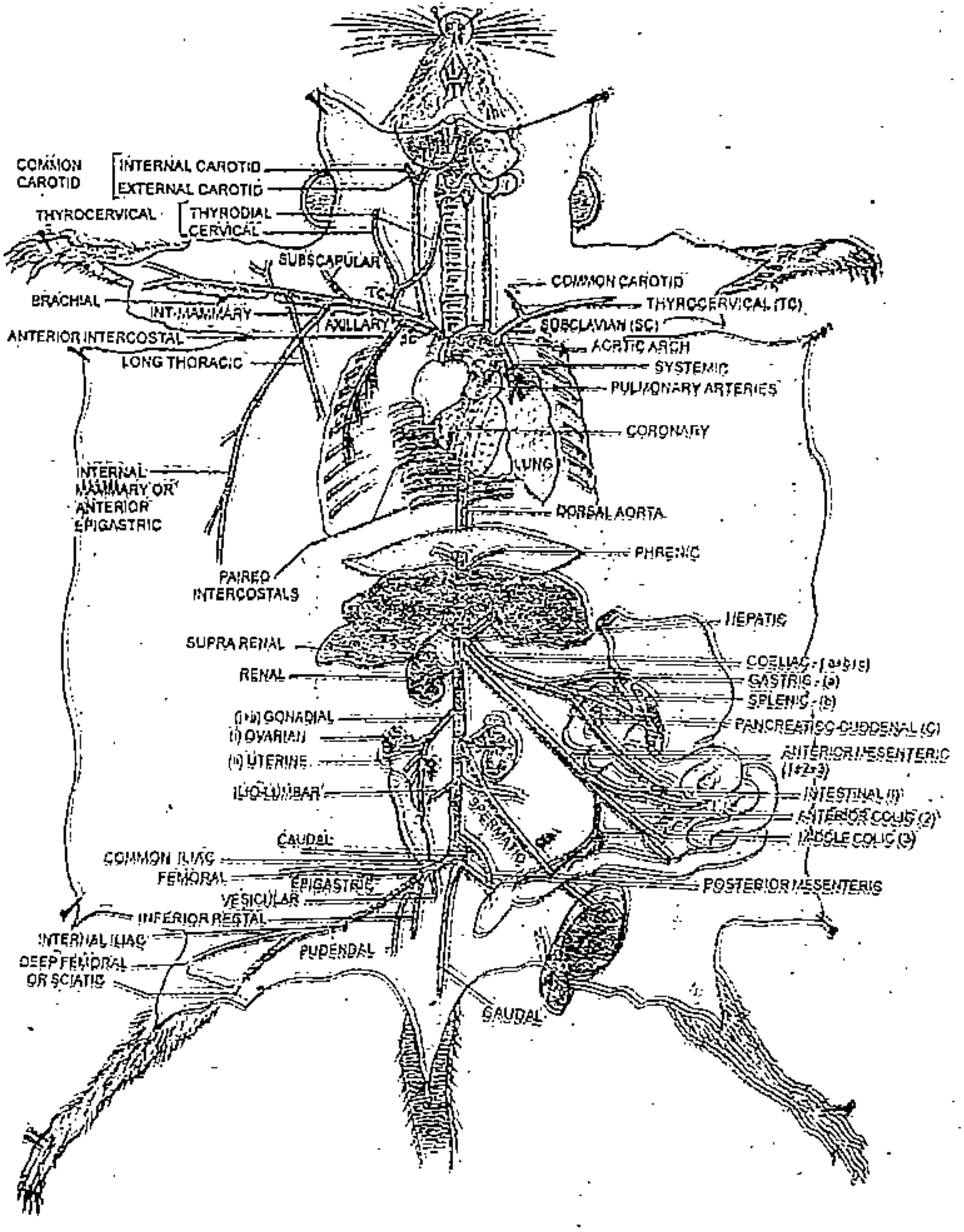

Fig. 36.2: Arterial system of *Rattus rattus*.

36.4.2 Arteries of Thorax

1. Work on the rib cage to dissect and display the **anterior intercostal** artery.
2. Remove the pericardium to expose the heart, **aortic arch** and the **venae cavae**. Note that the aortic arch loops up and then curves down to the left side to disappear below the heart.
3. Look closely between the auricles; you can see a blood vessel curving down into the ventricles; this vessel is lodged in the groove between the two ventricles. As

stated earlier, this is the **coronary artery** along with the coronary vein; too small to be distinguished from each other.

4. Between the loop of the aortic arch and the auricles is a small gap; seen in this gap is a blood vessel bifurcating with each branch entering a lung. These two branches are the **pulmonary arteries** small enough to be missed but very significant as far as circulatory function is concerned. Push the heart to one side and stretch the lung of the other side to see the pulmonary artery. Do the reverse to see the artery of the other lung.
5. Lift the heart up; can you see the post-caval vein? It hides the descending limb of the dorsal aorta from view. THE REMOVAL OF ALL THE CAVAL VEINS IS CRUCIAL TO THIS DISSECTION.
6. Ligation and removal of the venae cavae involve the following steps:
   a) Clear away the remnants of the pericardial membrane and peritoneal membranes that hold the venae cavae to the adjoining structures.
   b) Once the venae cavae are freed, you can push the tip of a fine forceps under each vein, pulling a piece of thread below to ligate it.
   c) Tie each vein close to the heart tightly with two knots. All the caval veins must be ligated properly.
   d) Cut each caval vein away from the ligature and immediately mop up the blood with cotton or cloth so that flooding of blood does not occur.
   e) Drain the water, wash and refill the tray with clean water.
7. Look at the ascending limb of the aortic arch looping to the left; you have to shift the heart to the right and separate the two lungs so as to see the descending limb of the aorta as well. This descending limb empty remnants of the postcaval vein and the peritoneal membranes. It is now seen to pierce the diaphragm and enter the abdominal cavity.
8. Do not miss seeing the 8-9 **paired intercostal arteries** emerging from the dorsal aorta and supplying the ribs and muscles of the thorax.

36.4.3 Arteries of Neck, Shoulder and Arm

These arteries are now easier to trace after the veins have been drained off.

1. The loop of the ascending limb of the aortic arch gives rise to three stems of arteries – one to the right called **innominate** or **brachiocephalic artery** and two to the left, an inner **common carotid artery** and an outer **subclavian artery**.
2. The innominate on the right bifurcates into a common carotid and a subclavian while these two arteries have independent origins from the left side. From here onwards, the plan of the left and right side are identical.
3. Cut the muscles in the neck and clear the tissues to expose the trachea and thyroid gland. The left and the right common carotids can be seen running parallel with the trachea. On reaching the jaws, each common carotid bifurcates into an **external carotid** and an **internal carotid**. These branches supply the brain, head and jaws.
4. The subclavian artery and its branches can be traced with a fine forceps. Some stumps of vein with residual blood may be seen overlying the artery; remove them. This subclavian artery gives rise to branches from its anterior as well as its posterior side. The anterior side branch is the **thyrocervical artery** (supplying the neck and thyroid glands, running forward and crossing below the common carotids). The posterior side branch is the **anterior intercostal artery** (supplying the ventral part of the thorax). You have already traced it in a narrow flap of the cut rib cage.
5. After giving rise to the branches mentioned above, the subclavian artery continues as the axillary artery. This too has branches arising from its anterior and posterior sides. The anterior side branch is a **subscapular artery** moving obliquely outwards and round the arm to supply the shoulder region. The posterior side has two branches; and **internal mammary** that runs in the skin along the mammary line parallel to the corresponding vein, and a **long thoracic artery**, outer to the former but crossing it to supply the flanks or the lateral sides

of the thorax. You have to tease the fascia over the muscles to expose these arteries.

6. The continuation of the axillary artery following its branching is the **brachial artery**. It gives rise anteriorly to a **circumflex humeral artery** (supplying the upper arm and elbow) and then continues into the forearm and paws as two arteries – the **radial artery** and the **ulnare artery**.

36.4.4 Arteries of Abdominal Region

The abdominal segment of the dorsal aorta runs the same course as the postcaval vein and lies close to its left. It can be distinguished from the vein by its greyish-white colour and narrower diameter. Remove the remnants of the postcaval vein. The dorsal aorta gives rise to two types of veins – unpaired (to the alimentary canal) and paired (to the rest of the visceral organs).

Unpaired arteries – These have a slightly different plan from that of the veins. The branches are:

i) **Coeliac artery** whose further branches are the **oesophageal artery** (to the oesophagus); the **gastric artery** (to the stomach); the **splenic artery** (to the spleen) and the **pancreatico-duodenal artery** (to the pancreas and the duodenum).
ii) **Anterior mesenteric artery** whose further branches are the **intestinal artery** (to the jejunum and ileum); the **anterior colic artery** (to the caecum and the ascending colon) and the **middle colic artery** (to the transverse colon).
iii) **Posterior mesenteric artery** (to the descending colon and the rectum).

