

07 Structural and Computational Biology

☛ Theory	217
☛ Check Understanding (Solutions)	223
☛ Exercise	224
☛ Multiple Choice Questions	224
☛ Short Answer Questions	224
☛ Long Answer Questions	225
☛ Inquisitive Answer Questions	226
☛ Additional MCQs	227
☛ Additional Short Answer Questions	228
☛ Self Assessment	231

08 Plant Physiology

☛ Theory	223
☛ Check Understanding (Solutions)	254
☛ Exercise	256
☛ Multiple Choice Questions	256
☛ Short Answer Questions	257
☛ Long Answer Questions	259
☛ Inquisitive Answer Questions	260
☛ Additional MCQs	260
☛ Additional Short Answer Questions	262
☛ Self Assessment	265

09 Human Digestive System

☛ Theory	267
☛ Check Understanding (Solutions)	277
☛ Exercise	277
☛ Multiple Choice Questions	277
☛ Short Answer Questions	278
☛ Long Answer Questions	280
☛ Inquisitive Answer Questions	281
☛ Additional MCQs	282
☛ Additional Short Answer Questions	283
☛ Self Assessment	285
☛ Entrance Test (MCQs)	286

10 Human Respiratory System

☛ Theory	287
☛ Check Understanding (Solutions)	299
☛ Exercise	300
☛ Multiple Choice Questions	300
☛ Short Answer Questions	301
☛ Long Answer Questions	303
☛ Inquisitive Answer Questions	303
☛ Additional MCQs	304
☛ Additional Short Answer Questions	305
☛ Self Assessment	307
☛ Entrance Test (MCQs)	308

11 Human Circulatory System

☛ Theory	309
☛ Check Understanding (Solutions)	327
☛ Exercise	329
☛ Multiple Choice Questions	329
☛ Short Answer Questions	330
☛ Long Answer Questions	332
☛ Inquisitive Answer Questions	333
☛ Additional MCQs	334
☛ Additional Short Answer Questions	335
☛ Self Assessment	338
☛ Entrance Test (MCQs)	339

12 Human Skeleton & Muscular Systems

☛ Theory	341
☛ Check Understanding (Solutions)	360
☛ Exercise	362
☛ Multiple Choice Questions	362
☛ Short Answer Questions	364
☛ Long Answer Questions	367
☛ Inquisitive Answer Questions	368
☛ Additional MCQs	369
☛ Additional Short Answer Questions	370
☛ Self Assessment	373
☛ Entrance Test (MCQs)	374

Chapter 01

BIODIVERSITY AND CLASSIFICATION

Student Learning Outcomes (SLOs)

After studying this chapter, the students will be able to:

- Discuss the meaning of the terms species and speciation.
- Describe the classification of organisms into three domains: Archaea, Bacteria and Eukarya.
- Describe the classification of organisms in the Eukarya domain into the taxonomic hierarchy of kingdom, phylum, class, order, family, genus and species.
- Outline the characteristic features of the kingdoms Monera, Protocista, Fungi, Plantae and Animalia.
- Outline how viruses are classified.
- Define the terms ecosystem and niche.
- Explain the different levels at which biodiversity can be assessed.
- Explain the importance of random sampling in determining the biodiversity of an area.
- Describe and use suitable methods to assess the distribution and abundance of organisms in an area.

Fundamental Concept in Biology:

- Biodiversity and classification are fundamental concepts in biology that provide insight into the vast array of life forms on Earth and their evolutionary relationships.
- In this chapter, we will study biodiversity, highlighting the variety of life at genetic, species, and ecosystem levels.
- We will also explore the principles and methods of biological classification, which scientists use to organize and categorize organisms.

THREE-DOMAIN SYSTEM OF CLASSIFICATION

Five Kingdom System of Classification:

Proposed By:

- American ecologists Robert Whittaker in 1969.
- According to five kingdom system all organisms were divided into five kingdoms: (i) Monera (ii) Protista (iii) Fungi (iv) Plantae (v) Animalia
- According to this system, the kingdom Monera included prokaryotes while all the other four kingdoms included eukaryotes.

Groups of Prokaryotes:

- In 1990, American microbiologist Carl Woese suggested that there are two separate groups of prokaryotes: (i) Archaea (ii) Bacteria
- He classified all the living organisms into three domains: (1) Domain Archaea (2) Domain Bacteria (3) Domain Eukarya

• **Phylogeny:** The evolutionary relationship among organisms is called phylogeny. The diagram to show phylogeny, is called phylogenetic or evolutionary tree.

- According to his **three-domain system**, domain Archaea and domain Bacteria contain prokaryotes but they differ in a number of features.
- **Common Ancestors:** Now biologists believe that Archaea and Bacteria evolved independently from some common ancestor. Molecular evidence suggests that archaea are more closely related to eukaryotes than to bacteria. In other words, **Eukarya evolved from Archaea**, after archaea split off from the Bacteria (Figure).

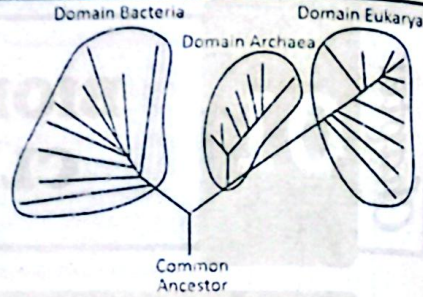


Figure: Evolutionary tree of the three domains

(*) Domain Archaea:

- The name Archaea comes from the Greek archaios ("ancient").
- In the five-kingdom system, this domain was included in kingdom Monera.

Characteristics of Domain Archaea:

- **Prokaryotes:** They are prokaryotes which diverged from bacteria in very ancient times.
- **Size:** Individual archaeans range from **0.1 μm to over 15 μm** in diameter. Some form aggregates or filaments up to **200 μm** in length.
- **Shapes:** They occur in various shapes, such as **spherical, rod-shape, spiral, lobed**, or rectangular.
- **Reproduction:** Archaea reproduce asexually by binary or multiple fission, fragmentation, or budding.
- **No Mitosis & Meiosis:** Mitosis and meiosis do not occur in archaea.

• **Archaeobacteria:** Archaea were initially classified as a group of bacteria, and were called archaeobacteria.

Q. Compare and contrast the domains Archaea and Bacteria and discuss how these differences reflect their evolutionary histories. [Exercise L.Q.1]

How are Archaea unique?

Unique Properties of Archaea vs Eukarya & Bacteria:

(i) Cell membrane:

Cell Membrane in Archaea	Cell Membrane in Eukarya & Bacteria
<ul style="list-style-type: none"> • Their cell membrane contains lipids with ether-linkage between glycerol and fatty acid chains. • The fatty acid chains are branched. • That's why their cell membranes are more resistant to extreme conditions. 	<ul style="list-style-type: none"> • Bacteria and Eukarya have membrane lipids with fatty acids attached to glycerol by ester linkages. • The fatty acid chains are unbranched

(ii) Cell Wall Composition:

Cell Wall of Archaea	Cell Wall of Bacteria & Eukarya
<ul style="list-style-type: none"> • Cell walls of archaea lack cellulose and peptidoglycan. • Instead, they contain distinct polysaccharides and proteins. Some archaea have pseudopeptidoglycan. 	<ul style="list-style-type: none"> • Bacterial cell walls contain peptidoglycan, a polymer consisting of sugars and amino acids that provides structural support. • In Eukarya, the cell walls, if present, are composed of cellulose (in plants) or chitin (in fungi).

(iii) Genetic Differences:

- Archaea share several genetic sequences and regulatory features with eukaryotes, highlighting their closer evolutionary relationship.

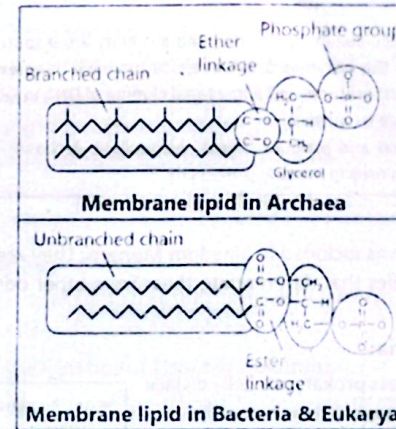


Figure: Difference in membrane lipids of Archaea and other organisms

Check Understanding!

1. Why are Archaea more resistant to extreme environments than Bacteria?

A) Unbranched fatty acids
 B) Presence of peptidoglycan
 C) Ether-linked branched lipids
 D) Presence of a nucleus

Check Understanding!

2. Despite being classified with bacteria in the past, what unique structural features of Archaea challenge their placement within Kingdom Monera?

(iv) Metabolism:

Metabolism in Archaea	Metabolism in Bacteria & Eukarya
<ul style="list-style-type: none"> • Archaea have unique metabolic processes like methanogenesis (production of methane), which is not found in bacteria or Eukarya. 	<ul style="list-style-type: none"> • Bacteria exhibit metabolic pathways, including photosynthesis, nitrogen fixation, and fermentation. • In Eukarya, the metabolic processes are often more complex and include cellular respiration, photosynthesis (in plants and algae), and various forms of fermentation.

(v) Major Groups of Archaea:

- The major groups of Archaea include:


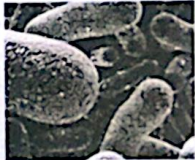
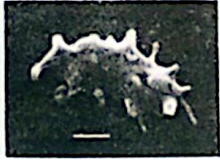
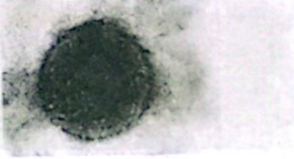
<p>(i) Methanogens: The Archaea which produce methane as a metabolic byproduct.</p>  <p style="text-align: center;">Methanogens</p>	<p>(ii) Halobacteria: Which live in extremely saline environments.</p>  <p style="text-align: center;">Halobacteria</p>
<p>(iii) Thermococci: Which are found in hot environments.</p>  <p style="text-align: center;">Thermoplasma</p>	<p>(iv) Thaumarchaeota: Which involved in nitrogen cycle.</p>  <p style="text-align: center;">Thermococci</p>

Figure: Major groups of Archaea

Significance of Archaea

Survive Under Harsh Condition: The archaeans which live in high acidity and alkalinity are a source of enzymes that can function under harsh conditions. For example, the enzymes of DNA replication have been extracted from such archaeans. These enzymes can work best at high temperatures and allow rapid cloning of DNA in laboratory. Similarly, the methanogen archaeans are a vital part of sewage treatment.

Produce Biogas: They carry out anaerobic digestion and produce biogas. **Acidophilic Archaea:** These are used to extract metals such as gold, cobalt and copper from ores in mineral processing.

2) Domain Bacteria:

- In the five-kingdom system, this domain was included in kingdom Monera. They are the true bacteria. They possess several distinct characteristics that differentiate them from other domains i.e., Archaea and Eukarya.

General Characteristics of Domain Bacteria:

- Cell Structure:** Like archaea, bacteria possess prokaryotic cell i.e., lack a true nucleus and membrane-bound organelles.
- Cell Wall Composition:** Bacteria have a cell wall composed of peptidoglycan, a unique polymer that provides structural support and shape.
- Genetic Material:** Like Archaea bacteria possess a single, circular chromosome composed of DNA, located in the nucleoid region.
- Plasmids:** Most bacteria have small, circular DNA molecules that can be transferred between bacteria, aiding in genetic diversity and adaptation.
- Reproduction:** Bacteria primarily reproduce asexually through binary fission, a process where a single cell divides into two identical daughter cells.
- Nutritional Modes:** Include autotrophs (self-feeding, e.g., photosynthetic bacteria) and heterotrophs (feeding on organic matter, e.g., decomposer bacteria).
- Morphology:** Bacteria exhibit a variety of shapes, such as cocci (spherical), bacilli (rod-shaped), spirilla (spiral-shaped), and vibrios (comma-shaped).
- Arrangement:** Cells may be found singly, in pairs (diplococci), chains (streptococci), clusters (staphylococci), or other arrangements based on species-specific characteristics.
- Flagella:** Many bacteria have one or more flagella, whip-like structures that enable movement.
- Pili and Fimbriae:** These are hair-like structures in some bacteria. They help in attachment to surfaces and in exchange of genetic material with other bacteria.
- Respiration:** Bacteria can be obligate aerobes (only respire in presence of O₂), obligate anaerobes, facultative anaerobes, microaerophiles, or aerotolerant anaerobes. Some bacteria perform fermentation to produce energy in the absence of oxygen.
- Extremophiles:** Some bacteria thrive in extreme conditions, such as high temperatures (thermophiles), high salinity (halophiles), and low pH (acidophiles).
- Pathogenicity:** Some bacteria cause diseases in humans, animals, and plants, producing toxins or other virulence factors.
- Symbiosis:** Many bacteria live in symbiotic relationships with other organisms, including mutualism (both benefit) and commensalism (one benefits, the other is not harmed).

• In humans, intestinal gas is largely the result of the metabolism of methanogens.

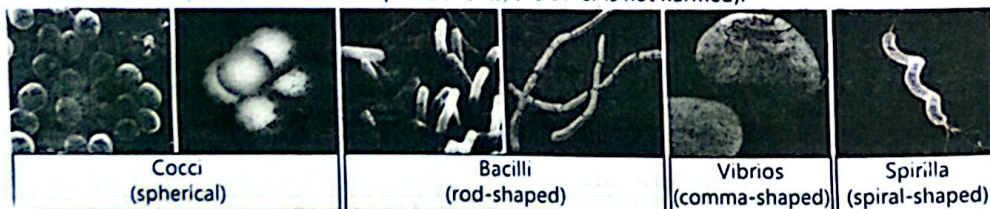


Figure: Different forms of Bacteria

Major Groups of Bacteria with Examples:

- Proteobacteria** Examples: *Escherichia coli*, *Rhizobium*, *Helicobacter pylori*
- Firmicutes** Examples: *Bacillus subtilis*, *Lactobacillus*, *Clostridium botulinum*.
- Actinobacteria** Examples: *Streptomyces*, *Mycobacterium tuberculosis*
- Cyanobacteria** Examples: *Anabaena*, *Spirulina*.
- Spirochaetes** Example: *Treponema pallidum*,
- Acidobacteria** Example: *Acidobacterium*.
- Aquificae** Example: *Aquifex pyrophilus*

(3) Domain Eukarya:

The domain Eukarya contain all organisms with eukaryotic cells, which are fundamentally different from the prokaryotic cells of Bacteria and Archaea.

