

Introduction

Kingdom Animalia include all the animals found in this world. The word Animalia is derived from the Latin (anima means soul or breath). All those animals in which the outer most covering of the cells is a "cell membrane" (not a hard cell wall) are classified as member of kingdom Animalia. According to the recent reports kingdom Animalia is comprised of more than half a million species of animals. Some important characteristics of animals can be described as follows:

- Animals develop from two dissimilar, haploid gametes i.e. a larger egg and a smaller sperm.
- The outer most covering of all their cells is a cell membrane.
- They have a multicellular body.
- They are made of diploid eukaryotic cells.
- Animals are heterotrophic and they ingest their food.

Evolutionists believe that animals have been evolved from the single celled organisms included in kingdom Protocista, but it has yet to be decided that from which group of protocists, they have evolved. Their ancestry is still a topic of hot debate among the biologists.

9.1 Classification of Animals

Being a very diverse group, animals need to be classified for the convenience of study. In ancient times when the knowledge of cells and facility of microscopic studies were not available, scientists roughly divided the animals into two groups on the basis of presence or absence of the vertebral column.

a. Vertebrata: This group includes all those animals which possess a back bone or vertebral column. Vertebrata included fishes, amphibian, reptiles, birds and mammals.

b. Invertebrata: All those animals which do not possess backbone were included in this group. Invertebrata was divided into following phyla.

1. Phylum Porifera
2. Phylum Coelenterata
3. Phylum Platyhelminths
4. Phylum Aschelminths
5. Phylum Annelida
6. Phylum Mollusca
7. Phylum Arthropoda
8. Phylum Echinodermata
9. Phylum Chordata (excluding subphylum vertebrata)

Few invertebrate animals which do not fit to any of the above mentioned phyla

are classified into "phylum ctenophora" and "minor phyla" but the number of animals and their species present in these phyla are so much less that they are generally ignored. They are inhabitants of deep seas and we know very little about them.

Animals have also been classified on the basis of the cellular composition of their body into following three groups.

1. **Protozoa :**

Animals have a single celled body which performs all the vital functions of the life e.g. amoeba, paramecium, plasmodium, trypanosoma etc. (In recent classification protozoa has been treated as a separate kingdom Protista).

2. **Parazoa:**

These are simple multicellular animals believed to evolve from protozoa. They are just collection of cells which are not differentiated into tissues and organs. For example, porifera.

3. **Metazoa:** Animals of this group are composed of many cells. The cells are arranged into tissues, organs and organ systems. This group includes all other phyla from coelenterates to chordates. For example, metazoa are kept in a subkingdom Eumetazoa.

Another way of classifying animals is on the basis of arrangement of their cells in to layers. In this classification all those animals in which body cells are arranged into two layers ectoderm and endoderm are called **diploblastic**. Names of these two layers are the ectoderm and the endoderm. The only diploblastic animals are coelenterates. The animals in which the body is composed of three layers of cells i.e. ectoderm, mesoderm and endoderm are called **triploblastic**. All the phyla from platyhelminthes to chordates are included in this group.

9.2 Complexity in Animals

Eumetazoa are classified into two groups on the basis of symmetry of the body. Those having a radial symmetry are included in grade **Radiata**. Their body can be divided in to equal parts in more than one plane. These animals are diploblastic. Animals of phylum coelenterata (cnidaria) are included in this group.

Animals with a bilateral symmetry are included in to grade **Bilateria**. Body of these animals can be cut into two identical halves only in one plane that is they have a right and left side of the body. They mostly possess a distinct anterior end. In majority of the bilateria the anterior end possess a head, in which nervous tissues are concentrated and opening of digestive tube is located. Among the phyla described previously, platyhelminthes, nematode, annelida, mollusca, arthropoda, and chordata are all included in this group. All the animals in grade Bilateria are triploblastic.

9.2.1 Diploblastic and Triploblastic Organization

Animals in which the body is composed of two layers of cells are called diploblastic animals. In between these two layers a jelly like non-cellular material

present called mesogloea. Although they have developed some organs but they show lesser degree of specialization, hence the organ system is not well developed. They do not possess any transport system and the nervous system is in the form of a network of neurons without any central control (brain). Their body contains a central cavity called coelenteron or gastro-vascular cavity. The anterior end of this cavity is mouth, through which water and food enters. As they do not possess any anus that is why the undigested food is also excreted through the same opening. This type of digestive system is called as sac like digestive system. They reproduce both asexually and sexually.

In triploblastic animals the body is composed of three layers of cells called ectoderm, mesoderm and endoderm. In triploblastic animals the cells show greater degree of specialization into organs and organ systems. Their digestive system is tube like and most of them have a separate opening for taking food and excretion of undigested wastes respectively.

The ectoderm forms skin (integumentary system) and nervous system. The endoderm forms the lining of the digestive tract and associated glands. Rest of the organs are formed by the mesoderm like muscular, reproductive, excretory and skeletal systems etc. Triploblastic animals may be classified into acoelomates, pseudoceolomates and coelomates.

a. Acoelomates are those animals which do not possess a body cavity or coelom. In these animals instead of forming parietal and visceral layer the mesoderm forms a loose, cellular tissue which fills the space between epidermis and gastrodermis. This loose tissue is called mesenchyma or parenchyma. Function of mesenchyma is to support and protect the internal organs by filling the spaces between them like a packing material.

Acoelomates do not have much developed body systems. Only excretory and nervous systems are developed to certain extent. Animals of phylum platyhelminthes are classified as acoelomates.

b. Pseudocoelomates: These are the animals which although possess a fluid filled body cavity, but it is not a true body cavity formed between the layers of mesoderm. It rather develops from blastocoel and not from the archenteron of gastrula. Pseudocoelom is not lined by coelomic epithelium. It is rather lined externally with a muscular layer and internally with the cuticle of intestine. Pseudocoelom has no relation with reproductive and excretory systems. Animals of phylum Aschelminthes are included in this group.

Did you know?

Animals of phylum echinodermata are bilaterally symmetrical in their larval stages but the adults gain a radial symmetry secondarily due to their special mode of life.

c. **Coelomates** are the animals having a true body cavity or coelom. The cavity is filled with coelomic fluid. All the animals from phylum annelida to phylum chordata are coelomates. Coelomates are classified as Protostomes and deuterostomes. **Protostomes** (mollusks, annelids, and arthropods) develop so that the first opening in the embryo is the mouth (protostome = first mouth). Protostomes are bilaterally symmetrical, have three germ layers, the organ level of organization, the tube-within-a-tube body plan, and a true coelom. **Deuterostomes** (as exemplified by the echinoderms and chordates) develop the anus first, then the mouth at the other end of the embryo. Deuterostomes are coelomate animals having the following embryological characteristics:

- Radial cleavage in embryonic cell division: the daughter cells lie on top of

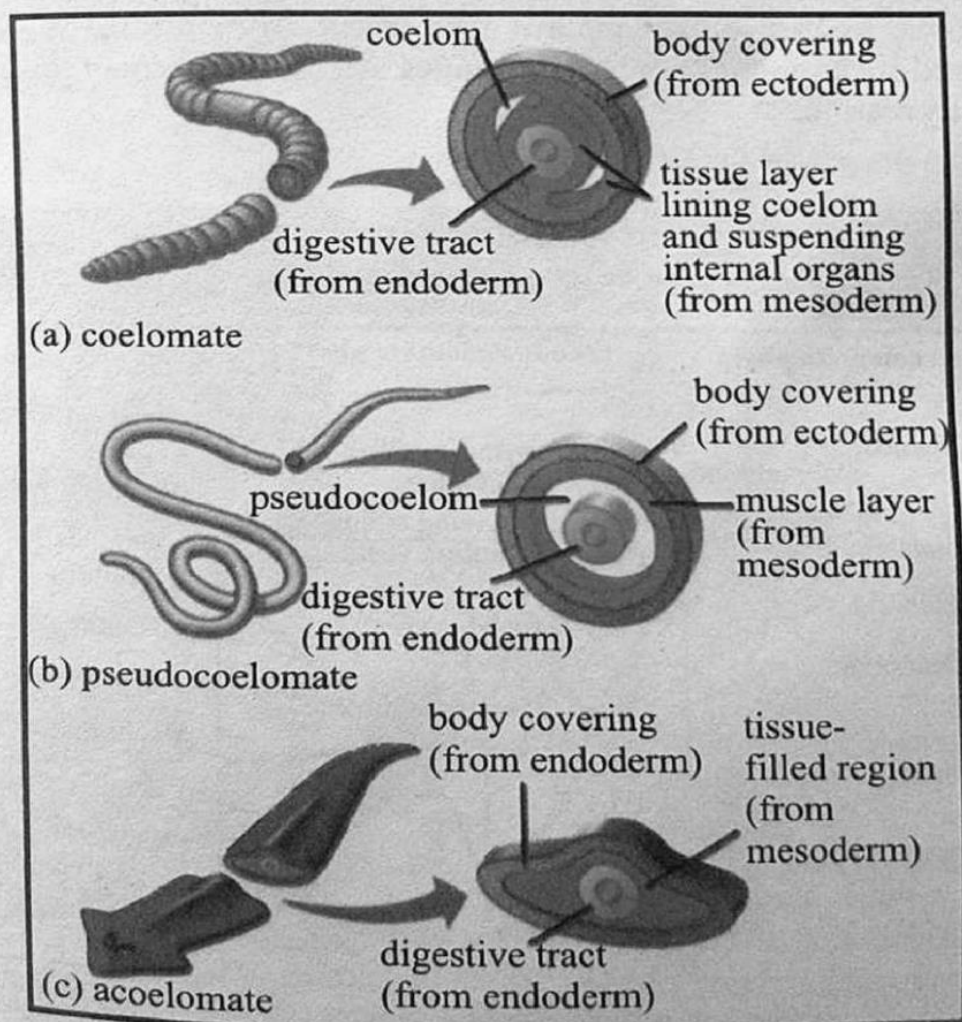


Fig: 9.1 Classification of triploblastic animals

previous cells.

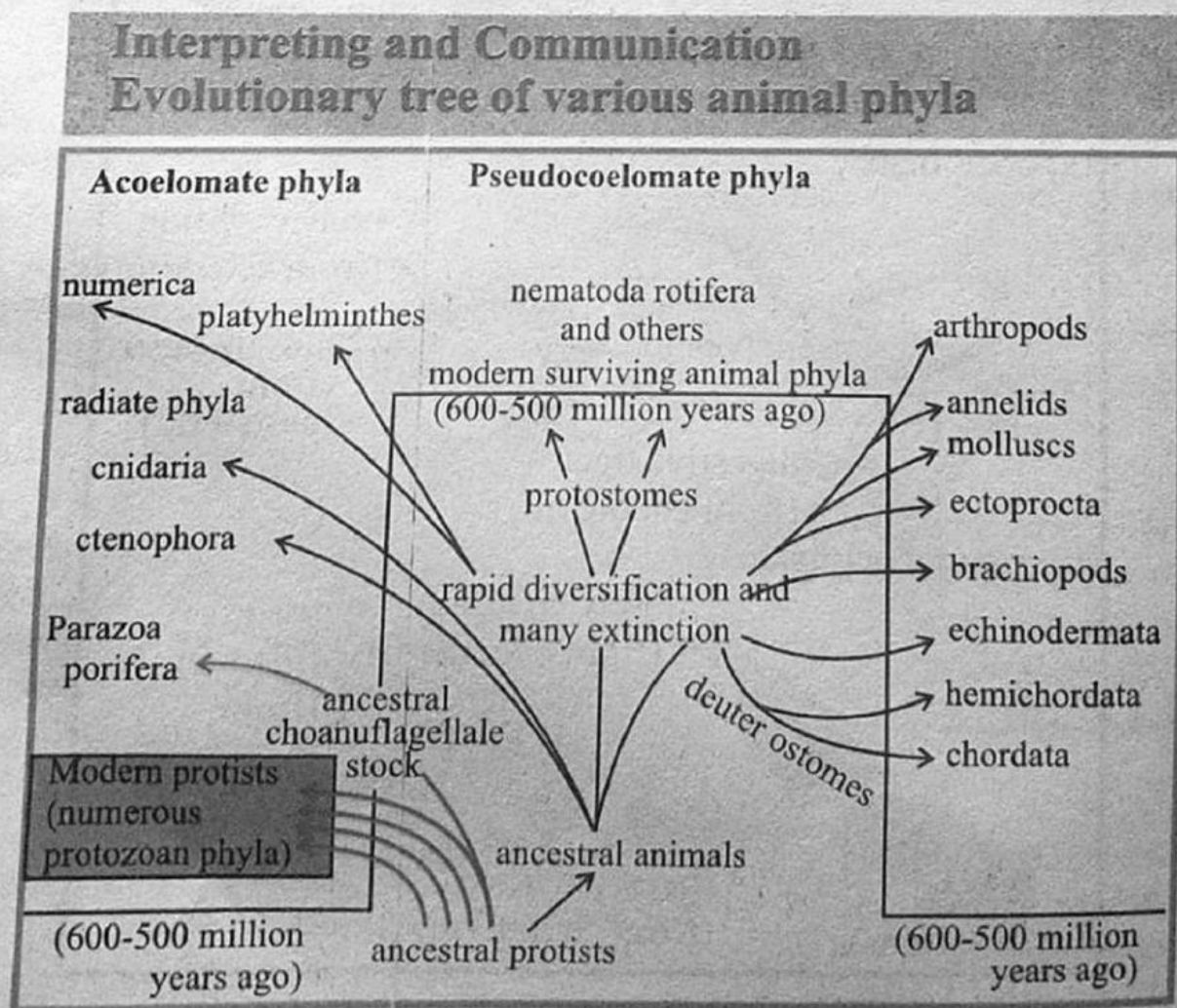
- Fate of cells is indeterminate; if embryonic cells are separated, each one develops into a complete organism.
- The blastopore is associated with the anus, and the second embryonic opening is associated with the mouth

9.3 Subkingdom Parazoa

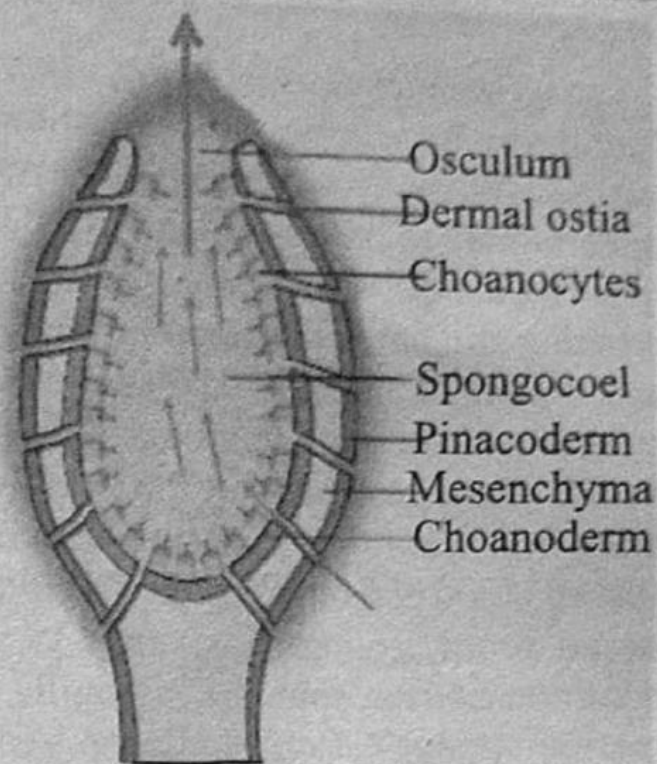
The only phylum included in this subkingdom is Phylum porifera

9.3.1 Phylum Porifera

Word porifera is derived from Latin; Porus means minute holes or tiny openings and ferra means to bear. Hence animals of this phylum bear small holes or pores all over the body. These pores are called **ostia**. Their bodies are made of groups of cells but the tissues and organs are not present. They are the most primitive metazoans and are commonly called as **sponges**. All the members of this phylum are aquatic mostly marine.

