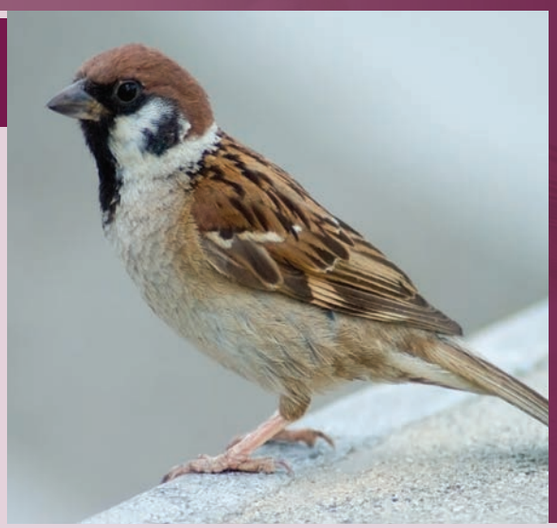
UNIT I

Chapter 2

Kingdom Animalia

Chapter Outline



March 20th is celebrated as World Sparrow day to conserve this endangered species, House sparrow (*Passer domesticus*)

Learning Objectives:

- *Justifies the need for classification.*
- *Understands the salient features of the animal phyla.*

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Kingdom Animalia comprises millions of animal species and studying them without a basic classification may lead to confusion. In addition to this, there are several new species of animals being constantly discovered. Classification is very essential for identification, naming and assigning a systematic position to the newly discovered species. Animal Kingdom is classified mainly based on the closely resembling characteristic features. Kingdom Animalia is characterised of eukaryotic, multicellular, heterotrophic organisms. They include about 35 phyla of which 11 are considered as major phyla. Almost 99 percent of animals are invertebrates or animals without backbone. The remaining represents vertebrates or animals with backbone. On the basis of the presence or absence of notochord (vertebral column), animals are also categorised into two major groups and they are non chordates and chordates.

2.1 Basis of classification

Multicellular organisms are structurally and functionally different but yet they possess certain common fundamental features such as the arrangement of cell layers, the levels of organisation, nature of coelom, the presence or absence of segmentation, notochord and the organisation of the organ system.

2.1.1 Levels of organisation

All members of Kingdom Animalia are metazoans (multicellular animals) and exhibit different patterns of cellular organisation. The cells of the metazoans are not capable of

independent existence and exhibit division of labour. Among the metazoans, cells may be functionally isolated or similar kinds of cells may be grouped together to form tissues, organ and organ systems.

Cellular level of organisation

This basic level of organisation is seen in sponges. The cells in the sponges are arranged as loose aggregates and do not form tissues, i.e. they exhibit cellular level of organisation. There is division of labour among the cells and different types of cells are functionally isolated. In sponges, the outer layer is formed of pinacocytes (plate-like cells that maintain the size and structure of the sponge) and the inner layer is formed of choanocytes. These are flagellated collar cells that create and maintain water flow through the sponge thus facilitating respiratory and digestive functions.

Animals such as sponges lack nervous tissue and muscle tissue, what does this tell you about sponges?

Tissue level of organisation

In some animals, cells that perform similar functions are aggregated to form tissues. The cells of a tissue integrate in a highly coordinated fashion to perform a common function, due to the presence of nerve cells and sensory cells. This tissue level of organisation is exhibited in diploblastic animals like cnidarians. The formation of tissues is the first step towards evolution of body plan in animals (*Hydra* - Coelenterata).

Organ level of organisation

Different kinds of tissues aggregate to form an organ to perform a specific function. Organ level of organisation is a further advancement over the tissue level of organisation and appears for the first time in the Phylum Platyhelminthes and seen in other higher phyla.

Organ system level of organisation

The most efficient and highest level of organisation among the animals is exhibited by flatworms, nematodes, annelids, arthropods, molluscs, echinoderms and chordates. The evolution of mesoderm in these animals has led to their structural complexity. The tissues are organised to form organs and organ systems. Each system is associated with a specific function and show organ system level of organisation. Highly specialized nerve and sensory cells coordinate and integrate the functions of the organ systems, which can be very primitive and simple or complex depending on the individual animal. For example, the digestive system of Platyhelminthes has only a single opening to the exterior which serves as both mouth and anus, and hence called an **incomplete digestive system**. From Aschelminthes to Chordates, all animals have a **complete digestive system** with two openings, the mouth and the anus.

Similarly, the circulatory system is of two types, the **open type**: in which the blood remains filled in tissue spaces due to the absence of blood capillaries. (arthropods, molluscs, echinoderms and urochordates) and the **closed type:** in which the blood is circulated through blood vessels of varying diameters (arteries, veins and capillaries) as in annelids, cephalochordates and vertebrates.

2.1.2 Diploblastic and Triploblastic organisation

During embryonic development, the tissues and organs of animals originate from two or three embryonic germ layers. On the basis of the origin and development, animals are classified into two categories: Diploblastic and Triploblastic.

Animals in which the cells are arranged in two embryonic layers (Figure 2.1), the external ectoderm, and internal endoderm are called **diploblastic animals**. In these animals the ectoderm gives rise to the epidermis (the outer layer of the body wall) and endoderm gives rise to gastrodermis (tissue lining the gut cavity). An undifferentiated layer present between the ectoderm and endoderm is the mesoglea. (Corals, Jellyfish, Sea anemone)

Animals in which the developing embryo has three germinal layers are called **triploblastic** animals and consists of outer ectoderm (skin, hair, neuron, nail, teeth, etc), inner endoderm (gut, lung, liver) and middle mesoderm (muscle, bone, heart). Most of the triploblastic animals show organ system level of organisation (Flat worms to Chordates).

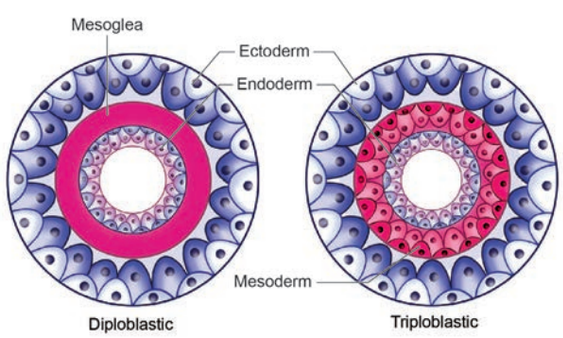


Figure 2.1 Germinal layers

2.1.3 Patterns of symmetry

Symmetry is the body arrangement in which parts that lie on opposite side of an axis are identical. An animal's body plan results from the animal's pattern of development. The simplest body plan is seen in sponges (Figure 2.2). They do not display symmetry and are **asymmetryical**. Such animals lack a definite body plan or are irregular shaped and any plane passing through the centre of the body does not divide them into two equal halves (Sponges). An asymmetrical body plan is also seen in adult gastropods (snails).

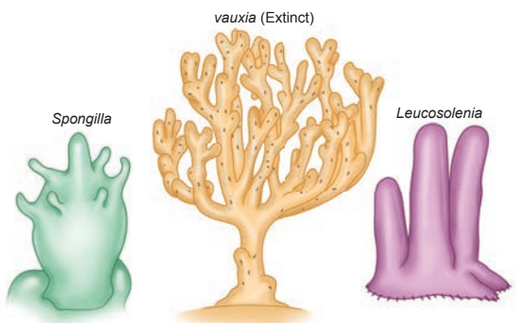


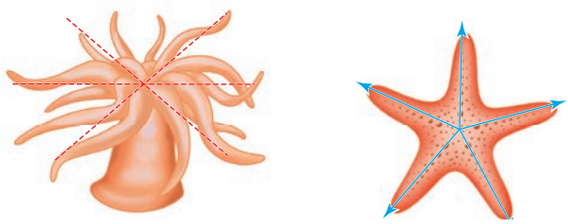
Figure 2.2 Asymmetry in sponges

Symmetrical animals have paired body parts that are arranged on either side of a plane passing through the central axis. When any plane passing through the central axis of the body divides an organism into two identical parts, it is called **radial symmetry**. Such radially symmetrical animals have a top and bottom side but no dorsal (back) and ventral (abdomen) side, no right and left side. They have a body plan in which the body parts are organised in a circle around an axis. It is the principal symmetry in diploblastic animals. Cnidarians such as sea anemone and corals (Figure 2.3) are radially symmetrical. However, triploblastic animals like echinoderms (e.g., starfish) have five planes of symmetry and show **Pentamerous radial symmetry**.

Animals which possess two pairs of symmetrical sides are said to be

biradially symmetrical (Figure 2.4). Biradial symmetry is a combination of radial and bilateral symmetry as seen in ctenophores. There are only two planes of symmetry, one through the longitudinal and sagittal axis and the other through the longitudinal and transverse axis. (e.g., Comb jellyfish – *Pleurobrachia*)

Animals which have two similar halves on either side of the central plane show **bilateral symmetry** (Figure 2.5). It is an advantageous type of symmetry in triploblastic animals, which helps in seeking food, locating mates and escaping from predators more efficiently. Animals that have dorsal and ventral sides, anterior and posterior ends, right and left sides are bilaterally symmetrical and exhibit cephalisation, in which the sensory and brain structures are concentrated at the anterior end of the animal.