General Characteristics of Domain Eukarya:

General characteristics of the domain Eukarya which justify its classification as a separate domain:

(i) Cell Structure:

- Have True Nucleus:** They possess eukaryotic cells - with true nucleus enclosed by a nuclear membrane.
- Membrane Bounded Organelles:** Cells have membrane-bounded organelles e.g., mitochondria, chloroplasts (in plants and algae), endoplasmic reticulum, Golgi apparatus, lysosomes, and peroxisomes.
- Cytoskeleton:** Cells also have cytoskeleton i.e., a complex network of microtubules, microfilaments, and intermediate filaments that provides structural support, enables cell movement, and facilitates intracellular transport.

(ii) Genetic Material: Their DNA is organized into multiple linear chromosomes within the nucleus. DNA is associated with histone proteins, which help in the organization and regulation of genetic material.

(iii) Reproduction: Most eukaryotes undergo sexual reproduction involving meiosis and fertilization, leading to genetic diversity. Some eukaryotes can also reproduce asexually through mitosis, producing genetically identical offspring.

(iv) Complex Cellular Organization: In multicellular eukaryotes, cells differentiate into specialized types forming tissues and organs with specific functions.

(v) Evolutionary Relationships: Eukaryotes are believed to have originated through endosymbiosis, where certain prokaryotic cells (such as mitochondria and chloroplasts) were engulfed by a host cell, leading to a symbiotic relationship.

TAXONOMIC HIERARCHY**Definition:**

- Taxonomic hierarchy** is a system of classification that ranks organisms in a series of increasingly specific groups from most general to most specific.
- Use of Taxonomic Hierarchy:** The classification of living organisms is organized into a hierarchical system that allows scientists to categorize and understand the relationships between different forms of life.
- This system includes several levels, known as **taxa** (singular: taxon), each representing a rank in the biological classification system.
- Primary Levels of Hierarchy:** kingdom, phylum, class, order, family, genus, and species. Below is a detailed description of each level.

Domain (Highest level of classification):

- Currently, there are three domains:
(a) Archaea (b) Bacteria (c) Eukarya

Kingdom:

- The kingdom is one of the highest taxonomic ranks, just below domain.
- It groups together all forms of life that share fundamental characteristics.
- **Example:** In the domain Eukarya, there are several kingdoms:
(a) Animalia (animals) (b) Plantae (plants)
(c) Fungi (fungi) (d) Protista (protists)

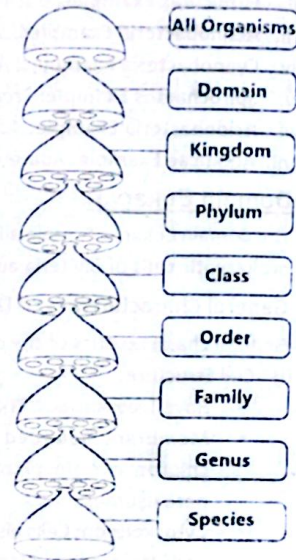


Figure : Taxonomic hierarchy

ii) Phylum:

- Phylum is the next level of classification below kingdom. Organisms within a phylum share a basic body plan and significant structural features.
- **Example:** In the kingdom Animalia, the phylum Chordata includes all animals with a notochord, such as mammals, birds, reptiles, amphibians, and fish.

iv) Class:

- Class further divides organisms within a phylum based on more specific common traits.
- **Example:** Within the phylum Chordata, the class Mammalia includes all mammals, which are characterized by having hair and mammary glands.

v) Order:

- Order includes organisms within a class based on additional shared characteristics and evolutionary history.
- **Example:** Within the class Mammalia, the order Primates includes humans, monkeys, and apes, characterized by their large brains and opposable thumbs.

(vi) Family:

- Family groups organisms within an order that are even more closely related, sharing more precise common attributes.
- **Example:** Within the order Primates, the family Hominidae includes great apes and humans.

(vii) Genus:

- Genus is a more specific rank within a family, grouping species that are very closely related and often visually similar.
- **Example:** Within the family Hominidae, the genus Homo includes humans and our closest extinct relatives.

(viii) Species:

- Species is the most specific level of classification, representing a single type of organism. Members of a species can interbreed and produce fertile offspring.
- **Example:** Within the genus Homo, the species Homo sapiens refers to modern humans.

Check Understanding!

3. Which of the following taxonomic levels would show the least number of shared characteristics between organisms but the greatest diversity?
A) Family B) Genus
C) Kingdom D) Species

Taxonomic Rank	Human (<i>Homo sapiens</i>)	Sparrow (<i>Passer domesticus</i>)	Onion (<i>Allium cepa</i>)
i. Domain	Eukarya	Eukarya	Eukarya
ii. Kingdom	Animalia	Animalia	Plantae
iii. Phylum	Chordata	Chordata	Angiosperms
iv. Class	Mammalia	Aves	Monocots
v. Order	Primates	Passeriformes	Asparagales
vi. Family	Hominidae	Passeridae	Amarylidaceae
vii. Genus	Homo	Passer	Allium
viii. Species	<i>Homo sapiens</i>	<i>Passer domesticus</i>	<i>Allium cepa</i>

SALIENT FEATURES OF KINGDOMS OF DOMAIN EUKARYA

- Eukarya consists of:
(1) Kingdoms Protista (2) Kingdom Fungi (3) Kingdom Plantae (4) Kingdom Animalia
 - It includes all eukaryotes which consist of complex, eukaryotic cells containing nucleus and other membrane-bound organelles.
- **Parasitic Protists:** Certain protists are parasitic and cause diseases like malaria (*Plasmodium*), amoebic dysentery (*Entamoeba histolytica*), and sleeping sickness (*Trypanosoma*).
- (1) Kingdom Protista:**
- Kingdom Protista includes eukaryotes which are unicellular or colonial or filamentous or simple multicellular.
 - Simple multicellular means that they do not have multicellular sex organs.

Q. Describe the major groups of Kingdom Protista and Kingdom Fungi.

(Exercise 1.0.1)

➤ Major Groups of Protists:

There are three types of protists.

(a) Protozoa: (Animal Like Protists):

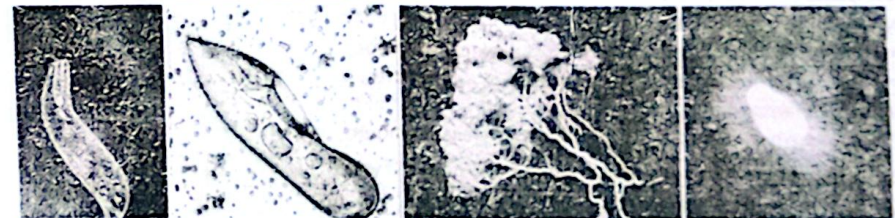
- They are unicellular and are heterotrophic.
- **Examples:** Paramecium, Amoeba, Plasmodium, and Trypanosoma.

(b) Algal (Plant-like Protists):

- They have cell walls made of cellulose. They have chlorophyll and are autotrophs.
- **Examples:** Euglena diatoms.

(c) Molds: (Fungus Like Protists)

- The groups Myxomycota and Oomycota include Fungi-like protists.
- They have hyphae-like structure and are saprophytic
- **Examples:** slime molds and water molds.



Euglena Paramecium Slime mold Water mold

Figure : Common protists

Kingdom Fungi:

General Characteristics:

Fungi are eukaryotic, heterotrophic organisms that are unicellular or multicellular.

Chitin in Cell Wall: Their cells are covered by cell wall made of chitin (a polysaccharide).

Fungi get nutrients in a unique way. They do not ingest food like animals and some protists. They absorb food from surroundings.

Examples: Mushrooms, rusts, smuts and molds.

Major Groups of Fungi:

The following are the major groups of fungi:

Zygomycota:

- Includes the fungi which lack septa in their hyphae.
- Examples:** Rhizopus (bread molds), which grow on moist bread, fruits etc.

ii) Ascomycota:

- It includes the largest groups of fungi.
- They have septate hyphae.
- Examples:** Common molds, morels, truffles, cup fungi, Neurospora and yeasts.

iii) Basidiomycota:

- Which includes the fungi with septate hyphae.
- Examples:** Mushrooms, toadstools, puffballs, jelly fungi and bracket/shelf fungi, rusts and smuts.



Smut fungi on leaf Toadstool Bracket fungi Sweet Tooth Fungi
Figure : Common fungi

Use of Fungi

- Some fungi are used in the production of bread, cheese and beer.
- Others have medicinal properties, such as penicillin, an antibiotic derived from the fungus *Penicillium*.

Known Species of Fungi

- There are about 100,000 known species of fungi.
- Most of the Ascomycetes are found in lichens and some are found in mycorrhizae.

End of Ans LO.3 of Exercise

Kingdom Plantae:

General Characteristics:

- It includes plants which are eukaryotic, multicellular organisms with cell walls made of cellulose.
- Autotrophs:** They are autotrophic and prepare food through photosynthesis.
- All plants develop from embryos.
- Examples:** Mosses, ferns, conifers and flowering plants.

Major Groups of Plants: (Plants are divided into two major groups)

(i) Nonvascular Plants or Bryophytes:

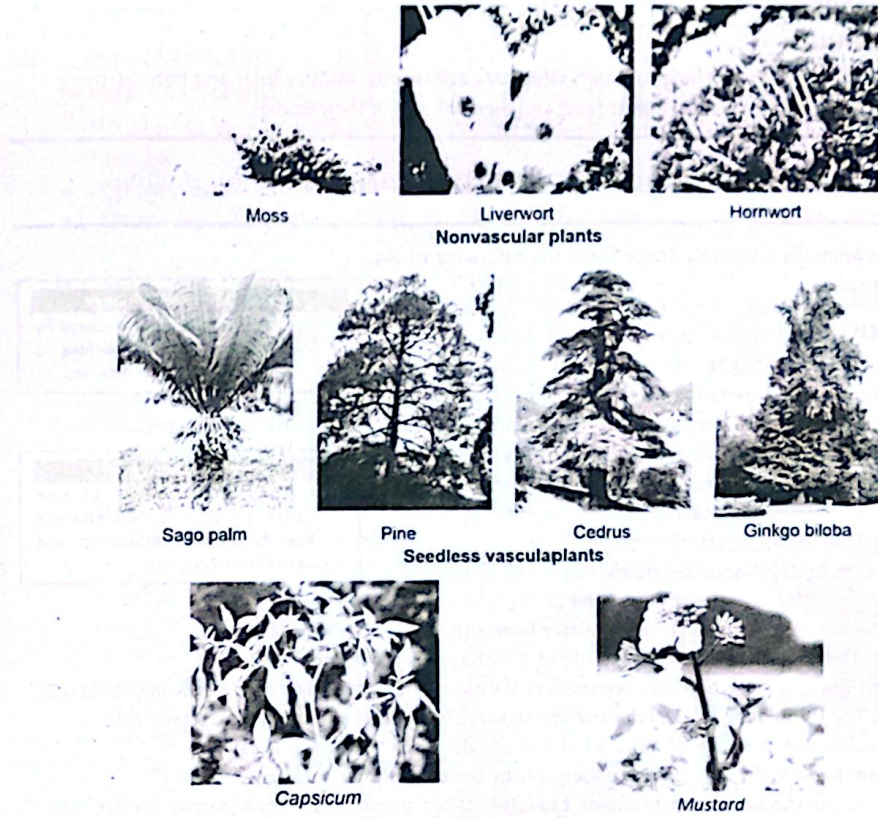
- Plants which lack conducting tissues (xylem and phloem).
- Examples** include liverworts, hornworts, and mosses.

(ii) Vascular Plants:

- Plants which have conducting tissues. Xylem & phloem

Types of Vascular Plants (Vascular plants are of two types):

- seedless plants **Example:** Ferns.
- seed plants **Examples:** Conifers and flowering plants).



Moss Liverwort Hornwort
Nonvascular plants

Sago palm Pine Cedrus Ginkgo biloba
Seedless vascular plants

Capsicum Mustard
Seed plants

Figure: major groups of Kingdom Plantae
Table: Distinguishing Characteristics of the kingdoms of three domains

Domain	Bacteria	Archaea	Eukarya			
• Kingdom	Monera		Protista	Fungi	Plantae	Animalia
• Cell Type	Prokaryotic	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
• Nuclear Envelope	Absent	Absent	Present	Present	Present	Present
• Presence of Cell Wall	In all	In all	In some	In All	In all	Absent
• Composition of Cell Wall	Peptidoglycan	Various chemicals	Various chemicals	Chitin	Cellulose and other polysaccharides	No Cell wall
• Mode of Nutrition	Autotroph or heterotroph	Autotroph or heterotroph	Photosynthetic or heterotroph, or combination	Absorptive heterotroph	Photosynthetic autotrophs	Ingestive heterotroph
• Multi cellularity	Absent	Absent	Absent in most forms	Present in most forms	Present in all forms	Present in all forms

(4) Kingdom Animalia:

➤ General Characteristics:

- This kingdom of eukaryotes includes animals which are eukaryotic, multicellular and heterotrophic.
- They develop from embryos. They ingest food and digest it within their bodies.