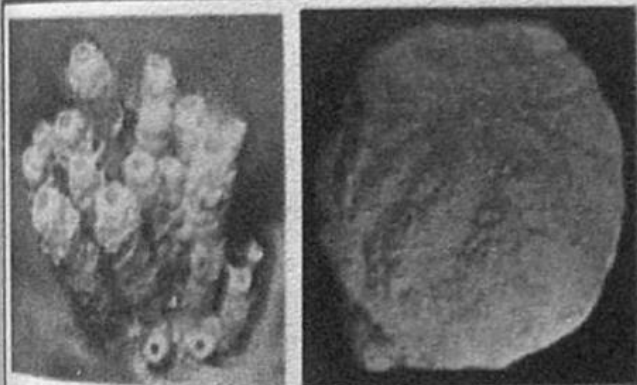


The ostia are part of canal system in which water circulates and brings food to the body. This food is digested inside body cell (intracellular digestion) as well as in the spongeocoel (extracellular digestion). Food of porifera includes phytoplanktons, zooplanktons, protozoans, crustacea and other small organisms but the major part (80%) of the food is comprised of dead decaying organic matter. Sponges are sessile (stationary) and do not contain any locomotary organ. Their dispersal takes place during asexual reproduction by budding and gemmule formation or by sexual reproduction through the formation of eggs and sperms. Process of excretion takes place by diffusion.



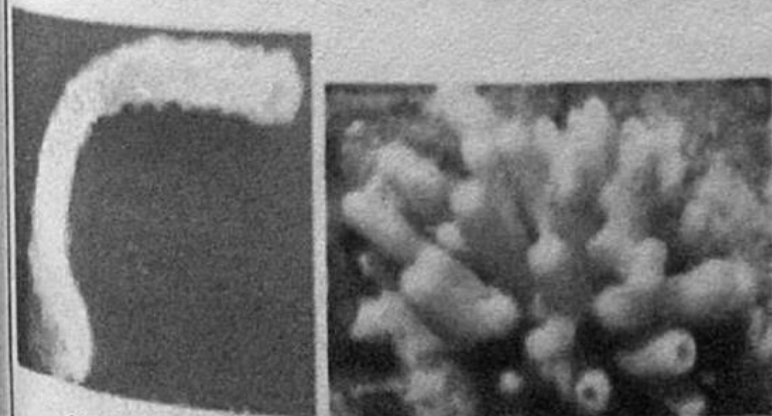
Ascon type canal system
(Leucosolenia)

Fig: 9.2 T.S of sponge
body to show canal system



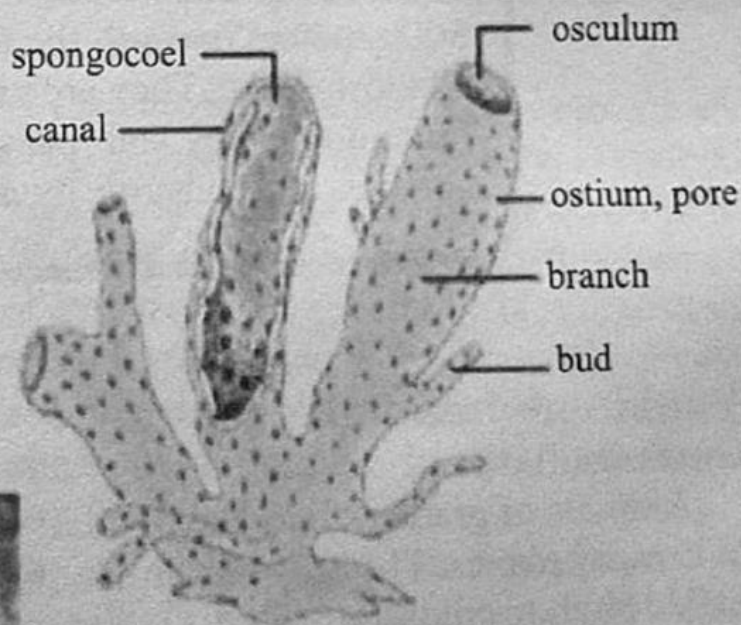
leucosolenia

spongia



euplectella

scypha (sycon)



leucosolenia

Fig: 9.3 Sponges

Sponges also lack any nervous system. Neurosensory cells and neurons are found which are believed to coordinate the flow of water.

All sponges except class mycospongia have skeleton. The skeleton consists of carbonate of lime or silicon in the form of spicules or of spongin (a fibrous protein) in the form of fibers. Sponges are economically important animals as they are used for washing and bathing by human beings from ancient times. Even after the production and availability of artificial sponges, still natural sponges have their demand in the market and they make a considerable proportion of the total business all over the world. Sponges found in the warm waters of Mediterranean Sea are commercially more important. Sponges are used in surgical operations because of their ability to absorb blood and other fluids. To reduce the noise pollution and to make the buildings sound proof, sponges are used to absorb sound waves. Examples are sycon (a common marine sponge), spongilla (a freshwater sponge) leucosolenia (a tubular marine sponge), Euplectella or Venus flower basket (a very beautiful, delicate siliceous sponge appear to be made of glass framework) etc.

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Predatory sponges have recently been discovered near the lip of a mud volcano in Barbados trench, 5000 meters beneath the sea. They belong to family Cladorhizidae. They are very large, about the size of a large dog. They stab passing crustaceans with their spicules and consume them.

9.4 Subkingdom Eumetazoa

a. Grade Radiata

Animals of grade radiata have radial symmetry and can be divided into equal halves in many planes. The only phylum included in this grade is phylum coelenterata also called phylum cnidaria.

I. Phylum Coelenterata (Cnidaria)

The word coelenterata is derived from Greek: Kolios means Hollow, enteron means intestine, and hence the animals of this phylum have a hollow, sac like intestine. Phylum coelenterata is also called cnidaria because the animals of this group have certain specialized cells, cnidocytes which give rise to nematocyst (special stinging cells).

Coelenterates are exclusively aquatic; majority live in marine environment but some live in freshwater as well.

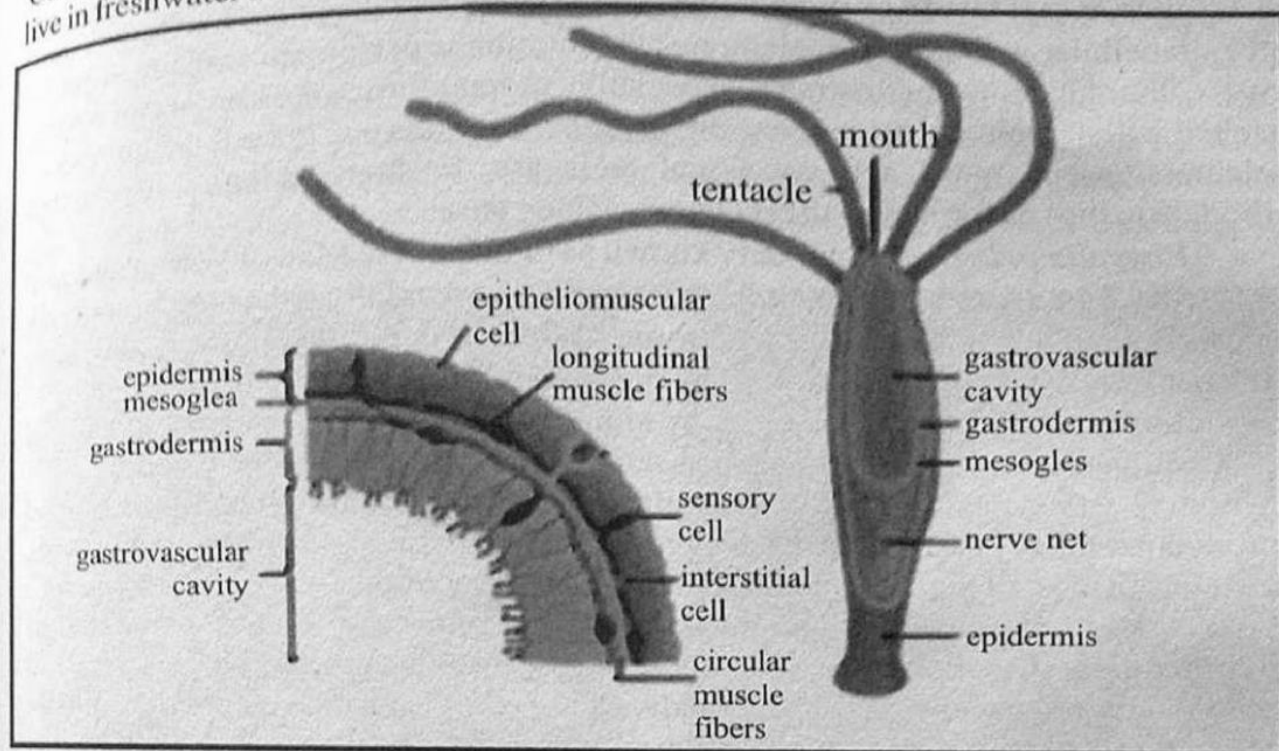


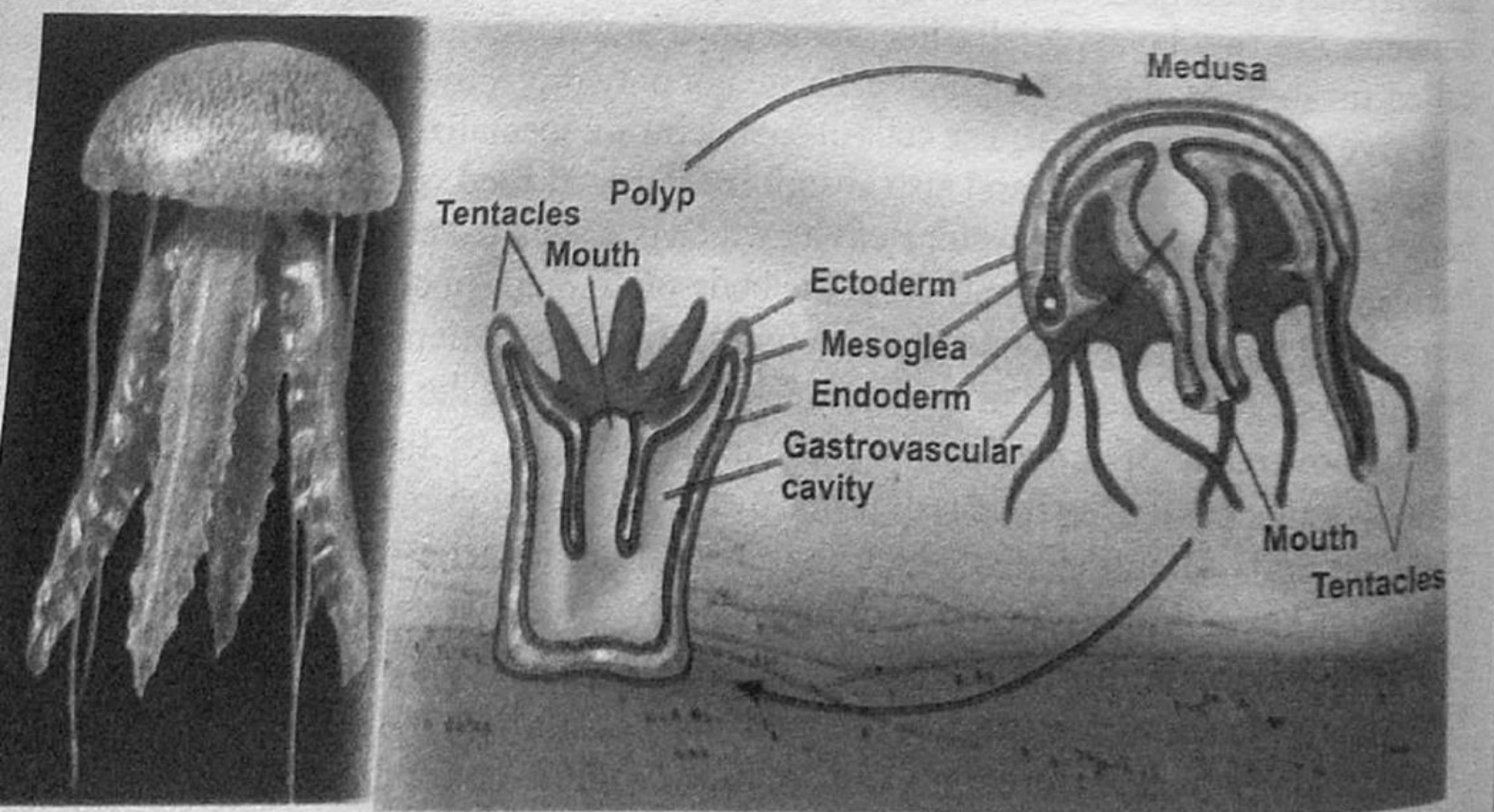
Fig: 9.4 T.S of Hydra

Coelenterates have a diploblastic organization in which the cells are arranged in to tissues and organs. The outer layer is ectoderm and the inner layer is endoderm. In between the two layers a jelly like, noncellular and nonliving material is present, called **mesoglea**. The ectodermal cells are not only protective in function but they also give rise to nematocyst. The cells of endoderm are specialized for digestion. They release digestive enzymes and also absorb the digested food. The only cavity in the body is **enteron** or **gastrovascular cavity** which is associated not only with digestion but also with many other functions of the body of animal. In coelenterates mouth is surrounded by number of tentacles which bears organs of offense and defense called **nematocyst**. As soon as an organism touches the tentacles the nematocysts are fired which movement of tentacles the animals is brought to the mouth. Inside the gastrovascular cavity, the food is digested by the action of the enzymes released by the glandular cells of endoderm, which digest the food and the remaining undigested material is again thrown out of the mouth. The digested material is absorbed into the cells of endoderm lining the enteron through diffusion and is also provided to the cells of ectoderm. In some coelenterates there are special feeding **zooids** which are called "gastrozooids" which perform only the function of nutrition for the whole colony. This

arrangement is found in Obelia and the animals of order siphonophora. Coelenterates are carnivorous. Their food varies according to their size from zooplanktons, crustaceans, insect larvae to small fishes. Both the type of digestion i.e. Intracellular and extracellular is found. In coelenterates locomotion is performed in many different ways. Although many coelenterates, especially colonial forms, are sessile and remain attached with certain object in the water e. g. obelia, corals etc. but a large number of coelenterates can move actively. Coral reefs are the huge volumes of calcium carbonate in the sea formed by the skeleton of stony corals.

Physalia pelagica, commonly known as "Portuguese Man of War", can swim at a rate of 12.1 cm/sec by the rhythmic contraction waves. Jelly fishes are fast moving coelenterates. They release water with force from their umbrella like body and move in the backward direction. This type of locomotion is called Jet-propulsion method. Respiration and excretion takes place by simple diffusion. Both asexual and sexual reproduction is found in coelenterates. Asexual reproduction is more common. It is performed either budding or regeneration or rarely by fragmentation. Sexual reproduction takes place by means of eggs and sperms which are produced in ovaries and testes. In most of the coelenterates, the sexes are separate.

A very important characteristic of coelenterates is the presence of **polymorphism** (Gr: Poly-many, morphe-Form). The existence of a single species in more than two morphological forms (individual types) is termed as polymorphism. These individual are called as **zooids**. Two major types of zooids are **Polyps** (tube like body) and **Medusae** (Umbrella like body). Another very important phenomenon found in coelenterates is **alternation of generation** or **metagenesis**. In this phenomenon asexual generation alternates sexual generation.



For example in Obelia, the polyp form, called blastostyle reproduces in to saucer shaped medusae. These medusae develop gonads in which eggs or sperms are formed. The sperms fertilize the eggs and the planula larva is formed which grows into a new polyp. In this way the polyp produces a medusa and the medusa produces a polyp.

Some common example of this phylum are Hydra, Obelia, Jelly fish, sea anemone and Corals. Corals are economically very important as they form coral reefs. Jelly fishes are eaten as delicacy. Some of them are poisonous and cause serious health threat for divers and swimmers. Corals live in colonies and they make huge structures called coral reefs.