Radial symmetry in sea anemone *Pentamerous radial symmetry in starfish*

Figure. 2.3 Radial and Pentamerous radial symmetry

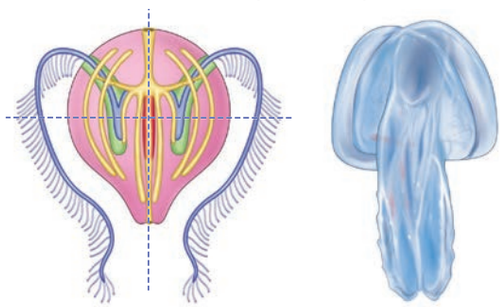


Figure 2.4 Biradial symmetry in comb jelly

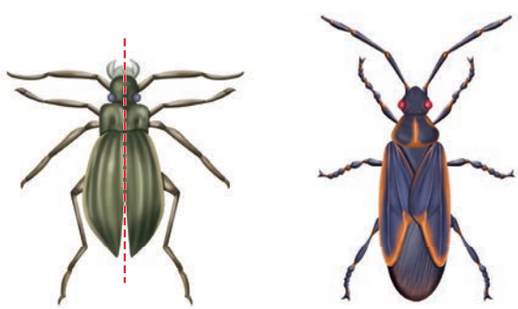


Figure 2.5 Bilateral symmetry in Insects

2.1.4 Coelom

The presence of body cavity or coelom is important in classifying animals. Most animals possess a body cavity between the body wall and the alimentary canal, and is lined with mesoderm (Figure 2.6)

Animals which do not possess a body cavity are called **acoelomates**. Since there is no body cavity in these animals their body is solid without a perivisceral cavity, this restricts the free movement of internal organs. (e.g., Flatworms)

In some animals, the body cavity is not fully lined by the mesodermal epithelium, but the mesoderm is formed as scattered pouches between the ectoderm and endoderm. Such a body cavity is called a **pseudocoel** and is filled with pseudocoelomic fluid. Animals that possess a pseudocoel are called **pseudocoelomates** e.g., Round worms. The pseudocoelomic fluid in the pseudocoelom acts as a hydrostatic skeleton and allows free movement of the visceral organs and for circulation of nutrients.

Eucoelom or true coelom is a fluid-filled cavity that develops within the mesoderm and is lined by mesodermal epithelium called peritoneum. Such animals with a true body cavity are called coelomates or **eucoelomates**. Based on the mode of formation of coelom, the eucoelomates are classified into two types, **Schizocoelomates** – in these animals the

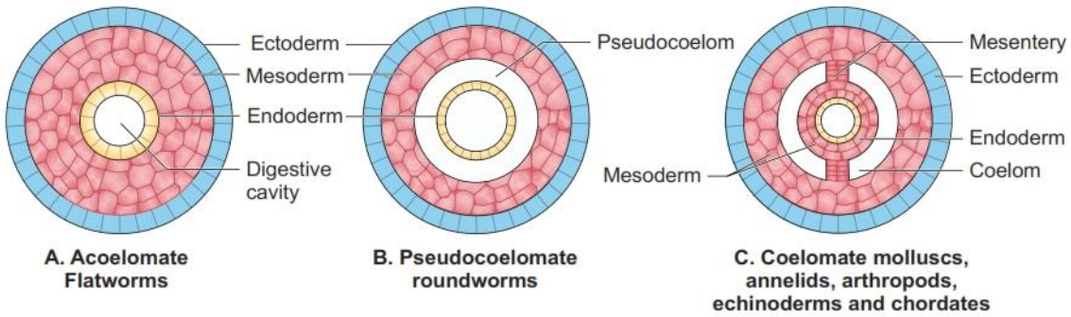


Figure 2.6 Diagrammatic representation of coelom in animals

body cavity is formed by splitting of mesoderm. (e.g., annelids, arthropods, molluscs). In **Enterocoelomate animals** the body cavity is formed from the mesodermal pouches of archenteron. (e.g., Echinoderms, hemichordates and chordates) (Figure 2.7).

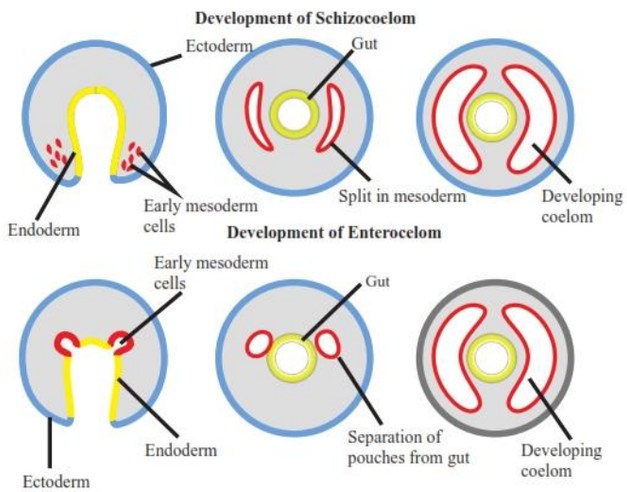


Figure 2.7 Development of Schizocoelomata and Enterocoelomata

What is the advantage of true coelom over a pseudocoelom?

2.1.5 Segmentation and Notochord

In some animals, the body is externally and internally divided into a series of repeated units called segments with a serial repetition of some organs **(Metamerism)**. The simplest form of segmentation is found in Annelids in which each unit of the body is very similar to the next one. But in arthropods (cockroach), the segments may look different and has different functions.

Animals which possess notochord at any stage of their development are called chordates. Notochord is a mesodermally derived rod like structure formed on the dorsal side during embryonic development in some animals. Based on the presence or absence of notochord, animals are classified as chordates (Cephalochordates, Urochordates, Pisces to Mammalia) and nonchordates (Porifera to Hemichordata).

2.2 Classification of Kingdom Animalia

Animal kingdom is divided into two sub-kingdoms, the Parazoa and Eumetazoa based on their organisation.

1. Parazoa: These include the multicellular sponges and their cells are loosely aggregated and do not form tissues or organs.

2. Eumetazoa: These include multicellular animals with well defined tissues, which are organised as organs and organ systems. Eumetazoans includes two taxonomic levels called grades. They include **Radiata** and **Bilateria**.

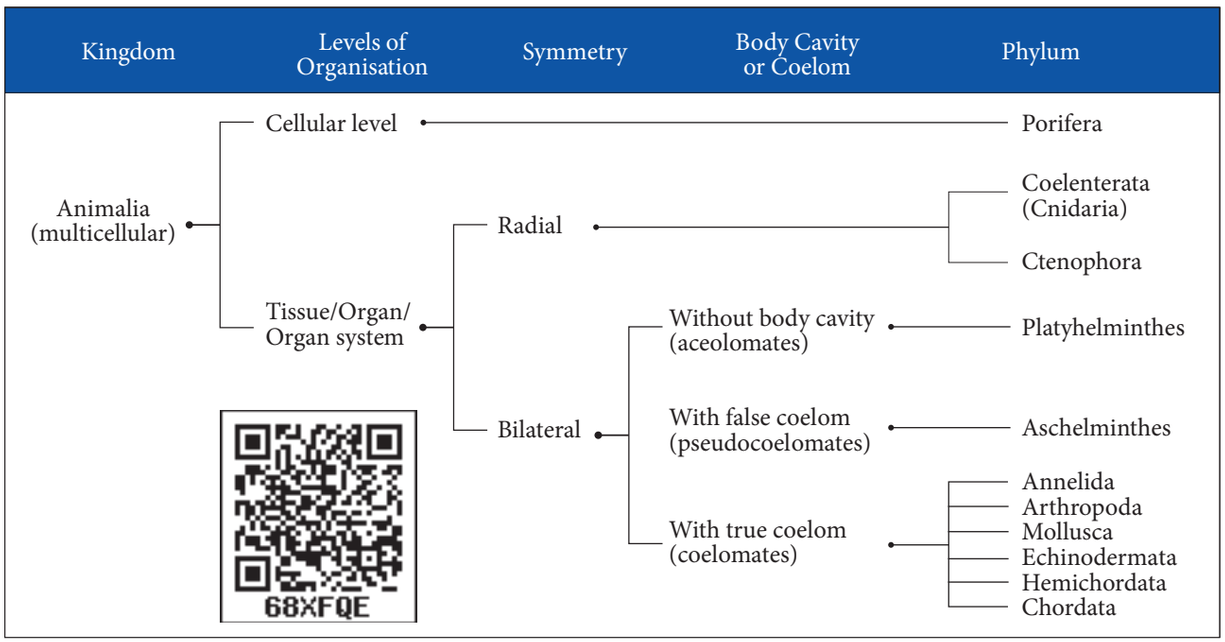


Figure 2.8 Classification of Kingdom Animalia based on common fundamental features

Grade 1: Radiata

Among the eumetazoa, a few animals have an organisation of two layers of cells, the outer ectoderm and inner endoderm, separated by a jelly like mesoglea. They are radially symmetrical and are diploblastic. Examples: Cnidarians (sea anemone, jelly fish) and Ctenophores (comb jellies).