CLASSIFICATION OF KINGDOM ANIMALIA

• The kingdom Animalia is broadly divided into the following phyla.

(1) Phylum Porifera:

➤ General Characteristics:

- This phylum contains sponges.
- **Habitat:** Most of them are marine while some live in freshwaters.
- **Marine Sponges:** Leucosolenia and Euplectella (Venus' flower basket) are marine sponges.
- **Fresh Water Sponges:** Spongilla is a common freshwater sponge.
- **No Tissue Level:** Sponges do not have tissue level organization.
- Most sponges are asymmetrical but some have radial symmetry.
- They do not have nervous system.
- **Ostia (Pores on Body):** There are numerous pores in body wall called ostia. Through ostia, water enters the body.
- **Osculum:** The larger pore through which water leaves the body is called osculum.
- **Outer Layer:** The outer layer of body is made of thin, flat cells called pinacocytes.
- **Middle Layer:** The second layer is jelly-like and is called mesohyle or mesoglea. It contains amoeboid cells.
- **Inner Layer:** The third layer, which lines the spongocoel, is made of choanocytes or collar cells.
- They have skeleton in the form of minute needles of calcium carbonate or silica.
- **Reproduction:** Most sponges reproduce asexually by budding or regeneration.
- **Gemmules:** Some sponges form resistant capsules, called gemmules. When parent sponge dies, it releases its gemmules.
- In favourable environment, amoeboid cells come out of the gemmules and form a new sponge

Use of Commercial Sponge
 • A commercial sponge is prepared by drying, beating, and washing a sponge until all cells are removed.

Check Understanding!
 4. How does the absence of true tissues in Phylum Porifera influence their functional coordination and survival strategy?

Check Understanding!
 5. Which feature is primarily associated with the medusa form in Cnidarians, distinguishing it functionally from the polyp form?
 A) Sessile lifestyle and asexual reproduction via budding.
 B) Motile, free-swimming existence and sexual reproduction.
 C) Anchoring to substrates using a basal disc.
 D) Dominant role in building coral reef frameworks.

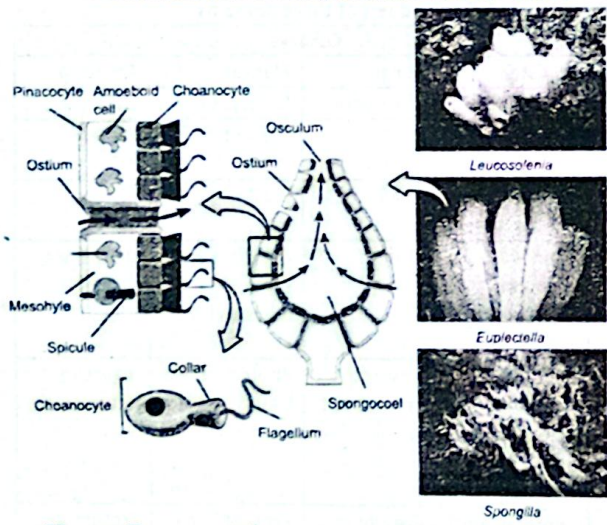


Figure: Representative sponges and general structure

Q. Describe the general characteristics of Phylum Cnidaria.

[Exercise L.O.40]

(2) Phylum Cnidaria:

➤ General Characteristics:

- **Habitat:** Almost all cnidarians are marine, although a few are found in freshwater e.g., hydra and jellyfish.
- **Cellular Organization:** Most cnidarians are colonial e.g., obelia, corals, sea fans etc.
- **Locomotion:** Most of them are sessile e.g., hydra, coral, obelia etc. Some cnidarians are motile e.g., jellyfish.
- **Symmetry:** They are radially symmetrical animals.
- **Diploblastic:** It means that the adult body contains two tissue layers i.e., the epidermis and the gastrodermis, derived from ectoderm and endoderm respectively. Between the epidermis and gastrodermis, a jelly-like mesoglea is present. It contains amoeboid cells that have originated either from ectoderm or endoderm.
- **Have Cnidocytes:** They possess special cells, called cnidocytes. A cnidocyte contains a special organelle, called nematocyst. Nematocysts defend the body and captures prey. Cnidarians have a blind-ending cavity, called gastrovascular cavity or enteron which opens outside by a single opening, the mouth.
- **Mouth Also Acts As Anus:** Mouth also acts as anus for the removal of undigested material. Mouth is surrounded by a series of projections, called tentacles.
- **Have Sac Like Digestive System:** This types of digestive system in which there is a single opening for the entry of food and removal of undigested matter, is called sac-like digestive system.
- **Nervous System but No CNS:** The nervous system is in the form of a network of neurons in the body wall. There is no central nervous system (brain and spinal cord). They do not have respiratory, excretory and transport systems.
- **Forms of Body:** There are two body forms in cnidarians i.e., polyps and medusae.
 - (i) **Polyps:** They cylindrical and are attached to a substrate at the aboral end. They reproduce asexually.
 - (ii) **Medusae:** They umbrella-like and are free-swimming. They reproduce sexually.

Corals are colonial cnidarians. They produce hard exoskeleton of Calcium carbonate. The skeleton makes coral islands and coral reefs.

Coral reef

Check Understanding!
 6. How do parasitic Platyhelminthes (e.g., tapeworms) adapt to their host's environment for survival and reproduction?

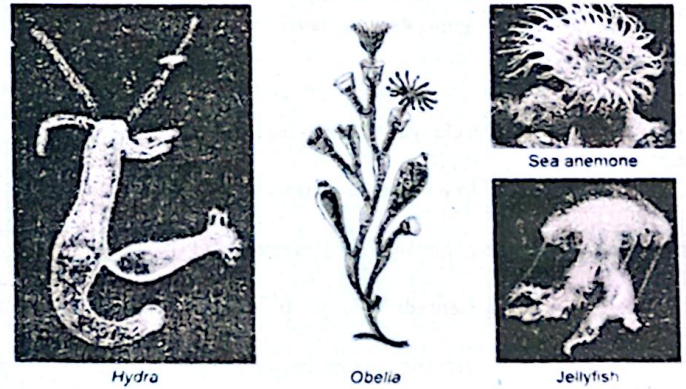


Figure: Representative cnidarians

Q. Describe the general characteristics of Phylum Platyhelminthes.

(Exercise L.O.4(iii))

(3) Phylum Platyhelminthes:

- **Flatworms:** They are called "flatworms".
- **Unsegmented + Soft Body:** They are unsegmented and body is soft and dorsoventrally compressed.
- **Habitat:** Most of them are free-living e.g., planaria. Some are endoparasites of humans and other animals e.g., liver fluke, tapeworm, and blood-fluke.
- **Triploblastic:** They are triploblastic i.e., the tissues of the body are derived from three embryonic layers; ectoderm, mesoderm and endoderm.
- **Acoelomates:** They are acoelomates. A loose connective tissue called parenchyma fills space between the body wall and body organs.
- **Bilateral Symmetry:** They have bilateral symmetry with distinct left and right sides as well as dorsal and ventral sides.
- **No Respiratory and No Circulatory System:** They do not have respiratory and circulatory (transport) systems.
- **Excretory System:** They have a network of tubular protonephridia. These tubules have numerous branches. Each branch ends in a bulb-like cell called flame cell. The cilia of flame cells beat to suck surrounding fluid into the tubules. The tubules filter the waste materials from fluid and release them out of body wall through a small opening called a nephridiopore.
- **Nervous System:** They have a network of neurons. There are cerebral ganglia in the anterior end (head). These ganglia are attached to longitudinal nerve cords that are interconnected across the body by transverse branches.
- **Eyespots:** Most free-living flatworms have two simple eyespots at their anterior end.
- **Reproduction (Asexual + Sexual):** Flatworms reproduce asexually by "fission" in which the animal constricts in the middle and then divides into two pieces. Each piece then regenerates the missing part. The sexually-reproducing flatworms are hermaphrodites (bisexual).



Planarian

Liver fluke

Tapeworm

Figure : Representative flatworms

(4) Phylum Nematoda:

➤ General Characteristics:

- **Shapes:** They are roundworms with elongated worm-like (round) body with pointed ends.
- **Habitat:** Some roundworms are free-living (in water and soil) e.g., *Caenorhabditis elegans*.
- Many are parasites e.g., ascaris, hookworm, pinworm, and whipworm.
- **Triploblastic + Bilateral + Unsegmented:** They are triploblastic, bilateral symmetrical, and possess unsegmented body.
- **Pseudocoelomates:** They are pseudocoelomates because they possess a false body cavity called pseudocoelom filled with fluid.

- The pseudocoelomates are classified in seven phyla.
- These phyla are grouped as a unit called Aschelminths.
- Phylum Nematoda is the representative phylum of this group.

- **Have Tube like Digestive System:** They possess tube-like digestive system. It consists of an alimentary canal with two openings; mouth at anterior end and anus at posterior end. The parasitic roundworms have simplified digestive systems.
- **Excretory System:** Their excretory system consists of protonephridia and two excretory canals, which unite at the anterior end to form a single canal. The single canal then opens outside through a nephridiopore on the ventral surface.
- **Nervous System:** They possess a network of neurons in body. There is a nerve ring around the pharynx, which is attached to four longitudinal nerve cords. They have raised hair-like sense organ called sensory papillae, present on lips.
- **No Respiratory Circulatory System:** They do not have defined respiratory and circulating systems.
- **Reproduction:** They are unisexual i.e.; male nematodes have testes and female nematodes have ovaries.

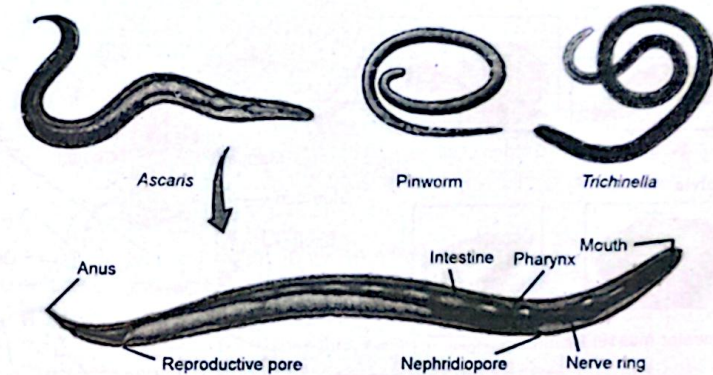


Figure : Representative roundworms and general structure

Q. Describe the general characteristics of Phylum Mollusca.

(Exercise L.O.4(iii))

(5) Phylum Mollusca:

➤ General Characteristics:

- **Soft Body + Unsegmented:** Molluscs have soft un-segmented bodies.
- **Habitat:** They are widely distributed in natural habitats. Some of them are exclusively aquatic e.g., mussels, octopus and oyster. The others live in moist places e.g., land snail.
- **Triploblastic + Bilateral:** Molluscs are triploblastic and have bilateral symmetry.
- **Have True Coelom:** They possess true coelom. Among coelomates, they are included in the group called protostomes.
- **Parts of Body:** Their body can be divided into three parts:
 - (a) Head
 - (b) Visceral mass (contains organs of digestion, excretion and reproduction)
 - (c) Foot (attached with visceral mass).
- **Mantle Cavity:** They have an epithelial envelope around the visceral mass, called as mantle. The space between mantle and visceral mass is called as mantle cavity. In most molluscs, the outer surface of mantle secretes a calcareous shell.
- **Radula (Tongue Like Organ):** All molluscs (except bivalvia) have a rasping tongue-like organ, called radula.
- **Open Blood Circulatory System:** All of them (except cephalopods) have open type blood circulatory system. Their heart consists of a single ventricle and two auricles.

- In open-type system, the blood does not retain the vessel.
- Rather, it directly bathes cells in tissue spaces (sinuses).

Check Understanding!

7. What structural feature of Annelida allows efficient locomotion through soil?
- A. Open circulatory system
 - B. Parapodia with cilia
 - C. Segmented body with circular and longitudinal muscles
 - D. Flattened body with radial symmetry

- **Tube like Digestive System:** They possess tube-like digestive system in which the gut has two openings, i.e., mouth and anus.
- **Excretory System:** Their excretory system consists of paired tubular structures called nephridia. Wastes are gathered from sinuses and discharged into coelom around the heart. The nephridia open in this coelom. They have tiny cilia around their openings, which move the fluid from coelom into the nephridia. Nephridia discharge waste materials in mantle cavity, from where they are expelled out.
- **Organs for Gases Exchange:** In molluscs, gills work for the exchange of gases.
- **Nervous System:** They have **three pairs of interconnected ganglia** present in the head, visceral mass and foot. The ganglia are interconnected by means of nerve cord.
- **Locomotion:** They move with the help of muscular foot. Some molluscs are sessile.
- Most molluscs are unisexual.

Class Gastropoda

Slug



Garden snail

Class Bivalvia

Freshwater mussel



Oyster

Class Cephalopoda

Cuttlefish



Octopus

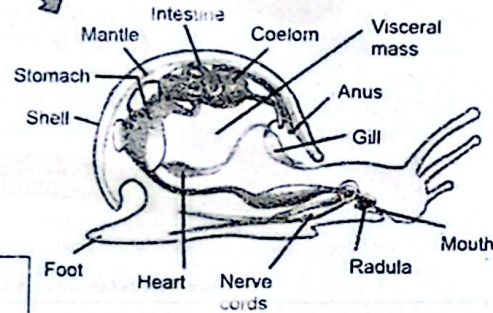


Figure: Representative molluscs and general structure

6) Phylum Annelida:

- **Segmented Worm:** Annelids are commonly called segmented worms.
- **Habitat:** They are found in
 - Marine water (e.g., nereis).
 - Freshwater (e.g., leech), and in damp soil (e.g., earthworm).
 - Parasites: Some annelids are ectoparasites e.g., leeches.
- **Segmented Body:** Their body is divided transversely into a number of similar parts called segments.
- **Metameric Segmentation:** Internally, the segments are separated from each other by cross walls called septa. Each segment is provided with its own circulatory, excretory and neural elements. This type of segmentation in body is called metameric segmentation.
- **Bilateral + Triploblastic:** Annelids are bilaterally symmetrical and triploblastic.
- They are protostome coelomates.
- **Locomotory Structure:** Annelids have special parts called setae. Setae are chitinous bristles in the ventral wall of each segment. Setae are absent in leeches.
- **Cuticle:** Their body wall is surrounded by a moist, acellular cuticle secreted by epidermis.