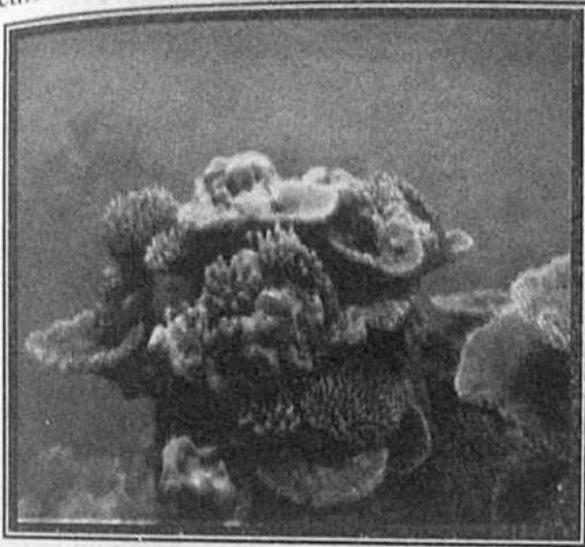


Fig: 9.6 Corals

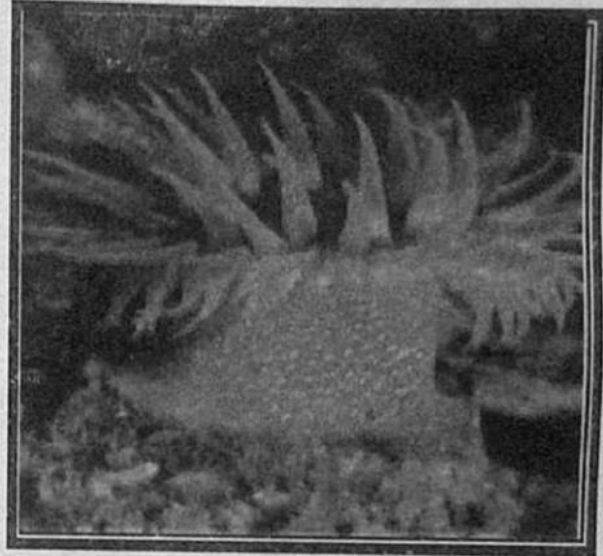


Fig: 9.7 Sea anemone

b. Grade Bilateria

Animals included in this grade have bilateral symmetry. Body of these animals can be cut into two identical halves only in one plane that is they have a right and left side of the body. All the phyla from platyhelminthes to chordates are bilaterally symmetrical. They are all triploblastic as well.

1. Phylum Platyhelminthes

Body of all the animals included in this phylum is dorso-ventrally flattened, i.e. leaf like or paper like hence called flat worms. They are bilaterally symmetrical. They are the first triploblastic metazoa and are acoelomates. Their bodies are either unsegmented or superficially segmented, and true segmentation is absent. In free living form the ectoderm is ciliated but in parasitic forms the cilia are absent and a thick coat of cuticle is present for protection. Organs of attachment are present in the form of hooks or suckers. Digestive system in free living form is developed but in parasitic forms it is either poorly developed (Class Trematoda) or completely absent (Class Cestoda). No circulatory or respiratory system is present. Excretory system is with few flame cells (flame cell is a structure with thin elastic walls with a nucleus and a cavity containing many long cilia flickering like a flame) attached with ducts which open at excretory pore. Nervous system is with a pair of anterior cerebral ganglia and a

ventral ganglion connected by nerve ring and one or three nerve cords.

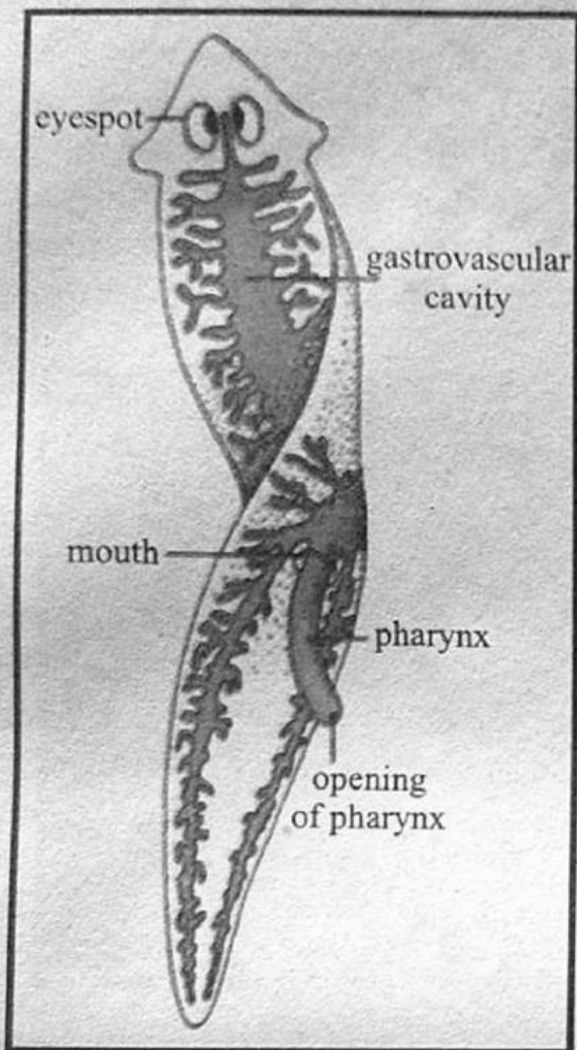


Fig: 9.8 Planaria showing digestive system

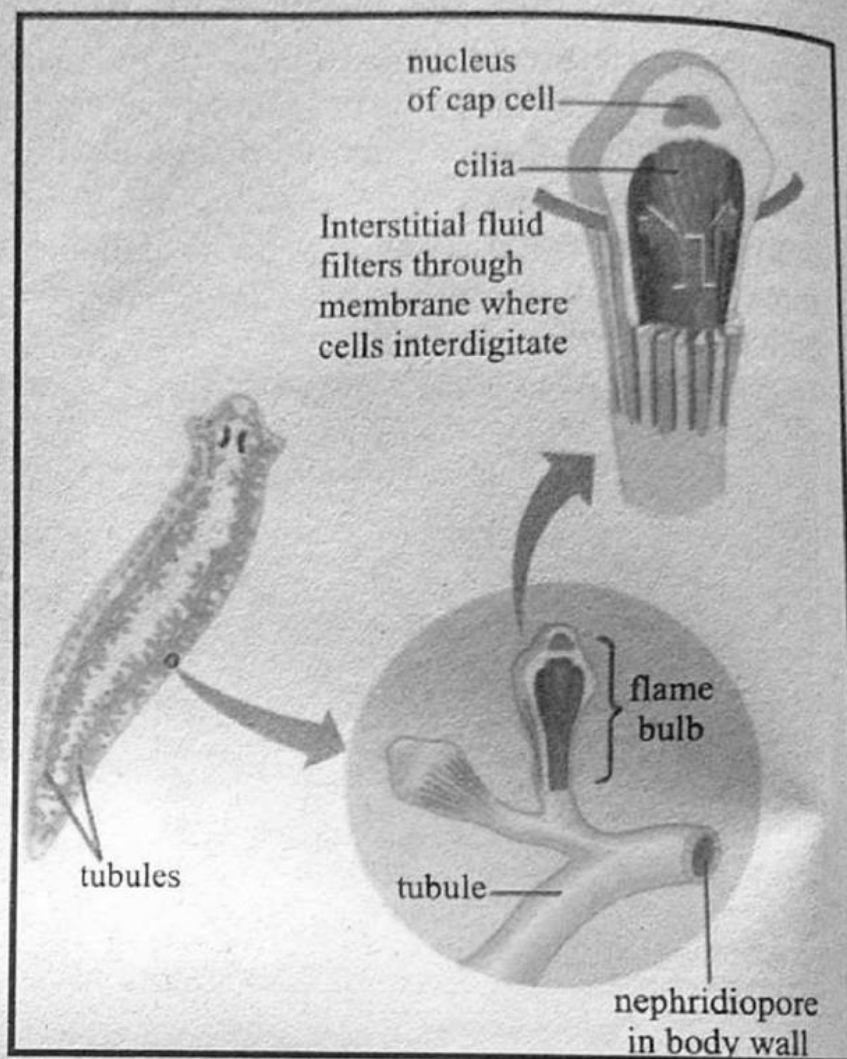


Fig: 9.9 Planaria showing excretory system

Muscular layer is well developed in free living forms which help in locomotion. They are hermaphrodite i.e. both sex organs are found in the same animal. Reproductive system is well developed with gonads, their ducts and copulatory organs. Eggs are small with yolk and are produced in very large number. Self and cross both types of fertilization is present among platyhelminthes. Fertilization is always internal. The fertilized eggs are passed out which either directly grow into a new individual as in planaria and tape worm or different type of larvae are formed as in liver fluke.

Regeneration ability is present in Class Turbellaria (Planaria) but Class Trematoda (liver flukes) and Class Cestoda (tape worms) being parasitic do not show any regeneration. All the members of this phylum are solitary i.e. not found in colonies.

In Cestods (Tapeworms) the digestive system is completely absent. Tape worm absorbs digested food from the wall of the intestine of the host where they remain attached with the help of scolex (head) which is provided with hooks and suckers.

Platyhelminthes is a diverse group with about 15000 species ranging in size from few millimeters (Planaria is about 10 mm) to many feet (tape worm reaches to 16 feet or about 5 meters). Economically they are very important. Liver flukes and tape worms cause serious diseases in sheep, goat, cow, buffalo, pigs, horse, donkey and other domesticated animals causing heavy mortality which inflicts great economic losses. Human tapeworm *Taenia saginata* is a serious health hazard in poor and developing countries of Asia and Africa. Its infection results in retarded growth, nausea, weight loss, abdominal pain and nervous disorders (resembling epilepsy) and in case of children death may also be caused.

Common examples of this phylum is Planaria (Dugesia), Liver fluke (*Fasciola hepatica*), Tape worm (*Taenia solium*) etc.

2. Phylum Aschelminths (Nematoda)

The word nematoda is of Greek origin which means thread. Nematodes are also called as round worms. In nematodes the body is long and cylindrical tapering at both ends. They are bilaterally symmetrical and are triploblastic. They are **pseudocoelomates** i.e. the body cavity is not a true coelom. The body is **non-segmented**.

Nematodes do not have any cilia on their body. A hard layer of cuticle is present on the body for protection. No respiratory or circulatory system is present. The fluid contained in the body cavity performs the function of the blood. The alimentary canal is well developed with an anterior opening (mouth) and posterior opening (anus).

The excretory system consists of two longitudinal canals on each side which open on the ventral side by a small excretory pore close behind the mouth. Nervous system consists of a nerve ring which encircles the pharynx and sends its branches in different parts of body.

In nematodes the muscles are arranged in four longitudinal bands. Circular muscles are not present in these worms. Therefore, they show specific type of whipping movements.

Sexes are generally separate. Males are smaller than females. Power of regeneration is absent.

In male the testes is a long, coiled thread with a seminal vesicle which posteriorly opens in to rectum by a short ejaculatory duct. Female reproductive organs are a pair of very much coiled ovaries passing into uterus and two uteri unite posteriorly forming vagina which on the ventral surface at the female genital aperture situated in the middle line.

The most common animal of this phylum is *Ascaris lumbricoides*. It is an endoparasite in the small intestine of man. It lives freely in the lumen (cavity of the small intestine). The body is elongated, cylindrical and tapering on both ends. Sexes

are separate. The female is 8-16 inches long but the male is 6-12 inches in length.

The anterior part of both male and female is similar that is pointed but the posterior part of the male ascaris is curved with two spine like structures called penial setae. In female the posterior end is not sharply pointed.

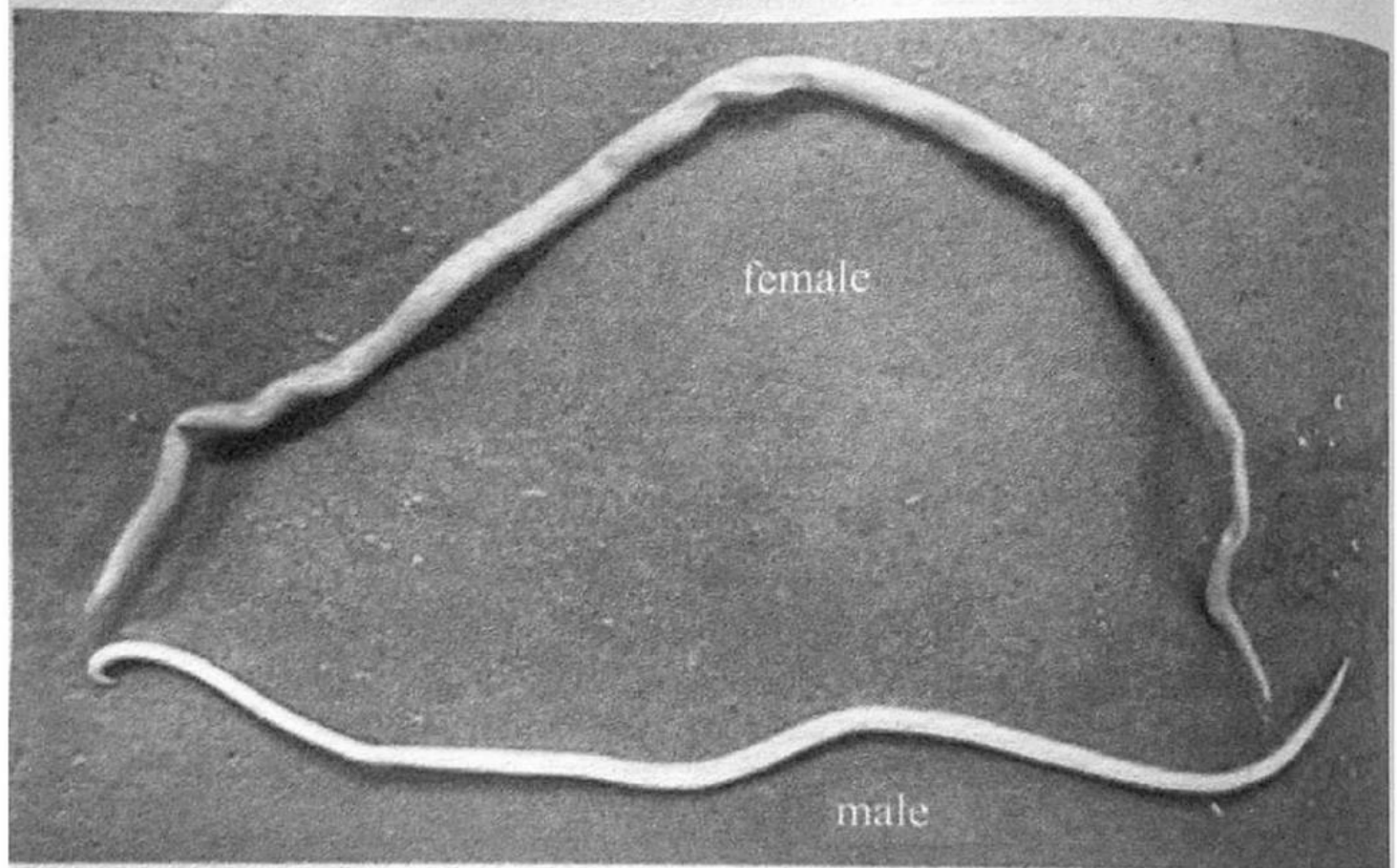


Fig: 9.10 Ascaris

Enterobius vermicularis is another human parasite commonly known as pinworm. It mostly parasitizes children which ingest its eggs with soil or in some other way. It lives in the caecum, colon and appendix of its host.

It causes severe itching of the anus, inflammation of the mucus membrane of colon and appendix. This results in sleeplessness (insomnia) and loss of appetite.

Nematodes are found every where in fresh and salt water, in soil etc. A lump of soil may contain thousands of nematodes. Many of them are free living but some are parasitic on plants and animals including man.

These parasitic forms cause great economic losses in terms of expenditure in health sector and crop destruction. Free living soil nematodes decompose organic matter and play a major role in soil fertilization.