Grade 2: Bilateria

The eumetazoans other than Radiata, show organ level of organisation and are bilaterally symmetrical and triploblastic. The grade Bilateria includes two taxonomic levels called **Division.**

Division 1: Protostomia

(*Proto*: first; *stomium*: mouth)

Protostomia includes the eumetazoans in which the embryonic blastopore develops into mouth. This division includes three subdivisions namely **acoelomata, pseudocoelomata and schizocoelomata.**

Division 2: Deuterostomia

(*deuteron*: secondary; *stomium*: mouth)

Eumetazoans in which anus is formed from or near the blastopore and the mouth is formed away from the blastopore. It includes only one subdivision **Enterocoelomata.** They have a true coelom called enterocoel, formed from the archenteron.

2.3 Non Chordates (Invertebrata)

2.3.1 Phylum: Porifera

(L. *poros*-pore; *ferre*-to bear)

These pore bearing animals are commonly called **sponges.** They are aquatic, mostly marine, asymmetrical and a few species live in freshwaters. They are primitive, multicellular, sessile animals with cellular level of organisation in which the cells are loosely arranged. They are either radially symmetrical or asymmetrical animals.

They possess a water transport system or **canal system** where water enters through minute pores called **ostia** lining the body wall through which the water enters into a

central cavity (**spongocoel)** and goes out through the osculum. This water transport system is helpful in food gathering, circulation, respiration and removal of waste. **Choanocytes** or collar cells are special flagellated cells lining the spongocoel and the canals. The body is supported by a skeleton made up of calcareous and siliceous **spicules** or **spongin** or both. Nutrition is holozoic and intracellular. All sponges are hermaphrodites (i.e.) the ova and sperms are produced by the same individual. They also reproduce asexually by fragmentation or **gemmule formation** and sexually by the formation of gametes. Development is indirect with different types of larval stages such as **parenchymula and amphiblastula**.

Examples: *Sycon* (Scypha), *Spongilla* (fresh water sponge), *Euspongia* (bath sponge) *Euplectella* (Venus flower basket) (Figure 2.9).

Sycon

Hyalonema

Chalina

Euplectella

Figure 2.9 Examples of Porifera

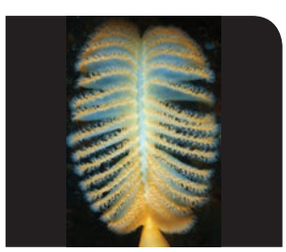
The underwater sea bed is the new habitat where the discovery and development of Marine Pharmaceuticals are in peak. Anticancerous, Antimalarial drugs and other bioactive molecules have been isolated and tested successfully.

2.3.2 Phylum: Cnidaria

(G. *knode* -needle or sting cells)

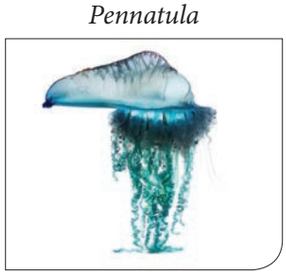
Cnidarians (were previously called Coelenterata), are aquatic, sessile or free swimming, solitary or colonial forms with radial symmetry The name Cnidaria is derived from **cnidocytes** or **cnidoblasts** with **stinging cells** or **nematocyst** on tentacles. Cnidoblasts are used for anchorage, defense, and to capture the prey. Cnidarians are the first group of animals to exhibit tissue level organisation and are diploblastic. They have a central vascular cavity or **coelenteron** (serves both digestion and circulatory function) with a single opening called mouth or hypostome, which serves the process of ingestion and egestion. Digestion is both extracellular and intracellular. The nervous system is primitive and is formed of diffused nerve net. Cnidarians like corals have a skeleton made up of calcium carbonate. Cnidarians exhibit two basic body forms, polyp and medusa. The **polyp** forms are sessile and cylindrical (e.g. *Hydra, Adamsia*), whereas the **medusa** are umbrella shaped and free swimming. Cnidarians which exist

Adamsia



Pennatula

Meandrina



Physalia

Figure 2.10 Examples of Cnidarians

in both forms, also exhibit alternation of generations in their life cycle (**Metagenesis**). The polyp represents the asexual generation and medusa represents the sexual generation. Polyps produce medusa asexually and medusa forms polyps sexually. Development is indirect and includes a free swimming ciliated **planula larva**.

Examples: *Physalia* (Portugese man of war), *Adamsia* (Sea anemone), Pennatula (Sea pen), *Meandrina* (Brain coral) (Figure 2.10).

Compare the advantages and disadvantages of direct and indirect development.

2.3.3 Phylum: Ctenophora

(G. *Ktenos* -comb; *phoros* -bearing)

Ctenophora are exclusively marine, biradially symmetrical, diploblastic animals with tissue level of organisation. Though they are diploblastic, their mesoglea is different from that of cnidaria. It contains amoebocytes and smooth muscle cells. They have eight external rows of ciliated comb plates (comb jellies) which help in locomotion, hence commonly called **comb jellies** or **sea walnuts**. **Bioluminescence** (the ability of a living organism to emit light) is well marked in ctenophores. They lack nematocysts but possess special cells called **lasso cells** or **colloblasts** which help in food capture. Digestion is both extracellular and intracellular. Sexes are not separate (monoecious). They reproduce only by sexual means. Fertilization is external and development is indirect and includes a larval stage called **cydippid larva**. e.g., *Pleurobrachia* (Figure 2.11).

Examples : *Pleurobrachia and Ctenoplana*.

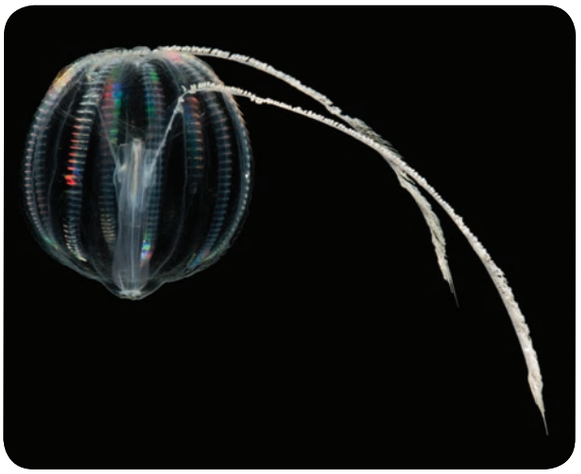
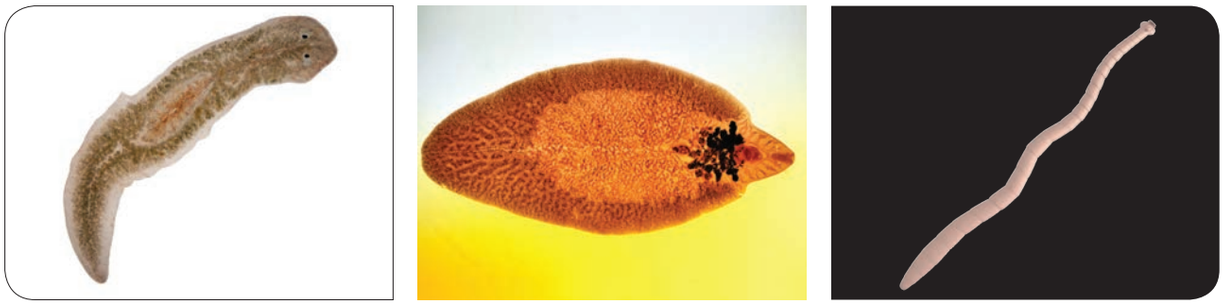


Figure 2.11 Example of Ctenophora- *Pleurobrachia*

2.3.4 Phylum: Platyhelminthes (Flatworms)

(G. *Platy* -broad or flat; *helmin*-worm)

They have a dorsoventrally flattened body and hence called flatworms. These animals are bilaterally symmetrical, triploblastic, acoelomate with organ system level of organisation. They show moderate cephalization and unidirectional movement. They are, mostly endoparasites of animals including human beings. Hooks and suckers are present in the parasitic forms and serve as organs of attachment. Their body is not segmented, but some exhibit pseudosegmentation. Some of the parasitic flatworms absorb nutrients directly from the host through their body surface. However, flatworms like liver fluke have an incomplete digestive system. Specialized excretory cells called **flame cells** help in osmoregulation and excretion. Sexes are not separate (monoecious); fertilisation is internal and development is through larval stages (miracidium, sporocyst, redia, cercaria). **Polyembryony**



Planaria *Liverfluke* *Tapeworm*

Figure 2.12 Examples of Platyhelminthes

is common in some flatworms (Liver flukes). Some members like *Planaria* show high regeneration capacity (Figure 2.12).