• The segments are indicated externally by constrictions of the body surface in the form of little rings ("Annelid" means "little ring").

- **Tube like Digestive System:** They possess tube-like digestive system. The digestive tube is divided into distinct parts, each performing a specific function. The parasitic annelids have simplified digestive system.

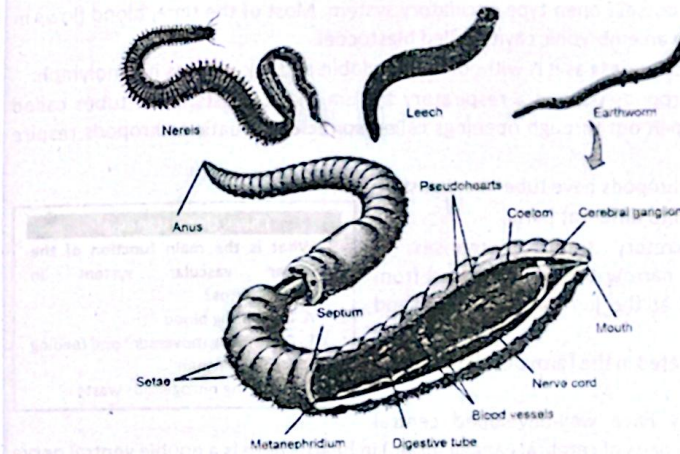


Figure: Representative annelids and general structure

- **Excretory System (Metanephridia):** Their excretory system consists of ciliated, funnel-shaped metanephridia. Each segment has one pair of metanephridia.
- **Closed Circulatory System:** They possess a closed-type circulatory system. Blood always flows in blood vessels.
- **Pseudo-hearts:** They have specialized pulsating blood vessels (pseudohearts).
- **Respiratory Pigments:** Blood of most annelids has respiratory pigment, haemoglobin, dissolved in blood plasma.
- **Gas Exchange:** Gaseous exchange occurs through the skin.
- **Nervous System:** There is a cerebral ganglion or brain in the anterior segment. A double, longitudinal ventral nerve cord arises from brain and gives nerves in each segment. Ganglia are also present in each segment.
- **Types of Receptors:** They have tactile receptors, chemoreceptors, balance receptors, and photoreceptors. Some annelids also well-developed eyes with lenses.
- **Sexes:** Most annelids are hermaphrodite (e.g., earthworm, leech) and some are unisexual (e.g., nereis).

Check Understanding!
8. How does the coelom and mantle in molluscs support both structural complexity and survival in diverse habitats?

Q. Describe the general characteristics of Phylum Arthropoda.**[Exercise L.Q.4(iv)]****(7) Phylum Arthropoda:**

- **Examples:** Diverse groups such as insects, crustaceans, spiders, scorpions, and centipedes are included in this phylum.
- **Habitat:** They are found in every type of habitat. Many of terrestrial members can also fly.
- **Triploblastic + Bilateral Symmetry + Coelomates:** They are triploblastic, bilateral symmetrical, protostome coelomates. The coelom is reduced and is present only around reproductive and excretory systems.
- **Appendages:** They have jointed appendages which are modified for specialized functions e.g., running, crawling swimming, capturing prey, respiration, reproduction etc. In different arthropods, the jointed appendages around the mouth, are modified in different ways and form mouth parts.
- **Tagmata:** The body is segmented. Some segments are fused to form specialized body regions called tagmata.
- **Parts of Body:** These include: (a) Head (b) Thorax (c) Abdomen
- **Chitinous Exoskeleton:** They have exoskeleton or cuticle, which is secreted by the epidermis of body wall. It is made chiefly of chitin.

• Arthropods are the most successful of all invertebrates.
• About 900,000 species two thirds of all the named species on Earth arthropods.

- **Shed Exoskeleton in Young:** In young arthropods, exoskeleton is shed from time to time.
- **Moulting + Ecdysis:** After shedding the exoskeleton, the animal grows at a fast rate and then re-secretes new exoskeleton. This process is called ecdysis or molting.
- **Open Circulatory System:** They possess open-type circulatory system. Most of the time, blood flows in hemocoel, which is derived from an embryonic cavity called blastocoel.
- **Colourless Blood:** Their blood is colourless as it is without haemoglobin and is known as haemolymph.
- **Respiratory System:** Most arthropods possess a respiratory system that consists of air tubes called trachea. Main tracheal tubes open out through openings called spiracles. Aquatic arthropods respire through gills.
- **Tube Like Digestive System:** Arthropods have tube-like digestive system.
- The alimentary canal is divided into different parts.
- **Excretory System:** Their excretory system comprises of Malpighian tubules. These are narrow tubules projected from the alimentary canal, attached at the junction of midgut and hindgut.
- The nitrogenous wastes are excreted in the form of solid uric acid crystals.
- **Central Nervous System:** They have well-developed central nervous system with three fused pairs of cerebral ganglia (brain) in head. There is a double ventral nerve cord which has ventral ganglia in each segment. Smaller nerves arise from ventral ganglia in each segment. They have well developed compound eyes and antennae.
- **Mode of Locomotion:** They can swim, crawl or fly depending on their habitat.
- They are unisexual.

Check Understanding!

9. What is the main function of the water vascular system in echinoderms?

- Circulating blood
- Controlling movement and feeding
- Storing calcium
- Excreting nitrogenous waste

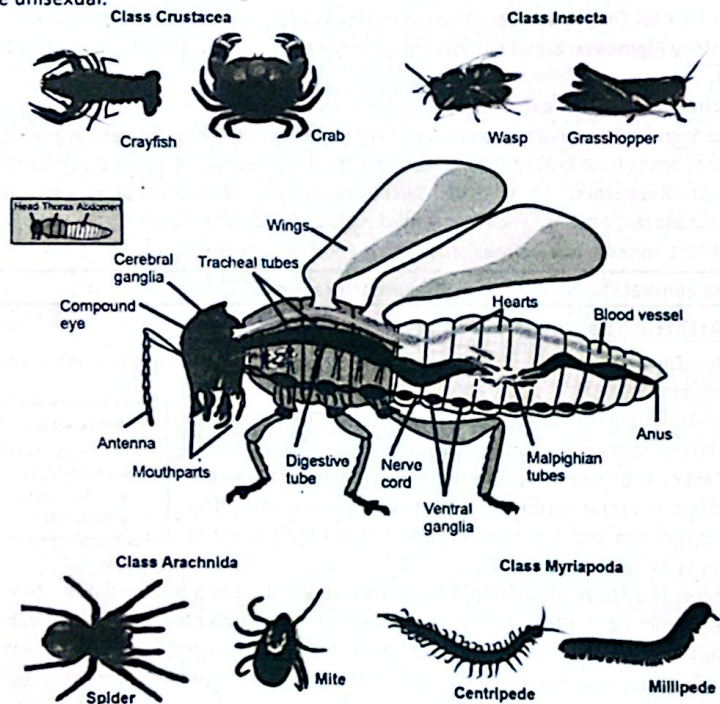


Figure: Representative arthropods and general structure

- **Important Examples of Arthropods:** Insects (e.g., mosquito, butterfly, moth, wasp, beetles, grasshopper, crabs, lobsters, prawn, shrimps, crayfishes, spider, tick, mite, scorpion, centipedes and millipedes).

Q. Describe the general characteristics of Phylum Echinodermata.

(8) Phylum Echinodermata:

General Characteristics:

- **Habitat:** They are exclusively marine animals.
- **Shapes:**
 - Some are flattened like **biscuit** (e.g., cake urchin),
 - Some are **star-shaped with short arms** (e.g., sea star or starfish),
 - Some are **globular** (e.g., sea urchin),
 - Some are **star-shaped with long arms** (e.g., brittle star),
 - Some are **elongated** (e.g., sea cucumber).
- They are triploblastic and deuterostomes coelomates.
- **Bilateral At Larval Stage + Adults Have Radia:** Their larvae are bilateral symmetrical but the adults show radial symmetry. In their radial symmetry, the body parts are arranged in five, or multiple of five, around an oral-aboral axis.
- **Ossicles:** They possess a calcareous endoskeleton in the form of plates called ossicles. These plates are derived from mesoderm but come out of skin also and make spines on the skin.
- **Water Vascular System:** They have water-vascular system consisting of tubes and spaces present in the coelom.
- **Madreporite:** A ring canal surrounds the mouth. It opens outside through a **sieve-like plate**, called **madreporite**. Five (or a multiple of five) radial canals branch from the ring canal. Many lateral canals emerge from each radial canal and each lateral canal ends at a tube foot.
- **Tube feet:** These are the extensions of water vascular system. The tube feet extend and attach with some substrate. When water is drawn back from the sucked tube feet, they contract and body is pulled.
- **Tube Like Digestive System:** Echinoderms possess tube-like digestive system. The mouth leads to oesophagus, stomach, intestine and rectum. The rectum opens out through anus.
- **No Respiratory + No Excretory System:** There are no specialized organs for respiration and excretion.
- **Poorly Developed Nervous System:** They possess a poorly developed nervous system made of a nerve net, a nerve ring, and five (or multiple of five) radial nerves. Most sensory receptors are distributed over the surface of the body and tube feet.
- **Reproduction:** Asexual reproduction involves division of the body, followed by the regeneration of each half. Echinoderms are unisexual.

• Many Echinoderms are able to regenerate the lost parts, and some, especially sea stars and brittle stars, drop various parts when they are under attack and then regenerate the lost parts.

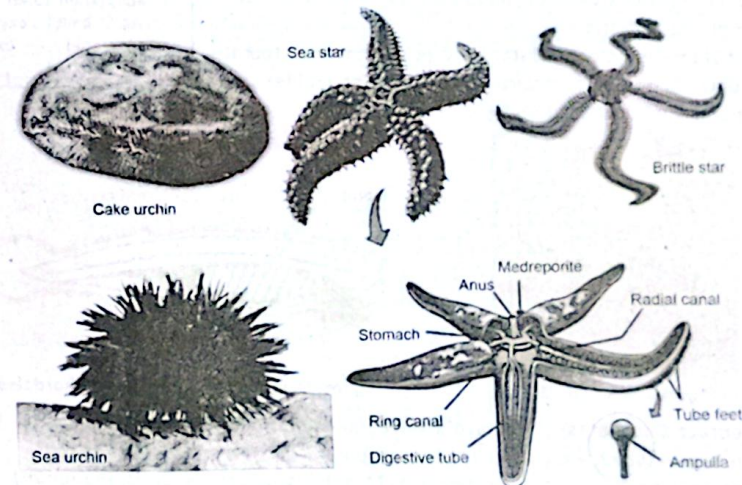


Figure: Representative echinoderms and general structure

Describe the general characteristics of Phylum Chordata.

(Exercise L.Q.5)

Phylum Chordata:

- Chordates are bilateral symmetrical, triploblastic, deuterostome coelomates.

Unique Characteristics of Chordates:

The following four characteristics are unique to chordates, present at some stage in development.

(i) Notochord:

- All chordates develop notochord during embryonic life. It is a rod-like semi rigid body of vacuolated cells. It extends throughout the length of body between gut and dorsal nerve cord.
- The lower chordates retain this notochord throughout life. While, in vertebrates it is partly or entirely replaced by vertebral column, during development.

(ii) Pharyngeal Slits:

- These are a series of openings in the lateral walls of pharynx. All chordates develop paired gill slits in embryonic stage.
- In some chordates (e.g., Amphioxus and fishes), these develop into gills. In some (e.g., most amphibians), these are functional for some period in their life history.
- In others (e.g., reptiles, birds and mammals), these are modified for various purposes.

(iii) Tubular Nerve Cord:

- In all chordates, a tubular nerve cord runs through the longitudinal axis of the body, just dorsal to the notochord.
- It expands anteriorly as a brain.

(iv) Post Anal Tail:

- All chordates develop a tail, posteriorly beyond the anal opening.
- Some chordates retain it throughout life while others degenerate it during embryonic life.



Figure: Amphioxus

Major Groups of Chordata:

Phylum chordata includes two major groups: (1) Invertebrate Chordates (2) Vertebrates

(a) Invertebrate Chordates:

It is divided into two groups:

- Subphylum Urochordata:** They include the invertebrate chordates in which notochord and nerve cord are present only in their free-swimming larvae.
- Example:** Sea squirts
- Subphylum Cephalochordata:** They include the invertebrate chordates in which notochord persists throughout life.
- Example:** Amphioxus common

Check Understanding!

10. How do gills and a single-loop circulatory system in bony and cartilaginous fishes reflect adaptation to an aquatic lifestyle, yet limit oxygen efficiency compared to terrestrial vertebrates?



Figure: Sea squirts

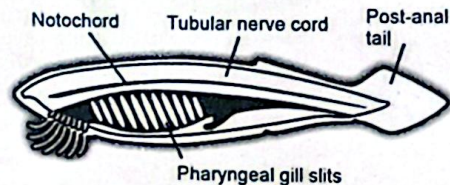


Figure: Diagnostic characters of chordates

- (2) Vertebrate Chordates: They have a vertebral column and cranium. Vertebrates are divided into seven classes which are placed into two groups.