In order to display the arteries of the alimentary canal, shift the tract to the left spreading the mesenteries and the coils. DO NOT DAMAGE ANY BLOOD VESSEL WHILE UNCOILING AND SPREADING THE INTESTINAL LOOPS. If there is a rupture, just mop up with cotton.

Paired arteries – These are the:

i) **Phrenic arteries** to the diaphragm.
ii) **Hepatic arteries** to the liver.
iii) **Renal arteries** to the kidneys with suprarenal branches to the adrenal glands.
iv) **Gonadial arteries** to the gonads and the gonoducts (the plan is identical in the male and the female rats unlike the gonadial veins). The right gonadial artery arises independently from the dorsal aorta while the left arises as a branch of the left renal artery. The gonadial artery in the male is much longer as it has to reach down to the testis.
v) **Iliolumbar arteries** to the pelvic girdle and muscles.

36.4.5 Arteries of Pelvic – Pubic – Inguinal Area and Legs

1. Look at the dorsal aorta below the iliolumbars where it bifurcates in the pelvic region. Each fork is the **common iliac artery** entering the thigh.
2. Tease the muscles in the thigh to follow the course of the common iliac. It runs a short distance to split into an outer **epigastric artery** or **external iliac** and an **inner internal iliac**.
3. The internal iliac forms three arteries immediately inferior in position. They are the **vesicular** to the urinary bladder, the **inferior rectal** to the urethra, rectum and anus, and the **pudendal** to the external genitalia. The internal iliac further continues as the **deep femoral** or **sciatic artery** into the inner sides of the thigh.
4. The epigastric or the external iliac proceeds as the **femoral artery** to the hip joint and outer sides of the thigh.
5. The tail has a single median **caudal artery** running between its muscles. It arises from the dorsal aorta just above the fork point. You have to trace and expose it just as you do the vein.

36.5 TERMINAL QUESTIONS

1. Make a neat labelled drawing of your dissection of venous system. Have you ruptured any vein? Draw it nevertheless, as shown in the figure 36.1 and put an X mark over it.

2. Which part of the body do the following arteries supply?

   i) Femoral artery ....

   ii) External iliac artery ....

   iii) Pudendal artery ....

   iv) Brachial artery ....

3. Differentiate between systemic and pulmonary veins.

   ....

   ....

   ....

4. Make a neat labelled drawing of your dissection of arterial system. You can take the guidance from Fig. 36.2. Have you ruptured any artery? Draw it nevertheless, as shown in the figure and put an X mark over it.

5. In what region of the body you can find the following veins?

   i) Jugular veins ....

   ii) Coronary vessel..

   iii) Sciatic veins..

6. Write down the do's and don't that you should follow while dissecting the venous and arterial system of the common rat.

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EXERCISE 37 *RATTUS RATTUS* III: THE URINOGENITAL SYSTEM

Structure

37.1 INTRODUCTION

The urinogenital system (Refer Unit 9, Block 3, Course LSE-10) consists of two independent systems, quite unrelated in function. They are:

1. The urinary or excretory system that functions to filter metabolic wastes from the blood and eliminates them; it also functions to regulate the salt-water balance of body fluids.
2. The genital or reproductive system which functions to produce haploid sex cells or gametes and sex hormones for maintenance of reproductive functions; in the female it further serves to support and nourish the developing offspring.

These two systems, although functionally unconnected, are physically in intimate contact due to developmental similarities. Some parts of their duct systems have a common embryological origin, later diverging and modifying to suit individual functions.

In the male, the terminal part of the duct or urethra is still a common passage shared by the two systems for the discharge of urine and semen.

In the female, however, there is absolutely no connection at all because of a separate urethra (exclusively for the passage of urine) and a vagina (exclusively for the discharge of gonoduct secretions and the birth of the offspring). Thus, in the female at least, the term 'urinogenital' becomes a misnomer.

The two systems do share some common features with respect to their organisation. Both have a main functional organ, followed by a system of ducts as a passage for the functional products, and a discharge aperture outside the body in the pubic region.

In the excretory system, the main functional organ is the **kidney**, the duct system consists of the **ureters** and the **urethra**, and the discharge aperture is the urinary or urethral orifice.

In the male reproductive system the main functional organ is the testis and the duct system consists of the **epididymis** and **vas deferens** ending in the common urethra. The genital orifice therefore, is the urethral orifice as well (a common urinogenital aperture).

In the female reproductive system the main functional organ is the **ovary**, the duct system consists of the **fallopian tube**, the **uterus**, the **cervix** and the **vagina** and the discharge aperture is a separate genital orifice.

In the present exercise, you will see that the excretory systems are exactly similar in both the sexes while the reproductive systems are grossly different. Shown below are two simplified diagrams of the male and female reproductive systems of the rat (Fig. 37.1). Make a comparative study before you proceed with either of the two dissections.

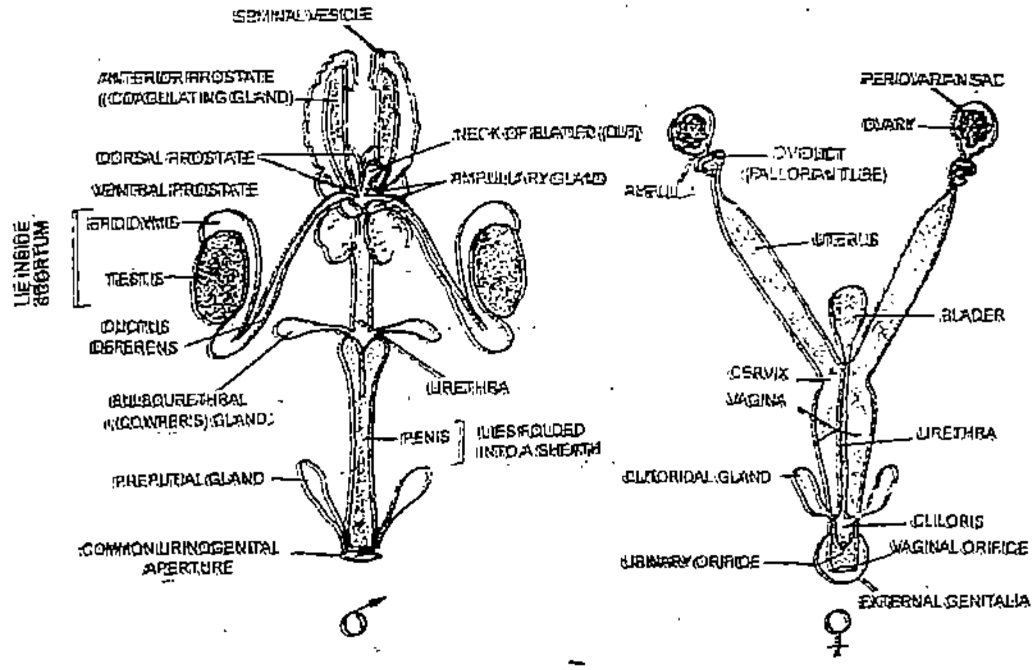

Fig. 37.1: Simplified diagrams of the male (♂) and female (♀) urinogenital systems.

Objectives

After completing this exercise, you should be able to:

- dissect and flag label the urinogenital systems of both the male and female rat,
- demonstrate and compare the organisation of both the systems.
- briefly describe the functions of the various structures.
- draw neat labelled diagrams of the male and female reproductive systems and highlight their differences.

Points to remember

You have learnt to differentiate between a male and female rat under section 35.4 of exercise 35 and shown in Fig. 35.2.

1. In a male, the scrotal sac is not always prominent as sometimes, the testes ascend into the abdominal cavity. If you see a wrinkled perineal skin without any aperture, then massage the abdomen downwards and the testes will descend down.
2. If you find a female in an advanced state of pregnancy, do proceed to dissect it. In such a female there is less fat masking the structures that are all hypertrophied and prominent. You must of course dissect a non-pregnant rat as well.

37.2 MATERIAL REQUIRED

1. Mature rats
2. Chloroform
3. Killing jar with lid
4. Dissection tray
5. Pins
6. Large beakers with water
7. Petri dishes to collect discarded tissues

8. Cotton wool
9. Blotting sheets
10. Napkins
11. Dissection instruments
12. Any antiseptic solution
13. Hand lens
14. White and black paper
15. Flag labels
16. Laboratory manual
17. Pencil and eraser

37.3 THE MALE URINOGENITAL SYSTEM OF *Rattus rattus*

37.3.1 Structural Organization of the System

The following description is a brief explanation of the structural organisation of the various parts of the male urinogenital system.