Examples: *Taenia solium* (Tape worm), *Fasciola hepatica* (Liver fluke), *Schistosoma* (Blood fluke).

2.3.5 Phylum: Aschelminthes (Round Worms)

(G. *Askes* –cavity; *helminths* – worms)

Previously called Nematoda, this phylum is now named as Aschelminthes. The body of these worms is circular (round) in cross section and hence are called round worms. They are free living or parasitic on aquatic and terrestrial plants and animals. They are bilaterally symmetrical, triploblastic and pseudocoelomate animals with organ system level of organisation. The body is unsegmented and covered by a transparent, tough and protective collagenous layer called cuticle. The alimentary canal is complete with a well developed mouth, muscular pharynx and anus. Excretory system consists of renette glands. Sexes are separate; and exhibit sexual dimorphism; often females are longer than males. Fertilisation is internal; majority are oviparous (e.g. *Ascaris*) few are ovoviviparous (*Wuchereria*). Development may be direct or indirect.

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Examples. *Ascaris lumbricoides* (Round worm), *Enterobius vermicularis* (Pin worm), *Wuchereria bancrofti* (Filarial worm), *Ancylostoma*a *deuodenale* (Hook worm) (Figure 2.13).

2.3.6 Phylum: Annelida (Segmented worm)

(L. *annulus* -a ring, and G. *edios*- form)

Annelids were the first segmented animals to evolve. They are aquatic or terrestrial, free living but some are parasitic. They are triploblastic, bilaterally

Ascaris *Filarial worm* *Hook worm*

Figure 2.13 Examples of Aschelminthes

Earthworm *Nereis* *Leech*

Figure 2.14 Examples of Annelida

symmetrical, schizocoelomates and exhibit organ system level of body organisation. The coelom with coelomic fluid creates a hydrostatic skeleton and aids in locomotion. Their elongated body is metamerically segmented and the body surface is divided into segment or metameres. Internally the segments are divided from one another by partitions called septa. This phenomenon is known as **metamerism**. The longitudinal and circular muscles in the body wall help in locomotion. Aquatic annelids like *Nereis* have lateral appendages called **parapodia**, which help in swimming. Chitinous setae in Earthworms, and suckers in Leech help in locomotion. The circulatory system is of closed type and the respiratory pigments are **haemoglobin** and **chlorocruorin**. Nervous system consists of paired ganglion connected by the lateral nerves to the double ventral nerve cord. They reproduce sexually. Development is direct or indirect and includes a **trochophore larva**. Some are monoecious (earthworms) while some are dioecious (Neries and Leech). (Figure 2.14)

Examples: *Lampito mauritii* (earthworm), *Neries* (sand worm), *Hirudinaria* (leech).

How is cephalisation advantageous to animals in finding food?

Filariasis has been a major public health problem in India next only to malaria. The disease was recorded in India as early as 6th century B.C. by the famous Indian physician, Susruta in his book **Susruta Samhita.** In 7 th century A.D., **Madhavakara** described signs and symptoms of the disese in his treatise ' Madhava Nidhana' which holds good even today. In 1709, Clarke identified elephantoid legs in Cochin. The **microfilariae** in the peripheral blood was first identified by Lewis in 1872 in Calcutta (Kolkata).

2.3.7 Phylum: Arthropoda

(G. *arthros*- jointed; podes- feet)

This is the largest phylum of the Kingdom Animalia and includes the largest class called **insecta** (total species ranges from 2-10 million). They are bilaterally symmetrical, segmented, triploblastic and schizocoelomate animals with organ system grade of body organisation. They have jointed appendages which are used for locomotion, feeding and are sensory in function. Body is covered by chitinous exoskeleton for protection and to prevent water loss, It is shed off periodically by a process called **moulting** or **ecdysis**. The body consists of a head, thorax, and abdomen with a body

cavity called **haemocoel**. Respiratory organs are gills, book gills, book lungs and trachea. Circulatory system is of open type. Sensory organs like antennae, eyes (compound and simple), statocysts (organs of balance/ equilibrium) are present. Excretion takes place through **malpighian tubules**, **green glands**, **coxal glands**, etc. They are mostly dioecious and oviparous; fertilization is usually internal. Development may be direct or indirect. Life history includes many larval stages followed by metamorphosis.

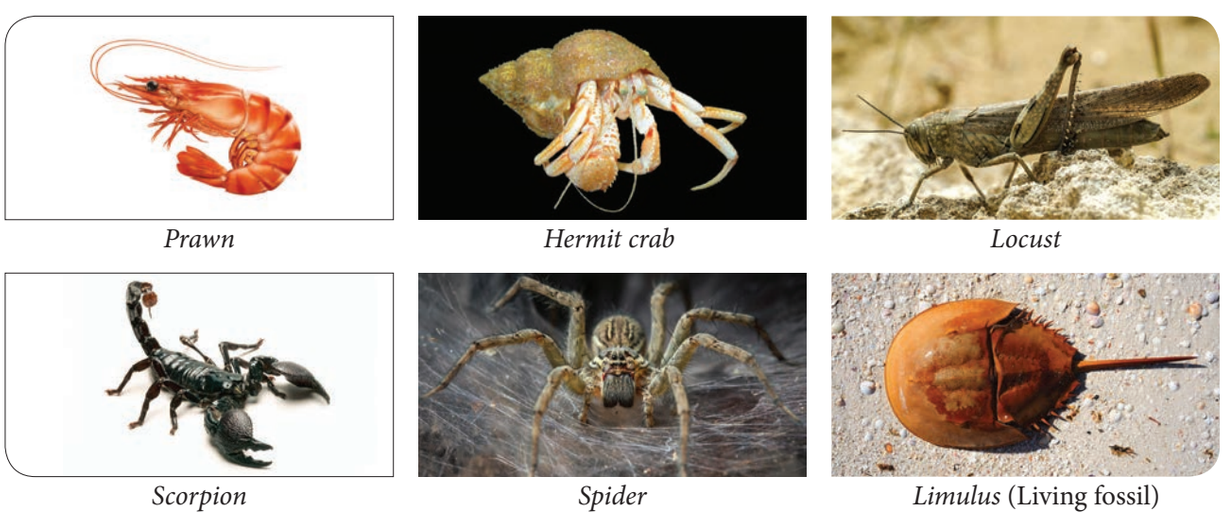
Examples : *Limulus* (King crab, a living fossil), *Palamnaeus* (Scorpion), *Eupagarus* (Hermit crab), *Apis* (Honey bee), *Musca* (House fly), Vectors- *Anopheles*, *Culex*, *Aedes* (mosquitoes), Economically important insects - *Apis*- (Honey bee), *Bombyx* (Silk worm), *Laccifer* (Lac insects), Gregarious pest - *Locusta* (Locust) (Figure 2.15)

Spider silk is five times stronger than steel of the same diameter. It has been suggested that a Boeing 747 could be stopped in flight by a single pencil-width strand and spider silk is almost as strong as Kevlar, the toughest man-made polymer.

2.3.8 Phylum: Mollusca

(L. *molluscs* –soft bodied)

This is the second largest animal phylum. Molluscs are terrestrial and aquatic (marine or fresh water) and exhibit organ system level of body organisation. They are bilaterally symmetrical (except univalves eg. apple snail) triploblastic and coelomate animals. Body is covered by a calcareous shell and is unsegmented with a distinct head, muscular foot and a visceral hump or visceral mass. A soft layer of skin forms a mantle over the visceral hump. The space between the visceral mass and **mantle** (pallium) is called the mantle cavity in which a number of feather like gills (**ctenidia)** are present, which are respiratory in function. The digestive system is complete and mouth contains a rasping organ called **radula** with transverse rows of chitinous teeth for feeding (radula is absent in bivalves). The sense organs are tentacles, eyes and **osphraidium** (to test the purity of water and present in bivalves and gastropods). Excretory organs are nephridia. Open type of circulatory system is seen except for cephalopods such as squids, cuttle fishes and octopus. Blood contains **haemocyanin**, a copper containing



Prawn | *Hermit crab* | *Locust*

Scorpion | *Spider* | *Limulus* (Living fossil)

Figure 2.15 Examples of Arthropoda

respiratory pigment. They are dioecious and oviparous. Development is indirect with a **veliger larva** (a modified trochophore larva).

Examples: *Pila* (Apple snail), *Lamellidens* (Mussel), *Pinctada* (Pearl oyster), *Sepia* (Cuttle fish), *Loligo* (Squid), *Octopus* (Devil fish) (Figure 2.16).