(i) Pisces (Fishes) (ii) Tetrapodes (Amphibian, Reptiles, Birds, Mammals)

CLASSIFICATION OF VERTEBRATES

Vertebrates are divided into two groups.

(1) Group Pisces: It includes 3 classes:

(a) Cyclostomata (b) Chondrichthyes (c) Osteichthyes

- They do not have limbs.

(2) Group Tetrapoda: It includes 4 classes:

(a) Amphibia (b) Reptilia (c) Aves (d) Mammalia

- They have four limbs.

(1) Group Pisces:

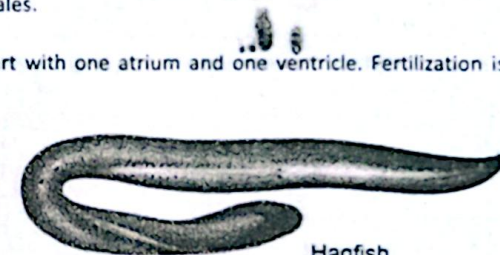
(a) Class Cyclostomata:

General Characteristics:

- These are jawless fishes.
- Examples: Lampreys and hagfish
- Their bodies are eel-like and not covered with scales.
- They possess cartilaginous skeleton.
- Like other fishes, they have a single-circuit heart with one atrium and one ventricle. Fertilization is external.



Sea lamprey



Hagfish

Figure: Jawless fishes

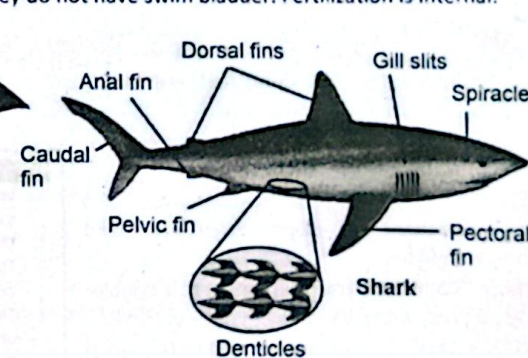
(b) Class Chondrichthyes:

General Characteristics:

- Examples: Sharks, skates, rays, and ratfishes.
- They have skeleton of cartilage. Their body is covered by placoid (tooth-like) scales, called denticles.
- They have jaws and biting mouthparts. The pectoral and pelvic fins are paired. There are two dorsal fins.
- They possess single-circuit heart with one atrium and one ventricle.
- Spiracle:** There is a pair of small openings, called spiracle, behind eyes. These are used for breathing.
- No Swim Bladder:** They do not have swim bladder. Fertilization is internal.



Skate fish



Shark

Denticles

Figure: Cartilaginous fishes



Ray fish

(c) Class Osteichthyes:

- **Bony Endoskeleton:** They have bony endoskeleton.
- Have **streamlined body**, **dermal bony scales**, and **terminal mouth** with jaws (with or without teeth).
- Notochord is replaced by vertebral column, but some bony fishes may retain it in reduced form.
- **Swim Bladder:** They also have a swim bladder that helps in buoyancy.
- **Fins:** They possess both median (dorsal, caudal and ventral) and paired (pelvic and pectoral) fins.
- **Gills:** They contain four pairs of gills.
- **Operculum:** A protective bony flap called operculum, protects the gills.
- **Nervous System:** They have well developed nervous system in which there are ten pairs of cranial nerves.
- Fertilization is mostly external.
- **Examples (Fresh Water):** The freshwater bony fishes include seahorse, flying fish and angler fish etc.
- **Examples (Marine):** The marine bony fishes include rohu, trout, Katla, catfish etc.

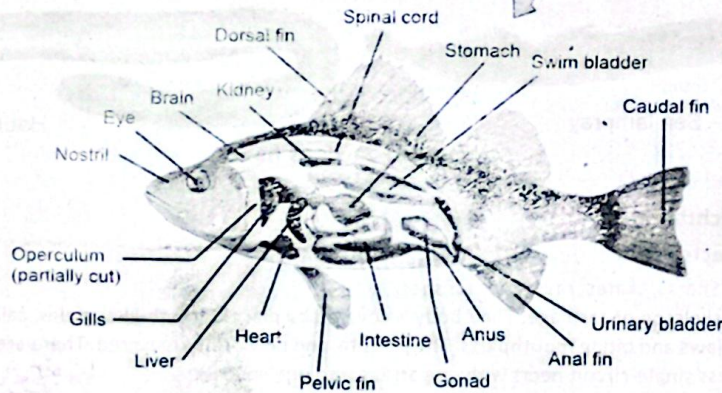


Figure: Representative bony fishes and general structure

(2) Group Tetrapoda:

(a) Class Amphibia:

- It is the first class of **tetrapods**. They have **bony endoskeleton**.
- **Have Neck:** Unlike fishes, amphibians have a neck.
- The first vertebra (cervical vertebra) moves against the back of skull and allows the skull to nod vertically.
- **Smooth + Moist Skin:** Their skin is smooth (without scales) and moist, skin helps in gas exchange, temperature regulation, and absorption and storage of water.
- **Double Circuit + Three Chambered Heart:** Their heart is double-circuit. It is three-chambered, with two atria and one ventricle.
- **Respire Through Gills + Skin:** They respire by gills in the larval stage and by lungs and skin in the adult stage.

Ectotherms: They depend on external heat source and so are ectotherms.

Check Understanding!

11. Why must amphibians stay near moist environments?
- Their lungs collapse in dry air
 - Their skin must stay moist for gas exchange
 - Their kidneys cannot concentrate urine
 - Their eggs need air exposure

SCHOLAR BIOLOGY (11th)

- **Poikilotherms:** They cannot regulate their body temperature and cannot maintain it constant. So, they are poikilothermic animals and hibernate in winter.
- **Tailed Amphibians:** Salamander, newts, and mud puppies are tailed amphibians.
- **Tail-less Amphibians:** Frogs and toads are tail-less amphibians, and caecilians.
- Amphibians are **unisexual**. Fertilization is usually **external**.

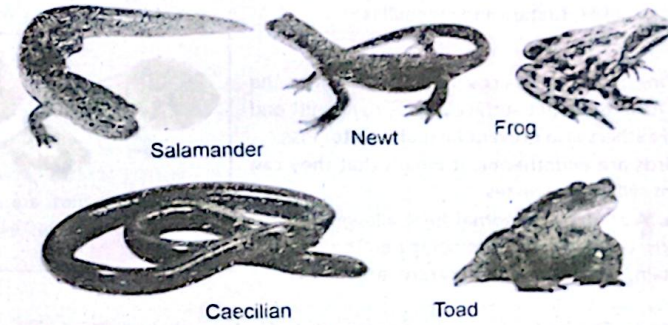


Figure: Representative amphibians

(b) Class Reptilia:

- **Have Amniotic Egg:** Reptiles are the first animal group that possess amniotic eggs.
- **Role of Amniotic Egg:** Amniotic eggs make protective extra-embryonic membranes i.e., amnion, allantois, and chorion. These membranes protect the embryo from drying out, nourish it and enable it to develop on land.
- **Large Amount of Yolk:** The amniotic eggs also contain a large amount of yolk, the primary food supply for the embryo. Such eggs have abundant albumin, which provides additional nutrients and water.
- **Leathery + Calcareous:** The amniotic eggs are also covered with leathery calcareous shell which is partially permeable to gases but not to water.

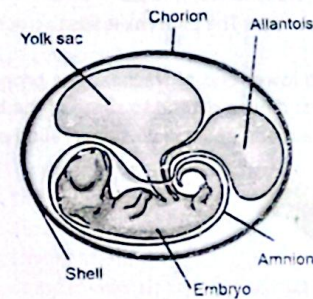


Figure: Amniotic egg

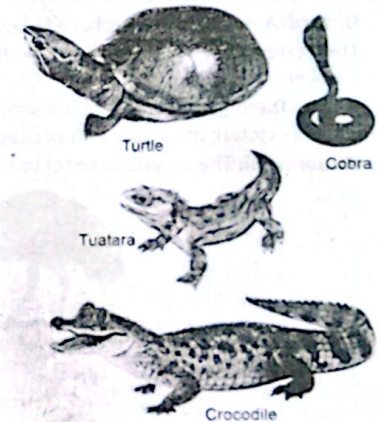


Figure: Representative reptiles

- **Dry Scaly Skin + Bony Endoskeleton:** Reptiles have dry scaly skin. The bony endoskeleton of reptiles is harder than amphibians.
- **Larger Skull:** The skull is longer than amphibians.
- In reptiles, first two cervical vertebrae (atlas and axis) allow more movements of head.

Completely Partitioned Ventricle: In their heart, ventricle is incompletely partitioned, into left and right ventricles.

Ectotherms: Reptiles, like amphibians, are ectothermic and use external heat source for thermoregulation.

Poikilotherms: They cannot keep their body temperature at constant, and are poikilotherms.

Fertilization is internal. They are oviparous (egg-laying).

Example: Lizards, snakes, tuatara and crocodiles.

Class Aves:

Forelimbs as Wings: Birds have a covering of feathers on the body. Feathers form the flight surfaces that provide lift and aid in steering. Feathers also prevent heat and water loss.

Endotherms: Birds are endotherms. It means that they can obtain heat from cellular processes.

Homeotherms: A source of internal heat allows them to maintain a nearly constant core temperature. The animals who can maintain their core temperature are known as homeotherms.

Spindle Shape Body: The body of birds is streamlined and spindle shaped. The forelimbs are modified into wings.

Light + Hollow Bones: Their bones are light due to large air spaces.

Bill: A lighter sheath called bill replaces the teeth.

Keel/Boat Shape Sternum: The sternum (chest bone) bears a large, bone called keel for the attachment of flight muscles.

Crop: In many birds a diverticulum of the oesophagus, called crop, is a storage structure that allows birds to quickly ingest large quantities of food.

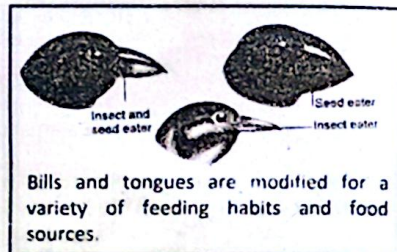
Four Chambered Heart: Their heart is four-chambered, with complete separation of atria and ventricles. Birds have much developed nervous system. Vision and hearing are important senses for most birds.

Gizzard: A region of stomach, called gizzard, has muscular walls to crush food.

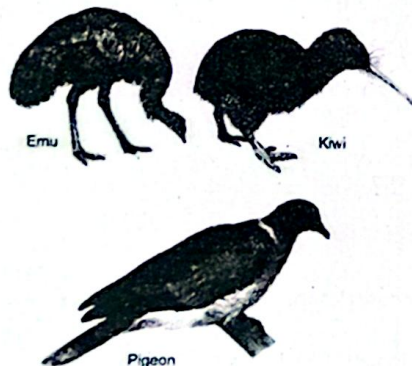
Their external nares open in pharynx through nasal passage ways. The pharynx leads to trachea and then bronchi.

Syrinx: The organ of voice, called syrinx, is situated at the lower end of trachea. The bronchi lead to a complex system of air sacs that occupy much of the body and even extend to some of the bones.

Parabronchi: The air sacs connect to birds lungs, which are made of small air tubes called parabronchi.



Check Understanding!
12. How does the avian respiratory system differ from that of mammals, and how does it support the high-energy demands of flight?



- **Eggs with Large Yolk + Albumin:** Like reptiles and mammals, birds have amniotic eggs with large amounts of yolk and albumin. Such eggs are also covered with leathery shell.
- **Fertilization Internal + Development External:** In birds, fertilization is internal and development is external i.e., they are oviparous.
- **Running Birds:** Some birds have secondarily lost the power of flight and are called running birds e.g., ostrich, kiwi, rhea, cassowary, and emu.
- **Flying Birds:** The flying birds include pigeon, parrot, crow, eagle, robin etc.

(d) Class Mammalia:

- **Mammary Glands:** Mammalia includes the group of vertebrates which are nourished by milk from the mammary glands of mother, and have hair on their body. Mammary glands are functional in female mammals.
- **Skin Glands:** Mammals have skin glands, developed from epidermis.
 - (a) Sebaceous (oil) glands secrete oily secretion.
 - (b) Sudoriferous (sweat) glands release watery secretions used in evaporative cooling.
- **Two Sets of Teeth:** Most mammals have two sets of teeth during their lives i.e., milk teeth and permanent teeth.
- **Pinna External Ear:** External ear or pinna (external) is present. The middle ear has a chain of three bones (a) Incus, (b) malleus (c) stapes.
- **Endothermic + Heterothermic:** Mammals are endothermic and homeothermic animals.
- They possess four-chambered heart.
- **Muscular Diaphragm:** They have a muscular diaphragm that separates the coelom into thoracic and abdominal cavities.
- **Voice organ:** They have well developed voice apparatus in the form of larynx (with vocal cords) and epiglottis.
- In mammals, fertilization is internal.

Check Understanding!
13. Which features help mammals maintain a constant body temperature?
A. Gills and a two-chambered heart
B. Moist skin and cutaneous respiration
C. Diaphragm and four-chambered heart
D. Air sacs and unidirectional lungs

Q. Write notes on the three groups of mammals.

(Exercise L.Q.6)

➤ **Groups of Mammals:** There are three groups of mammals:

(i) Placental Mammals:

- Most mammals (placental mammals) give birth to young ones. i.e., they are viviparous.
- **Placenta:** These are most advanced mammals.
- **Importance of Placenta:** During development, a structure called placenta, is formed between mother's uterus wall and foetus body.
- The foetus is nourished and wastes from foetus are removed through this placenta.
- **Examples of Placental Mammals:** Dolphin, rat, monkey, bat, elephant and human.

