CHAPTER-04

ANIMAL KINGDOM

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Animal kingdom shows a great diversity of life in comparison with the plant kingdom.
All animals are **metazoans** (multicellular, eukaryotic, and heterotrophic animals).

BASIS OF CLASSIFICATION

Classification is based on their features like
Arrangement of cells
Level of body organization
Body symmetry
Nature of coelom
Patterns of digestive, circulatory, or reproductive systems.

LEVEL OF ORGANISATION

It exhibits considerable variation among animals.
Following are the major types

• **Cellular level.**
Cells are arranged as loose cell aggregates.
It shows no co-ordination to form tissues.
Individual cells are capable of performing specific functions.
E.g.: sponges

• **Tissue level.**
Cells performing a similar function are aggregated to form tissues.
E.g.: Coelenterates (hydra)

• **Organ level.**
Tissues are grouped to form organs.
Each organ is assigned to execute a specific function.
Eg: Platyhelminthes and other higher phyla

• **Organ system level.**
A group of organs working together as a larger unit is called an organ system
Organ system exists in various patterns as illustrated below

Digestive system

In animals, the mouth, tongue, teeth, salivary glands, pharynx, oesophagus, stomach, small intestine, large intestine, liver, gall bladder, bile ducts, and pancreas together constitute the digestive system. It is of two types

• **Incomplete: the** digestive system has only a single opening to the outside of the body. It acts as both anus and the mouth. Eg: Platyhelminthes and Coelenterates

• **Complete:** The digestive system has two separate openings at each end, the mouth, and the anus.Eg: Man

Circulatory system:

It is of two types.

• **Open type**: blood is pumped out of the heart, and the tissues are bathed in it.Eg: arthropods and molluscs

• **Closed type:** Blood flows inside blood vessels of varying diameters (arteries, veins, capillaries) without coming in direct contact with body cells.Eg: in many invertebrates (cephalopods), and all vertebrates

SYMMETRY

Arrangement of body parts on the sides of the main median axis of the body. This idea was given by **Haeckel.**

Animals exhibit 3 types of symmetry :

• **Asymmetry:** The body cannot be divided into two halves through any plane passing through the centre.Eg: sponges

• **Radial symmetry:** The body can be cut into two exact halves through any plane which passes through the central axis. Such animals have two ends in the main body axis the oral and aboral end, but no left and right sides. Eg: Coelenterates, Ctenophora, and Echinodermata

• **Bilateral symmetry:** The body can be divided into two identical halves only through a single plane passing through the central axis. These animals have a front and rear end. They also have an upper and lower side. They have equivalent left and right lateral sides.
Eg: Annelids, Arthropods, etc

DIPLOBLASTIC AND TRIPLOBLASTIC ORGANISATION

This classification is based on the number of embryonic cell layers and divided into two:

• **Diploblastic:** Cells are arranged into two embryonic layers, i.e. outer ectoderm and inner

endoderm and a middle undifferentiated mesoglea.Eg: Coelenterates and Sponges

• **Triploblastic**: Three embryonic layers are present i.e. .outer ectoderm, middle mesoderm, and inner endoderm. All the tissues and organs are formed from these three layers. Ectoderm gives rise to epidermis and nervous system etc., mesoderm to muscles, endoskeleton, reproductive organs, coelom, etc, and endoderm to the alimentary canal, lungs, etc.• Eg: Platyhelminthes

COELOM

The fluid-filled body cavity in between the body wall and the digestive tract of animals is called the **coelom**. The coelom is lined by mesodermal epithelium on either side. All the internal organs are suspended in the coelom.

The coelom allows greater **body flexibility**.

It acts as a **shock absorber**. In soft-bodied animals, it protects internal organs from external shocks.

In some animals, it acts as an internal skeleton. E.g.: earthworm

Animals are divided into 3 groups based on the nature of the coelom.

Acoelomates: Body cavity is absent and coelomic space is occupied by parenchyma like cells.
Eg: Platyhelminthes

Pseudocoelomates: Animals having false coelom. The body cavity is not formed from the mesodermal epithelium. Mesoderm appears as scattered pouches in between ectoderm and endoderm. In these animals, pseudocoelom is formed from the embryonic cavity called the blastocoel.
Eg: Aschelminthes

•**Coelomates or Eucoelomates**: Animals with the true body cavity
Eg: Annelids, Molluscs, Arthropods, Echinoderms, Hemichordates, and Chordates.

SEGMENTATION

In some animals, the entire length of the body is transversely divided into some ring-like parts called segments. This phenomenon of segmentation is called **metamerism**.

This pattern is seen in annelids like earthworm and arthropods like millipedes and centipedes.

In earthworms, the segmentation helps in locomotion.