The reproductive system begins with a pair of gonads or **testes** lodged extra-abdominally in the scrotal pouch. Their internal duct system connects externally to the gonoduct system. The gonoduct system begins with a minute set of **efferent ductules** (not visible to the naked eye), that lead into the **epididymis**. The epididymis is a prominent C-shaped organ embracing the testis. It is divisible into a cobra-hood like head (caput), a long, slender body (corpus) and a bulbous end portion (cauda). The vas deferens arises as a narrow, long tubular duct from the end of the epididymis. It makes a sharp bend reflecting upwards from the scrotal pouch into the pelvic cavity via the inguinal passage. Here, it enters the **urethra** close to the neck of the urinary bladder. Its entry point is largely masked by well-developed accessory sex glands, mainly the **prostate gland**. To continue with the explanation of the duct system, the urethra as mentioned earlier receives the contents of the urinary bladder as well as sperms from the vas deferens. It thus becomes a common passage for the two systems. The urethra continues its passage outside as an extension, the **phallus** or penis.

The accessory sex glands are of different types and very well developed in the male. They are each a pair of **seminal vesicles**, **coagulating glands (anterior prostate)**, **ventral prostates**, **dorsal prostates**, **bulbourethral glands (or Cowper's glands)**, **ampullary glands** and the **preputial glands**. Excepting the Cowper's and the preputial glands, all others are concentrated around the anterior part of the urethra. The Cowper's glands are situated at the junction of the urethra and the penis. The preputial glands are situated at the terminal end of the penis as part of the prepuce or foreskin.

The excretory system begins with a pair of asymmetrically placed **kidneys**. These bean-shaped structures have their concave facets inwards from where a fine translucent white duct, the ureter, emerges. The two ureters run posteriorly and dorsal to the seminal vesicles and the end of the vas deferens. From here, they curve upwards to cross the vas deferens and enter the neck of the urinary bladder. The urinary bladder, as mentioned, drains into the urethra.

37.3.2 Procedure for Dissection and Display

1. Pin the animal high up in the tray so as to bring the pelvic region in the middle. This will give you more freedom to work in the posterior region. You can cut the tail if you find it interfering although it is not necessary to do so. Keep the figure 37.2 at your side for the guidance.
2. DO NOT ADD WATER TO THE TRAY UNTIL YOU REMOVE THE ALIMENTARY CANAL. YOU HAVE TO BE SPEEDY WITH YOUR WORK OR THE TISSUES WILL DRY UP.

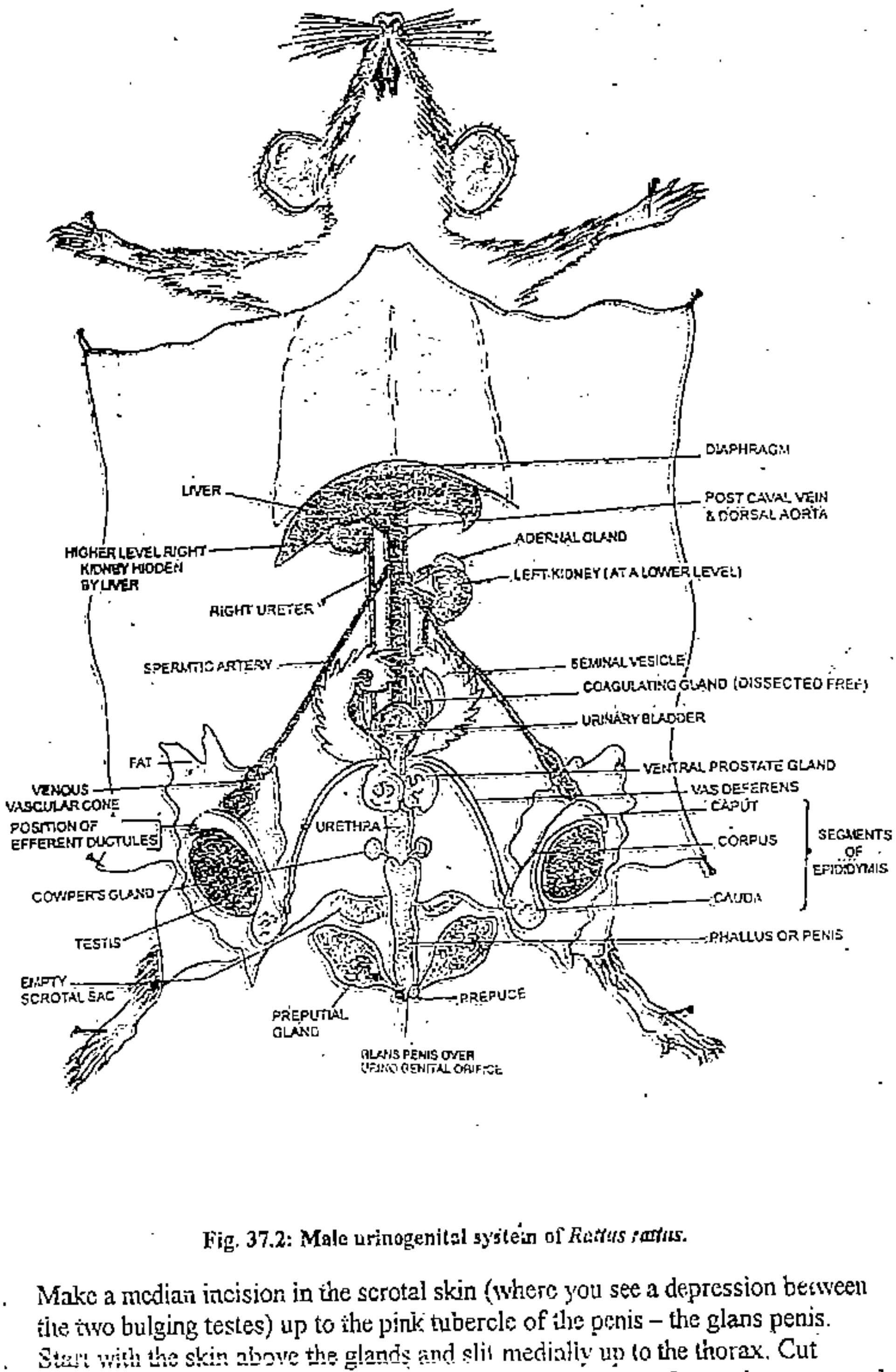

Fig. 37.2: Male urinogenital system of *Rattus rattus.*

3. Make a median incision in the scrotal skin (where you see a depression between the two bulging testes) up to the pink tubercle of the penis – the glans penis.
4. Start with the skin above the glands and slit medially up to the thorax. Cut sidewards bordering the thorax; we don't need to go further forwards as our work area concerns the posterior region only. Cut the skin in the legs and free the flaps from the underlying fascia and pin.
5. Note that there is no fascia or muscle below the scrotal skin. Do you see a translucent and glossy membrane inside? Cut this membrane and tease on both the sides. You can now see the two testes as two large ovoid cream-coloured glossy structures. Hold each testis by a blunt forceps and pull outwards gently. Look below. You can see the epididymis in close contact beneath it. Even with a slight pressure applied to them, the testes along with the epididymis disappear into the pelvic cavity. It does not matter if they do. Proceed further with the dissection.

6. Look into the muscles on either side of the glans penis; lodged in the muscle is a pair of large, flat, spoon-shaped structures. These are the preputial glands. Release them by teasing the surrounding muscles. They are flat, rubbery and light pink in colour with short ducts opening into the prepuce.
7. Your next step concerns with straightening the penis out from its sheath. In repose i.e., when withdrawn, it lies like an S within the sheath. Trim the prepuce all around the glans taking care not to cut the preputial glands away. Gently pull the tip of the penis while releasing the surrounding tissues; its full length now becomes visible. Straightening the penis out from its sheath must be done before proceeding to cut open the viscera as otherwise, it may get cut away while slitting the muscle.
8. Cut open the viscera and pull out the loops of the alimentary tract. Locate the colon and cut as far down as possible. BE CAREFUL NOT TO DAMAGE ANY MAJOR BLOOD VESSELS, THE URETERS OR THE URINARY BLADDER. Make another cut between the oesophagus and the stomach. The alimentary canal is not yet free as it is held by the mesenteries and blood vessels; cut these as well. Bleeding will occur; mop up, clean and wash. Discard the cut alimentary tract. ADD WATER TO THE TRAY AT THIS STAGE.
9. Look for the urinary bladder; it can be seen as a small straw-coloured balloon just above the pubic bone.
10. Two prominent cream-coloured structures curving like horns lie just above the bladder. They have saw-like margins and are the seminal vesicles.
11. Lodged in the inner curvature of the seminal vesicles can be seen an elongate, pale-pink coloured coagulating gland. Try and separate the two glands by releasing the membrane between them.
12. Just below the urinary bladder are a pair of bulging and spongy glands which are the ventral prostates.
13. On either side of these glands can be seen the entry point of the vas deferens. Tease the tissues surrounding the terminal end to be able to see the ampullary glands. They may not always be distinct.
14. If the testes are still in the scrotal pouch, push them up so that all the structures i.e., the testes, epididymis and the vas deferens can be seen together.
15. Locate the ureters from the kidneys to the neck of the urinary bladder. Tilt the bladder down to see their entry dorsally. Can you see the ends of the ureters crossing the ends of the vas deferens?
16. Further clearing requires the cutting of the pubic symphysis and removing wedges of pubic bone. Insert the blunt end of your large scissors lifting the blade up as you cut the symphysis. Make two more cuts on either sides of the median cut and remove the bone. Bleeding will occur and is unavoidable. Change the water and proceed. Look into the space from where the pubic bone was removed. The urethra can now be seen as a short and broad tube just below the urinary bladder and ventral prostates.
17. Clear the tissues around and below the urethra and note its continuation with the penis.
18. Turn the seminal vesicles and bladder down to see the dorsal side of the urethra. Two compact, pink and spongy lobes similar in texture to the ventral prostates can be seen. These are the dorsal prostates.
19. The Cowper's glands lie at the junction of the urethra and the penis; but they are somewhat deep-seated to be seen immediately. To expose them, put a finger below the base of the tail and push upwards while teasing the muscles at the junction. A small pea-shaped white gland will pop up. Hold the gland and clear further to see its duct entering the junction. Repeat on the other side.
20. Your dissection is now complete. To display, lay black paper below the testes, penis and preputial glands and pin to hold them in place. Also slip appropriately sized strips of black paper below the urethra, ureters and the glands. Flag label all the parts you want to display.