Pila


Octopus

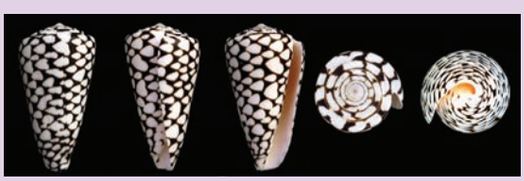

Squid


Oyster

Figure 2.16 Examples of Mollusca

Marbled Cone Snail
(*Conus marmoreus*)

This cone-shaped snail can deliver dangerous venom which may result in vision loss, respiratory failure, muscle paralysis and eventually death. There is no anti-venom available.



2.3.9 Phylum Echinodermata

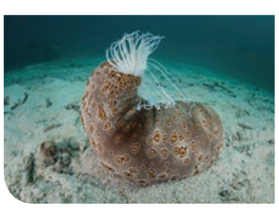
(G. *Echinos* – spiny; *dermos* –skin)

All Echinoderms are marine animals. The adults are **radially symmetrical** but the larvae are **bilaterally symmetrical**. These animals have a mesodermal endoskeleton of calcareous ossicles and hence the name Echinodermata (spiny skin). They are exclusively marine with organ system level of organisation. The most distinctive feature of echinoderms is the presence of the **water vascular system** or a**mbulacral system** with **tube feet** or **podia**, which helps in locomotion, capture and transport of food and respiration. The digestive system is complete with mouth on ventral side and anus on the dorsal side. Excretory organs are absent. The nervous system and sensory organs are poorly developed. The circulatory system is open type without heart and blood vessels. Sexes are separate. Reproduction is sexual and fertilization is external. Development is indirect with free swimming bilaterally symmetrical larval forms. Some echinoderms exhibit autotomy with remarkable powers of **regeneration.** e.g. Star fish. (Figure 2.17)

Examples: *Asterias* (Starfish or Sea star), *Echinus* (Sea-urchin), *Antedon* (Sea-lily), *Cucumaria* (Sea-cucumber), *Ophiura* (Brittle star)


Starfish


Brittle star


Sea cucumber


Sea urchin

Figure 2.17 Examples of Echinodermata

2.3.10 Phylum: Hemichordata

(G.*hemi* –half; *chorda*-string)

Hemichordates were earlier treated as a subphylum of Chordata (or Prochordata). They are now regarded to be an independent phylum of invertebrates, close to Echinodermata. The animals of this group possess the characters of invertebrates as well as chordates.

This phylum consists of a small group of worm-like, soft marine animals, mostly tubiculous and commonly called the **'acorn worms'** or **'tongue worms'**. They are bilaterally symmetrical, triploblastic and coelomate animals with organ system level of organisation. Their body is cylindrical and is divided into three regions, the anterior proboscis, a short collar and a long trunk. Most hemichordates are ciliary feeders. Their circulatory system is simple and open or lacune type with a dorsal heart. Respiration is through paired gill slits opening into the pharynx. Excretion is by a single **proboscis gland** or **glomerulus** situated in the proboscis. Nervous system is primitive. Sexes are separate and exhibit sexual mode of reproduction; Fertilization is external. Development is indirect with a free swimming **tornaria larva**.

Figure 2.18 Example of Hemichordata - Balanoglossus

Examples: *Balanoglossus*, *Saccoglossus, Ptychodera flava (*Indian Hemichordate found in Kurusadai islands in Tamilnadu) (Figure 2.18).

2.4 Phylum: Chordata

(G. *Chorda –string*)

Chordata is the largest phylum with most familiar group of animals, such as fishes, amphibians, reptiles, birds and mammals and less known forms such as **lancelets** (Amphioxus) and **tunicates** (Ascidian). All chordates possess three fundamental distinct features at some stage of their life cycle (Figure 2.19), they are:

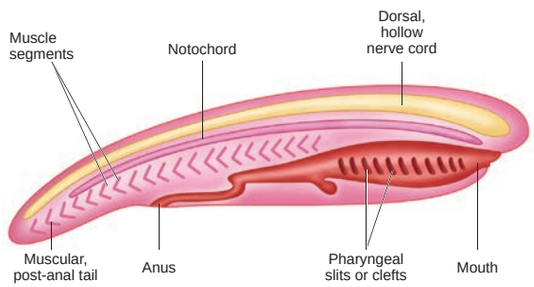


Figure 2.19 A Typical Chordate

1. Presence of elongated rod like notochord below the nerve cord and above the alimentary canal. It serves as a primitive internal skeleton. It may persist throughout life in lancelets and lampreys. In adult vertebrates, it may be partially or completely replaced by backbone or vertebral column.
2. A dorsal hollow or tubular fluid filled nerve cord lies above the notochord and below the dorsal body wall. It serves to integrate and co-ordinate the body functions. In higher chordates, the anterior end of the nerve cord gets enlarged to form the brain and the posterior part becomes the spinal cord, protected inside the vertebral column.
3. Presence of pharyngeal gill slits or clefts in all chordates at some stage of their lifecycle. It is a series of gill slits or clefts that perforates the walls of pharynx and appears during the development of every

Table. 1 Comparison of chordates and non-chordates

Chordates	Non-chordates
Notochord is present	Notochord is absent
Dorsal, hollow and single nerve cord	Double ventral solid nerve cord
Pharynx perforated by gill slits	Gill slits absent
Heart is ventrally placed	Heart is dorsal or laterally placed or absent
A post anal tail is present	A post anal tail is absent
Alimentary canal is placed ventral to the nerve cord	Alimentary canal is placed dorsal to the nerve cord

chordate. In aquatic forms, pharyngeal gill slits are vascular, lamellar and form the gills for respiration. In terrestrial chordates, traces of non-functional gill clefts appear during embryonic developmental stages and disappear later. Besides the above said features, chordates are bilaterally symmetrical, triploblastic, coelomates with organ system level of organisation; they possess post anal tail, closed circulatory system with a ventral myogenic heart except in *Amphioxus*.

List the three features common to all chordates at sometime in their life.

2.4.1 Subphylum: Urochordata or Tunicata

(G. *Oura* – A tail; L. *Chord* – cord)

They are exclusively marine and are commonly called **sea squirts**. Mostly sessile, some pelagic or free swimming, exist as solitary and colonial forms. Body is unsegmented and covered by a test or tunic. Adult forms are sac like. Coelom is absent, but has an atrial cavity surrounding the pharynx. Notochord is present only in the tail region of the larval stage, hence named urochordata. Alimentary canal is complete and circulatory system is of open type. The heart is ventral and tubular. Respiration is through gill slits and clefts. Dorsal tubular nerve cord is present only in the larval stage and a single dorsal ganglion is present in the adults. Mostly hermaphrodites, development indirect and includes a free swimming **tadpole larva** with chordate characters. **Retrogressive metamorphosis** is seen (Figure 2.20).

Examples: *Ascidia, Salpa, Doliolum*

2.4.2 Subphylum: Cephalochordata

(L. *Cephalo-* 'head' ; G. *chorda* 'cord'.)

Cephalochordates are marine forms, found in shallow waters, leading a burrowing mode of life. They are small

Ascidia

Salpa

Doliolum

Figure 2.20 Examples of Urochordata

fish like coelomate forms with chordate characters such us notochord, dorsal tubular nerve cord and pharyngeal gill slits throughout their life. Closed type of circulatory system is seen without heart. Excretion is by **protonephridia**. Sexes are separate, Fertilization is external. Development is indirect and includes a free swimming larva (Figure 2.21).

Example: *Branchiostoma* (Amphioxus or lancelet)

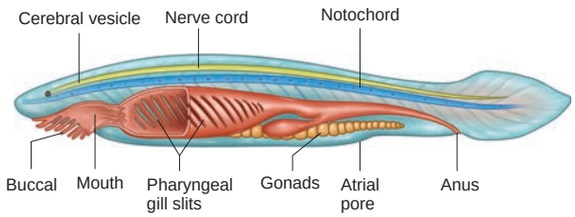


Figure 2.21 Example of Cephalochordata - Amphioxus

2.4.3 Subphylum-Vertebrata

(L. *Vertebrus* –back bone)

Vertebrates are also called higher chordates and they possess notochord during embryonic stage only. The notochord is replaced by a cartilaginous or bony vertebral column in the adult. **Hence all vertebrates are chordates but all chordates are not vertebrates.** Vertebrates possess paired appendages such as fins or limbs. Skin is covered by protective skeleton comprising of scales, feathers, hairs, claws, nails, etc. Respiration is aerobic through gills, skin, buccopharyngeal cavity and lungs. Vertebrates have a ventral muscular heart with two, three or four chambers and kidneys for excretion and osmoregulation.

Subphylum Vertebrata is divided into two divisions, **Agnatha** and **Gnathostomata**. Agnatha includes jawless fish-like aquatic vertebrates without paired appendages. Notochord persists in the adult. Gnathostomata includes jawed vertebrates with paired appendages. Notochord is replaced partly or wholly by the vertebral column. Agnatha includes one important class – Cyclostomata. **Gnathostomata** includes **jawed fishes** (Pisces) and **Tetrapoda** (amphibia, reptilia, aves and mammals). The superclass Pisces includes all fishes which are essentially aquatic forms with paired fins for swimming and gills for respiration. Pisces includes cartilaginous fishes (Chondrichthyes) and bony fishes (Osteichthyes).