In arthropods, the metameric segments may be paired appendages for various functions such as legs for locomotion, antennae for sensory functions, and mouth for feeding, etc.

In insects, these metameric segments are grouped to form body regions like the head, thorax, and abdomen.

NOTOCHORD

It is a mesodermally derived rod-like structure present dorsally during embryonic development

It is a stiff and flexible rod of tissue running along the dorsal side below the nerve cord and above the alimentary canal.

Based on the presence or absence of notochord, animals are classified into 2 groups

• **Chordates**: Animals with notochord. In chordates, the notochord is present at some stage in their life. eg: fishes, birds, mammals, etc.

• **Non-chordates:** Animals without notochord.
Eg: Porifera to Echinoderms.
They do not possess the notochord at any stage of their life.

CLASSIFICATION OF ANIMALS

The animal kingdom includes about 3 phyla, of which 11 are considered as major phyla and others are categorized as minor phyla. Almost 99% of animals are invertebrates.

Based on common fundamental features, the kingdom Animalia is broadly classified into 11 phyla.
• Porifera
• Coelenterata
• Ctenophora
• Platyhelminthes
• Aschelminthes
• Annelida
• Arthropoda
• Mollusca
• Echinodermata
• Hemichordata
• Chordata.

PHYLUM PORIFERA

(porous-opening; fere-to bear)

It is the group of the most primitive animals popularly called sponges.
These were recognized as animals by **ELLIS.**
The term Porifera was introduced by **ROBERT GRANT.**
The study of sponges is called **PARAZOOLOGY**.
Most of them are marine and remain attached to rocks. Some live in freshwater.
Spongilla is a freshwater sponge.

Important characteristic features:

They are sedentary in habitat and are solitary or colonial. They possess a cellular level of organization. Cells aggregate to form a body plan.

Most of them are asymmetrical animals while some are radially symmetrical.

They are pore bearing animals and their body is perforated by numerous openings or pores called Ostia.

• **Body wall**: Have two loosely differentiated layers of cells. An outer dermal layer of flat cells called

pinacocytes and an inner layer of flagellated cells called **collar cells or choanocytes**. They are **diploblastic.**

• **Water transport system(water canal system):**
The body is in the form of a cylinder which encloses a large cavity called **spongocoel**. Spongocoel opens out by a narrow opening called the **osculum**. This pathway helps them in food gathering, respiratory exchange, and removal of waste.
Ostia or pores (water enters) → spongocoel (central cavity) → osculum or pores (water goes out).

• **Choanocytes**: Each ostium leads to a canal which leads to **spongocoel**. The canal is lined with flagellated collar cells called choanocytes. It brings food and oxygen and carries away excretory and reproductive products.
Each choanocyte has a long flagellum projecting from the free end of each cell. The lower part of the
flagellum is surrounded by a transparent collar. In simple sponges, the canal is not well developed. In such cases the Ostia opens into the spongocoel through hollow cells called **porocytes** and the spongocoel is lined with choanocytes.

• In between the two layers of the body, there is a non – living gelatinous matrix called mesenchyme. The **mesenchyme** has some amoeboid cells, spicules, and sponging fibres.
Amoeboid cells: wander through the matrix carrying food between the cells.
Spicules are siliceous or calcareous structures formed of silica or calcium carbonate.
Sponging fibres: are silk elastic structures.

• **Skeleton**: it is made up of spicules and sponging fibres.

• Sponges are **holozoic** (take solid food) in nutrition. The digestion is intracellular.

• **Reproductive system**: they are **hermaphrodites** (sexes are not separate)
Reproduces both sexually and asexually.
Asexual reproduction takes place by fragmentation and budding.
Freshwater sponges during unfavourable conditions produce buds known as **gemmules** which remain dormant till favourable season.
Sexual reproduction: during sexual reproduction, some amoeboid cells become **egg** or **sperm.**

Fertilization is internal and the development of larva is indirect. After fertilization, the zygote develops into a larva. The larva of sponges is **ciliated** and free-swimming.
They are of 2 types: **amphiblastula** and **parenchymula.**

• All sponges possess great power of regeneration.

• Examples for common sponges are *Leucosolenia, Spongilla* (freshwater sponge), *Sycon (scypha), Euspongia* (bath sponge), *Eupelectella* (venus flower basket).Its dried skeleton is used as a costly marriage gift in Japan. It is considered a symbol of **the union until death**. *Hyalonema* (glass rope sponge), *Cliona* (sulphur sponge), *Chalina* (dead man finger sponge), *Proterion* (Neptune's cup) are some
more examples.

PHYLUM COELENTERATA

Animals belonging to the phylum Coelenterata are commonly called coelenterates of Cnidarians. They are more advanced than sponges in having true tissues.
It includes about 9000 species.
They are aquatic. Most of them are marine. **Hydra** is a **freshwater** form.