(ii) Egg Laying Mammals:

- Some mammals lay eggs and so are oviparous.
- In egg-laying mammals lay eggs in which whole development of their embryo proceeds. These mammals are found in Australia
- **Examples:** Duckbill platypus and echidna (spiny anteater).

(iii) Marsupials Mammals:

- Some mammals (marsupials) have a pouch (marsupium) on the abdomen of female.
- These mammals give birth to immature young ones which complete their development in mothers' pouch. They are called **ovoviviparous**.
- **Examples:** Opossum, kangaroo and Tasmanian wolf.



Duckbill platypus

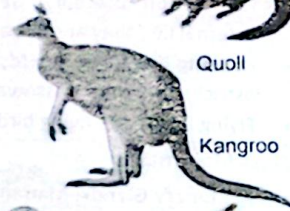


Spiny anteater

Figure: Representative egg-laying mammals



Quoll



Kangaroo



Opossum

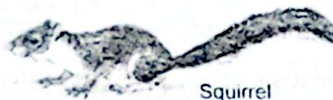
Figure: Representative pouched mammals



Bat



Dolphin



Squirrel



Musk deer



Walrus



Wild boar



Leopard

Figure: Representative eutherians

CLASSIFICATION OF VIRUSES

Characteristics of Viruses:

- **Acellular:** Viruses are not considered organisms because they are acellular i.e.; not made of cells.
- **Not Included in Any Domain:** They lack any of the characteristics of the three domains of life and are not classified in any domain and kingdom.
- **Have RNA or DNA + Protein Coat:** A virus consists of nucleic acid (DNA or RNA) surrounded by a protein coat.

Prions + Viroids: Prions and viroids are also acellular. They are also not considered living organisms.

- Prions are composed of protein only.
- Viroids are composed of circular RNA only.
- Both these particles cause infectious diseases in certain plants.

- **No Metabolism:** They cannot run any metabolism and depend upon the host cell (including plants, animals, and bacteria) to replicate and synthesize their proteins.
- **Base of Classification:** Viruses are classified based on several characteristics, including their genetic material, replication strategy, morphology, and the hosts they infect.
- The classification of viruses follows guidelines established by the International Committee on Taxonomy of Viruses (ICTV).

(a) Classification on the Basis of Host Range:

- Animal Viruses:** Infect animals, including humans. • **Examples:** Influenza virus, Rabies virus.
- Plant Viruses:** Infect plants. • **Examples:** Tobacco mosaic virus, Potato virus X.
- Bacteriophages:** Infect bacteria. • **Examples:** T4 phage, Lambda phage.
- Archaea Viruses:** Infect archaea. • **Examples:** Sulfolobus spindle-shaped virus.

Q. Outline the major classification systems for viruses based on their structural features and replication methods. Discuss the significance of these classifications in virology. **[Exercise L.Q.9]**

(b) Classification on the Basis of Morphology (Structure):

- Helical Viruses:** These have a capsid with a helical structure surrounding the nucleic acid. **Examples:** Tobacco mosaic virus, Rabies virus.
- Icosahedral Viruses:** These have a capsid with a symmetrical icosahedral shape. **Examples:** Adenoviruses, Herpesviruses.
- Complex Viruses:** These have a complex structure, often with a combination of icosahedral and helical features, and sometimes additional structures like tails. **Examples:** Bacteriophages (viruses that infect bacteria).
- Enveloped Viruses:** These have an outer lipid envelope derived from the host cell membrane, surrounding their capsid. **Examples:** Influenza virus, HIV.
- Non-enveloped (Naked) Viruses:** These lack an outer lipid envelope and consist only of a capsid enclosing the nucleic acid. **Examples:** Poliovirus, Adenovirus.

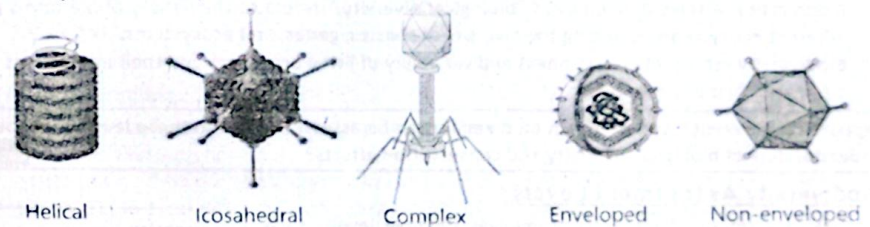


Figure: Basic shapes of viruses

Classification on the Basis of Replication Strategy

- Positive-Sense RNA Viruses:**
 - The RNA genome is directly translated into proteins by the host cell's ribosomes.
 - **Examples:** Poliovirus, Hepatitis C virus.
- Negative-Sense RNA Viruses:**
 - The RNA genome is transcribed into mRNA by a viral RNA polymerase before translation.
 - **Examples:** Rabies virus, Ebola virus.
- Reverse Transcribing Viruses:**
 - These viruses replicate through a DNA intermediate using the enzyme reverse transcriptase. They can have RNA or DNA genomes. Examples as given below:
 - **RNA genome:** Retroviruses like HIV (cause AIDS).
 - **DNA genome:** Hepadnaviruses like Hepatitis B virus.

Exercise L.Q. 8 (Remaining Part)

1. **Significance of Classification Based on Structure:**

- (i) **Helps in Identification and Diagnosis:** Structural features like cell wall type, shape, or organelles assist in classify and identify organisms, especially in medical microbiology.
- (ii) **Reveals Evolutionary Relationships:** Similar structures suggest common ancestry, helping scientists understand how organisms have evolved over time.

2. **Significance of Classification Based on Replication Methods**

- (i) **Aids in Disease Control and Treatment:** Knowing how organisms or viruses replicate helps in designing targeted drugs or vaccines that interrupt those specific steps.
- (ii) **Supports Biotechnology and Research:** Understanding replication mechanisms allows controlled use of organisms in genetic engineering and industrial processes.

(c) **Classification on the Basis of Genetic Material:**i. **DNA Viruses:**

Viruses with DNA as their genetic material. This DNA can be single stranded (ssDNA) or double-stranded (dsDNA). Examples as given below:

- **dsDNA viruses:** Adenoviruses (cause respiratory infections), Herpes viruses (cause herpes, chickenpox).
- **ssDNA viruses:** Parvoviruses (cause gastroenteritis).

ii. **RNA Viruses:**

Viruses with RNA as their genetic material. This RNA can be single stranded (ssRNA) or double-stranded (dsRNA). Examples as given below:

- **ssRNA viruses:** Coronaviruses (cause COVID-19), Influenza viruses (cause flu).
- **dsRNA viruses:** Rotaviruses (cause gastroenteritis).

BIODIVERSITY

- **Biodiversity:** A term derived from "biological diversity," refers to the variety of life forms present in different ecosystems, including the diversity of species, genes, and ecosystems.
- **Biodiversity** represents the richness and variability of living organisms and their interactions with each other and their environments.

Q. Explain the different levels at which biodiversity can be assessed. How do these levels contribute to our understanding of biological diversity and conservation efforts? (Exercise L.Q.9)

⇒ **Biodiversity Assessment Levels:**

- The assessment of biodiversity involves multiple levels, each providing unique insights into the complexity of life.

(i) **Species Level:**

- At the species level, biodiversity is assessed by identifying and counting the different species present within a given area.
- Species diversity includes not only the number of species but also their relative abundance and distribution.

(ii) **Genetic Level:**

- At the genetic level, biodiversity refers to the variety of genetic information contained within all individual organisms of a species. This genetic diversity is crucial for the adaptability and survival of species, enabling them to cope with environmental changes and challenges.

Ecosystem:

- An ecosystem is a dynamic and interactive system composed of living organisms and their physical environment. It includes all the biotic factors as well as the abiotic factors.

Niche:

- A niche refers to the role or function of an organism or species within an ecosystem.
- It includes its habitat, its interactions with other organisms (predation, competition, and symbiosis), and its role in energy flow within the ecosystem.

(iii) **Ecosystem Level:**

- At this level, biodiversity assessment includes the range of habitats, from forests and wetlands to grasslands and deserts.
- It involves understanding how different ecosystems function and how they contribute to overall ecological health.

Q. Discuss the importance of random sampling methods in ecological studies. (Exercise L.Q.10)

⇒ **Importance of Random Sampling in Determining Biodiversity:**

Random Sampling: It is a fundamental technique used in ecological studies for assessing biodiversity within a specific area. This method is crucial for several reasons:

- Minimizes Bias:** It ensures that every part of the study area has an equal chance of being sampled, which provides a more accurate representation of the overall biodiversity.
- Provides Reliable Estimates:** Random sampling allows for the collection of data that can be statistically analyzed to estimate species richness, abundance, and distribution.
- Facilitates Comparisons:** It enables comparisons between different areas or habitats by providing standardized methods of data collection.
- Enhances Representativeness:** By covering different parts of the study area, random sampling ensures that the sample represents the diversity of the entire area.
- Supports Conservation Efforts:** Accurate biodiversity assessments through random sampling are essential for identifying areas of high conservation value and for monitoring changes in biodiversity over time.

⇒ **Methods to Assess Biodiversity:**

Various methods are employed for assessing the distribution and abundance of organisms in an area:

Methods to Assess Distribution:(i) **Quadrat Sampling:**

- It involves dividing the study area into a grid and sampling within randomly selected squares (quadrats).
- **Use:** This method is particularly useful for studying plant populations or sessile organisms.
- **Example:** In a forest, a researcher might lay out quadrats of a fixed size and record the presence or absence of each plant species within these quadrats.

(ii) **Transect Sampling:**

- It involves laying out a line or strip (transect) across the study area and recording species at regular intervals along this line.
- **Use:** This method is effective for studying the distribution of species across environments.
- **Example:** In a coastal zone, a transect can be laid from the high tide line to the low tide line, to record the types and abundance of intertidal organisms.

(iii) **Aerial Surveys:**

- Aerial surveys use aircraft or drones to observe and record the distribution of organisms over large areas.
- **Example:** It can be used to track the distribution of bird species across a large wetland area or to monitor large mammal populations in savannas.



Quadrat Sampling

Transect Sampling

Aerial Surveys

Figure: Methods to assess distribution of organisms

➤ Methods to Assess Abundance:

i. Point Counts:

- Point counts involve observing and recording the number of individuals of a species from a fixed point over a specified period.
- Use: This method is commonly used for birds and other mobile animals.

ii. Mark-Recapture:

- It involves capturing, marking, and releasing individuals of a species, then recapturing them later to estimate population size and density.
- Use: This method is useful for animals that are difficult to count directly.

iii. Quadrat Counts:

- In this method, researchers use quadrats to count the number of individuals of a species within each quadrat and then infer these counts to estimate overall abundance.

iv. Capture-Recapture Methods:

- These models account for variables such as varying capture probabilities and movement between areas.

v. Remote Sensing:

- Remote sensing uses satellite or drone imagery to assess the abundance and distribution of species particularly for large-scale or inaccessible areas.

SPECIES AND SPECIATION

Q. Explain the concept of a species according to the biological species concept. How does this definition help in understanding species boundaries and the process of speciation? Provide examples to illustrate your points. (Exercise L.O.7)

(A) Species:

- The term "species" is a fundamental concept in biology.
- A species is generally defined as a group of individuals that can interbreed and produce fertile offspring under natural conditions.
- Members of the same species share common characteristics and genetic makeup, which distinguishes them from individuals of other species.

➤ Problems in Identifying the Species:

- Identification of species by using physical traits and similarities can sometimes be problematic due to the existence of cryptic species.
Cryptic Species: Organisms that appear similar but are genetically distinct called Cryptic Species.
- To address this, German-American biologist, Ernst Mayr, emphasized reproductive isolation as the key criterion for species identification.
- According to this concept, species are groups of interbreeding natural populations. Members of different species do not typically mate or produce viable, fertile offspring.

(B) Speciation:

- The evolutionary process by which new species arise from a common ancestor is called speciation.
- It involves the accumulation of genetic changes that lead to reproductive isolation between populations.

Q. Discuss the mechanisms of allopatric and sympatric speciation. (Exercise L.O.7)

➤ Mechanism of Speciation:

There are several mechanisms of speciation.

(i) Allopatric Speciation:

- It occurs when a population is geographically separated into two or more isolated groups.

- These groups experience different environments and evolve independently.
- Over time, the accumulated differences can become significant enough to prevent interbreeding, even if the geographical barrier is removed.
- Example: The speciation observed in Darwin's finches on the Galápagos Islands, where different populations adapted to diverse environments.

(ii) Peripatric Speciation:

- Speciation that occurs when a small population becomes isolated at the edge of a larger population, leading to the formation of a new species.
- It involves a small, isolated population at the edge of a larger population. The small population undergoes rapid evolutionary changes, leading to divergence from the original population.
- Examples:
 - It can be seen in island species that evolve from a small founding population.
 - The London Underground mosquito (*Culex molestus*) is believed to have evolved from above-ground populations after becoming isolated in the subway system.

(iii) Parapatric Speciation:

- Speciation that happens in neighboring populations where there is no physical barrier, but limited gene flow due to different environmental conditions.
- This occurs when populations are adjacent to each other but occupy different environments along a gradient. Gene flow between the populations is limited, and they evolve adaptations to their specific environments.
- Over time, this can lead to reproductive isolation.
- Examples:
 - The grass species "*Anthoxanthum odoratum*", which exhibits different adaptations to varying soil conditions across a gradient, leading to reproductive isolation in different soil types.
 - Grass species growing on contaminated soil near mines develop tolerance to heavy metals and diverge from nearby non-tolerant populations.