2.4.4 Class: Cyclostomata

(G.*cyklos*–circle; *stomata* -mouth)

All members of cyclostomata are primitive, poikilothermic, jawless aquatic vertebrates and are ectoparasites on some fishes. Body is slender and eel-like bearing six to fifteen pair of gill slits for respiration**.** Mouth is circular without jaws and suctorial. Heart is two chambered and circulation is of closed type. No paired appendages. Cranium and vertebral column are cartilaginous. Cyclostomes are marine but migrate to fresh waters for spawning **(anadromous migration)**. After spawning within a few days they die. The larvae **(ammocoete)** after metamorphosis returns to the ocean. Examples: *Petromyzon* (Lamprey) and *Myxine* (Hag fish) (Figure 2.22).

Lamprey

Hag fish

Figure 2.22 Examples of Cyclostomata

2.4.5 Class: Chondrichthyes

(*G. chondros* –cartilage; *ichthys* -fish)

They are marine fishes with cartilaginous endoskeleton. Notochord is persistent throughout life. Skin is tough covered by dermal **placoid scales** and the caudal fin is **heterocercal** (asymmetrical both externally and internally). Mouth is located ventrally and teeth are modified placoid scales which are backwardly directed. Their jaws are very powerful and are predaceous animals. Respiration by **lamelliform gills** without operculum (gill cover). Excretory organs are **mesonephric** kidneys. Two chambered heart is present. Cartilaginous fishes are **ureotelic** and store urea in their blood to maintain osmotic concentration of body fluids. They are **poikilothermic** and **viviparous**. Sexes are separate. In males pelvic fins bear claspers to aid in internal fertilisation.

Examples: *Scoliodon* (Shark), *Trygon* (Sting ray), *Pristis* (Saw fish) (Figure 2.23).

2.4.6 Class: Osteichthyes

(G. *osteon* –bone; *ichthys* -fish)

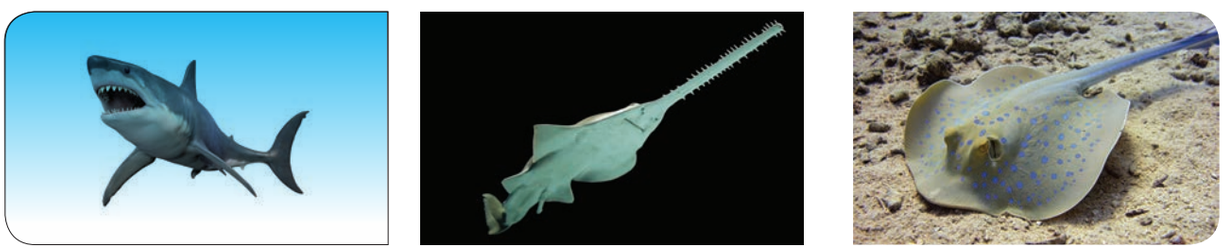
It includes both marine and freshwater fishes with bony endoskeleton and spindle shaped body. Skin is covered by **ganoid**, **cycloid** or **ctenoid scales**. Respiration is by four pairs of filamentous gills and is covered by an operculum on either side. Air bladder is present with or without a connection to the gut. It helps in gaseous exchange (lung fishes) and for maintaining buoyancy in most of the ray finned fishes. They have a ventrally placed two chambered heart. Excretory organs are **mesonephric kidneys** and are **ammonotelic**. Presence of well developed **lateral line sense organ**. Sexes are separate, external fertilization is seen and most forms are oviparous (Figure 2.24).

Examples: *Exocoetus* (Flying fish), *Hippocampus* (Sea horse), *Labeo* (Rohu), *Catla* (Catla), *Echeneis* (Sucker fish), *Pterophyllum* (Angel fish)

2.4.7 Class: Amphibia

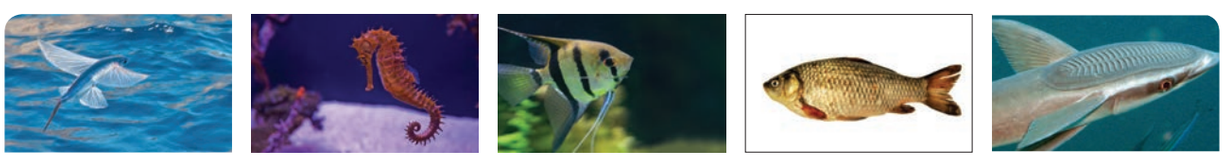
(G. *amphi*-both; *bios* -life)

Amphibians are the first vertebrates and tetrapods to live both in aquatic as well as terrestrial habitats.They are **poikilothermic**. Their body is divisible into the head and trunk and most of them have two pairs of limbs; tail may or may not be present. Their



Shark *Pristis* *Sting ray*

Figure 2.23 Examples of Chondrichthyes

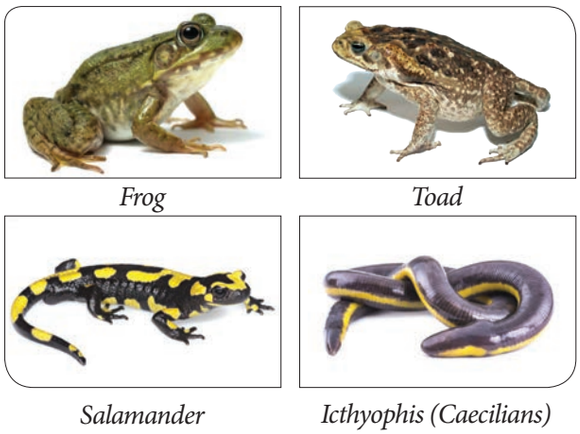


Flying fish *Sea horse* *Angel fish* *Carp* *Sucker fish*

Figure 2.24 Examples of Osteichthyes

skin is smooth or rough, moist, pigmented and glandular. Eyes have eyelids and the tympanum represents the ear. Respiration is by gills, lungs and through the skin. Heart is three chambered. Kidneys are **mesonephric.** Sexes are separate and fertilization is external. They are oviparous and development is indirect. They show **hibernation** and **aestivation**.

Examples: *Bufo* (Toad), *Rana* (Frog), *Hyla* (Tree frog), *Salamandra* (Salamander), *lcthyophis* (Limbless amphibians) (Figure 2.25).



Frog *Toad*

Salamander *Icthyophis (Caecilians)*

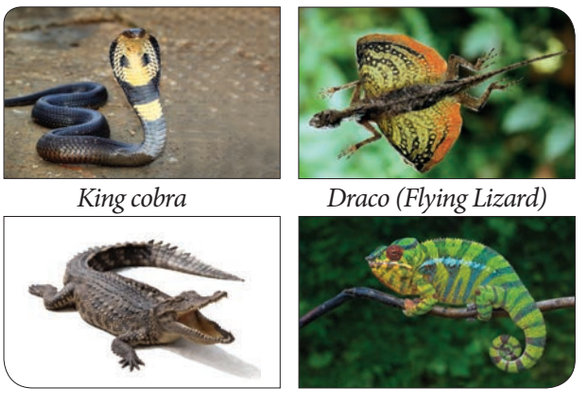
Figure 2.25 Examples of Amphibia

2.4.8 Class: Reptilia

(*L. repere* or *reptum* – to creep or crawl)

They are mostly terrestrial animals and their body is covered by dry, and cornified skin with epidermal scales or scutes. Reptiles have three chambered heart but four chambered in crocodiles. All are cold blooded amniotes (poikilotherms). Most reptiles lay **cleidoic eggs** with extraembryonic membranes like **amnion, allantois, chorion and yolk sac**. Excretion by metanephric kidneys and are uricotelic. Sexes are separate with well marked sexual dimorphism. Internal fertilization takes place and all are oviparous.