Important characteristic features
They are sessile or free-swimming.

They exhibit a tissue level of organization.

Acoelomates

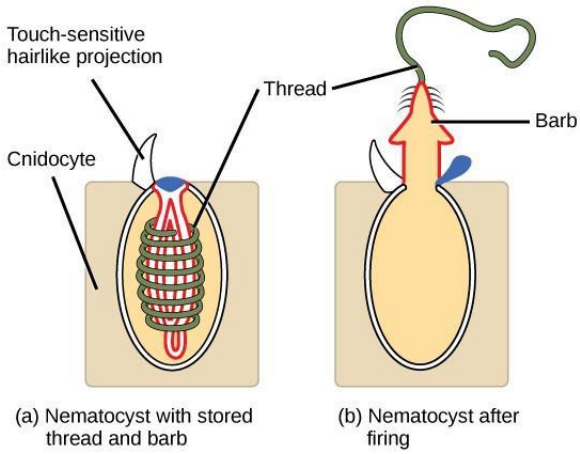
Radially symmetrical. But **sea anemone** is biradially symmetrical.

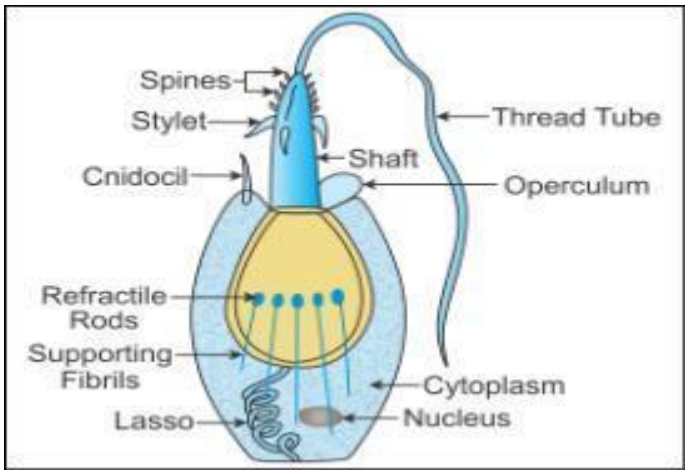
• **Body wall**: Diploblastic (outer ectoderm, inner endoderm, and middle mesoglea)

• **Body cavity**: A central gastrovascular cavity or coelenteron which opens out through **mouth** or **hypostome**. The anus is absent. The body cavity does both digestion and circulation of food.
Coelenterates are **holozoic** and **carnivorous** in nutrition.

• **Digestion**: it is intracellular and extracellular. The mouth is surrounded by many fingers like structures called **tentacles**. It is used for food capture and defence.

• **Cnidoblasts**: Certain ectodermal cells are modified into stinging cells or cnidoblasts or cnidocytes, hence the name Cnidaria. Each cnidoblast possesses a stinging capsule called **nematocyst** containing poisonous fluid. Cnidoblasts are defensive cells used to kill or paralyse other prey and enemies. They are mainly found on the tentacles.
The nematocyst poison of *Physalia* is a neurotoxin





• Phylum includes two distinct types of individuals.

- **Polyp**: sedentary, with a tubular body and mouth surrounded by a circlet of tentacles. It represents the asexual stage. Eg: *Hydra* and *Adams*.
- **Medusa**: free-floating with a soft, transparent bell-like body with tentacles at the margin.Umbrella like. Mouth at the central defence of the concave surface which is directed downward. It represents the sexual stage. Medusa can be regarded as an upside-down polyp. Eg: *Aurelia*
- In **hydra** medusa stage is absent. It reproduces sexually in the polyp stage.

• **Reproduction**: asexually and sexually.
Asexual reproduction: It takes place by **budding** in polyp and gives rise to medusa.
During **sexual reproduction**, medusa liberates gametes into the water. After fertilization; the the zygote develops into a larva.
Larvae of cnidarians are ciliated and free-swimming. They are called **planula.** The planula grows into a sessile polyp.
Coelenterates exhibit **alternation of generation** in their life cycle. In coelenterates that exist in both forms (polyp and medusa), the asexual polyp generation alternates with sexual medusa generation. Eg: *Obelia*

• **Polymorphism**: many colonial cnidarians exhibit this phenomenon where the individuals (zooids) of the colony show morphological and functional differentiation.
Eg: *Halistemma, Physalia* etc.

• **Examples of common coelenterates** are *Hydra, Obelia* (sea fur), *Aurelia* (jellyfish), *Physalia* (Portuguese man of war), *Adamsia* (sea anemone), *Vallela* (sail by wind), *Fungia* (mushroom coral), *Astraea* (star coral), *Pennatula* (sea pen), *Gorgonian* (sea fan), *Madrepora* (staghorn coral), *Meandrina* (brain coral), *Corallium* (red coral), *Porpita*.