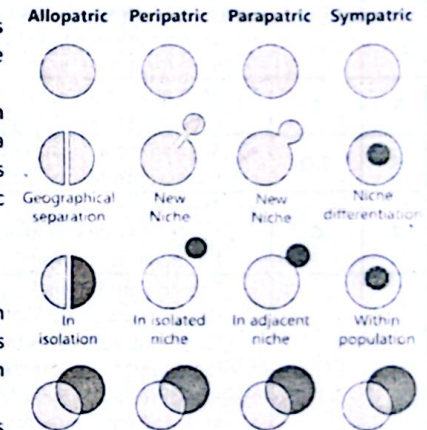


Figure: Modes of speciation

(iv) Sympatric Speciation:

- Speciation that occurs within the same geographic area, often due to genetic changes, behavior differences, or use of different ecological niches.
- In this form, new species arise within the same geographical area without physical barriers. Sympatric speciation often occurs through mechanisms such as polyploidy (where an organism has multiple sets of chromosomes) or niche differentiation (where different sub-populations exploit different resources).
- For instance, certain plants can undergo polyploidy, leading to immediate reproductive isolation and the formation of new species.

Check Understanding (Solutions)

Sr. #	Option	Explanation
1.	C	Archaea have ether-linked lipids with branched fatty acids, unlike bacteria, which helps them survive in extreme environments.
2.	S.Q	Archaea have ether-linked membranes with branched fatty acids and lack peptidoglycan in their cell walls, instead containing unique polysaccharides and proteins. These features distinguish them structurally from bacteria, supporting their placement in a separate domain.
3.	C	The kingdom is among the highest taxonomic ranks and includes organisms with broad similarities. It groups together a wide diversity of life forms, unlike species which is the most specific and includes organisms that are very similar and can interbreed.
4.	S.Q	<ul style="list-style-type: none"> • Cellular Independence: Each cell functions independently, allowing greater flexibility in response to environmental changes. • Functional Plasticity: Cells like amoebocytes can change roles, supporting repair, digestion, and reproduction without tissue compartmentalization. • Simplicity as Strength: This simplicity reduces energy demands and allows survival in nutrient-poor aquatic habitats. • Coordination via Water Flow: Despite no tissues, coordination is achieved through canal systems driven by choanocytes.
5.	B	<ul style="list-style-type: none"> • Medusae (e.g., jellyfish) are planktonic, using bell contractions for movement, and produce gametes for genetic diversity.
6.	S.Q	<ul style="list-style-type: none"> • Specialized attachment organs: Suckers/hooks anchor them to host tissues. • Hermaphroditism: Ensures reproduction even in isolated host environments.
7.	C	<ul style="list-style-type: none"> • The combination of segmentation and two muscle types allows annelids to perform peristaltic movement, where segments contract and expand in coordination. This is crucial for movement through soil, making Option C the correct choice.
8.	S.Q	<ul style="list-style-type: none"> • The coelom provides space for organ development and efficient circulation, supporting larger, more complex bodies. • The mantle secretes the shell in many mollusks, offering protection and reducing water loss in terrestrial species. • It also forms a cavity for respiration and excretion, allowing adaptation to both aquatic and land environments. • Together, these features enhance survival across ecological niches.
9.	B	<ul style="list-style-type: none"> • The water vascular system in echinoderms uses hydraulic pressure to operate tube feet, essential for locomotion, capturing food, and respiration. It's a hallmark feature of the phylum, making Option B correct.
10.	S.Q	<ul style="list-style-type: none"> • Gills extract dissolved oxygen efficiently from water, a key aquatic adaptation. • The single-loop circulatory system sends blood from the heart to the gills and then to the body. • However, oxygenated blood loses pressure after passing through gills, reducing delivery efficiency. • This limits activity levels compared to terrestrial vertebrates with double circulation.
11.	B	<ul style="list-style-type: none"> • Amphibians rely on cutaneous respiration, where gases are exchanged through the skin. This requires a moist surface, making them dependent on damp habitats. Option B accurately reflects this limitation.
12.	S.Q	<ul style="list-style-type: none"> • Birds have a unidirectional airflow system using lungs and air sacs, ensuring continuous oxygen supply. • This system maintains high oxygen levels even during exhalation. • It supports the intense metabolic demand of flight. • In contrast, mammalian respiration is bidirectional and less efficient.
13.	C	<ul style="list-style-type: none"> • These ensure efficient respiration and circulation, key to maintaining endothermy.

Exercise

Exercise

MULTIPLE CHOICE QUESTIONS (MCQs)

Section 01

- Which domain of life is characterized by organisms that often inhabit extreme environments and have cell membranes with ether-linked lipids?
(a) Bacteria (b) Archaea (c) Eukarya (d) Protista
- What is a key difference between the domains Bacteria and Archaea?
(a) Bacteria have membrane-bound organelles, while Archaea do not.
(b) Bacterial cell walls have peptidoglycan, while Archaeal cell walls do not have it.
(c) Archaea are only found in extreme environments, while Bacteria are not.
(d) Bacteria are all unicellular, while Archaea include multicellular organisms.
- Which of the following kingdoms includes organisms that are mostly unicellular, eukaryotic, and can be autotrophic or heterotrophic?
(a) Fungi (b) Animalia (c) Plantae (d) Protocista
- In which kingdom are organisms predominantly multicellular, autotrophic, and have cell walls made of cellulose?
(a) Animalia (b) Fungi (c) Plantae (d) Protocista
- Which of the following criteria is commonly used to classify viruses?
(a) Their ability to cause specific diseases (b) The type of nucleic acid they contain
(c) The colour of the virus particles (d) Their mode of transmission
- Which virus group includes viruses such as Coronaviruses and Influenza viruses?
(a) Double-stranded DNA viruses (b) Single-stranded DNA viruses
(c) Double-stranded RNA viruses (d) Single-stranded RNA viruses
- At which level of biodiversity assessment do we evaluate the variety of different species within a particular habitat or ecosystem?
(a) Genetic diversity (b) Ecosystem diversity (c) Species diversity (d) Functional diversity
- Which method is best suited for assessing the distribution of species across a gradient of environmental conditions within a single geographical area?
(a) Quadrat Sampling (b) Point Counts (c) Transect Sampling (d) Remote Sensing
- Which of the following statements is true regarding the concept of a species?
(a) A species is always defined by its physical characteristics alone.
(b) Different species can interbreed and produce fertile offspring.
(c) Members of the same species are reproductively isolated from members of other species.
(d) The concept of a species can be defined solely based on genetic similarity.
- What type of speciation occurs when populations are geographically separated by a physical barrier?
(a) Sympatric Speciation (b) Parapatric Speciation (c) Allopatric Speciation (d) Peripatric Speciation

Answer Key with Explanations

Sr.No.	Option	Answer	Explanations
1.	(b)	Archaea	<ul style="list-style-type: none"> • Archaea are known for surviving in extreme environments like hot springs or salt lakes, and their cell membranes contain ether-linked lipids which are more stable in harsh conditions.
2.	(b)	Bacterial cell walls have peptidoglycan, while Archaeal cell walls do not.	<ul style="list-style-type: none"> • The presence of peptidoglycan is a defining feature of bacterial cell walls, while Archaea have different components, helping to distinguish the two domains.

3.	(d)	Protocista	<ul style="list-style-type: none"> Protocists (Protists) include diverse organisms that are mostly unicellular, eukaryotic, and can either make their own food (autotrophs) or consume other organisms (heterotrophs).
4.	(c)	Plantae	<ul style="list-style-type: none"> Members of Kingdom Plantae are multicellular, perform photosynthesis (autotrophic), and have cellulose in their cell walls, making them unique among kingdoms.
5.	(b)	The type of nucleic acid they contain	<ul style="list-style-type: none"> Viruses are categorized based on whether their genetic material is DNA or RNA, which is crucial for their replication and behavior.
6.	(d)	Single-stranded RNA viruses	<ul style="list-style-type: none"> Both coronaviruses and influenza viruses are examples of viruses that contain single-stranded RNA, which helps classify them.
7.	(c)	Species diversity	<ul style="list-style-type: none"> Species diversity measures the variety and abundance of species in an area, making it the most accurate for assessing biodiversity in an ecosystem.
8.	(c)	Transect Sampling	<ul style="list-style-type: none"> Transect sampling involves recording species along a line, which is ideal for studying distribution changes across environmental gradients.
9.	(c)	Members of the same species are reproductively isolated from members of other species.	<ul style="list-style-type: none"> Reproductive isolation is a key biological concept defining species — they can breed among themselves but not with different species.
10.	(c)	Allopatric Speciation	<ul style="list-style-type: none"> When populations are physically separated (e.g., by a mountain or river), they evolve independently, leading to new species — this is known as allopatric speciation.

Exercise

SHORT ANSWER QUESTIONS

Section 02

Q.1 What are the three domains of life and how do they differ in terms of cellular structure?

Ans.	Three Domains of Life	Cellular Structure
	(i) Bacteria	<ul style="list-style-type: none"> Prokaryotic cells, cell walls contain peptidoglycan, lack membrane-bound organelles.
	(ii) Archaea	<ul style="list-style-type: none"> Prokaryotic, but with unique membrane lipids and no peptidoglycan in cell walls.
	(iii) Eukarya	<ul style="list-style-type: none"> Eukaryotic cells with membrane-bound organelles and nuclei.

Q.2 Describe one key feature that differentiates Archaea from Bacteria.

Ans. Key Difference between Archaea from Bacteria:

(i) Cell Wall Composition:

- Bacteria have cell walls made of peptidoglycan.
- Archaea lack peptidoglycan and instead have pseudopeptidoglycan or other unique polymers.

(ii) Membrane Lipids

- Bacteria have fatty acid chains linked to glycerol by ester bonds.
- Archaea have branched isoprene chains linked to glycerol by ether bonds, which stabilize membranes in extreme environments.

Q.3 How do sponges reproduce asexually?

Ans. Sponges Reproduce Asexually:

- Budding:** A small outgrowth forms on the parent sponge, detaches, and develops into a new individual.
- Fragmentation:** Broken pieces (due to environmental stress or predation) regenerate into complete sponges.
- Gemmule Formation (In freshwater sponges):** Survivable clusters of cells (gemmules) encased in protective coats hatch into new sponges under favorable conditions.

Q.4 Differentiate the following:

- | | |
|---|-----------------------------------|
| (i) Sac like and tube-like digestive system | (ii) Polyps and medusa |
| (iii) Urochordata and cephalochordate | (iv) Ectotherms and endotherms |
| (v) Marsupial and placental mammals | (vi) Gymnosperms and angiosperms. |

Ans. (i) Sac-like vs. Tube-like Digestive System:

Sac-like	Tube-like
<ul style="list-style-type: none"> Sac-like has one opening. Sac-like mixes food and waste. Sac-like is less efficient system. Sac-like is found in simpler animals; 	<ul style="list-style-type: none"> Tube-like has two (mouth and anus). Tube-like separates digestion and excretion. Tube-like is more efficient system. Tube-like found in complex animals.

(ii) Polyps vs. Medusa:

Polyps	Medusa
<ul style="list-style-type: none"> Polyps are sessile. Polyps have mouth facing upward. Polyps are cylindrical. Polyps reproduce asexually. 	<ul style="list-style-type: none"> Medusae are free-swimming. Medusae have mouth facing downward. Medusae are bell-shaped. Medusae reproduce sexually.

(iii) Urochordata vs. Cephalochordata

Urochordata (Tunicates)	Cephalochordata (Lancelets)
<ul style="list-style-type: none"> Urochordates have notochord only in larvae. Urochordates adults are sessile. Urochordates have a tunic. Urochordates lose some chordate features in adulthood. 	<ul style="list-style-type: none"> Cephalochordates have notochord lifelong. Cephalochordates are motile. Cephalochordates do not have a tunic. Cephalochordates retain all chordate features.

(iv) Ectothermic vs. Endothermic

Ectotherms	Endotherms
<ul style="list-style-type: none"> Ectotherms rely on external heat. Ectotherms have variable body temperature. Ectotherms require less food energy. Ectotherms become inactive in cold. 	<ul style="list-style-type: none"> Endotherms generate internal heat. Endotherms maintain constant temperature. Endotherms require more food energy. Endotherms remain active.

(v) Marsupial vs. Placental Mammals

Marsupials	Placental Mammals
<ul style="list-style-type: none"> Marsupials give birth to immature young. Marsupials carry young in pouch. Marsupials have shorter gestation. Marsupials are mostly found in Australia. 	<ul style="list-style-type: none"> Placentals to mature young. Placentals develop young inside uterus. Placentals have longer gestation. Placentals are worldwide.

(vi) Gymnosperms vs. Angiosperms

Gymnosperms	Angiosperms
<ul style="list-style-type: none"> Gymnosperms have naked seeds. Gymnosperms do not have flowers. Gymnosperms usually have needle-like leaves. Gymnosperms reproduce using cones. 	<ul style="list-style-type: none"> Angiosperms have seeds in fruits. Angiosperms have flowers. Angiosperms have broad leaves. Angiosperms use flowers for reproduction.

Q.5 Which kingdom is characterized by organisms with chitin in their cell walls and that are mostly decomposers?

Ans. Kingdom Fungi:

- Organisms with chitin in their cell walls belong to the Fungi kingdom.
- Fungi are mostly decomposers, breaking down dead organic matter.
- They secrete enzymes that digest complex substances externally.
- This process helps recycle nutrients back into the environment.
- Chitin provides strength and rigidity to their cell walls.

Q.6 What type of speciation occurs when populations are geographically separated?