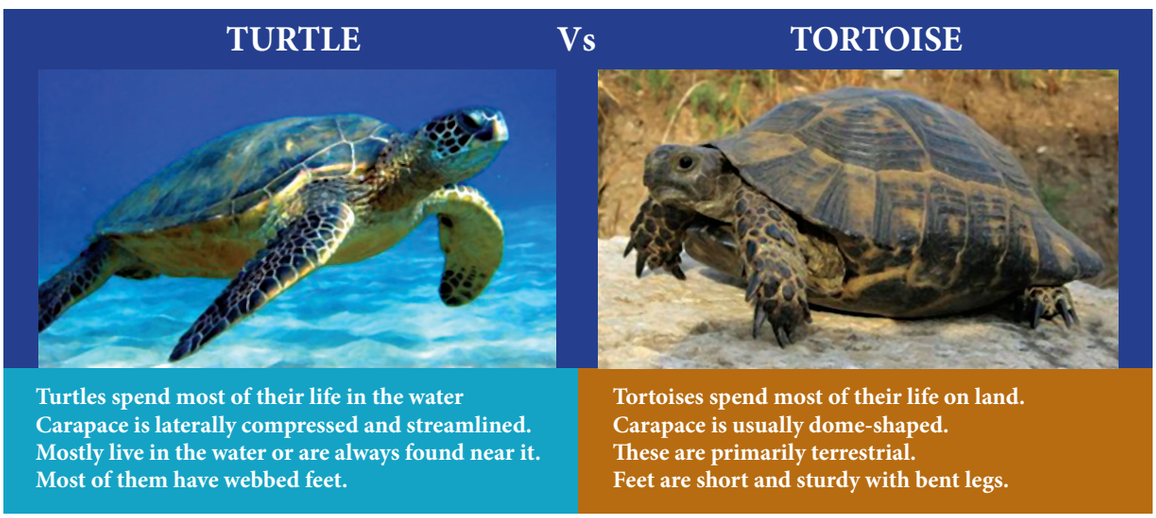
Examples : *Chelone* (Turtle), *Testudo* (tortoise), *Hemidactylus* (House lizard), *Chameleon* (Tree lizard), *Calotes* (Garden lizard), *Draco* (Flying lizard), *Crocodilus* (crocodile), Poisonous snakes - *Naja* (Cobra), *Bangarus* (Krait), *Vipera* (Viper) (Figure 2.26).



King cobra *Draco (Flying Lizard)*

Crocodile *Chameleon*

Figure 2.26 Examples of Reptiles



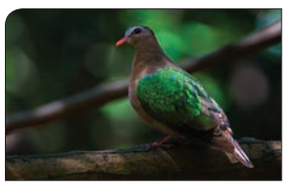
2.4.9 Class Aves (L. *Avis* –bird)

Aves are commonly known as birds. The characteristic feature of Aves is the presence of feathers and the ability to fly except for flightless birds (Eg. *Ostrich, Kiwi, Penguin*). The forelimbs are modified into wings, and the hind limbs are adapted for walking, running, swimming and perching. The skin is dry and devoid of glands except the **oil gland** or **preen gland** at the base of the tail. The exoskeleton consists of epidermal feathers, scales, claws on legs and the horny covering on the beak. The endoskeleton is fully ossified (bony) and the long bones are hollow with air cavities **(pneumatic bones)**. The pectoral muscles of flight **(pectoralis major** and **pectoralis minor)** are well developed. Respiration is by compact, elastic, spongy lungs that are continuous with air sacs to supplement respiration. The heart is four chambered. Aves are **homeothermic**. Migration and parental care is well marked. Urinary bladder is absent. Sexes are separate with well marked sexual dimorphism. In males, the testes are paired but in females, only the left ovary is well developed while the right ovary is atrophied. All birds are oviparous. Eggs are **megalecithal** and **cleidoic**. Fertilization is internal.

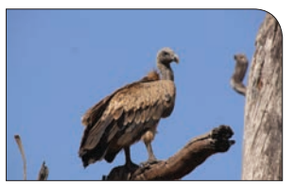
Hooded Pitohui
(*Pitohui dichrous)*

The Hooded Pitohui is a songbird found in the rain forests of New Guinea, The first poisonous bird to be documented A neurotoxin called Homobatrachotoxin is found in its skin and feathers, causes numbness and tingling in those touching the bird.

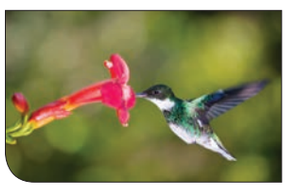
Examples *Corvus* (Crow), *Columba* (Pigeon), *Psittacula* (Parrot), *Pavo* (Peacock), *Aptenodytes* (Penguin), *Neophron* (Vulture), *Chalcophaps indica* (Tamilnadu state bird, Common Emerald Dove) (Figure 2.27).



Common Emerald Dove (Tamil Nadu State Bird)



Vulture



Humming Bird

Penguin

Figure 2.27 Examples of Aves

2.4.10 Class: Mammalia

(L. *Mamma* – Breast)

They are found in a variety of habitats. Their body is covered by hair, a unique feature of mammals. Some of them are adapted to fly or live in water. Presence of **mammary glands** is the most unique feature of mammals. They have two pairs of limbs adapted for walking, running, climbing, burrowing, swimming and flying. Their skin is glandular in nature, consisting of sweat glands, scent glands and sebaceous glands. Exoskeleton includes horny epidermal horns, spines, scales, claws, nails, hooves and bony dermal plates. Teeth are **thecodont**, **heterodont** and **diphyodont**. External ears or pinnae are present. The heart is four chambered and possess a left systematic arch. Mature RBCs are circular, biconcave and non nucleated. Mammals have a large brain when compared to other animals They show greatest intelligence among all animals. Their kidneys are

metanephric and are **ureotelic**. All are homeothermic, sexes are separate and fertilization is internal.

Examples Oviparous- *Ornithorhynchus* (Platypus), Viviparous- *Macropus* (Kangaroo), *Pteropus* (Flying fox), *Macaca* (Monkey), *Canis* (Dog), *Felis* (Cat), *Elephas* (Elephant), *Equus* (Horse), *Delphinus* (Common dolphin) *Balaenoptera* (Blue whale), *Panthera tigris* (Tiger), *Panther leo* (Lion), *Homo sapiens* (Human) *Bos* (Cattle) (Figure 2.28).

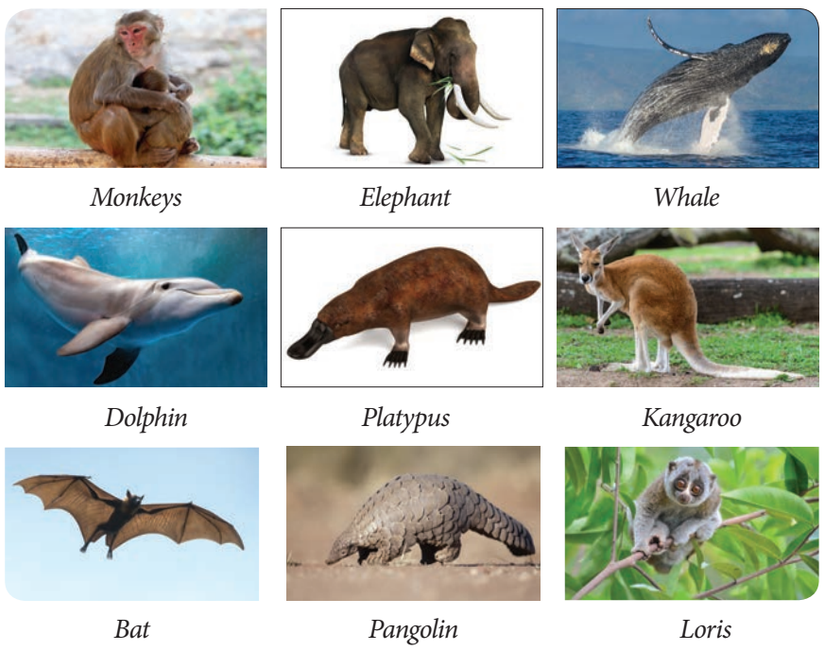


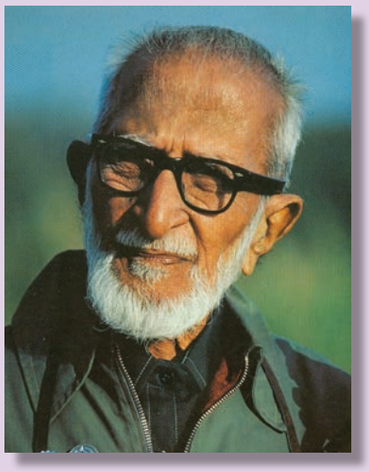
Figure 2.28 Examples of Mammals

Summary

Kingdom Animalia comprises of a broad range of animal species, from tiny parasitic nematodes to the largest mammal the blue whale. The basic fundamental features such as levels of organisation, diploblastic and triploblastic organisation, patterns of symmetry, coelom, segmentation and notochord have enabled us to broadly classify the animal kingdom. Besides the fundamental features, there are many other distinctive characters which are specific for each phyla or class.

Animals are broadly classified into invertebrates and chordates. The animals which lack vertebral column are called invertebrates. The chordates are characterized by the presence of notochord, solid ventral nerve cord and gill slits. Kingdom Animalia are classified into eleven animal phyla as Porifera, Cnidaria, Ctenophora, Platyhelminthes, Aschelminthes, Annelida, Arthropoda, Mollusca, Echinodermata, Hemichordata and Chordata. Chordata is the largest phylum with three sup phyla Urochordata, Cephalochordata and Vertebrata. Subphylum Vertebrata includes two divisions, Agnatha and Gnathostomata. Agnatha comprises of the class Cyclostomata. Gnathostomata includes jawed fishes (Pisces) and Tetrapoda which includes the classes amphibia, reptilia, aves and mammals.