Nematodes are an important part of most food chains and food webs and are therefore economically very important.



Fig: 9.11 Pinworm

3. Phylum Mollusca

Name of the phylum has been originated from a Latin word “molluscus” which means soft; hence animals in this phylum have soft bodies which are mostly protected by calcareous shells. This is the second largest phylum of invertebrates having more than 80,000 species (in addition 35,000 fossils forms are also reported). General characters of molluscs are following:

They are soft bodied, triploblastic animals possessing bilateral symmetry. They are coelomates. Most of them are protected by a shell of calcium carbonate (CaCO_3) secreted by the mantle. The shell may be in one piece or two pieces. In some molluscs the shell may be internal, reduced or totally absent. The body can be differentiated into a head, a dorsal visceral hump and a ventral muscular foot. The body is covered by a tough, fleshy membrane called mantle which also secretes shell.

The space between the body and mantle is called mantle cavity in which kidneys and anus open. They respire through gills present in mantle cavity. They have a rasping tongue called **radula**. The digestive system is well developed. The body cavity is a haemocoel. Blood vascular system consists of a single heart (with one ventricle and one or two auricles) arteries, veins and haemocoelic chambers. The nervous system consists of three pairs of orange coloured ganglia connected by nerve cords. Nerves arise from these ganglia and enter different organs of the body. Sexes are generally separate. The testes are white and ovaries are of reddish colour. Fertilization is external. Development is either direct or a larva is formed called **Glochidium larva**.

Animals of this phylum are economically very important. They are mostly marine but many molluscs live in fresh water or even in terrestrial environment. Shells of molluscs are used as ornament and are also used to make decoration pieces. The pearl formed by the marine mussel is used in jewelry. Octopus and cuttle fish and large sized mussels are eaten as delicacy in many countries of the world.

Common examples of this phylum are garden snail (*Helix aspersa*), slug (*Limax maximus*), Freshwater mussel (*Anodonta grandis*), marine mussel (*Mytilus edulis*) oyster (*Ostrea lurida*) which makes pearl, squid (*Loligo pealii*), cuttle fish (*Sepia officinalis*) and octopus (*Octopus bairdi*).

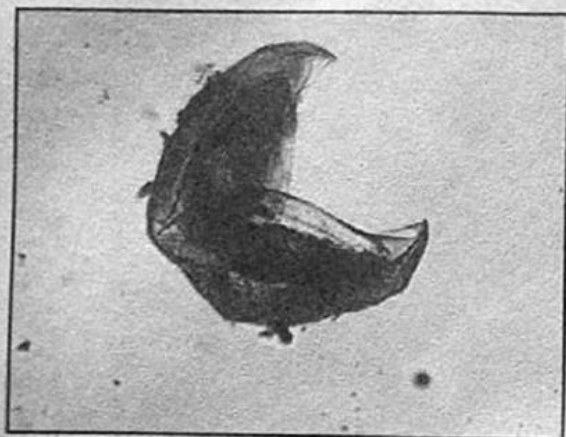


Fig: 9.12 Glochidium larva

Ticbit

In certain molluscs like octopus and cuttle fish a blue coloured respiratory pigment **haemocyanin** is present. The blue colour of the pigment is due to the presence of a copper molecule (as iron in haemoglobin). Haemocyanin can transport three times more oxygen as compared to haemoglobin.

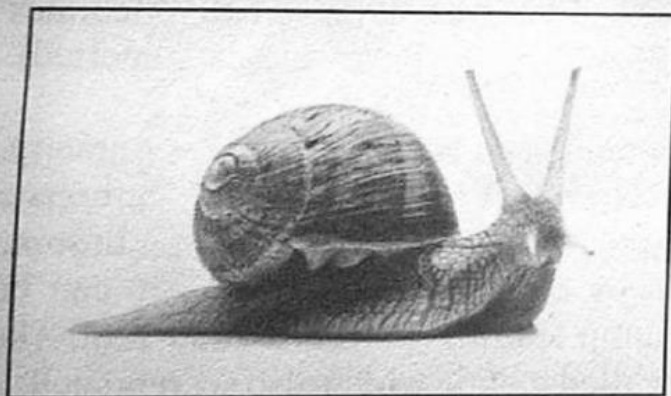
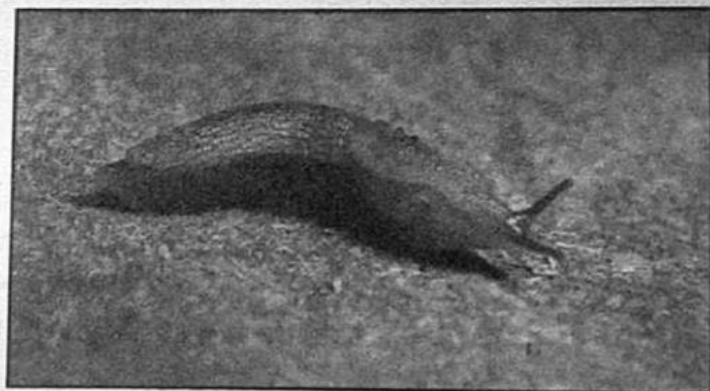


Fig: 9.13 a. Garden snail (*Helix aspersa*)



b. slug (*Limax maximus*)

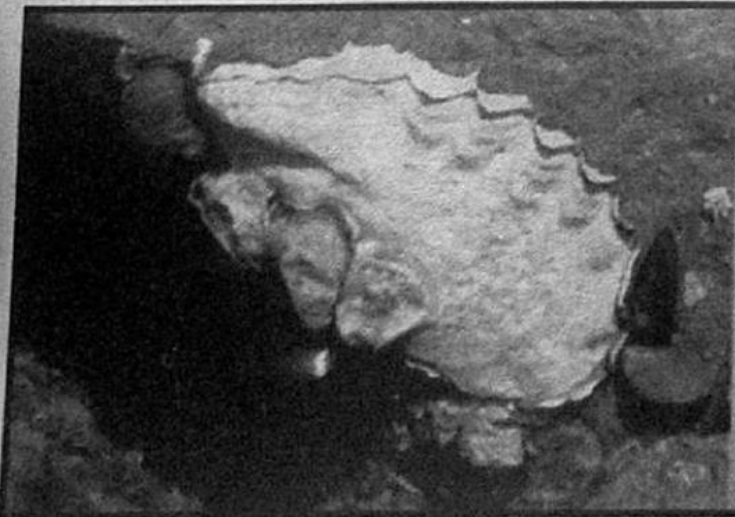
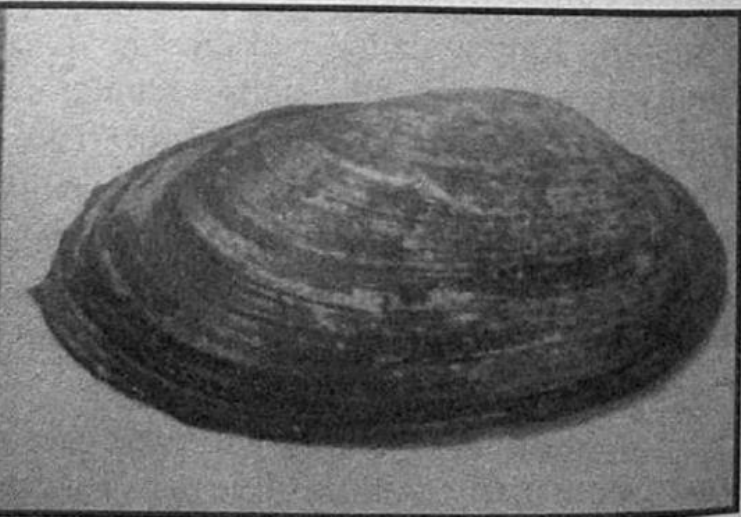


Fig: 9.14 a. Oyster (*strea lurida*)



b. Mussel (*Anodonta grandis*),

4. Phylum Annelida (First true Coelomates)

The word annelida is of Greek origin; annelus means little ring, the animals of this phylum have their bodies divided in to rings (segmented body) hence called annelids. Body of annelids is bilaterally symmetrical. The body may be cylindrical as in earthworm, or dorso-ventrally compressed as in neries. Body is **metamerically segmented** i.e. the organs are repeated in every segment. They are triploblastic. They are coelomates having a true **coelom**. They have a closed circulatory system. In earthworm four to five pairs of hearts called **pseudo-hearts** are present, which contract rhythmically to keep the blood moving in the system. Colour of the blood is red due to haemoglobin dissolved in the plasma.

The digestive system is well developed especially in free living species. Different digestive organs are well formed. Excretory system consists of metamerically arranged **nephridia**. Nephridium opens to the exterior through **nephridiopore**. The body is covered with glandular epidermis, which secretes mucus and keeps the skin moist. Locomotory organs are **setae** (in earthworm) or **parapodia** (in neries). Respiration is through general surface but some annelids e.g. neries have **gills** under parapodia. The body is covered with cuticle.

Annelids are mostly **hermaphrodite** i.e. the same animal contains both type of sex organs; ovaries and testes but cross fertilization is common. **Trochophore larva** is formed during life cycle of some annelids especially in marine species. They are found everywhere in damp soil, fresh and marine water and some species are parasitic too.

In annelids like earthworm every segment of the body contains a blood vessels, epidermal structures (like setae etc.), nervous and excretory organs. This pattern is repeated in most of the segment with some variation.

Annelids are economically very important group of invertebrates. Earthworm makes the soil porous and fertile which increases the production of crops. Animals of this group are an integral part of the food chains both in aquatic and terrestrial environment. Leech being a parasite of cattle damages their health and growth. Common examples are *Pheritema posthuma*

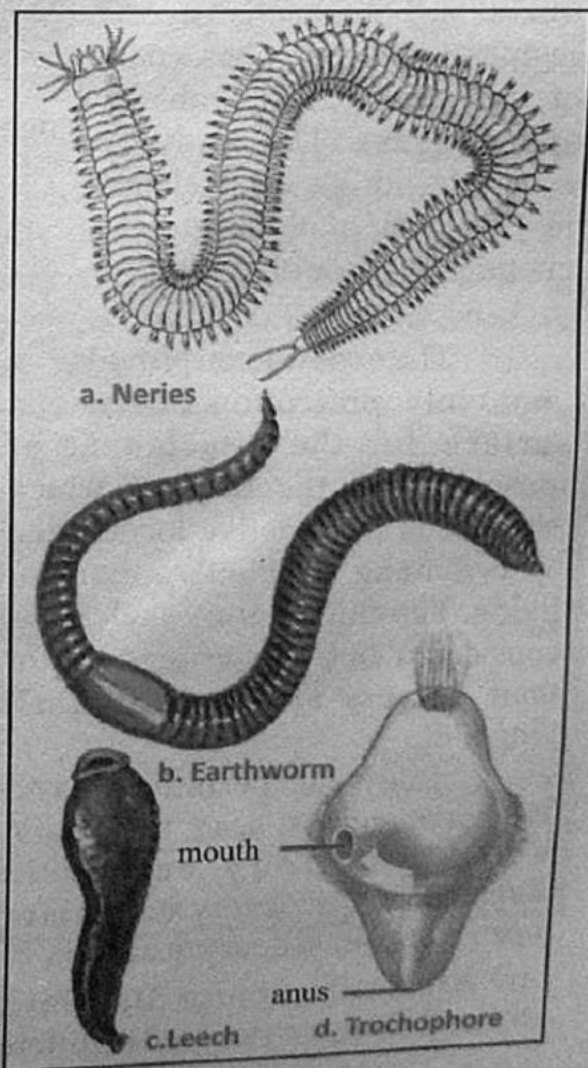


Fig. 9. 15 Annelides

(earthworm), *Hirudinaria medicinalis* (medicinal leech), *Neries* etc.

5. Phylum Arthropoda

The word arthropoda is derived from two Greek words; *Arthoros* means Jointed and *Podos* means limbs or legs hence, arthropoda includes all those animals having jointed appendages. This is the most successful group and the largest phylum of the animals.

They are triploblastic and bilaterally symmetrical. The body is metamerically segmented. They have jointed limbs and generally every segment of the body has a pair of legs (also called limbs or appendages). The body is covered with an exoskeleton in the form of thick cuticle chemically made of **chitin**.

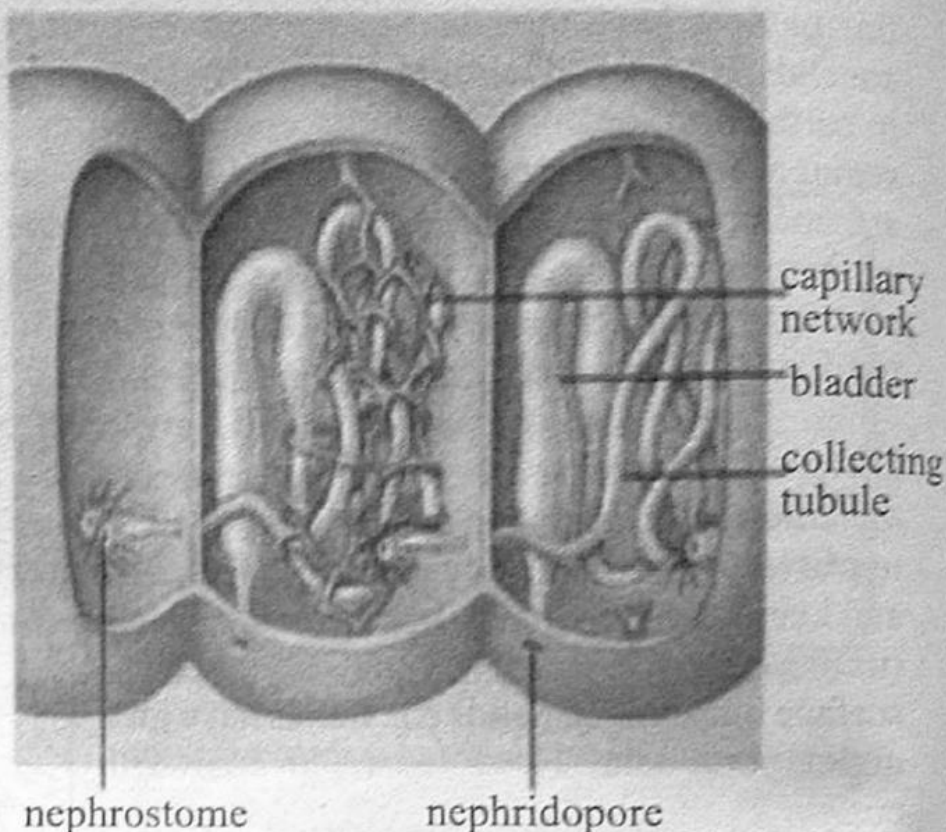


Fig: 9.16 Nephridium

The exoskeleton provides not only protection but also a surface for the attachment of muscles with the help of which arthropods show active locomotion by swimming, crawling, walking or flying. The chitinous exoskeleton is considered one of the reasons for their success among the animal kingdom.

Body can be differentiated into three regions; head, thorax and abdomen. Body cavity is **haemocoel**. Circulatory system is of open type. Blood does not contain

any respiratory pigment. Blood is called **haemolymph** because (it does not carry oxygen) it only carries food to different tissues of the body.

Science Technology and society

Processing of organic materials by earthworms into homogeneous and humus-like material is called vermicomposting. This material is a complex mixture of fecal matter of earthworms and microorganisms. In vermicomposting system, earthworms act as voracious feeder, modifying composition of organic waste, gradually reducing its organic carbon and C:N ratio and retains more nutrients (nitrogen, potassium, phosphorus, calcium).