PHYLUM CTENOPHORA

(Ktene-comb; phors-bearing)

This phylum was first recognized by **Eschololz** in 1928.
It includes only a small group of animals (50 species).
The animals belonging to the phylum are commonly called **sea walnuts** or **comb jellies.**

Important characteristic features:

They are free-swimming or pelagic.
They are marine animals.
The body is soft gelatinous and transparent.
They are acoelomates and have the property of **bioluminescence**.

Symmetry: They are **radially** symmetrical (arrangement of comb plates gives the appearance of radial symmetry) but the tentacles and branching of gastrovascular cavities show **bilateral** symmetry. So some zoologist explain it is as **biradial** symmetry

Diploblastic organism and exhibit **tissue level** of organization**.**

Comb plates: animal body bears 8 external rows of cilia. Cilia in each row join together to form **comb plates**. The ciliary movements of comb plates help in locomotion.

Tentacles: a pair of long, retractile tentacles arise from blind pouches in opposite sides of the body, tentacles bear **colloblast or collocates** which help in food capture.

Digestion: it is both extracellular and intracellular.

Statocyst: a peculiar sense organ is seen in the opposite end of the mouth. It helps in **equilibrium**.

Reproduction: sexually only. They are hermaphrodites. Fertilization is external. The development includes larva.

Common ctenophores are *Pleurobrachia* (sea-gooseberry), *Ctenoplana, Cestum* (venus girdle),
Hormiphora, Beroe.

PHYLUM PLATYHELMINTHES

(Platys-flat;helminths-worms)

Platyhelminthes was introduced by **GEGENBAUR**.
They are commonly called as flatworms.
There are about **13**,**000** species of flatworms known today.
The shape of the body is generally **dorsi-ventrally flat**, Hence the name **flatworm**.

This is the first group of animals in which the anterior part is developed into the head.

Important characteristic features:

The first group of animals to have an organ system level of organization.

Parasitic adaptations: Presence of hooks and suckers.

Bilaterally symmetrical with dorsal and ventral surfaces. The first group of animals that show bilateral symmetry.

Triploblastic animals: it is the first group of animals to possess **3 germ layers**.

Acoelomate animals: The space between the body cavity and the alimentary canal is filled with loose
parenchyma cells (mesenchyma cells) originated from mesoderm.

Alimentary canal: It is branched. It opens out by a single opening called the **mouth.** The anus is absent. In parasitic flatworms, the alimentary canal is absent. They absorb nutrients through their body wall while living in the host intestine.

Excretory system: it consists of branching tubes which end in specialized cells called **flame** cells

(**protonephridia**). The functions of these cells are osmoregulation and excretion.

Reproduction: Most of them are **hermaphrodites**. They reproduce asexually and sexually. Asexual reproduction takes place by **fragmentation** and **regeneration**. Some members possess a high regeneration capacity.

Fertilization: It takes place inside the body and development involves larval stages
The common examples for flatworms are Tapeworm (*Taenia* or pork tapeworm), Liver fluke (*Fasciola*), and Blood fluke (*Schistosoma*), *Planaria, Echinococcus* (Dog tapeworm).

PHYLUM ASCHELMINTHES

- Animals belonging to this phylum are commonly called roundworms or threadworms or bagworms or nematodes.
- It includes about 15,000 species. Out of which about 15 species are parasites of man.

Important characteristic features:

Aquatic or terrestrial, either **free-living** or **parasitic** in plants and animals.

Organ system level, bilaterally symmetrical, triploblastic, pseudocoelomate animals.

Body wall: It is tubular tapering at both ends and is covered with a thin **cuticle**.

The epidermis is **multinucleated.**

Digestive system: They have a tubular and complete **alimentary canal** within their body consisting of mouth, muscular pharynx, intestine, and anus. The mouth may possess **teeth** to cut and pierce the tissues. The **muscular pharynx** is well developed which helps in sucking food from the host.
Circulatory and respiratory system are absent. The nervous system is present.
They show flexible body movements.

Reproduction: Dioecious, sexual dimorphism present. The male is smaller than the female. Males have **copulatory** spicules which help in the process of **copulation**.

Fertilization: it is internal. The zygote has a thick wall to survive adverse conditions. Development is direct or indirect.

The common examples of this phylum are Parasites in human beings- Roundworms, Hookworms, Filarial worms, Pinworms, Guinea worms.
Other members of this phylum-Eye worm (*Loa loa*), Whipworm (*Trichuristrichura*), Trichina worm (*Trichinella*)

PHYLUM ANNELIDA

(annulus-little ring, lidos-form)

Animals belonging to this phylum are commonly called annelids or segmented worms
The term Annelida was introduced by **Lamarck** in 1809.
There are about 9,000 species of annelids known today.
They exhibit the most diverse forms ranging from 1mm to 2.5m in length.