37.4 THE FEMALE URINOGENITAL SYSTEM OF *Rattus rattus*

37.4.1 Structural Organization

The description below concerns the structural organization of the female reproductive system. The female reproductive system begins with a pair of gonads or **ovaries** situated in the pelvic cavity just below the kidneys. They are enclosed in a thin membranous sac, the **periovarian sac**. As they have no internal duct system, they release the gametes or ova by rupturing. The released ova are picked up by the first part of the gonoduct system viz. the **fallopian tubes**. The fallopian tube is a very small, white and tightly coiled narrow duct with its open end applied to the periovarian sac. The other end leads into the wider-bodied **uterus**. The rat uterus is bicornuate i.e., it has a short straight body or corpus leading anteriorly to two diverging horns or **cornua** (singular: cornu). The whole structure appears as a Y. The fallopian tube connects with the cornu of its side. The corpus leads into the **cervix** which is not visibly distinguishable from the former. The cervix can be felt to be a firm and hard structure compared to the soft and pliant corpus. The last segment of the gonoduct system is the **vagina**. It is a broad and long tube highly stretchable in nature. It opens outside by the genital orifice or **vulva**.

The accessory sex glands in the female are poorly developed structures not visible externally. The only visible structure is the preputial gland or the **clitoral gland**. It has the same appearance as in the male, its duct opens into the preputial akin covering the vulva and the genital tubercle or the glans clitoris above it. The excretory system in the female is exactly similar to that in the male. The only difference being that the urethra is a separate and exclusive passage for the urine. The vagina below it is exclusively a genital duct.

37.4.2 Procedure for Dissection and Display

1. Open the skin and muscles from the clitoris forwards up to the thorax. Proceed to open the viscera and pin the skin and muscles as explained earlier. Keep figure 37.3 along side for your reference.
2. Expose and clear the preputial glands.
3. Remove the alimentary canal and add water to the dissection tray.
4. Cut the pubic symphysis and remove the wedges of the pubic bone.
5. The two uterine cornua can be seen diverging upwards above the urinary bladder.
6. Look above each cornu for the minute tightly coiled fallopian tube. Use a hand lens for this purpose.
7. Just above the fallopian tube can be seen a reddish-pink and granulate structure. This is the ovary. In a non-pregnant or immature female, it is masked by a lot of fat. Remove the fat to reveal the ovaries.
8. Lift the uterine cornu up. You can see that the ovary along with the fallopian tube and the cornu has a sheet of peritoneal membrane stretching below. This is the mesovarium and mesometrium. Several fine branches of arteries and veins invade this membrane.
9. Pull the two uterine cornua slightly upwards and tilt the urinary bladder down. You can now see the short uterine corpus and feel for the hard cervix right below.
10. The urinary bladder lies just over the uterine corpus. Can you see the ureters curving below the end of the uterine cornua to enter the neck of the bladder?
11. A narrow duct leads down from the bladder to open out through the urinary orifice. This is the urethra in the female. It is attached by membranes to the vagina below. To release it, follow the next step.
12. Push the blades of a blunt forceps through the genital orifice. Once left in, the open ends of the blades stretch the vagina. Its extensive stretchability can thus be seen. This step also makes the narrow urethra above it quite distinct.
13. Hold the clitoris along with the preputial glands and trim the prepuce. Pull the structure upwards releasing the urethra from the underlying vagina.

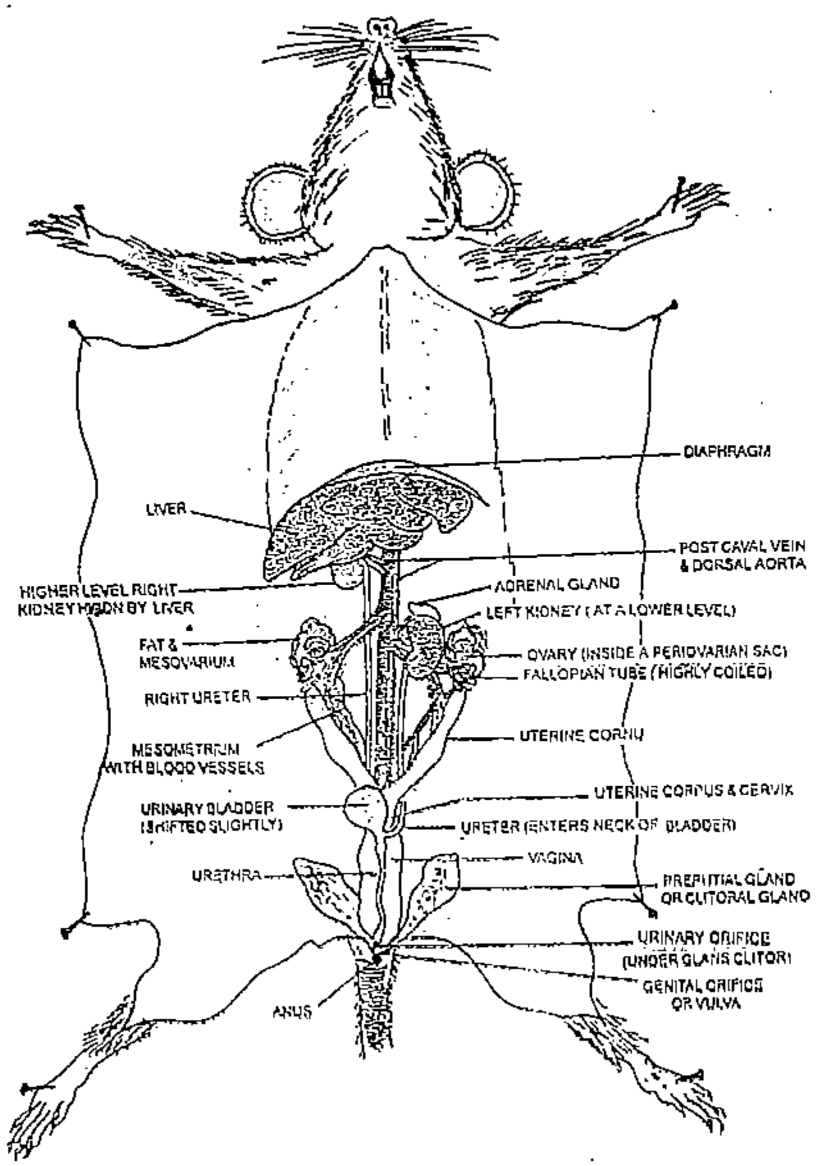

Fig. 37.3: Female urinogenital system of *Rattus rattus*.

14. The kidneys and ureters are as described earlier.
15. Your dissection is now complete. Slip appropriately sized strips of black paper below all the structures to highlight them. Flag label the relevant structures.

37.5 TERMINAL QUESTIONS

1. Write down the precautions you should take while dissecting the urinogenital systems of male and female rats.

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2. Make a neat labelled drawing of your dissections. You can take the guidance from Fig. 37.2 and 37.3.

   a) Male urinogenital system

   b) Female urinogenital system

EXERCISE 38 FIELD TRIP FOR IDENTIFICATION AND OBSERVATION OF ANIMALS IN A NATIONAL PARK/ SANCTUARY/RESERVE/BREEDING PARK/AQUARIUM/MUSEUM/ ZOOLOGICAL PARK

Structure

38.1 INTRODUCTION

The concept of "Live and let live", conservation and preservation of plants and animals has been an old age practice in India. Three hundred years before Christ, Chanakya wrote in Arthashastra that it is forbidden to cut trees for fire, destroy leaves, burn wood, kill animals, remove their skins and collect bones, because this would disrupt normal lives of all living beings including humans.