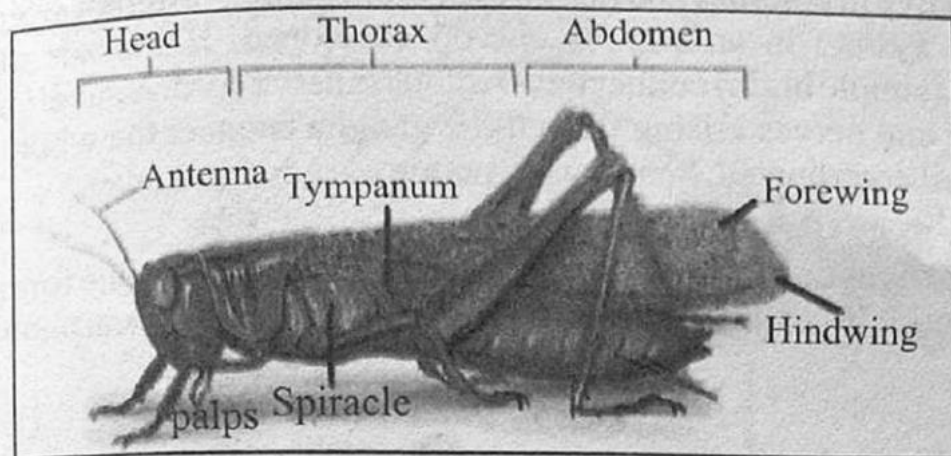


Fig: 9.17 Grass hopper showing morphological features

Respiration takes place in aquatic forms through gills and in terrestrial forms (especially insects) through **trachea**. Trachea are air tubes which divide repeatedly to form numerous fine branches distributed to all the tissues of the body. They communicate with exterior through openings on each side of the body known as **Spiracles**. Arachnids, a group of arthropods including scorpion, spider etc. respire through special structures, arranged side by side like books in a book shelf, hence called **book lungs**.

Excretion takes place either through **malpighian tubules** (as in insects) or green gland or coxal gland (as in crustacean). Fertilization is internal. Sexes are generally separate. Sexual dimorphism is generally present i.e. male and female can be differentiated from each other on the basis of their morphology. During development they exhibit either complete metamorphosis or incomplete metamorphosis. Some insects like honey bees, ants, termites etc. show social

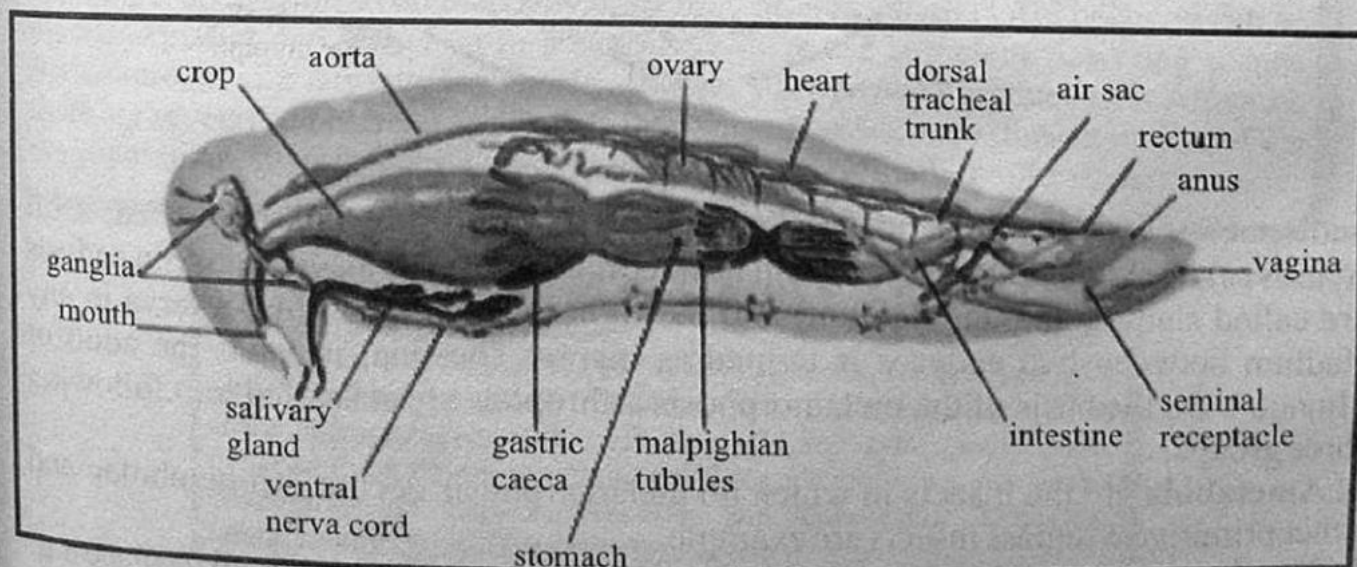


Fig: 9.18 Grass hopper showing anatomical features

behaviour. They live in colonies and divide their work among different groups.

Nervous system in arthropods is well developed. It consists of a pair of cerebral ganglia (simple brain) connected to a double nerve cord. A ganglion is present in each segment and nerves arising from these ganglia connect the whole body. The responses are well coordinated. Sensory organs are eyes and antennae.

a. Metamorphosis in Arthropodes

All the changes occurring from the fertilization of an egg to the formation of an adult are collectively called **metamorphosis**. During metamorphosis a larva

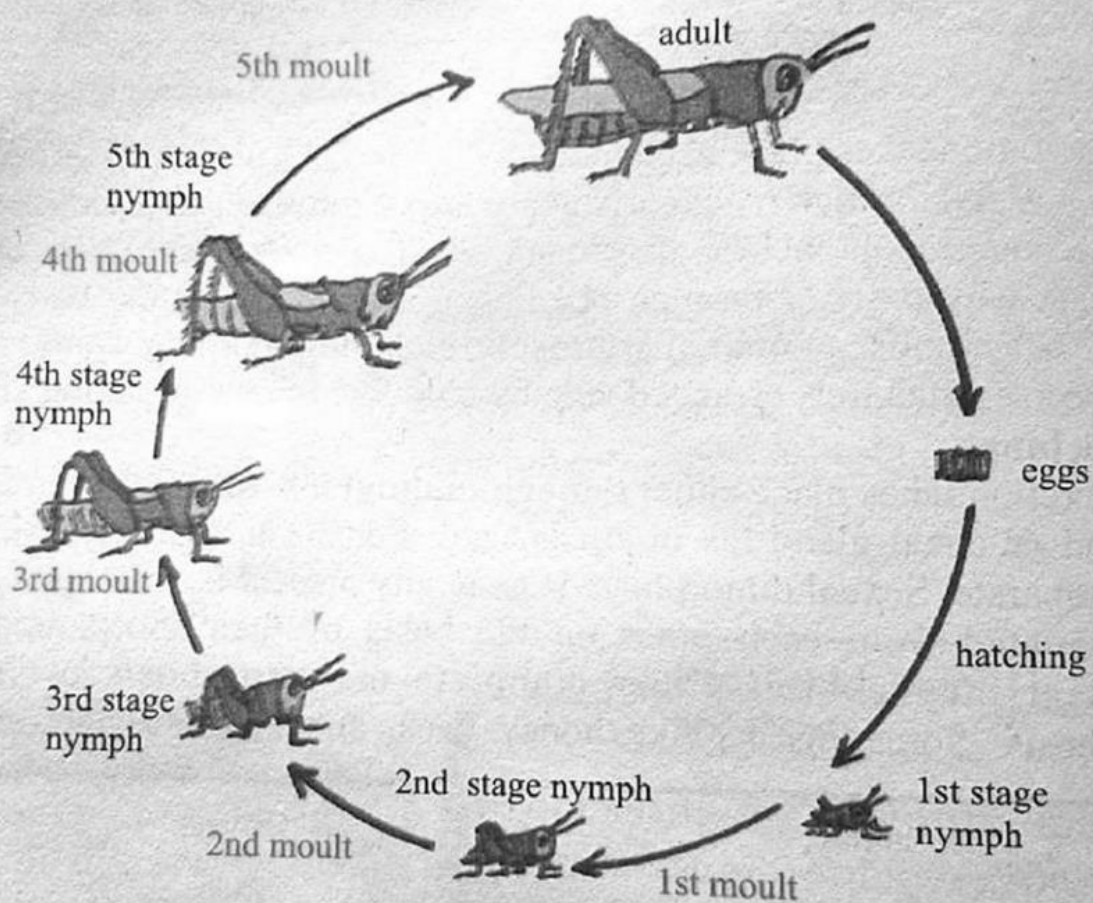


Fig: 9.19 Incomplete metamorphosis in Cockroach

undergoes a series of changes called **ecdysis** or **moulting** in which it casts off (removes) its skin many times to attain its maximum size. The stages between ecdysis are called **stadia** (singular stadium) and the form attained by an insect larva in any stadium between two ecdyses is termed as **instar**. The final instar is the adult or "Imago". On the basis of the metamorphosis arthropods are classified into following three groups.

- a. **Ametabola** are the insects in which no metamorphosis occurs. Collembolan and other primitive wingless insects are example.
- b. **Hemimetabola** are the insects in which incomplete metamorphosis takes place e.g. This type of meta morphosis is found in insects like Cockroaches, Wasps etc
- c. **Holometabola** are those insects in which complete metamorphosis takes place.

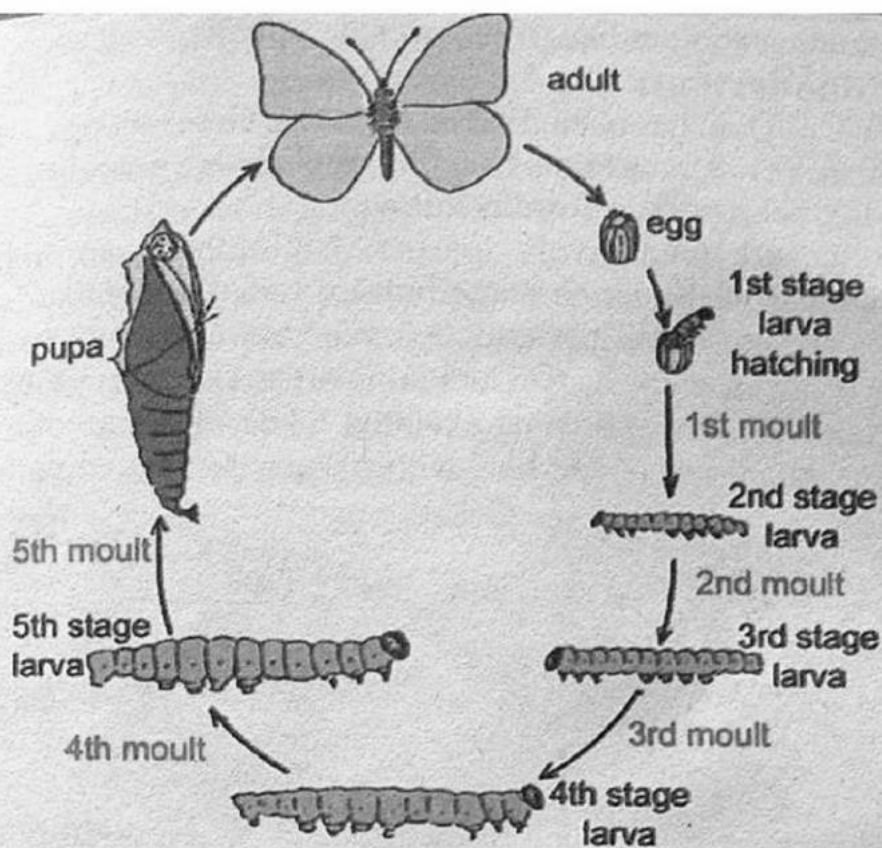


Fig: 9.20 Complete metamorphosis in butterfly

Science Technology and society

Apiculture is the scientific method of rearing honeybees. "It is the care and management of honey bees for the production of honey and the wax. In this method of apiculture, bees are bred commercially in apiaries, an area where a lot of beehives can be placed. Apiaries can be set up in areas where there are sufficient flowering plants. Sericulture, or silk farming, is the cultivation of silkworms to produce silk. Although there are several commercial species of silkworms, *Bombyx mori* (the caterpillar of the domestic silkworm) is the most widely used and intensively studied silkworm.

Ticbit

Members of Onychophora, a group of arthropods, are believed to be separated from the main evolutionary line of the arthropods. They share characteristics with both annelids and arthropods, hence believed to be the most primitive arthropods and are considered a connecting link between Annelids and Arthropods. This class contains only about 70 species classified in 10 genera.

Most insects are holometabolites like flies, butterflies, moths, beetles etc.

6. Phylum Echinodermata

Name of the phylum has been derived from two Greek words; *ekhin* means spine and *derma* means skin. Animals of this phylum have spiny skins. General characters of phylum echinodermata are as follows.

Echinoderms are exclusively marine, triploblastic animals. They are bilaterally symmetrical in the larval stage but are radially symmetrical as adults. Usually five arms are present. They are coelomate animals with distinct oral and aboral surfaces. A water vascular system including organs known as tube feet is found used for locomotion. They have a spiny skeleton made of calcareous plates. Body shape is rounded to cylindrical or star like, with simple arms radiating from a central body.

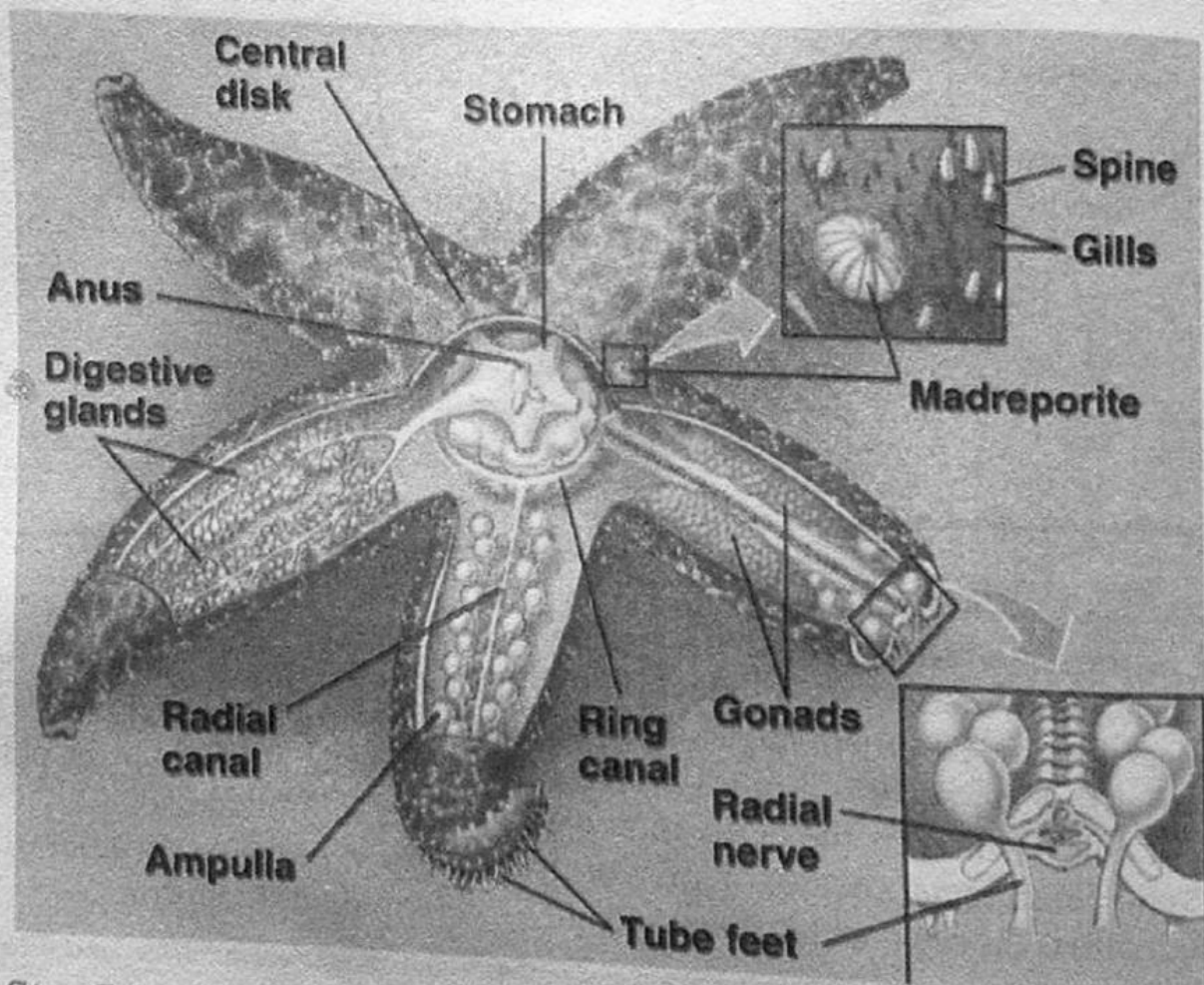


Fig: 9.21 Star fish a representative animal of echinoderm body showing various systems

Body consists of an outer epidermis, a middle dermis and an inner lining of peritoneum. Alimentary canal is usually a coiled tube opening at mouth and anus. A typical circulatory system is present also called heamal system.