Important characteristic features:
They are terrestrial or marine or freshwater or parasitic
.
They possess an organ system level of body organization.

Bilaterally symmetrical, triploblastic, true coelomates.

Metamerically segmented: the body is externally divided into **segments** called **metameres**.

A remarkable feature of annelids is the **true segmentation**.
The body surface is covered by a thick cuticle. The body wall has both longitudinal and circular muscles.
The organs of **locomotion** are **setae** or unjointed lateral appendages called **parapodia** which helps swimming in aquatic annelids, eg: ***Nereis***.

Digestive system: it is complete and consists of the pharynx, oesophagus, stomach, intestine, etc.

Typhlosole: A longitudinal fold present in the intestine which increases the surface for secretion and absorption.

Chloragogen cells: Present in the cavity of typhlosole which stores up food material. They synthesize glycogen and store fat. They also perform the excretory function.
Excretory system: Excretory organs are paired segmentally arranged coiled tubes called **nephridia**.

They also help in **osmoregulation**.

Circulatory system: it is a closed type. Blood flows through a closed blood vessel. A heart to move the oxygen-carrying blood is found for the first time in the evolution of animals.

They show **skin respiration**.

Nervous system: It consists of a brain, segmented ganglia, and a double ventral nerve cord.

Reproduction: They are either dioecious or monoecious
.
They **reproduce** sexually. In many members, a trochophore larval stage is noted.

The common examples of this phylum are:
Earthworms (*Pheretima, Megascolex*)**,** *Nereis, Hirudinaria* (bloodsucking leeches), *Aphrodite* (sea mouse), *Tubifex*, *Chaetopterus, Terebella*.

PHLUM ARTHROPODA

(**Atheros- joint; pods-appendages**)

They are animals with jointed legs and appendages.
Introduced by **Von Siebold.**
It is the **largest phylum** in the animal kingdom.
It includes 2/3 of the total named species of the animal world on earth.
They have evolved about 600 million years ago. **Trilobites** are fossil arthropods that existed about 600 million years ago.
TRILOBITES: The **horseshoe crab**, an ancient relative of the Arachnids is found living in warm estuarine zones like the Sunderbans, in Bengal.

Important characteristic features.
They are **cosmopolitan** in distribution. They are found in everywhere, in freshwater, in marine water, on land and in the air.

They are **joint footed** animals. They possess an **organ system level** of body organization.

Bilaterally symmetrical.

They are **triploblastic** animals.

They are **segmented** animals.

They are **coelomates**. The true coelom is reduced. The body cavity is filled with blood and is called **hemocoel**.

The **segmented** body is divided into 3 regions- head, thorax, and abdomen, e.g, insects. In some cases head and thorax fuse to form a single region called **the cephalothorax**
eg: Arachnids, Crustaceans, etc.

In some arthropods, the body is divided into head and trunk only eg: myriapods.
Exoskeleton: the whole body is covered by **a chitinous** jointed exoskeleton. The exoskeleton is lightweight, tough, and composed of proteins and a polysaccharide known as chitin, resulting in a **chitinous cuticle**. The casting of the old exoskeleton is known as **moulting or ecdysis**.

Podomeres: They have jointed appendages that are differentially modified to perform different functions. Each body segment bears a pair of segmented appendages. Their segments are called **podomeres**.

Circulatory system: It is an open type with a dorsal heart.

Digestive system: It is well **developed and complete**. The mouth is surrounded by mouthparts which are modified into different types according to the feeding habits of different arthropods.

Respiratory system: Respiratory organs are gills (eg: prawn) or gill books (eg: horseshoe crab) in aquatic forms, and book lungs (eg: scorpion) or tracheal system (eg: insects)in terrestrial forms.

Excretion: Excretory organs are **green glands or Malpighian tubules**. Nephridia are absent.
Cilia is absent.
The brain is present.
Sensory organs are well developed.
Eyes may be simple or compound.
The compound eye is made up of some independent visual units called **ommatidia** each with its lens.

Sound receptors are present in chirping crickets and cicadas.

Heads of many arthropods have feelers called **antennae** for perceiving odour and **sensation of touch**.

Insects also communicate by chemicals called **pheromones**.

Reproduction: they are mostly dioecious. Fertilization is **external** in **aquatic** arthropods and **internal** in**land** arthropods.

Arthropods are generally **oviparous.** Some are **viviparous.** In such arthropods, the eggs hatch within the female, and the young ones are born.

In many arthropods the development is **direct** and the young ones **resemble** the adult.
In several groups of insects, the development is **indirect**. In such arthropods, the egg hatches into an independent larva which **does not resemble** the adult.