Indian forests give shelter to many exclusive and rare animals such as Kashmir stag, rhinoceros, brown antlered deer, golden langur, lion tailed macaque, slow loris, wild ass, wild dogs, musk deer, lion and above all tigers.

Due to direct or indirect interference by man many animal and plant species have been reduced to a very low level. This loss can not be recovered unless, animal species are provided protection by law and some safe healthy forests are kept reserved where animals can live freely and breed undisturbed. The Red Data Book (prepared by International Union for conservation of Nature and Natural Resources) lists 103 animal species from India which are considered highly endangered. Mountain quail, Pink headed duck, Lesser one horned rhino, Jerdon's courser and Cheetah which once roamed freely in Indian forests are extinct.

The Govt. of India constituted the central board for wildlife in 1949 later it was renamed as the Indian Board of Wildlife (IBWL) in 1952 to safeguard wildlife; same year an Animal Welfare Board (AWB) was also constituted which defined areas of interest into National Park, Sanctuary, Protected area (Breeding area), Reserve. Later Museums, Aquariums and Zoos were also added.

This exercise is a field trip in which you would be expected to visit any one of the following – a zoo/a natural history museum/a wild life park/ sanctuary/reserve/ breeding park/aquarium near your study centre. After your visit we expect you to write a short account of the kinds of animals that you observed, their habit and habitat and any other interesting features that you may have observed.

In sections 38.3 and 38.4, we have described Sariska Tiger Reserve as an example. You could make your notes about the field trip along similar lines.

Let us proceed further with the definitions of National parks, sanctuary etc. so that you are able to differentiate between the various nomenclatures.

Definitions

National Park: Area dedicated by statute (legislation/law) for all times to come, to conserve the natural or historical objects of National significance and to conserve wildlife therein, in such a manner and by such a means, so as to leave them unimpaired for enjoyment of future generations, with only such modifications as local connections may demand. All private rights in such areas are suspended and all forestry operations, and other usages such as grazing are prohibited.

Sanctuary: Area constituted by competent authority in which killing, hunting, shooting or capturing of any species of animals is prohibited except by or under the control of the highest authority in the department responsible for the management of the area. Private ownership rights may be permitted to the extent that they do not adversely affect wildlife.

Protected Area: Area where special protection is granted to wildlife on the verge of extinction to reestablish them; protection to wildlife around large towns.

Reserve forest: Area in which wildlife is protected under the Forest law.

Breeding Park: Small fenced area where endangered animals are kept, research is conducted to promote breeding in captivity. Recently conservationists have realized the full value of captive breeding in zoos for aiding in the rescue of endangered species of wildlife.

Zoo: A zoological garden where living wild animals are kept, maintained and displayed mainly for the amusement and recreation of human beings. They also form an important part of education and research on the behaviour of endangered animals specially beneficial for breeding them captivity. Animals bred so are rehabilitated in the wild.

Museum: A place or building for the preservation and exhibition of objects illustrating antiquities, art, science and technology, animals and plants. The museums have their own importance. In a museum of natural history run by government or non-government organization, or museum of life sciences (zoology and botany), museums of Zoological and Botanical surveys of India one learns about the present and past animals and plants.

Aquarium: An artificial tank, pond or vessel in which aquatic plants and animals are kept alive for amusement, research and breeding.

Objectives

After returning from the field trip you should be able to:

- describe the geographical location, area, habitat, climate and the special features of the place you had visited,
- identify, draw, name and list the naturally occurring large animals of the area,
- handbook (such as the Book of Indian Animals by Prater, BNHS publication or Salim Ali's book on Birds of the Indian Subcontinent) for their description, distribution and behaviour,
- explain the importance of establishing wildlife parks, sanctuaries, reserves, aquaria, zoos and museums.

38.2 MATERIAL REQUIRED

1. Notebook and Pen
2. Cap and Sunglasses
3. Water bottle
4. Light colour clothes and comfortable foot wear
5. Relevant maps of the area
6. Binocular
7. Books or literature related to the subject or place to be visited

38.3 DESCRIPTION OF THE PLACE VISITED – AN EXAMPLE SARISKA

Before you plan a visit to any Sanctuary/Zoo/Museum, it is necessary to collect all the information about the place to be visited. You must find out about its geographical location, its total area, climate, kind of vegetation as well as the expected fauna and flora. It is very necessary to have knowledge on the above mentioned parameters, without which one loses ones bearing in the forest. For geographical location you must first look up the map of India, locate the state, city and area of your visit. To explain this to you we take Sariska Tiger Reserve of Alwar, Rajasthan as an example.

Sariska Tiger Reserve (Fig. 38.1) has an approximate area of 800 sq. km. The park spreads into the forests of Aravali hills near Alwar. This forest was the favourite hunting ground of Alwar Maharaja. In 1958 it was declared as a sanctuary, then in 1979 it became a tiger reserve under the auspices of Project Tiger. The total area of this park is divided into three cores. Core I – spreads about 480 sq. km and Core II and III include 370 sq. km, followed by a buffer zone (Fig. 38.1).

The forest is of a typical dry, deciduous-type with "dhak", "khair", "tendu", "ber", "surwal" and goria among the flora of the forest. The forest remains lush green during monsoon months, during winters also it remains green but in summers it is completely dry.

Likewise, you can procure or gather information about any such area you plan to visit. This information is generally available with the Incharge of that place, may it be a reserve to watch butterflies in northeast, or fishes of fresh water and sea in peninsular India, or dolphins of Ganga, garials of Chambal, hangul of Kashmir, birds of Bharatpur or wild ass of Rann of Kutch.

Similarly if you plan to visit an aquarium (like Taraporawala aquarium of Mumbai), or a museum (Zoological survey of India, Kolkatta) or a Zoo (almost one in every big city), go to the souvenir shop and buy the layout of that place and also a visitors hand book which always has small but important information of animals therein.

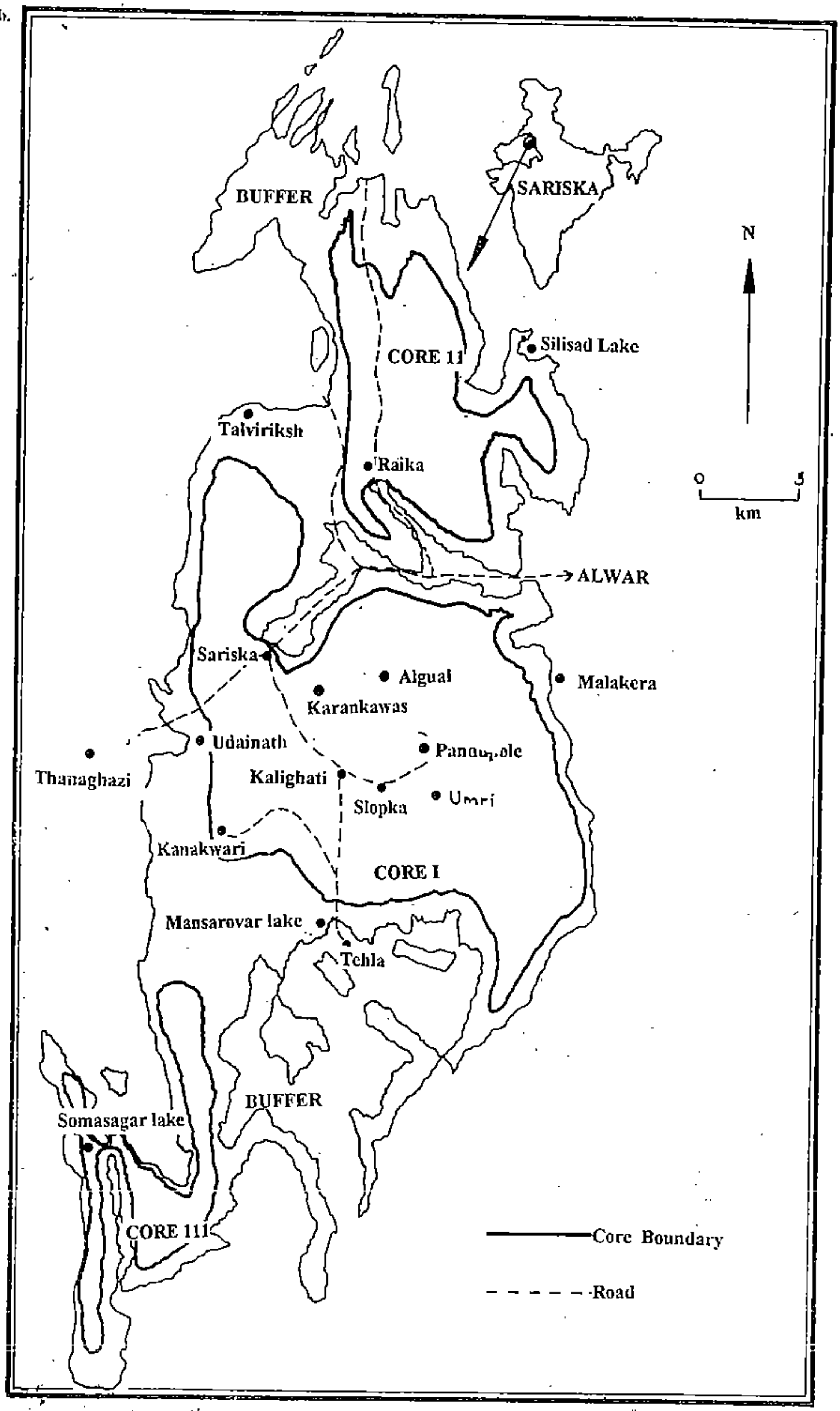

Fig. 38.1: Map of India, Rajasthan indicating the location of Alwar and map of Sariska Tiger Reserve.