Digestive system of echinoderms consists of a short coiled tube, the alimentary canal with ten pairs of pyloric caecae, the digestive glands. All echinoderms including starfish are carnivores. Food mainly consists of molluscs such as oysters, clams, mussels etc. Fish, crabs and other small animals are also taken as food. Tube feet help to capture prey.

Respiration occurs through a variety of structures e.g. papulae in star fishes, peristomical gills in sea urchins, genital bursae in brittle star and cloacal respiratory tract in sea urchins. Tube feet also help in respiration. Nervous system is primitive consisting of network concentrated into the radial ganglia containing nerve chords. Sense organs are poorly developed.

Sexes are usually separate with few exceptions. Reproduction is usually sexual but power of regeneration is well developed. Fertilization is external. Development is indeterminate including characteristic larvae called **bipinnaria larva** which undergo metamorphosis into the radially symmetrical adults.

Amoeboid cells known as amoebocytes roaming about in coelomic fluid absorb waste material and make their way out through the wall of rectal caecae. The amoebocytes are constantly produced in the body for this purpose.

Beside many nerve cells which lie among the epidermal cells, the radial nerve cord run along the ambulacral groove and unite with a nerve ring encircling the mouth.

The apical nervous system consists of a trunk in each arm which meets the other trunk at the centre of the disc. These trunks innervate the dorsal muscle of the arm. The tube feet are the principal sense organs. They receive nerve fiber from the radial nerve cord at the end of each radial canal, the radial nerve cord ends in a pigmented mass known as eye which is a light perceiving organ.

The star fish and other echinoderms have a remarkable power of regeneration. A single arm with part of central disc regenerates into a new animal.

Echinoderms: Ancestry and Evolution

Echinoderms are very different from other phyla. Some of the differences are:

- i) They have no parasitic member.
- ii) They are all marine.
- iii) They are unique in having bilateral

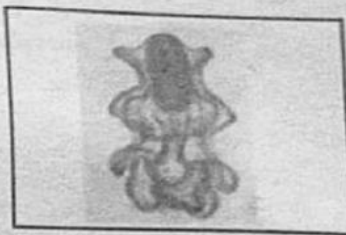


Fig: 9.22 Bipinnaria larva

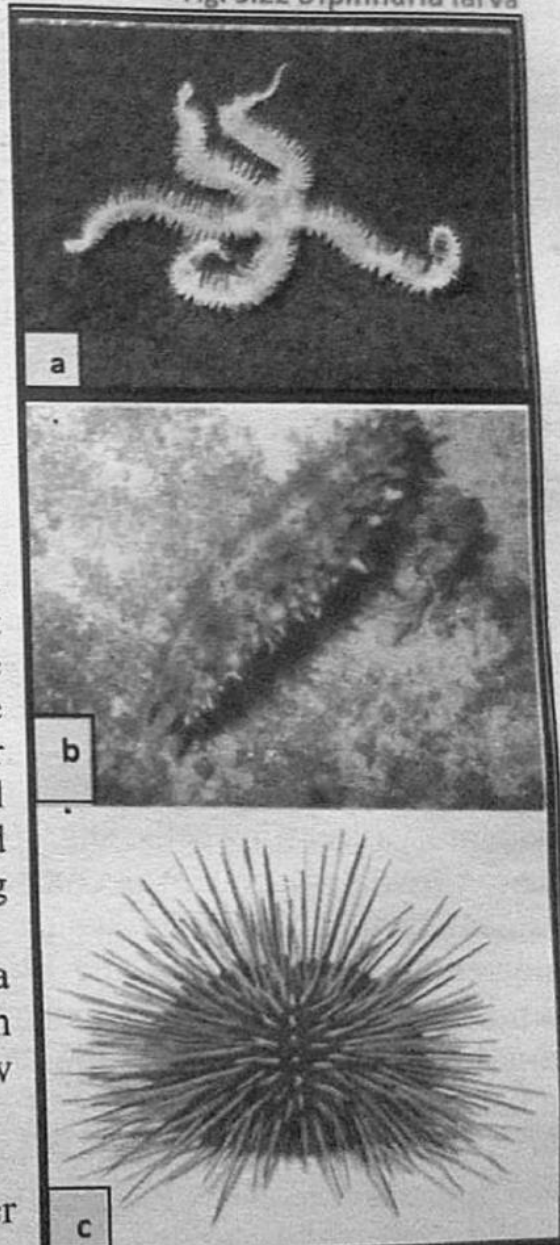


Fig: 9.23 Examples of Echinoderms

- a. *Ophiothrix fragilis* (brittle star)
- b. *Arbacia punctulata* (sea urchin)
- c. *Thyone briareus* (sea cucumber)

symmetry in larval stages but radial symmetry in adult stage which seems to be of secondary phylogenetic origin.

Although they are very different from all invertebrate phyla, still they have a strong affinity to phylum chordate especially to subphylum Hemichordata. Ciliated larvae of certain Hemichordates (e.g. *Tonaria* larva of *Balanoglossus*) and bipinnaria larva of echinoderms are very much similar in shape and structure. Pattern of cleavage of fertilized egg, formation of mesoderm, anus, mouth and coelom in echinoderms and hemichordates is similar. Creatinine phosphate in the muscles of both echinoderms and chordates are similar which produce energy for muscular activity. On the basis of these similarities the echinoderms and chordates appear to be closely related and evolved from a common ancestor. For this reason these two groups are placed near each other. Examples of this phylum are *Asterias rubens* (star fish), *Ophiothrix fragilis* (brittle star), *Arbacia punctulata* (sea urchin), *Thyone briareus* (sea cucumber) etc.

फ़ैब्रिट

Brittle star is called brittle because it can break off its arm if it is injured. This "autotomy" allows the animal to leave its arm behind and escape from an enemy to save life. The broken arm regenerates rapidly into a new brittle star.

7. Phylum Hemichordata:

Hemichordates are worm like animals found in shallow ocean bottom. They are closely related to chordates but show many similarities with echinoderms. They are included in the group of animals called deuterostomes along with echinoderms and chordates. General characteristics of this phylum are as follows:

Body is soft and worm like and is divided into three regions, an anterior protosome, middle mesosome and posterior metasome or proboscis, collar and trunk. Every region is with a coelomic compartment. Body wall is made of unicellular epidermis with mucus secreting cells. Digestive tract is complete and consists of a long straight tube. Circulatory system is composed of a dorsal and ventral vessel. Gill slits are present behind the collar which performs the function of respiration. A single glomerulus connected to the blood vessel constitutes the excretory system of hemichordates. Brain occurs in the mesosome and the main nerve tracts are present in mid dorsal and mid ventral line. Notochord is absent. Cleavage is holoblastic and radial. **Tornaria larva** is formed during the life cycle which resembles bipinnaria larva of echinoderms. Many hemichordates make colonies. Examples are *Saccoglossus kowalevskii*, (Acron worm), *Balanoglossus sp.* etc.

8. Phylum Chordata

Name of the phylum has been derived from the word Notochord which is found in all the animals of this group (chord means thread or rope). Animals of this

phylum posses following three basic characters generally termed as **chordate** characters.

1. A dorsal stiff rod is found in all the chordates called as **notochord**. In lower chordates it is retained but in higher chordates (vertebrates) this rod is replaced by a vertebral column.

2. All chordates have a central, dorsal, hollow nervous system which lies above the notochord.

3. All chordates develop gill slits (sometimes called perforated pharynx) at least in the embryonic stage. In some chordates these are non functional and are afterwards closed while in others they are still functional as in fish and amphioxus.

Phylum chordata has been classified into two main divisions and three sub phyla

Division 1. Protochordata or Acrania

These chordates do not posses cranium (skull). They are also called as lower chordates. They are further divided into two sub phyla:

Sub phylum Urochordata:

Notochord is present only in free swimming larvae and is absent in adults. They are also called tunicate as their body is covered by a sheath called tunic which is chemically made of tunicin, a substance related to cellulose. Larvae are free swimming but adults are sessile. Examples are *Ciona intestinalis*, *Molgula* etc.

Sub phylum Cephalochordata:

Notochord is well developed in adults. Their body is in the form of a long, pointed rod, hence called as sea lancelet. They have a hollow nerve cord which runs through out the length of body. They are free living and swim about in water. They are filter feeders. Examples is *Branchiostoma* (amphioxus).

Division 2. Craniata

These chordates posses a cranium or skull in which brain is present. They are

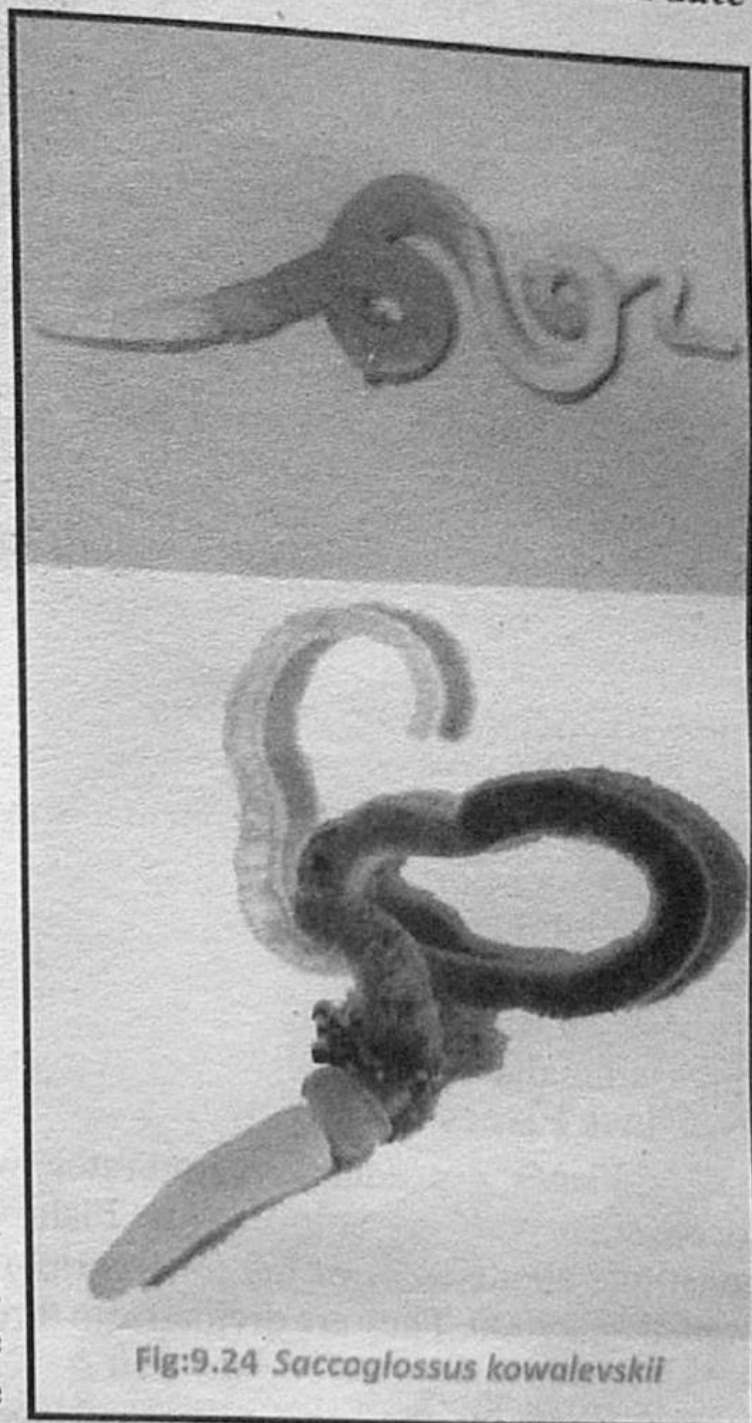


Fig:9.24 *Saccoglossus kowalevskii*

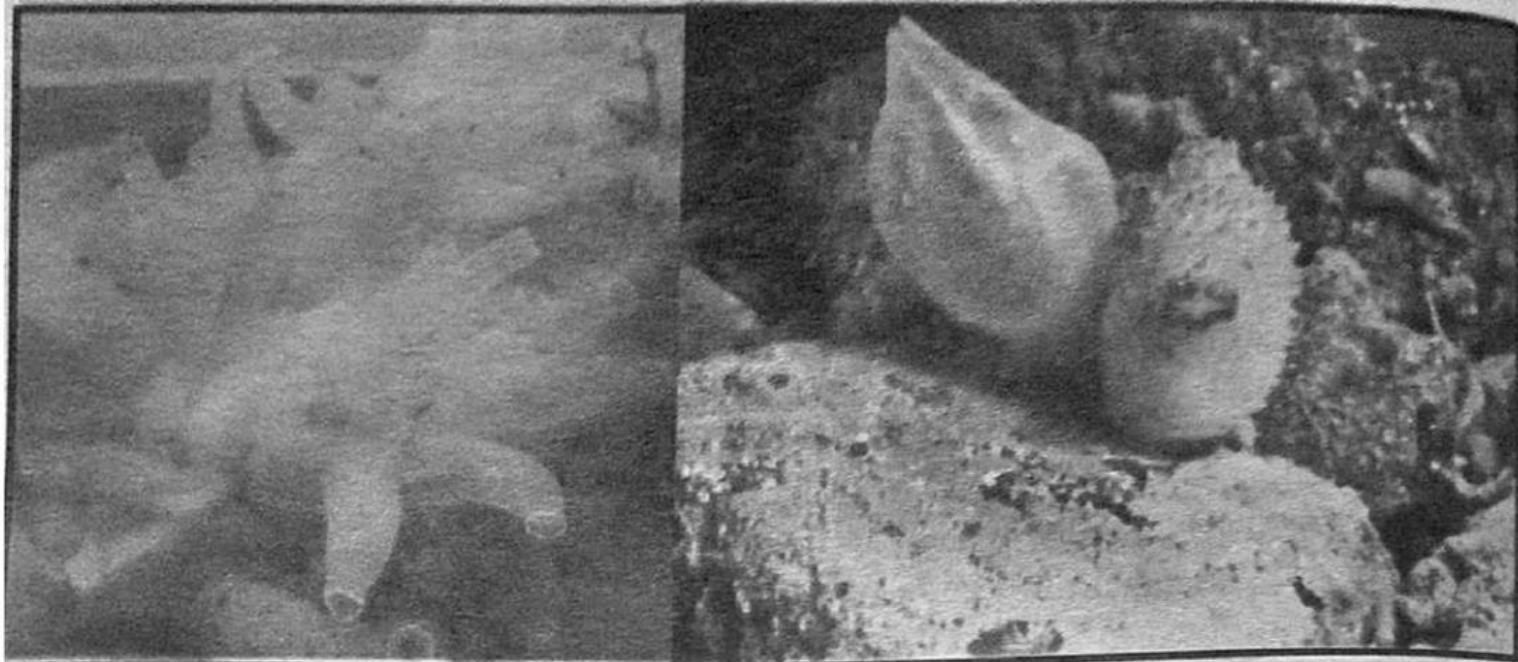


Fig: 9.25 a. *Clona intestinalis*,

b. *Molgula*

included in sub phylum vertebrata.