The common arthropods are *Araneus* (garden spider), *Limulus* (king crab), *Eupagurus* (hermit crab), *Cancer*, *Macrobrachium* (prawn), *Lepisma* (silverfish), *Periplaneta* (cockroach), *Apis* (bee), *Anopheles* (mosquito), *Musca* (housefly), *Triops* (tadpole fish), *Daphnia* (water flea), *Xensopsylla* (rat flea), *Cyclops, Squilla, Astacus* (crayfish), Barnacle (*Lepas* and *Balanus*)

PHYLUM MOLLUSCA

It is the second-largest phylum of the animal kingdom.
The term Mollusca was proposed by **Johnston**.
They are **soft-bodied** and also possess a **shell**.
The study of **molluscs** is called **Malacology** and the study of **molluscans shells** is called **conchology**.

Important characteristic features
T hey are generally aquatic forms. Most of them are marine, some are found in freshwater, and a few are terrestrial. The Grey slug is a terrestrial mollusc without a shell.

All molluscs are **soft-bodied** and **unsegmented** animals.

They possess the **organ system level** of body organization.

Bilaterally symmetrical except in univalves.

They are **triploblastic** animals.

They are true coelomates but the coelom is reduced in adults. The body cavity is a **hemocoel**.

Their soft body is protected by an **unsegmented** external **shell**. The **shell** is made up of **calcium carbonate** and is of one piece (univalve) or two pieces (bivalve). In some cases, the shell is internal or absent.

The body consists of four parts**: head, mantle, visceral hump, and foot.**

a. The head region has sensory tentacles.
b. The visceral hump contains important internal organs. It is covered by a soft and
c. spongy layer of skin called the mantle or pallium. The mantle secretes shell. The mantle cavity has gills.
d. Foot it is soft and muscular. It is the locomotory organ.

Digestive system: It is well developed, with salivary glands and liver.

Circulatory system: This is of the open type. The heart is chambered and valvular.

Excretion: It has Nephridia.

Nervous system: Consists of paired ganglia connected by nerves. Sense organs are tentacles and eyes.

Respiration: Gills (ctenidia) in aquatic forms. Pulmonary sacs in terrestrial form.

Reproduction: Dioecious.
Fertilization external or internal, mostly oviparous and a few viviparous. The larval forms are **Glochidium, Trocophere and Veliger.**

The common molluscans are *Pila* (apple snail)**,** *Achatina* (land snail)**,** *Lamellidens* (mussel)**,** *Pinctada* (pearl oyster)**,** *Sepia* (cuttlefish)**,** *Loligo* (squid) etc.

PHYLUM ECHINODERMATA

(Echinos-spines; derm-skin)
They are spiny skinned or spiny bodied animals.
The term Echinodermata was introduced by **J.Klein**.

Important characteristic features:
They are exclusively **marine** animals.

The body is covered by a large number of **spines** which are generally immovable and protective in function, but in some, the spines are movable and help in locomotion. Few spines also get modified to form organs of defence known as pedicellaria. Eg: Sea urchin, Starfish, etc.

They possess an **organ system level** of body organization. They are **triploblastic** animals.

They are **unsegmented** and pentamerous, **radially symmetrical** in the adult, but the **larval** forms are **bilaterally symmetrical**.

They possess an **endoskeleton** in the form of **calcareous plates** called **ossicles** embedded in the skin.

They are **true coelomates** but a major part of the coelom has undergone a modification to form the water-vascular system which helps in locomotion, capture and transport of food, and respiration.

Water vascular system or ambulacral system in which seawater enters through a porous plate called madreporite.

Tube feet: The water vascular system consists of radiating canals and tube-like appendages filled with water. These appendages are called tube feet (podia). Their main function is locomotion and capture of food.

Digestive system: Complete with the mouth on the ventral (lower) side and anus on the dorsal (upper
side).

Respiration: It takes place by **skin gills** which are protruded from the coelom over the skin.

Circulatory system: It is reduced.

Excretory system: It is absent. Nitrogenous wastes diffuse out through the gills.

Nervous system: It is in the form of a central nerve ring with radial nerves extending to each arm.

Reproduction: Sexes separate. Fertilization external. Development is indirect through a free swimming larva.

Echinoderms have a great power of **autotomy** and **regeneration**.

The common echinoderms are *Asterias* (starfish or sea star)**,** *Echinus* (sea urchin)**,** *Echinocardium* (heart urchin)**,** *Antedon* (feather star or sea silly)**,** *Cucumaria* (sea cucumber)**,** *Ophiura* (brittle star).