38.4 IDENTIFICATION, DISTRIBUTION AND BEHAVIOUR OF MAJOR ANIMALS

The first thing to do is to procure an approximate list of animals prior to your visit to that place. There are many good handbooks on the subject which may be available in your library. A list of some books is included at the end of this exercise. Look for those animals in such books, identify them, making a sketch is little difficult, the best way is to photocopy the diagrams of animals from the books available, then prepare your own hand book. Cut and paste diagrams of animals and with the help of those books classify and write major characters, their distribution and general behaviour. Now as you are watching those animals in reality. Note down peculiar external features and behaviour. To give you an example, besides tiger, and leopard. Sariska has plenty of sambar, chital, chinkara, neelgai, Wild boars, porcupines and even peacocks. You could choose to describe 5-10 big animals and any peculiar or extraordinary features that you come across during your visit. We have described some for you as examples.

38.4.1 Tiger (*Panthera tigris*)

1. The Indian tiger has rich fawn, mustard coloured fur coat and beautiful black stripes on it.
2. the average length and weight of adult male and female could be 9 ft., 200 kg. and 8 ft., 180 kg. respectively.
3. It was widely distributed all over India but now confined to 19 National Parks which are running under Project Tiger.
4. Presence of tiger in a jungle is an indicator of a healthy forest.
5. Tigers hunt between sunset and sunrise.
6. Females live with their cubs.
7. The males are territorial, like to roam around alone except for the breeding season when they form pairs with females.
8. Tigers prey on deer, neelgai, wild boar.
9. They have large canines and retractable sharp claws.
10. Inspite of heavy majestic body they run and swim fast and if the need arises can also climb trees.
11. The gestation period in female is 15-16 weeks, the litter size could be 2 to 6.
12. Sexual maturity is attained at 3-4 years.
13. The life span is estimated to be 20 years.

Fig. 38.2: Tiger.

38.4.2 Leopard (*Panthera pardus*)

1. Also known as Panther.
2. The length and weigh of male and female could be 7 ft., 68 kg and 6 ft., 50 kg, respectively.
3. Leopard has small, sleek body. Has bright mustard fur coat with small close set black rosettes, endorsing mustard colour in their centre.
4. Widely distributed throughout India, best found, seen and protected in sanctuaries and reserves.
5. Unlike tigers they can thrive well in open country among rocks and scrub.
6. They hunt during the day and can prey on cattle, deer, monkey, rabbits, porcupines.
7. For food, they even approach human dwelling in near by villages for calves, goats, sheep.
8. They are very agile, and climb trees with ease.
9. Leopard breed all through the year. Sexual maturity is attained at the age of 3-4 years. Gestation period is 80-90 days.
10. Usually 2 cups are born per litter.
11. The life span is about 15 years.

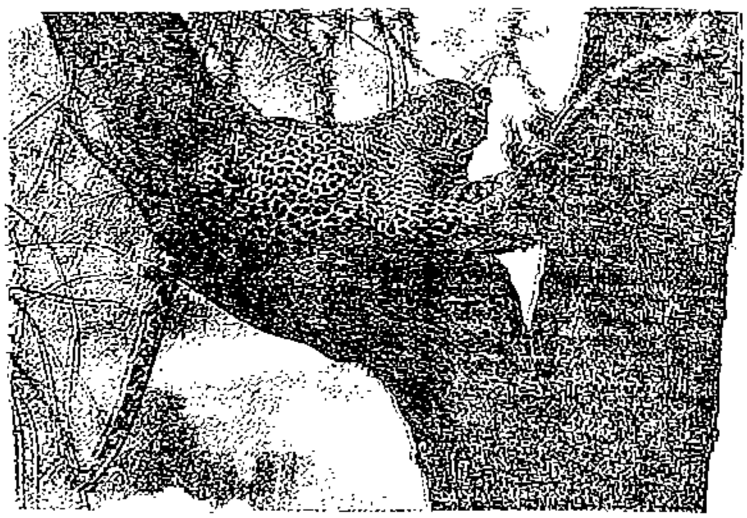

Fig. 38.3: Leopard. Note the rosettes on the body.

38.4.3 Sambar (*Cervus unicolor*)

1. It is the largest Indian deer. A full grown male is over 320 kg. The height at shoulder is 5 ft.
2. Widely distributed in India.
3. The coat colour of male is dark brown and the male has beautiful branching antlers. The females have fawn colour coat and no antlers.
4. The male, female and babies are respectively called stag, doe (also hind) and fawns.
5. Like to live on forested hill sides, preferably near cultivation.
6. Their food consists of gram, leaves, wild fruits.
7. They like to feed at night, but remain active during the day also.
8. They take to water easily and swim also.

9. Stags shed their antlers in March-April, the new antlers start growing in May, velvet (soft cover on antlers) is removed by rubbing against branches by November.
10. Stags fight and establish territories pairing is done by December, the stag possesses a harem (group of females).
11. After the breeding (rutting) male leaves the harem.
12. The fawns are born in May-June.

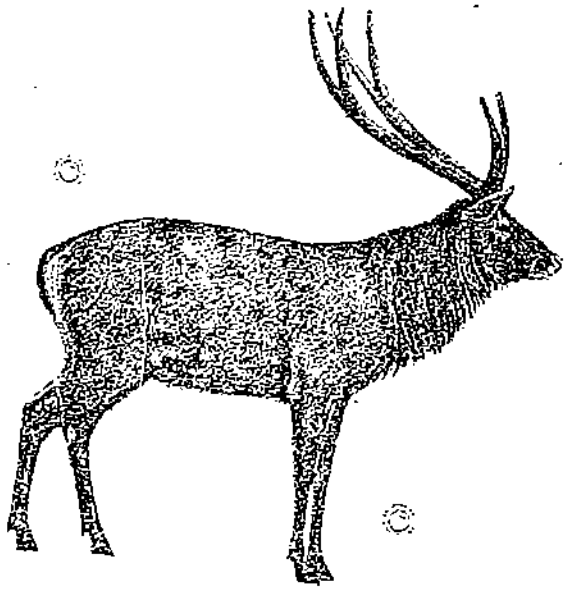

Fig. 38.4: Sambar.

38.4.4 Chital (*Axis axis*)

1. Also known as spotted deer, most beautiful of all deers.
2. Widely distributed. A well built stag stands 36 inches at the shoulder and weighs 85 kg.
3. Base coat colour is rich fawn with white spots. Stags have impressive branching antlers.
4. They are seen in large herds.
5. They are active during the day.
6. The core of the herd is formed of related females. The stags take possession of herds during rutting season.
7. Like sambar, chital stags also shed antlers every year.
8. They breed in winters.

38.4.5 Chinkara (*Gazella gazella*)

1. Also known as Indian Gazella, widely distributed in north-west and central India.
2. A full grown male measures about 26 inches at shoulders and weighs about 25 kg.
3. They have permanent horns, the males have bigger ringed horns, whereas, females have smooth, shorter horns.
4. The dorsal fur is light chestnut, the ventral side is white, they have typically white streak down each side of the face.
5. Wastelands broken up by nullahs and ravines, scattered bush and thin jungle are the usual hunts of chinkara.
6. They live in small groups, shy of humans, therefore, infrequently enter cultivated areas.
7. Sight, scent and hearing are well developed.
8. The average group size is 3 but can also be seen in a group of 25.
9. They do not have particular breeding season but have two birth peaks one in April and another in October.
10. The gestation period is of 5½ months.