Ans. Allopatric Speciation:

- Occurs when populations are isolated by physical barriers or geographical barrier such as mountains or rivers.
- It leads to genetic divergence over time.
- **Example:** The speciation observed in Darwin's finches on the Galápagos Islands, where different populations adapted to diverse environments.

Q.7 What is the role of genetic drift in the process of speciation?

Ans. Role of Genetic Drift in the Process of Speciation:

- Genetic drift causes random changes in allele frequencies, especially in small populations.
- Overtime, these random changes can make populations genetically different.
- If they become so different that they can no longer interbreed, thus new species can form.
- This is how genetic drift can lead to speciation.

Q.8 What is the primary method used to assess species distribution along an environmental gradient?

Ans. Primary Method Used To Assess Species Distribution Along An Environmental Gradient:

Transect Sampling:

- It involves laying out a line or strip (transect) across the study area and recording species at regular intervals along this line.
- **Use:** This method is effective for studying the distribution of species across environments.
- **Example:** In a coastal zone, a transect can be laid from the high tide line to the low tide line, to record the types and abundance of intertidal organisms.

Q.9 Which level of biodiversity assessment involves evaluating the variety of ecosystems in a region?

Ans. Ecosystem Diversity Assessment:

- Ecosystem diversity assessment involves evaluating the variety of ecosystems in a region.
- This level of biodiversity assessment looks at the different types of ecosystems, such as forests, grasslands, wetlands, and their distribution.
- It helps to understand the complexity and health of ecosystems.
- Ecosystem diversity is crucial for maintaining ecological balance.

Exercise

LONG ANSWER QUESTIONS

Section 03

Q.1 Compare and contrast the domains Archaea and Bacteria and discuss how these differences reflect their evolutionary histories.

Ans. See Page No. (02)

Q.2 Explain the concept of a species according to the biological species concept. How does this definition help in understanding species boundaries and the process of speciation? Provide examples to illustrate your points.

Ans. See Page No. (28)

Q.3 Describe the major groups of Kingdom Protista and Kingdom Fungi.

Ans. See Page No. (07)

Q.4 Describe the general characteristics of following animal phyla.

- (i) Phylum Cnidaria (ii) Phylum Plathelminthes (iii) Phylum Mollusca
(iv) Phylum Arthropoda (v) Phylum Echinodermata

Ans. See Page No. (11, 12, 13, 15, 17)

Q.5 Describe the general characteristics of phylum Chordata.

Ans. See Page No. (18)

Q.6 Write notes on the three groups of mammals.

Ans. See Page No. (23)

Q.7 Discuss the mechanisms of allopatric and sympatric speciation.

Ans. See Page No. (28)

Q.8 Outline the major classification systems for viruses based on their structural features and replication methods. Discuss the significance of these classifications in virology.

Ans. See Page No. (25)

Q.9 Explain the different levels at which biodiversity can be assessed. How do these levels contribute to our understanding of biological diversity and conservation efforts?

Ans. See Page No. (26)

Q.10 Discuss the importance of random sampling methods in ecological studies.

Ans. See Page No. (27)

Q.11 Describe the concept of an ecosystem and niche.

Ans. Ecosystem:

- An ecosystem is a dynamic and interactive system composed of living organisms and their physical environment. It includes all the biotic factors as well as the abiotic factors.

Niche:

- A niche refers to the role or function of an organism or species within an ecosystem.
- It includes its habitat, its interactions with other organisms (predation, competition, and symbiosis), and its role in energy flow within the ecosystem.

Exercise

INQUISITIVE ANSWER QUESTIONS

Q.1 How are viruses classified based on their nucleic acid content and replication method?

Ans. Classification of Viruses on the Basis of nucleic acid content and replication method:

Classification on the Basis of Nucleic acid Content:

I. DNA Viruses:

Viruses with DNA as their genetic material. This DNA can be single stranded (ssDNA) or double-stranded (dsDNA). Examples as given below:

- c) dsDNA viruses: Adenoviruses (cause respiratory infections), Herpes viruses (cause herpes, chickenpox).
d) ssDNA viruses: Parvoviruses (cause gastroenteritis).

II. RNA Viruses:

Viruses with RNA as their genetic material. This RNA can be single stranded (ssRNA) or double-stranded (dsRNA). Examples as given below:

- e) ssRNA viruses: Coronaviruses (cause COVID-19), Influenza viruses (cause flu).
f) dsRNA viruses: Rotaviruses (cause gastroenteritis).

Classification on the Basis of Replication Method:

- i. **Positive-Sense RNA Viruses:**
 - g) The RNA genome is directly translated into proteins by the host cell's ribosomes.
 - h) **Examples:** Poliovirus, Hepatitis C virus.
- ii. **Negative-Sense RNA Viruses:**
 - i) The RNA genome is transcribed into mRNA by a viral RNA polymerase before translation.
 - j) **Examples:** Rabies virus, Ebola virus.
- iii. **Reverse Transcribing Viruses:**
 - k) These viruses replicate through a DNA intermediate using the enzyme reverse transcriptase. They can have RNA or DNA genomes. Examples as given below:
 - l) **RNA genome:** Retroviruses like HIV (cause AIDS).
 - m) **DNA genome:** Hepadnaviruses like Hepatitis B virus.

Q.2 What may be the drawback in the definition of species according to the biological species concept?

Ans. Drawbacks of Biological Species Concept

1. **Limitation with Fossils and Asexual Organisms**
Can't apply to fossils or organisms that reproduce asexually.
2. **Hybridization Issues**
Doesn't account for species that can interbreed or hybridize.

Q.3 How does biodiversity help maintain balance in an ecosystem?

Ans. Biodiversity helps keep ecosystems balanced by:

- Making sure plants grow and animals survive by supporting different species.
- Helping ecosystems recover from problems like storms or disease.
- Supporting food chains for energy and nutrient flow.
- Controlling species numbers through natural predator-prey interactions.



ADDITIONAL MCQs

Q.1 Two organisms living in the same habitat and resembling each other morphologically may not be considered the same species because:

- A. They look alike
- B. They share a common niche
- C. They cannot interbreed and produce fertile offspring
- D. They have similar food habits

Q.2 Which of the following best differentiates the domains Archaea and Bacteria from Eukarya?

- A. Presence of a rigid cell wall
- B. Ability to survive in extreme environments
- C. Lack of membrane-bound organelles
- D. Mode of nutrition

Q.3 Which of the following sequences shows a correct hierarchy from broader to narrower taxon?

- A. Order → Family → Phylum → Class
- B. Kingdom → Phylum → Class → Order
- C. Genus → Species → Family → Class
- D. Domain → Order → Phylum → Species

Q.4 Which kingdom contains organisms that are eukaryotic, mostly unicellular, and may be autotrophic or heterotrophic?

- A. Kingdom Monera
- B. Fungi
- C. Protista
- D. Plantae

Q.5 Viruses are grouped based on their:

- A. Cell wall composition
- B. Nucleic acid type and replication method
- C. Ability to move
- D. Number of protein coats

Q.6 In a forest ecosystem, a woodpecker feeding on insects under tree bark is an example of its:

- A. Habitat
- B. Food chain role
- C. Niche
- D. Ecological level

Q.7 If scientists are studying the variation in leaf shapes among different oak species, they are assessing biodiversity at the:

- A. Ecosystem level
- B. Species level
- C. Genetic level
- D. Community level

Q.8 An ecosystem with multiple genetically different populations of the same species reflects:

- A. High species diversity
- B. High genetic diversity
- C. Low genetic variation
- D. Low ecosystem stability

Q.9 Random sampling is preferred over selective sampling because it:

- A. Reduces effort and cost
- B. Targets rare species directly
- C. Eliminates bias and gives a representative estimate
- D. Focuses only on dominant species

Q.10 A biologist places a 1m² frame randomly in a grassland and counts plant species. This technique is known as:

- A. Line transect
- B. Quadrat sampling
- C. Belt transect
- D. Tag-and-release

ANSWER KEY

1. C	2. C	3. B	4. C	5. B	6. C	7. B	8. B	9. C	10. B
------	------	------	------	------	------	------	------	------	-------

ADDITIONAL SHORT ANSWER QUESTIONS

Q.1 How is the term "species" defined in biological classification?

Ans. Species:

- A species is a group of organisms that can interbreed and produce fertile offspring.
- Members of a species share similar structural and genetic features.
- They are reproductively isolated from other species.

Q.2 Why is biodiversity essential for the stability of ecosystems?

Ans. Biodiversity Essential For The Stability Of Ecosystems:

- Biodiversity ensures ecosystem resilience and productivity.
- It maintains ecological balance through food chains and nutrient cycles.
- High biodiversity buffers against environmental changes.

Q.3 What is the basis for dividing organisms into three domains?

Ans. Basis For Dividing Organisms Into Three Domains:

- Domains are based on differences in cell type, genetic makeup, and molecular structures.
- The three domains are Archaea, Bacteria, and Eukarya.
- Archaea and Bacteria are prokaryotic; Eukarya includes all eukaryotes.

Q.4 How does taxonomic hierarchy help in biological classification?

Ans. Taxonomic Hierarchy Help In Biological Classification:

- It organizes organisms from broad to specific groups: Domain to Species.
- It shows relationships based on shared characteristics.
- It helps scientists identify, name, and group organisms systematically.

Q.5 How do organisms of Kingdom Fungi differ from those of Kingdom Plantae?

Ans. Differences between Kingdom Fungi and Kingdom Plantae:

Kingdom Fungi	Kingdom Plantae
<ul style="list-style-type: none"> • Fungi are heterotrophic decomposers. • While plants are autotrophic producers. 	<ul style="list-style-type: none"> • Fungi lack chlorophyll and do not photosynthesize. • Plant cells have chloroplasts and perform photosynthesis.

Q.6 What are the key features of organisms in Kingdom Protista?

Ans. Key Features of Organisms in Kingdom Protista:

- Mostly unicellular and eukaryotic.

- Some are autotrophic (e.g., algae), others are heterotrophic (e.g., protozoa).
- Found mostly in aquatic environments.
- They have characteristics like plants (algae) like animals (Protozoa) like fungi (molds).

Q.7 On what basis are viruses classified into groups?

Ans. Basis of Viruses Classification:

- Viruses are classified based on nucleic acid type (DNA or RNA) and replication method.
- Other criteria include shape, host range, and presence of an envelope.
- They are placed into families and genera accordingly.

Q.8 What is the difference between an ecosystem and a niche?

Ans. Differences between Ecosystem and a Niche:

Ecosystem	Niche
<ul style="list-style-type: none"> • An ecosystem includes all living organisms and their physical environment. 	<ul style="list-style-type: none"> • A niche refers to an organism's role and interactions in an ecosystem. • It includes diet, habitat, and contribution to energy flow.

Q.9 What are the three main levels of biodiversity?

Ans. Three Main Levels of Biodiversity:

- Genetic diversity: variety of genes within a species.
- Species diversity: variety of species in an area.
- Ecosystem diversity: variety of ecosystems in a region.

Q.10 Why is random sampling important in biodiversity assessment?

Ans. Importance of Random Sampling in Biodiversity Assessment:

- It gives an unbiased estimate of species diversity.
- Ensures representation of all types of organisms in the area.
- Helps in conservation and management decisions.

Q.11 How can species abundance and distribution be measured?

Ans. Measurement of Species Distribution:

- Techniques include quadrat sampling, transect lines, and mark-recapture method.
- These help in estimating population size and density.
- Useful for monitoring ecosystem health and biodiversity changes.



SELF-ASSESSMENT

Chapter 01

Total Mark: 30

Q.1 Encircle the correct option.

(1 × 6 = 06)

- What is a key difference between the domains Bacteria and Archaea?
 - (a) Bacteria have membrane-bound organelles, while Archaea do not.
 - (b) Bacterial cell walls have peptidoglycan, while Archaeal cell walls do not have it.
 - (c) Archaea are only found in extreme environments, while Bacteria are not.
 - (d) Bacteria are all unicellular, while Archaea include multicellular organisms.
- Which domain of life is characterized by organisms that often inhabit extreme environments and have cell membranes with ether-linked lipids?
 - (a) Bacteria
 - (b) Archaea
 - (c) Eukarya
 - (d) Protista
- In which kingdom are organisms predominantly multicellular, autotrophic, and have cell walls made of cellulose?
 - (a) Animalia
 - (b) Fungi
 - (c) Plantae
 - (d) Protocista
- Which virus group includes viruses such as Coronaviruses and influenza viruses?
 - (a) Double-stranded DNA viruses
 - (b) Single-stranded DNA viruses
 - (c) Double-stranded RNA viruses
 - (d) Single-stranded RNA viruses
- Which method is best suited for assessing the distribution of species across a gradient of environmental conditions within a single geographical area?
 - (a) Quadrat Sampling
 - (b) Point Counts
 - (c) Transect Sampling
 - (d) Remote Sensing
- What type of speciation occurs when populations are geographically separated by a physical barrier?
 - (a) Sympatric Speciation
 - (b) Parapatric Speciation
 - (c) Allopatric Speciation
 - (d) Peripatric Speciation

Q.2 Write short answers of the following questions.

(2 × 8 = 12)

- Describe one key feature that differentiates Archaea from Bacteria.
- Which kingdom is characterized by organisms with chitin in their cell walls and that are mostly decomposers?
- What is the role of genetic drift in the process of speciation?
- Which level of biodiversity assessment involves evaluating the variety of ecosystems in a region?
- How are viruses classified based on their nucleic acid content and replication method?
- What are the three domains of life and how do they differ in terms of cellular structure?
- What are the key features of organisms in Kingdom Protista?
- What is the difference between an ecosystem and a niche?

Q.3 Extensive Questions.

(4 × 2 = 8)

- (a) Describe the general characteristics of phylum Chordata.
- (b) How does biodiversity help maintain balance in an ecosystem?