PHYLUM HEMICHORDATA :

Have small worm-like marine animals.
Was earlier placed as a subphylum of Phylum Chordata.
Bilaterally symmetrical, triploblastic, and coelomate.
The body cylindrical has a proboscis, collar, and trunk.
Circulation is an open type.
Respiration by gills
Excretion by proboscis gland.
Sexes are separate.
External fertilization
Indirect development.
Examples: *Balanoglossus* and *Saccoglossus*.

PHYLUM CHORDATA:

Presence of Notochord (between gut and nerve cord)
Have a dorsal hollow nerve chord.
Have paired pharyngeal gill slits.
The heart is central.
Post anal tail present.
Bilaterally symmetrical, triploblastic, and coelomate with organ system level of organization.
Circulation is a closed type.

	Chordata	Non-Chordata
1.	The notochord is found in the embryonic stage	Absent
2.	The central nervous system is dorsal, hollow and single	Ventral, solid and double
3.	Pharyngeal gill slits present	Absent
4.	Ventral heart	Dorsal heart (if present)
5.	Post-anal tail present	Absent

Phylum Chordata is divided into
- **1.Urochordata** or **Tunicata**
- **2.Cephalochordata**
- **3**. **Vertebrata**.

SUB-PHYLA UROCHORDATA:

Notochord presents only in the tail of the larval stage.
The body is covered by test or tunic made up of tunicin
Exclusively marine
Retrogressive metamorphosis: During metamorphosis, the larva will lose all the chordate characters and attains an invertebrate like form. This type of metamorphosis, where highly advanced larval form ends in a lowly organized adult is called retrogressive metamorphosis.
Hermaphrodite
E.g., *Ascidia, Salpa, Doliolium*.

SUBPHYLUM CEPHALOCHORDATA:

The segmented notochord is persistently extending from head to tail.
The body contains a sac-like pharynx with gill slits both for filter feeding and respiration.
Exclusively marine
Fish-like
No definite coelom
Sexes are separate
E.g. *Branchiostoma (Amphioxus or Lancelet)*

SUB-PHYLA VERTEBRATA:

Have notochord only during the embryonic period.

Notochord gets replaced by the bony or cartilaginous vertebral column.
Have ventral muscular heart with two, three, or four chambers.
Paired appendages that may be fins or limbs.
Kidneys for excretion and osmoregulation.
Vertebrata: Has 2 divisions- Agnatha and Gnathostomata
Agnatha (Jawless): Includes 1 class: Cyclostomata

Class: Cyclostomata:

Have sucking and circular mouth without jaws.
Live as ectoparasites on some fishes.
Devoid of scales, no paired fins.
The cranium and vertebral column are cartilaginous.
Marine habit but migrates to freshwater for spawning and die after spawning.
Larva returns to the ocean after metamorphosis.
E.g., *Petromyzon* (Lamprey) and *Myxine* (Hagfish).

Division Gnathostomata (Bear Jaws)

SUPER-CLASS: PISCES

Class 1: Chondrichthyes :

Marine animals with a streamlined body and have a cartilaginous endoskeleton.
Mouth ventrally located.
Notochord persists throughout life.
Gill slits are separate and without operculum.
The skin has placoid scales.
Jaw contains teeth, which are modified placoid scales.
Mostly predaceous.
Swim bladder absent.
The heart is two-chambered. (One auricle and one ventricle)
Some of them contain electric organs (e.g. Torpedo)
Some possess poison sting. (e.g. Trygon)
Poikilotherm or cold-blooded.
Dioecious.
Sexually dimorphic, male's pelvic fin bears claspers.
Fertilization internal.
Many of them viviparous.
Examples: Torpedo (Electric ray), Rhinobatus (Guitarfish).

Class 2: Osteichthyes:

Includes both marine and freshwater fishes.
Bony endoskeleton.
The mouth is usually terminal.
Four pairs of gill slits are covered by an operculum.

The skin has cycloid/ctenoid scales.
The air bladder is present for buoyancy.
The heart is two-chambered.
Cold-blooded animals.
Dioecious.
Sexually monomorphic.
Fertilization external.
Mostly oviparous
Development is indirect.
Examples: **Marine** – *Exocoetus* (Flying fish), *Hippocampus* (Sea horse).**Freshwater** – *Labeo* (Rohu). *Catla* (Katla), *Clarias* (Magur).**Aquarium** – Betta (Fighting fish), *Pterophyllum* (Angelfish).

SUPER CLASS: TETRAPODA

Class-1: Amphibia

It is a class of terrestrial tetrapods that lead a dual life in water as well as on moist land as the skin is devoid of protective scales and the larval stage is aquatic.
The animal possesses two pairs of a jointed pentadactyl limb. Their digits do not possess claws, nails, or hoofs.
Body divisible into head and trunk.
Skin moist, without scales.
Tympanum represents ear.
Cloaca is the common chamber where alimentary, urinary, and reproductive tracts open.
Respiration by gills, lungs, or skin.
The heart is 3-chambered (two auricles and one ventricle)
Cold-blooded animals.
Sexes separate.
Fertilization is external and requires water.
Oviparous, Indirect development.
Examples: *Ichthyophis, Necturus, Siren, Amphiuma, Salamandra, Rana, Bufo, Hyla,* etc.