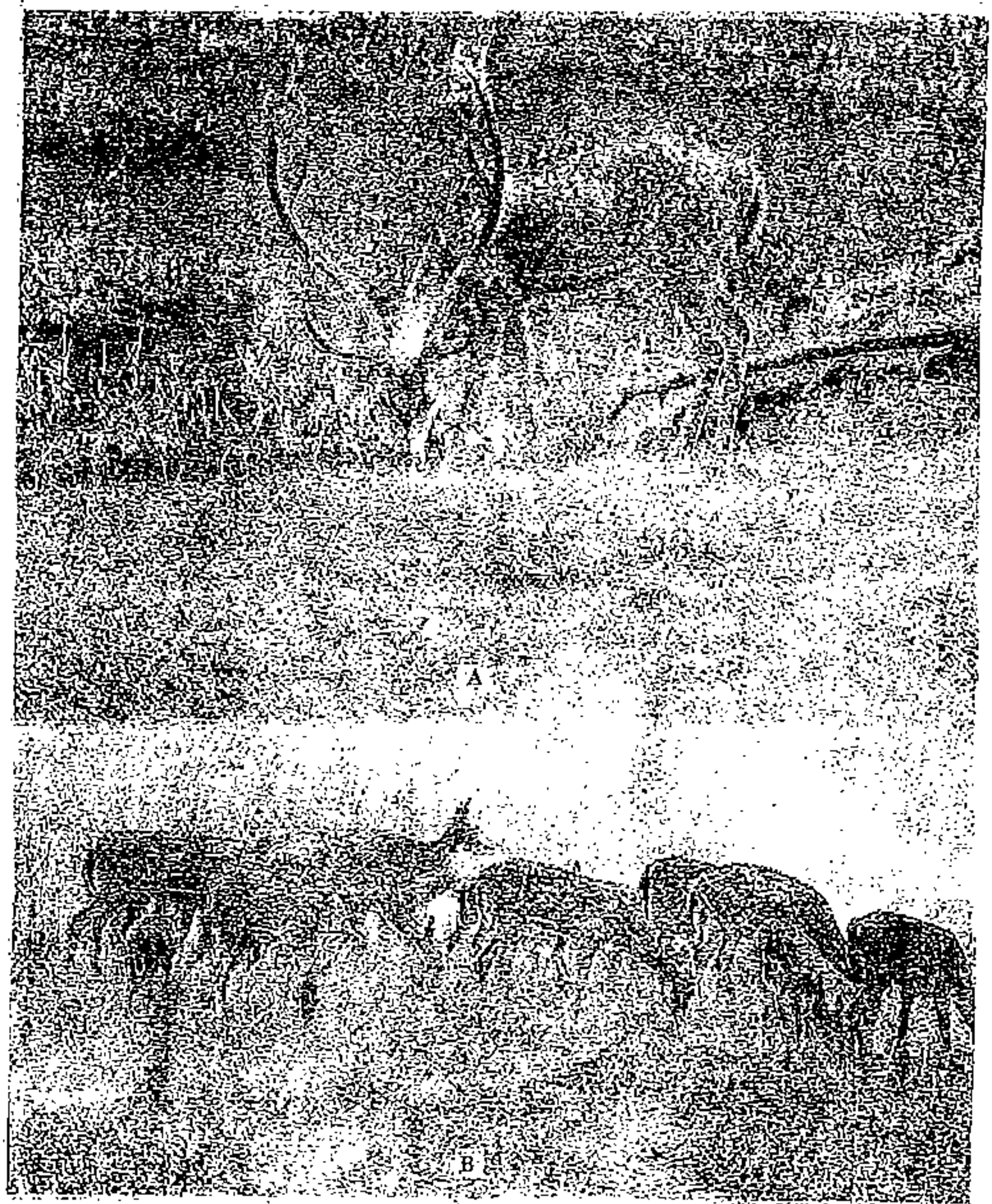

Fig. 38.5: Chital. A) Male. B) Herd of females and young ones.

Fig. 38.6: Chinkara. Male.

38.4.6 Nilgai (*Boselaphus tragocamelus*)

1. Also known as Blue Bull, very widely distributed.
2. Males measure 56 inches at shoulder and can weight 350-400 kg.
3. Horse like animal. Both have mane. The males are bluish-grey in colour, the females are fawn. Males have permanent horns and type of hair hanging from neck, the females lack both.
4. Both male and female have socks like colouring near their hooves.
5. They avoid dense forest, they live on hills with sparsely placed trees, grass and scrub.

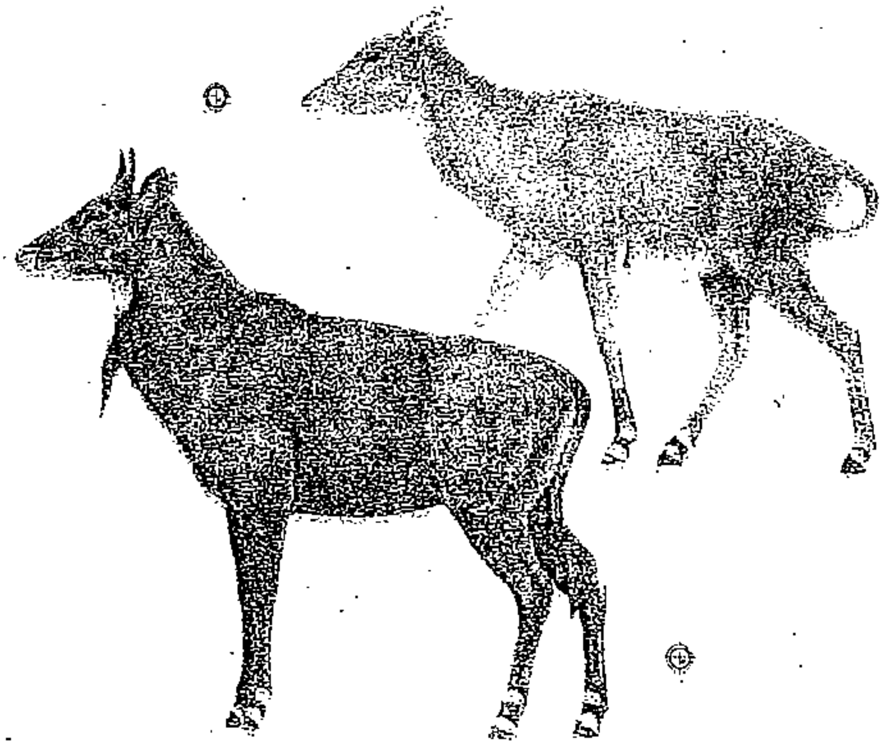

Fig. 38.7: Nilgai – Male and female.

6. They start feeding largely in the evenings, then night until down.
7. They graze and browse with interest on leaves and fruits of ber (*Zizyphus*) and mohwa.
8. A grunting sound which is the alarm cry, sends the herd away in different directions.
9. Smell and sight are good, hearing is poor.
10. Roam around in big groups in big areas, but deposit their droppings at one particular place.
11. The young are produced in all seasons, the gestation period is 8-9 months.

38.4.7 Indian Wild Boar (*Sus scrofa*)

1. Widely distributed.
2. A male stands 36 inches at shoulder and weighs 230 kg. The male also have deadly tusks which can be 12½ inches long.
3. They have rough, dirty blackish grey coat, they have mane of black bristles.
4. They live in grass or scanty bush jungles.
5. They are omnivorous, feeding early morning and late in the evening.
6. They are destructive to crops.
7. Their sense of smell is acute, eyesight and hearing is moderate.
8. Breed all through the year.
9. Move in very large groups.
10. Gestation period is 5 months.

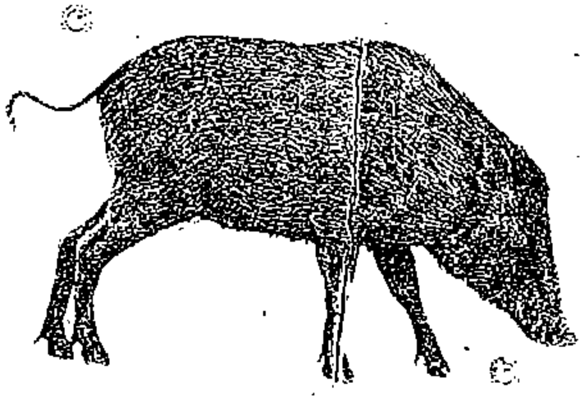

Fig. 38.8: Indian Wild Boar.

38.4.8 Indian Porcupine (*Hystrix indica*)

1. Head and body measure 28-35 inches tail 3-4 inches and spines 6 to 12 inches weigh around 11-18 kg.
2. Widely distributed, nocturnal. Body hair are modified into spines measuring 6-12 inches.
3. Each spine (also called quill) are black intercepted by white rings.
4. Like to live on rocky hill sides, moist and arid, open land and forest.
5. Nocturnal, forms a burrow for living generally eat vegetables, grains, fruits, roots but also like to chew the bones and dropped antlers of deer.
6. The calcium derived from bones is used for formation of spines.
7. When alarmed, they erect their spines, grunt and puff and rattle their hollow tail spines.
8. In aggression they run towards the enemy and embed them with spines.
9. If the spines go deep inside the enemy's body, the spines dislodge from porcupines body, which has led to a misbeleif that porcupines shoot their spines.
10. Porcupines grow new spines in place of dislodged spines.
11. 2-4 babies are born, both parents look after them.