CASE STUDY



Sálim Moizuddin Abdul Ali is the leading pioneer of Indian Ornithology and generally referred as **"Bird Man of India"**. He was born on 12 November 1896 in Bombay and he was the most respected and influential naturalist of 20th century in India, He passed away on 20 June 1987. Young Salim got interested in birds when he was at the age of ten. Later he has conducted many systematic bird surveys across India and the neighboring countries. He authored many bird books and popularized ornithology in India. 'Book of Indian birds' and the 'Hand book of Birds of India and Pakistan' are the most important books he has written. His autobiography **'Fall of a sparrow'** narrates the beginning and experience of his life with birds. Government of India honoured him with the award of Padma Bhusahan in 1958 and Padma Vibhushan 1976. He was nominated to Rajyasabha in 1985. Salim Ali through his books motivated thousands of people to the field of ornithology and natural history. Most of the environmentalists in India trace back their initial motivation to bird watching and Salim Ali's books.

In 1990, Government of India started a national research institution in his honour called Sálim Ali Centre for Ornithology and Natural History (SACON) in Coimbatore, Tamil Nadu. SACON is a Centre of excellence in research supported by the Ministry of Environment, Forest and Climate Change, Government of India. All the researches and activities of SACON is devoted to the cause of conservation of India's Biodiversity with focus on birds. The main campus of SACON is situated in the sylvan surrounding of Anaikatty, 24 kilometers northwest of Coimbatore city, within the Nilgiri Biosphere Reserve. SACON's mission is to help conserve India's biodiversity and its sustainable use through research, education and people's participation with birds at the centre stage. SACON conducts research in Ornithology covering all aspects of biodiversity and natural history. More than 50 research scholars have completed PhD in Ornithology and Natural history from SACON in its 25 years of existence. SACON is known for its many research papers published in national and international journals. Nature Education programme of SACON is very popular in the region which is inculcating love for birds and nature to thousands of people especially to school children every year. Children's Ecology Congress of SACON and Salim Ali Trophy Nature Competitions are flagship events. Salim Ali Naturalist Forum of SACON is the people's bird watching movement in Coimbatore facilitated by SACON.

Activity

Objectives:

Some Groups of organisms with their distinguishing characteristics are given. Construct a cladogram, interpret and analyze the cladogram in terms of how it shows common ancestry and degrees of evolutionary relationship.

Procedure:

Step 1. Refer your text book and identify the characteristics of the given animals. In the data table provided, place an "x" in the box if the animal has the characteristic.

Step 2: Below the Data Table on the Worksheet, make a Venn diagram, placing animals in groups to illustrate those characteristics which different animals have in common.

Step 3: Using the Venn diagram draw a cladogram to illustrate the ancestry of these animals. The diagram should reflect the shared characteristics as time proceeds.

Step 4: Draw the Venn diagram to reflect the shared characteristics of the given animal and draw a cladogram.







Sets	Traits	Kangaroo	Lamprey	Monkey	Frog	Human	Tortoise	Fish
Set#1	Dorsal Nerve cord, Notochord							
Set#2	Paired Appendages Vertebral column							
Set#3	Paired legs							
Set#4	Amnion (Amniotic sac)							
Set#5	Mammary gland							
Set#6	Placenta							
Set#7	Canine teeth							
	Total 'X' s							

Evaluation

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1. The symmetry exhibited in cnidarians is
   a. Radial
   b. Bilateral
   c. Pentamerous radial
   d. Asymmetrical
2. Sea anemone belongs to phylum
   a. Protozoa b. Porifera
   c. Coelenterata d. Echinodermata
3. The excretory cells that are found in platyhelminthes are
   a. Protonephridia b. Flame cells
   c. Solenocytes d. All of these
4. In which of the following organisms, self fertilization is seen.
   a. Fish b. Round worm
   c. Earthworm d. Liver fluke
5. Nephridia of Earthworms are performing the same functions as
   a. Gills of prawn
   b. Flame cells of Planaria
   c. Trachea of insects
   d. Nematoblasts of Hydra

6. Which of the following animals has a true coelom ?
   a. *Ascaris* b. *Pheretima*
   c. *Sycon* d. *Taenia solium*
7. Metameric segmentation is the main feature of
   a. Annelida b. Echinodermata
   c. Arthropoda d. Coelenterata
8. In *Pheretima* locomotion occurs with the help of
   a. circular muscles
   b. longitudinal muscles and setae
   c. circular, longitudinal muscles and setae
   d. parapodia
9. Which of the following have the highest number of species in nature?
   a. Insects b. Birds
   c. Angiosperms d. Fungi
10. Which of the following is a crustacean?
   a. Prawn b. Snail
   c. Sea anemone d. Hydra
11. The respiratory pigment in cockroach is
   a. Haemoglobin b. Haemocyanin
   c. Haemoerythrin d. None of the above
12. Exoskeleton of which phylum consists of chitinous cuticle?
   a. Annelida b. Porifera
   c. Arthropoda d. Echinodermata
13. Lateral line sense organs occur in
   a. Salamander b. Frog
   c. Water snake d. Fish
14. The limbless amphibian is
   a. Icthyophis b. Hyla
   c. Rana d. Salamander
15. Four chambered heart is present in
   a. Lizard b. Snake
   c. Scorpion d. Crocodile
16. Which of the following is not correctly paired?
   a. Humans – Ureotelic
   b. Birds – Uricotelic
   c. Lizards – Uricotelic
   d. Whale – Ammonotelic
17. Which of the following is an egg laying mammal?
   a. *Delphinus* b. *Macropus*
   c. *Ornithorhynchus* d. *Equus*
18. Pneumatic bones are seen in
   a. Mammalia b. Aves
   c. Reptilia d. Sponges
19. Match the following columns and select the correct option.

Column – I	Column – II
(p) Pila	(i) Devil fish
(q) Dentalium	(ii) Chiton
(r) Chaetopleura	(iii) Apple snail
(s) Octopus	(iv) Tusk shell

   a. p – (ii), q – (i), r – (iii), s – (iv)
   b. p – (iii), q – (iv), r – (ii), s – (i)
   c. p – (ii), q – (iv), r – (i), s – (iii)
   d. p – (i), q – (ii), r – (iii), s – (iv)
20. In which of the following phyla, the adult shows radial symmetry but the larva shows bilateral symmetry?
   a. Mollusca b. Echinodermata
   c. Arthropoda d. Annelida
21. Which of the following is correctly matched?
   a. Physalia – Portugese man of war
   b. Pennatula – Sea fan
   c. Adamsia – Sea pen
   d. Gorgonia – Sea anemone
22. Why are spongin and spicules important to a sponge?
23. What are the four characteristics common to most animals?
24. List the features that all vertebrates show at some point in their development.
25. Compare closed and opened circulatory system.

26. Compare Schizocoelom with enterocoelom.
27. Identify the structure that the archenteron becomes in a developing animal.
28. Observe the animal below and answer the following questions.

    a. Identify the animal.
    b. What type of symmetry does this animal exhibit?
    c. Is this animal Cephalized?
    d. How many germ layers does this animal have?
    e. How many openings does this animal's digestive system have?
    f. Does this animal have neurons?
29. Choose the term that does not belong in the following group and explain why it does not belong?

    Notochord, cephalisation, dorsal nerve cord and radial symmetry.
30. Why flatworms are called acoelomates?
31. What are flame cells?
32. Concept Mapping - Use the following terms to create a concept map that shows the major characteristic features of the phylum nematoda:

    Round worms, pseudocoelomates, digestive tract, cuticle, parasite, sexual dimorphism
33. In which phyla is the larva trochopore found?
34. Which of the chordate characteristics do tunicates retain as adults?
35. List the characteristic features that distinguish cartilaginous fishes with living jawless fishes.
36. List three features that characterise bony fishes.
37. List the functions of air bladder in fishes.
38. Write the characteristics that contributes to the success of reptiles on land.
39. List the unique features of bird's endoskeleton.
40. Could the number of eggs or young ones produced by an oviparous and viviparous female be equal? Why?

ICT Corner Cladogram

Let's do this activity to know about **Cladogram**.

Step – 1 Type the URL given below in the browser. Press 'Play Game' button then use your personal or school id to login. Otherwise use Guest Pass to enter and start the activity.

Step – 2 Initially you will be provided with two species and their characteristics. You should drag them into the small box provided and match them.

Step – 3 Use the mouse to drag and place the characteristics on the tree.

Step – 4 If you correctly match the tree, the game will proceed to the next level. If you fail to match them start from the beginning and play the game again until you learn the characteristics.

Evolution Lab's URL:

http://www.pbs.org/wgbh/nova/labs/lab/evolution/

B167_STD_11_ZOOLOGY_EM

* Pictures are indicative only