Class - 2: Reptilia

Creeping or crawling mode of locomotion.
The body has dry and cornified skin and epidermal scales or scutes.
Tympanum represents ear.
Limbs when present are two pairs.
Mostly three-chambered heart but 4-chambered in crocodiles.
Snakes and lizards shed scales as skin cast.
Poikilotherm.
Sexes are separate.
Fertilization is internal.
Oviparous, Direct development.

Examples: *Chelone* (Turtle), *Testudo* (Tortoise), *Chameleon* (Tree lizard), *Calotes* (Garden lizard),
Crocodilus (Crocodile), *Alligator* (Alligator), *Hemidactylus* (Wall lizard), Poisonous Snakes – *Naja* (Cobra), *Bangarus* (Krait), *Vipera* (Viper).

Class - 3: Aves

Presence of feathers and most of them fly except flightless bird-like ostrich.
The jaw was modified to beak without teeth.
Forelimbs are modified into wings.
Hind limbs have scales.
No glands on the skin except the oil gland at the base of the tail.
The endoskeleton is almost completely ossified.
Bones are spongy or pneumatic.
Long bones are hollow with air cavities.
Epiphyses are absent.
Skull is monocondylic.
The digestive tract has additional chambers like crop and gizzard.
The heart is four-chambered.
Homoiothermous or warm-blooded, able to maintain a constant temperature.
Air sacs are connected to the lungs to supplement respiration.
Oviparous. Direct development.
Examples: Pigeon, Crow, Sparrow, Peacock, etc.

Class- 4: Mammalia

Have mammary glands to nourish young ones by secreting milk.
Have two pairs of limbs.
The skin has hairs.
External ears or pinna present.
Different types of teeth in the jaw.
The heart is four-chambered.
Homoiothermous.
Respiration by lungs.
Sexes separate, fertilization internal.
Viviparous or oviparous.
Direct development.
Examples: Oviparous-*Ornithorhynchus* (Platypus).
Viviparous - *Macropus* (Kangaroo), *Pteropus* (Flying fox), *Camelus* (Camel), *Macaca* (Monkey), *Rattus*
(Rat), *Canis* (Dog), *Felis* (Cat), *Elephas* (Elephant), *Equus* (Horse), *Delphinus* (Common dolphin),
Balaenoptera (Blue whale), Panthera tigris (Tiger), Panthera leo (Lion).

IMPORTANT TERMS

body plan: an assemblage of morphological features shared among many members of a phylum-level group

heterotroph: an organism that requires an external supply of energy in the form of food, as it cannot synthesize its own

extant: still in existence; not extinct

Parazoa: a taxonomic subkingdom within the kingdom Animalia; the sponges

Eumetazoa: a taxonomic subkingdom, within kingdom Animalia; all animals except the sponges

epithelial tissue: one of the four basic types of animal tissue, which line the cavities and surfaces of structures throughout the body, and also form many glands

metamorphosis: a change in the form and often habits of an animal after the embryonic stage during normal development

Hox gene: genes responsible for determining the general body plan, such as the number of body segments of an animal, the number and placement of appendages, and animal head-tail directionality

blastula: a 6-32-celled hollow structure that is formed after a zygote undergoes cell division

sagittal plane: divides the body into right and left halves

radial symmetry: a form of symmetry wherein identical parts are arranged circularly around a central axis

bilateral symmetry: having the equal arrangement of parts (symmetry) about a vertical plane running from head to tail

protostome: any animal in which the mouth is derived first from the embryonic blastopore ("mouth first")

deuterostome: Any animal in which the initial pore formed during gastrulation becomes the anus, and the second pore becomes the mouth

diploblast: a blastula in which there are two primary germ layers: the ectoderm and endoderm
triploblast: a blastula in which there are three primary germ layers: the ectoderm, mesoderm, and endoderm; formed during gastrulation of the blastula

acoelomate: any animal without a coelom, or body cavity

coelomate: any animal possessing a fluid-filled cavity within which the digestive system is suspended.

schizocoely: the process by which protostome animal embryos develop; it occurs when a coelom (body cavity) is formed by splitting the mesodermal embryonic tissue

enterocele: the process by which deuterostome animal embryos develop; the coelom forms from pouches "pinched" off of the digestive tract

orthologous: having been separated by a speciation event

homoplasy: a correspondence between the parts or organs of different species acquired as the result of parallel evolution or convergence

monophyletic: of, about, or affecting a single phylum (or other taxa) of organisms