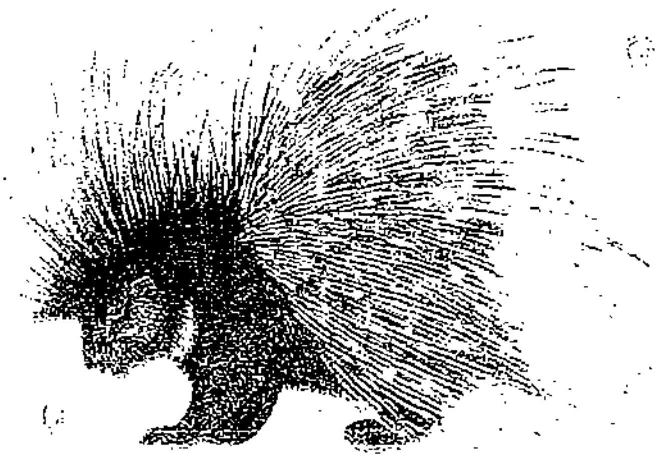

Fig. 38.9: Indian Porcupine.

38.4.9 Peafowl (*Pavo cristatus*)

1. National bird Peacock is a beautiful and magnificent bird.
2. Widely distributed, prefers dense scrub, forests and even houses, nurseries where there are big trees.
3. Peacocks have much larger and beautiful body than peahen.
4. Peacock has ornamented, vividly coloured gorgeous tail (1-1.5 mt long).

5. In male the head is crested and has bright green metallic shine.
6. Both sexes have strong hind limbs for walking and running.
7. Both sexes undertake short flights.
8. They live in a group of 4-5.
9. Feed on grains, vegetables, insects, lizards, even snakes.
10. Males give loud calls during breeding season which is in rainy season.
11. The males indulge a beautiful courtship dance.

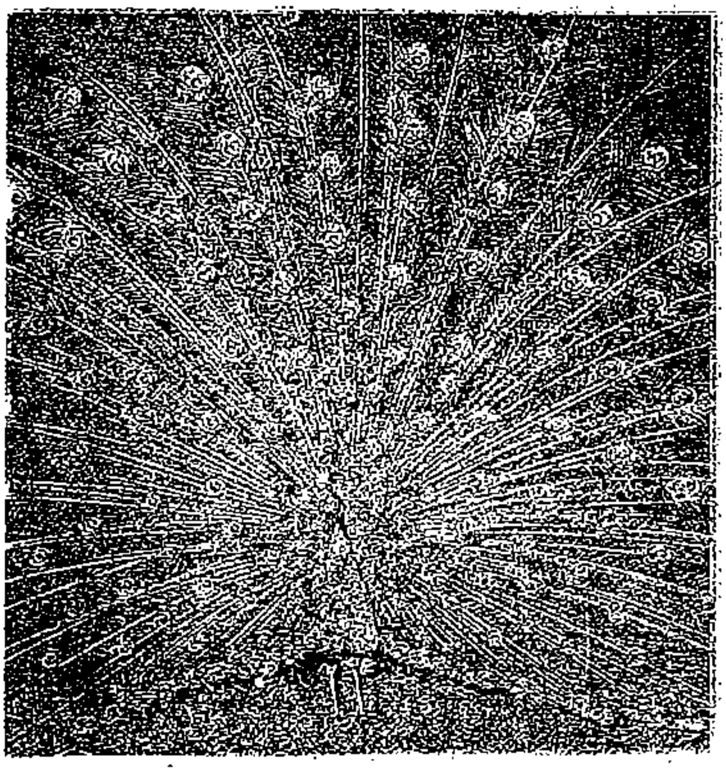

Fig. 38.10: Peacock.

38.5 WILD LIFE SANCTURIES IN INDIA

It is gratifying to note that the number of national park and sanctuaries has risen from a mere 33 in 1952 to a total of 221 by the end of December 1980, covering 2-3% of the total geographical area and 10% of the total forest area of the country.

Today, India has 80 national parks and 412 wildlife sanctuaries. In addition, there are 17 tiger reserves. The protected area is, thus, altogether over 4% of the geographical area of the country.

In recent years, there has been an increasing realization that wildlife conservation is a total concept involving animals, plants, micro-organisms and soil as also other physical elements of environment, in which they live and on which they depend.

But even then the conservation is concentrated mainly on animals and that too on mammals; plants have been taken for granted and have been left out of consideration in any meaningful programme of wildlife conservation. There is one gene sanctuary each for citrus and pitcher plants, both located in northeast India. The reason for emphasis on conservation of animals is apparent. It is assumed that "if all is well with the apex, the base of the ecosystem will also be alright". In other words, if the tiger is flourishing, then it is reasonable to assume that chital and other herbivorous prey are also flourishing and all plant life as also lesser forms of life are also flourishing. Plants are critical to the very existence of all life on the surface of earth.

Some of the important wildlife sanctuaries and national parks are listed in the following table.

Table 38.1: Important national parks and wildlife sanctuaries in India with indications of some of the more important animals (underlined).

State	Name of national parks/sanctuaries	Fauna
1	2	3
Andhra Pradesh	Pakhal Wildlife Sanctuary	Tiger, panther, hyaena, fox, jungle cat, chawsingha, etc. Horned games, aquatic birds, including spot bill.
Assam	Kaziranga National Park	Great Indian one-horned rhinoceros, wild buffalo, gaur, swamp deer, hog deer, sambar, elephant, tiger, leopard, cat, wild boar, langur, pelican, florican, partridge, python, etc.
	Manas Wildlife Sanctuary	Same as in Kaziranga, Tiger, golden langur, pigmy hog, water monitor, rich and interesting bird life.
Bihar	Hazaribagh National Sanctuary	Tiger, leopard, sloth bear, wild dog, hyaena, sambar, barking deer, chital, chawsingha, neelgai, civet cat, wild boar, etc.
Gujarat	Gir National Park	Indian lion, panther, hyaena, sambar, chital, neelgai, chawshingha, chinkara, wild boar, langur, crocodile.
	Nal sarovar Bird Sanctuary	Water birds
Haryana	Sultanpur Lake Bird Sanctuary	Most of the birds are migratory.
Jammu & Kashmir	Dachigam Wildlife Sanctuary	Hangul, musk deer, Himalayan black bear, brown bear, pine martin, other avian fauna.
Karnataka	Bandipur National Park	Elephant, gaur, sambar, chital, barking deer, chawsingha, wild boar, tiger, leopard, sloth bear, jungle cat, langur, wild dog, bird life quite rich.
	Ranganthitto Bird Sanctuary	Openbill, stork, white ibis, little egret, cattle egret, darter, cormorants, river tern, spoon bill, crocodile.

Kerala	Periyar Wildlife Sanctuary	Elephant, tiger, leopard, sloth bear, wild dog, gaur, neelgai, sambar, barking deer, wild boar.
Madhya Pradesh	Kanha National Park	Tiger, leopard, gaur, swamp, deer of hard ground, sambar, chital, black buck etc.
	Shivpuri National Park	Tiger, leopard, neelgai, chawsingha, sambar, chital etc.
Maharashtra	Dhakna-Kolkaz Wildlife Sanctuary (now under Project Tiger)	Tiger, panther, gaur, sambar, barking deer, chawsingha, sloth bear, wild boar and chital confined to flat tracts, rich bird life.
Orissa	Simlipal National Park (proposed)	Elephant, sambar, barking deer, leopard, tiger, etc.
Punjab	Abohar Wildlife Sanctuary	Black buck and several species of birds.
Rajasthan	Ranthambore (Tiger project)	Tiger, leopard, jungle cat, sloth bear, neelgai, sambar, chital, wild boar, etc.
	Sariska	Tiger, leopard, hyaena, jungle cat, sambar, neelgai, chawsingha, etc.
	Ghana Bird Sanctuary	About 300 species of migratory and resident birds. Also black buck, wild boar, sambar, chital, etc.
Tamil Nadu	Mudumalai Wildlife Sanctuary	Tiger, leopard, elephant, gaur, sambar, chital, sloth bear, wild dog.
	Vedanthangal Water Bird Sanctuary	Several species of Water birds.
Uttaranchal	Corbett National Park	Tiger, leopard, sloth bear, elephant, sambar, chital, hog deer, barking deer, chawsingha, wild boar, crocodile, rich bird life.
Uttar Pradesh	Dudwa National Park	Tiger, leopard, sloth bear, swamp deer, sambar, chital, hog deer, barking deer, neelgai.
West Bengal	Sunderbans Tiger Reserve	Tiger, sambar, chital, wild boar, several species of birds and crocodiles.

	Jaldapara Wildlife Sanctuary	Rhinoceros, elephants, tiger, leopard, wild boar, gaur, sambar, barking deer, hog deer.

** The species underlined are important protected species in the sanctuary/national park.*

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