9.5 Sub phylum Vertebrata

Vertebrates are divided in to following five groups or super classes:

- 1- Pisces or Fishes
- 2- Amphibia
- 3- Reptilia
- 4- Aves or Birds
- 5- Mammalia

Class Pisces

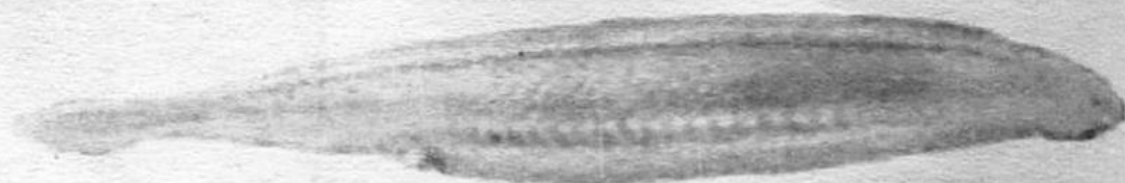


Fig: 9.26 *Branchiostoma*

Fishes are aquatic vertebrates which respire through gills and perform locomotion with the help of fins. Fishes are the largest group of vertebrates and constitute about 48 % of the total vertebrates. The number of living fish species is more than 29000. They are divided into three classes.

Class Cyclostomata or Agnatha

These are the most primitive jawless fishes having circular mouth. These fishes have a long, eel like body. Skin is naked i.e. without scales. They lack paired fins (appendages). Seven pairs of gills are found which open separately to the outside and are not covered with operculum.

Their skeleton is of lower grade, fibrous cartilage. They do not possess a stomach because of their parasitic way of life. Mouth is adapted for sucking. Sexes are separate. Examples are *Petromyzon marinus* (lamprey) and *Maxine glutinosa* (hagfish).

Class Chondrichthyes: (cartilaginous fishes)

Their skeleton is made of cartilage. They have streamlined bodies. All the chondrichthyes live in marine environment. Their mouth is ventral. Their body is

covered with placoid scales which are very small and numerous and give the skin a touch of sand paper.
 Circulatory system is with many pairs of aortic arches. They have heterocercal tails in which dorsal lobe is longer than ventral lobe. Respiration takes place through 5-7 pairs of gills. Gills are not covered with operculum and open separately. Most of them are carnivorous and sharks are very active hunters.
 Swim bladder is absent.
 Sexes are separate and many of them are viviparous. Examples are sharks, rays, skates and chimaeras.

c. Class Osteichthyes: (bony fishes)

These fishes have a skeleton made of bone hence called bony fishes. They are the most successful group of fishes and inhabit all types of aquatic habitats. Their body is covered with scales of different types; Median fins i.e. dorsal fin, anal fin, caudal fin and paired fins i.e. pectoral and pelvic fins are present in bony fishes.

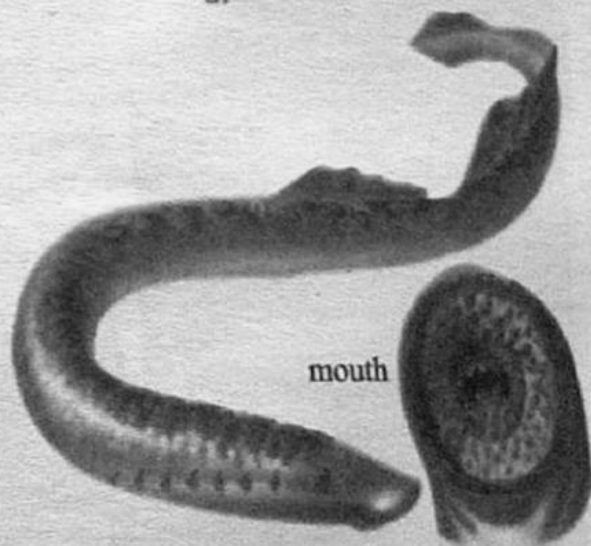
A specific organ swim bladder is found which is hydrostatic in function and provides buoyancy to the fish in water. They respire through well developed gills which are covered with a bony cover called **operculum**.

Jaws may be with or without teeth. Brain is developed with 10 pairs of cranial nerves. Heart consists of an auricle and a ventricle. Blood contains haemoglobin as respiratory pigment and its colour is red.

Sexes are separate and except few species the fertilization is external. Majority of bony fishes are oviparous but some are ovo-viviparous and viviparous.



a.



b.

Fig:9.27 a. Hag fish
 b. Lamprey (See the circular mouth)

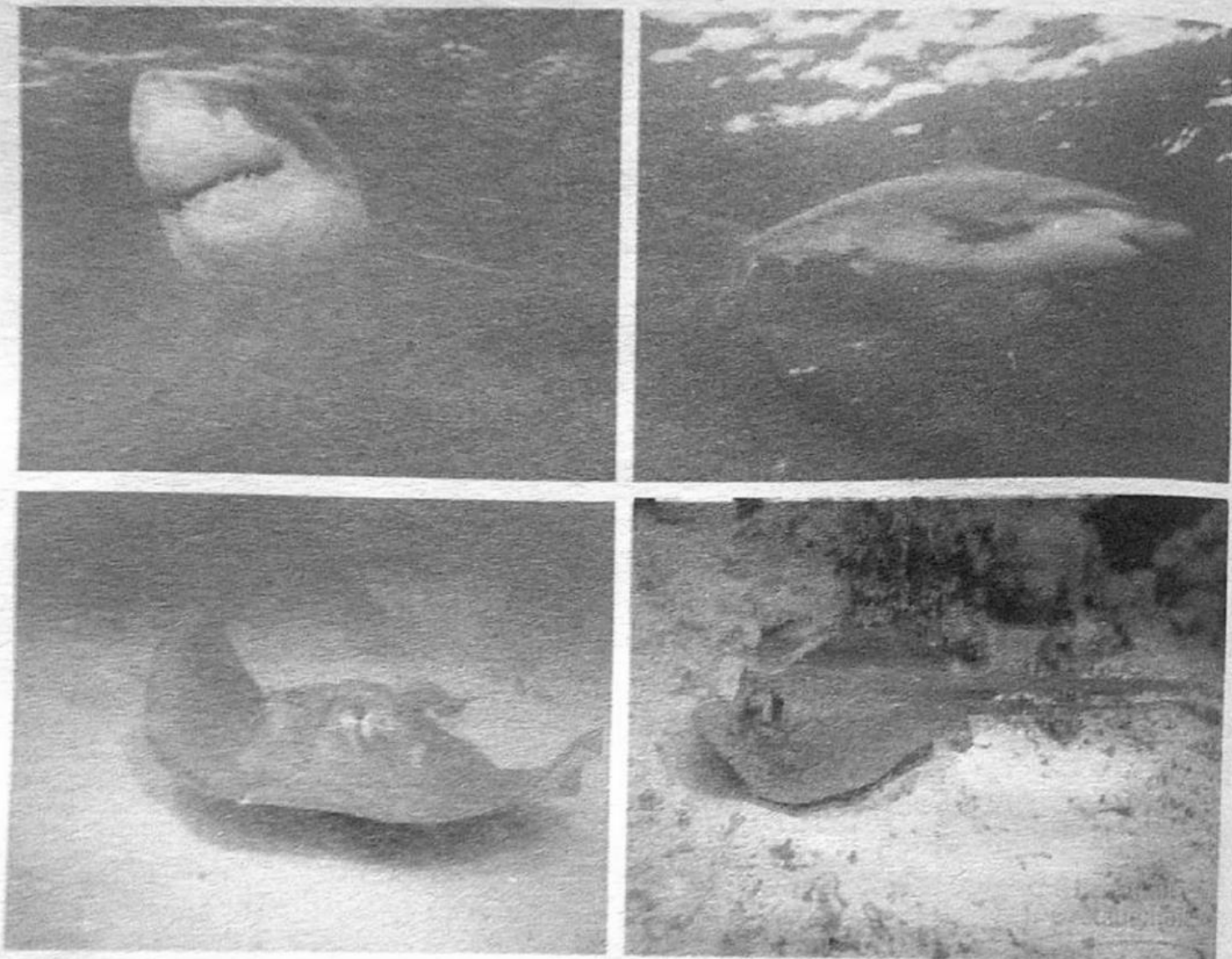


Fig: 9.28 Although with fearful reputation, the sharks, skates and rays are graceful swimmers .

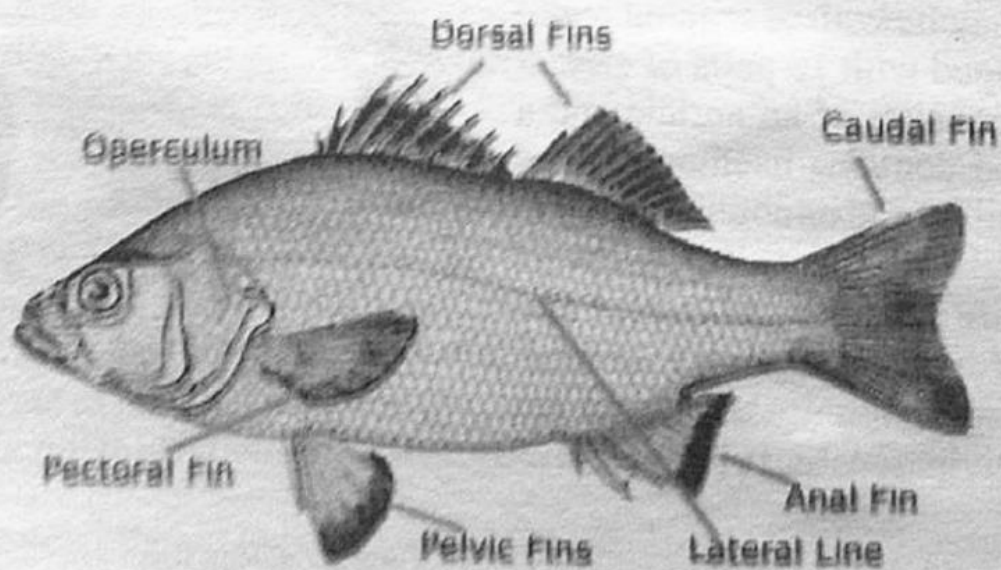


Fig: 9.29 lung fishes are considered to be a connecting link between fishes and amphibians

For your information

Fishes of sub class **Dipnoi** are called lung fishes. There are only three species left in the world. These fishes aestivate in the holes dug in the mud for few dry months and during this period respire through the extremely vascularized swim bladder which acts as a lung. When the rainy season comes again they come out and start their normal life in which they respire through gills like all other bony fishes.

Did you know

A very prominent feature of the some fishes is their migration to reach their feeding or breeding grounds. They travel thousands of kilometers in this process. For example, salmon fish.

2. Class Amphibia

Name of the class has been derived from a Latin word **Amphi** which means both. The animals of this class have characters of both aquatic and terrestrial animals. Amphibia are considered on the border line of these two groups. Transition from aquatic life to terrestrial life is clearly indicated in amphibia. It is believed that certain lobe fin fishes of the group **dipnoi** came to live in shallow water. They started crawling from one pool to another in search of food and to avoid overcrowding and competition. In this way they used to spend some time on land. These fishes are believed to give rise to amphibians.

Amphibia are poikilothermic (cold blooded) vertebrates. Sexes are separate and fertilization is external. They breed in water and their larva called **tadpole larva** lives in water and respire through gills and swim with the help of their laterally flattened tail. After developing gills during metamorphosis, they come out of water and start a terrestrial life. In some amphibia like *Necturus* the gills are retained throughout life. They are tetrapods having two

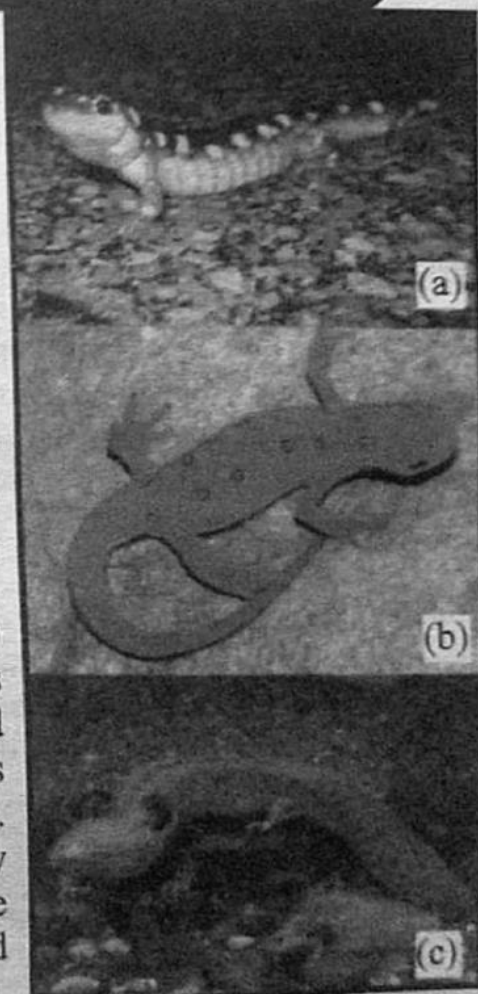


Fig: 9.30 a. salamander, b. newt, c. *Necturus* (tailed)

pectoral and two pelvic limbs. Some forms are **legless** e.g. caecilians. They have **webbed feet** but fingers are without claws. Their skin is pigmented, smooth and glandular which is always kept moist and help in respiration. Heart in amphibia is three chambered; two auricles and a single ventricle. Two additional tubes (sometimes considered chambers) truncus arteriosus and sinus venosus are also present. Their circulatory system is not very perfect as mixing of oxygenated and deoxygenated blood takes place in the ventricle. Most amphibians **hibernate** during winter. In this process they dig deep in the mud and survive by getting energy from the fat bodies deposited around their kidneys. Examples are frog, toad (tailless) and salamander, newt, necturus (tailed)

3. Class Reptilia

Reptiles are true land vertebrates. Their bodies are bilaterally symmetrical and can be divided in to four regions; head, neck, trunk and tail. They are poikilothermic, **pentadactyle** (having five fingers) tetrapods. They are terrestrial but some species secondarily has adopted aquatic life like aquatic snakes and turtles. They are lowest amniotes i.e. their embryos are surrounded by a protective covering amnion. Other protective membranes called **extra embryonic membranes** i.e. yolk sac, chorion, and allantois are also found.

Sexes are separate and fertilization is internal. They are **oviparous** and lay **shelled eggs** with considerable amount of yolk which provide all the nutritional required by the developing embryo within the egg, hence there is no larval stage and the young ones hatch out fully formed from the egg. Their skin is thick, scaly and devoid of glands. This is why skin is very dry and impervious to water.

Exoskeleton is present in the form of nails and epidermal scales and digits are with claws. Teeth are present on the jaws except in turtle and tortoise. All reptiles are carnivorous. Heart is four chambered with two auricles, a completely or partially divided ventricle and a pair of systemic arches. Colour of the blood is red due to the presence of haemoglobin as respiratory pigment. Respiration takes place through lungs which have spongy texture. Gill slits appear during embryonic stages but gills never



Fig: 9.31 Lizards, snakes, tortoises, turtles and Tuatara

factoid

Most of the Lizards never take water in their life. They survive with conserving the water present in their food.

develop in reptiles. Excretory organs are metanephric kidneys. Being adapted to live on land they are **uricotelic** i.e. excrete uric acid crystals to conserve water. Most of the modern reptiles live in temperate and tropical areas of the world.

It is believed that those amphibians which had totally departed from their aquatic environment were the ancestors of the reptiles. Reptiles were once the most dominant group on the land and that time in geological history is termed as **age of reptiles**.

Reptiles flourished in **Mesozoic** era (225- 65 million years back). Modern reptiles are the descendents of the Dinosaurs of **Jurassic** era (195- 136 million years back) and **Cretaceous** era (136- 65 million years back). At the end of Mesozoic era change in climatic conditions and environmental hazards caused the reptiles to become extinct. Those who could survive and are found today include lizards, snakes, tortoises, turtles and the Tuatara (*Sphenodon punctatum*) of New Zealand, a species also called living fossil.

4. Class Aves

All the birds are included in this class. Birds are unique among vertebrates in having feathers on their bodies. Both birds and mammals are considered to be evolved from reptilian ancestors. Scales on the legs and claws are the reptilian characters which are still very prominent in birds. Evolutionary history of birds is very interesting. In 1861 from the rocks of Jurassic period, fossil of a bird was found which was given the name of Archaeopteryx, the lizard tailed bird. It is of the size of a crow. Interesting about it is that it has characters of both reptiles and birds so can be considered a transition species between the two groups.

Some of the birds like characters of archaeopteryx are:

- i- Well developed contour and flight feathers covering the body.
- ii- Forelimbs modified in to flying wings.
- iii- Tail with two rows of feathers.
- iv- Skull large with a single occipital condyle.
- v- Jaws elongated to form a beak.

Reptilian characters of archaeopteryx

- i- Presence of scales on the legs.
- ii- Bones solid and heavy without air spaces.
- iii- Jaws with teeth present in sockets.
- iv- A long, tapering lizard like tail consists of 20 caudal vertebrae.

Tidbit

One specimen of archaeopteryx is present in Berlin museum and the other in British museum



v- Nine to ten cervical vertebrae.

vi- No fusion of trunk and sacral vertebrae.

vii- Sternum not keeled. Free cervical and abdominal ribs are also present.

viii- Simple brain with cylindrical cerebral hemisphere and unexpanded cerebellum.

ix- Fore limbs with three clawed fingers.

The above evidences prove that archaopteryx was a **connecting link** between reptiles and birds. Birds gradually evolved and became one of the most successful group of vertebrates

a. Distinguishing Characteristics of Birds

They are **homoiothermic** i.e. warm blooded animals because they can maintain their body temperature. The body is covered by different coloured feathers which are epidermal exoskeleton. Body is fusiform (streamlined) to allow better movement in air with less resistance. Fore limbs are modified into wings for flight. They have adapted a bipedal life and hind limbs are used for walking on land. The aquatic birds possess webbed feet. Skin is without epidermal glands except for uropygial gland present at the base of tail.

Bones of the birds are hollow having air spaces which make them light in weight. Sternum is well developed into a **keel** which not only helps in cutting the air during flight but also provides additional area for the attachment of muscles. Jaws are without teeth and are modified in the form of a beak. Digestive system has a crop to store the food and a gizzard to grind it.

Heart is four chambered with two auricles and two ventricles. A single aortic arch is present which curves to the right side. Blood is red due to haemoglobin contained in oval, nucleated RBCs.

Vocal cords are not present in larynx but a special sound box syrinx is present at the junction of trachea and bronchi. Lungs are provided with extra **air sacs**. These air sacs are extended into viscera.

Eyes are provided with a third eyelid, the **nictitating membrane** which can be drawn across the eye. A rudimentary pinna is present outside the external auditory opening.

Excretory organs are metanephric kidneys. Ureters open in common cloaca and nitrogenous wastes are excreted in the form of semi solid urates.

Sexes are separate and sexual dimorphism is found in many birds. Fertilization is internal. Female has only left ovary and oviduct is well developed. Females have shell

secreting glands. Birds are oviparous and have eggs with considerable amount of yolk covered with a hard calcareous shell. Birds are amniotes and have all the four extra embryonic membranes i.e. amnion, chorion, yolk sac and allantois. In many birds parental care is very developed.

6. Types of Birds

Birds are of two types:

- Flightless Birds
- Flying Birds

i. Flightless Birds are those which do not fly in the air. They are called running birds as instead of flying they secondarily has adapted a running mode of life. Their bones are not hollow and sternum is not keeled. Tail feathers are irregularly arranged e.g. ostrich, emu, kiwi, cassowary, penguin etc.



Fig: 9.32 Flightless Birds

ii. Flying Birds are the birds with strong wings for flight and keeled sternum. Their bones are hollow. Tail feathers are well developed and are used for steering the bird in air during flight. e.g. pigeon, sparrow, parrot, eagle, owl etc.

5. Class Mammalia

Mammals are the animals in which females nourish their babies with milk produced by mammary glands. The development of brain and nervous system in mammals is the most remarkable character which has placed them at the top of the evolutionary tree.

Because of possessing solid and hard bones and being the most recently evolved forms, the fossil record of mammals is more continuous and complete. Mammals are believed to be evolved from reptiles. Ancestors of mammals lived simultaneously with reptiles in Jurassic period and are called mammal like reptiles. A

fossils animal (named varanope) has been recovered from Texas which has 50% mammalian characters. The ancestors of mammals were of the size of mice and lived on trees. Mammals became dominant in **Cenozoic era**. Today we are living in the **age of mammals**.

Following are general characteristics of mammals:

Mammals are warm blooded, air breathing, tetrapods which are mostly terrestrial. Their body is covered with hairs which insulate the body and help in maintaining temperature. Mammals have two pairs of pentadactyle limbs which are adapted for walking, running, climbing, burrowing, swimming, gliding. In aquatic orders hind limbs are absent. Skin is glandular with sweat glands and sebaceous glands and mammary glands in females for secreting milk. Brain is well developed with two large cerebral hemispheres and 12 pairs of cranial nerves. Sense organs are well developed. Eyes are protected by movable eyelids. Ears have an external **pinna** for collection of sound waves. Internal ear contains a set of three bones viz. **incus**, **malleus** and **stapes** which are the smallest bones of the body. Sense of smell, taste and touch are also well developed.

Respiration takes place through lungs which are spongy in texture due to the presence of air sacs. Larynx is well developed with vocal cords. Heart is four chambered and a complete separation of oxygenated and deoxygenated blood is maintained. Only left aortic arch is present. Colour of the blood is red due to the presence of haemoglobin in biconcave, non nucleated RBCs. Nitrogenous wastes are filtered by highly glomerular kidneys and are excreted in the form of urine. Teeth are present in jaws which have their roots in the jaws. Canine, incisors, premolar and molar type teeth are found in varying numbers in mammals.

Sexes are separate and sexual dimorphism is prominent in most mammals. Testes of male mammals lie in scrotal sac outside the body. Fertilization is internal and they are viviparous. Embryo is kept inside the body of the female for development, the process is called gestation. To absorb nutrition from the body of mother a glandular tissue develops between foetus and uterine wall of the mother called **Placenta**. Mammals are also **amniotes**. The extra embryonic membranes help in the formation of placenta. Parental care is highly developed in mammals. Mammals are divided into three sub classes.

- a. Subclass Prototheria or monotremata
- b. Subclass Metatheria or marsupials
- a. Subclass Eutheria or placentalia
- a. Subclass Prototheria or Monotremata

These are the most primitive mammals and are also called as egg laying mammals. They have certain characters of reptiles like they lay eggs but these eggs are kept in long oviduct where they are fertilized and later on development takes place. In these mammals there is no connection between the body of mother and foetus for

transfer of nutrients.
 These animals are more rightly be called as ovo- viviparous. The youngs are given birth in an immature form and are nourished by the teats present on the ventral side of the body in females until they grow enough to survive and start taking their own food.



Fig: 9.33 Platypus and spiny ant eater

Prototheria are restricted to Australian region and are found in Australia, Tasmania, New Guinea and their neighbouring islands. They are insectivorous, borrowing, nocturnal animal. In adults teeth are absent and a horny beak is found. Their body temperature varies between 25- 28 °C. Example of these mammals are duck billed platypus (*Ornithorhynchus*) and spiny ant eater (*Tachyglossus*).

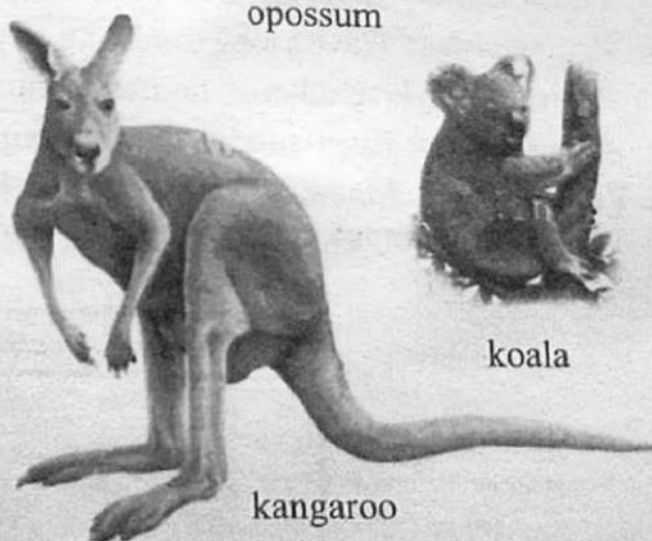
b. Subclass Metatheria or Marsupials

These mammals are also called pouched mammals. Females of these animals bear a pouch or **marsupium** on the ventral side of the belly in which young ones are kept as they are born in a very under developed and immature stage. Teats of the mammary glands are present in the pouch from which the babies suckle milk. In these animals placenta is poorly developed and babies come out of the body earlier in immature form.

Marsupials are also confined to Australian region with the exception of only one species, American opossum. Their body is covered with hairs. They are terrestrial, burrowing or arboreal (living in trees) in habit. Examples are Kangaroo, Opossum, Koala etc.



opossum



kangaroo



koala

Fig: 9.34 Marsupials

c. Subclass Eutheria or Placentalia

These animals are the true mammals having the highest degree of evolution of brain and body structures. They are also called placental mammals as placenta of different types is formed in these mammals with the help of which the developing embryo gets nourishment and oxygen from the body of mother and removes its metabolic wastes. Young ones develop inside the uterus to a relatively mature stage. After birth mother feeds them on her milk produced in the mammary glands with well developed teats. Teeth are present in jaws. Cloaca is absent and urino-genital duct opens independently of rectum. Testes are in scrotum hanging outside the body either throughout life or at least descend to scrotum during breeding season.

Eutheria are divided into sixteen orders. Some important orders with examples are mentioned below:

Insectivora: Feed on insects, includes moles and shrews.

Chiroptera: Flying mammals like bats, flying squirrels.

Cetacea: Aquatic mammals e.g. whale, dolphin, porpoises, sea lion etc.

Carnivora: Flesh eating like dog, cat, lion, Wolves

Rodentia: Cutting habit like rats, mice, squirrel, beavers etc.

Edentata: Adults with no or poorly developed molar teeth like South American anteater, sloths.

Pholidota: Body covered with large, overlapping, horny scales e.g. Pangolin

Proboscidea: Have a long trunk like elephant.

Perissodactyla: Odd-toed hoofed mammals like, horse, zebra etc.

Artiodactyla: Even-toed hoofed mammals like cow, goat, deer etc.

Primates: Mammals with highest brain development like lemur, monkeys, apes, tarsiers, human beings etc.

Do You know?



Markhor is the national animal of Pakistan.

KEY POINTS

- Animals have been evolved from the single celled organisms included in kingdom Protocista, but it has yet to be decided that from which group of protocists, they have evolved.
- System of naming of animals is called **binomial nomenclature**.
- According to modern classification simplest animals which don not have tissues organized into organs belong to subkingdom **Parazoa**. Animals of all other phyla are included in subkingdom **Eumetazoa**.
- In diploblastic animals the body is composed of two layers of cells.
- In triploblastic animals the body is composed of three layers of cells.
- Triploblastic animals may be classified into acoelomates, pseudocoelomates and coelomates.
- Porifera possess skeleton in the form of spicules.
- Coelenterates possess a body cavity or coelenteron or enteron.
- Flat worms (platyhelminthes) are bilaterally symmetrical triploblastic, unsegmented and hermaphrodite. Organs of excretion in flat worms are flame cells.
- Round worms and thread worms (nematodes) are bilaterally symmetrical, triploblastic, unsegmented animals in which the sexes are separate.
- Annelids have bilaterally symmetrical bodies.
- Arthropods posses paired jointed appendages.
- Organs of respiration in arthropods are the trachea, gills or book lungs.
- Insects belong to class insecta (phylum Arthropods). Their bodies are divided in to a head, thorax and abdomen. The thorax bears two pairs of wings and three pairs of legs.
- Organs of excretions in insects are malpighian tubules.
- Molluscs are fundamentally bilaterally symmetrical generally provided with shells of various types.
- Echinoderms are radially symmetrical with calcareous skeleton. Organs of locomotion are the tube feet which are connected with water vascular system.
- Phylum chordata characteristics are presence of notochord at least in the embryonic condition, presence of gills slits at least in the embryonic condition and presence of dorsal hollow central nervous system.

EXERCISE ?

A. Select the correct answers in the following questions.

1. Animals are believed to be evolved from:
a. Non living matter b. Higher plants
c. Water Plants d. Prokaryotes
2. The most important and basic category of taxonomy is:
a. Phylum b. Class
c. Family d. Species
3. An animal found from ocean was observed to have no tissue organization is most likely to be the member of phylum.
a. Porifera b. Coelentrata
c. Echinodermata d. Hemichordata
4. Cells of the inner lining of the endoderm in diploblastic animals are called
a. Cnidoblast b. Choanocytes
c. Pinnacocytes d. Amoebocytes
5. Animals found in more than one morphological form are said to exhibit:
a. multigenecity b. polymorphism
c. pseudomorphism d. isolation
6. A flat worm was divided into three pieces during an experiment and was kept in the nutrient medium. All parts grow into new worm. The animals may be:
a. liver fluke b. tape worm
c. planaria d. hydra
7. Group of vertebrates in which placenta is formed
a. Fishes b. Amphibia
c. Aves d. Mammalia
8. Organs of excretion in annelids are
a. Flame cells b. Nephridia
c. Malpighian tubules d. Kidneys



Members of the order 'perissodactyle' are also named as:

9.
 - a. ungulates
 - b. hoofed mammals
 - c. eutheria
 - d. All of the above

Acoelomates are characterized by:

10.
 - a. the absence of brain.
 - b. the absence of mesoderm
 - c. a solid body without a cavity surrounding internal organs.
 - d. a coelom that is not completely lined with mesoderm.

11. Which of the following characteristic is probably most responsible for the great diversification of insects on land?

- a. Segmentation
- b. Antenna
- c. Bilateral symmetry
- d. Exoskeleton

12. Mammals and living birds share all of the following characteristics EXCEPT:

- a. endothermy.
- b. descent from common amniotic ancestor.
- c. a dorsal, hollow nerve cord.
- d. an archosaur common ancestor.

13. Archaeopteryx shows features of:

- a. reptiles and mammals.
- b. reptiles and amphibians.
- c. reptiles and aves.
- d. aves and mammals.

B. Write short answers to the following questions.

1. Why certain animals are called living fossils?
2. What is the reason for the formation of larva during the life cycle of many animals?
3. What is the importance of polymorphism?
4. Cuttle fish, jelly fish, star fish are invertebrates and are not fishes. Why many invertebrates are called fish?
5. Why the reptiles excrete nitrogenous wastes in the form of uric acid crystals?
6. In what hemolymph is different from blood?

EXERCISE ?

7. Differentiate between Proterostomes and Deuterostomes.
8. Why alternation of generation is required .
9. What is the difference between haemocoel and coelom?
10. List down three organisms, each representing radial symmetry and bilateral symmetry?
11. Differentiate between prototheria and metatheria.

D. Write down the detailed answers of these question.

1. Describe the importance of classification in animal kingdom. What are different categories used for classification?
2. What are the salient features of phylum Annelida? Describe their economic importance as well.
3. Describe the parasitic adaptations in phylum platyhelminths.
4. Compare the structure of heart in different phyla of animal kingdom and especially in different classes of vertebrates.
5. Discuss the distinguishing characters of phylum arthropoda. How will you evaluate the economic importance of class insecta?
6. What adaptations are found in birds for aerial life? Describe evolutionary history of birds with special reference to the fossil birds.
7. Write short notes on the following.
 - a. Binomial nomenclature
 - b. Parazoa
 - c. Poikilothermic animals

Projects

- Make a collection of insects present in your locality. Identify their scientific names. An exhibition of this collection may be arranged under the guidance of teacher.
- Working in group of four, prepare a presentation discussing the main causes/events of extinction of major animal species. Collect information from reference books and internet. Share your findings in the classroom.