

UNIT - I

CHAPTER – 1: LIVING WORLD

Biology is the science of life forms and non-living processes. The living world comprises an amazing diversity of living organisms. In order to facilitate the study of kinds and diversity of organisms, biologists have evolved certain rules and principles for identification, nomenclature and classification of organisms. The branch of biology dealing with these aspects is referred to as Taxonomy.

Life is a characteristic that distinguishes objects that have signaling and self-sustaining processes from those that do not, either because such functions have ceased (death), or else because they lack such functions and are classified as inanimate. Biology is the science concerned with the study of life.

Characteristics features of Living things / Differences between living and non-living things:

- a) Growth
- b) Reproduction
- c) Metabolism
- d) Response to stimuli

Biodiversity: Range of organisms present on earth (1.7 – 1.8 million)

Identification: Comparing similarities and differences with already known ones.

Nomenclature: Naming of organisms. The names are unique and universal.

Rules for nomenclature are provided by;

- a) ICBN – International Code for Botanical Nomenclature
- b) ICZN – International Code for Zoological Nomenclature

Binomial Nomenclature:

Carolous Linnaeus – Father of Taxonomy

Name with two parts: - Generic name (**Genus**) & Specific epithet (**Species**)

Guidelines and Principles for Nomenclature:

- a) It should be in Latin / derived from Latin.
- b) If it is written in Italics when types and underlined when handwritten.
- c) It contains two parts, first word is Genus ; second word is Species.
- d) Genus name starts with Capital while species name starts with small letters.
- e) Name should be short, precise & easy to pronounce.
- f) Name of the author is written in an abbreviated form after the species name. Ex. *Mangifera indica* Linn.

Example:

Mangifera indica (Mango)

Homo sapiens (Human)

Panthera pardus (Leopard)

Felis domestica (Cat)

Classification – Grouping of organisms in to categories based on observable characters. (category –taxa)

Taxonomy - Characterization, identification , classification and nomenclature are the process of taxonomy.

Systematics - Different kinds of organisms and their relationships Linnaeus – *Systema Naturae* (evolutionary relationships among organisms).

Taxonomical Hierarchy – Similarities decreases/ Differences increases

Species → Genus → Family → Order → Class → Phylum → Divisions → Kingdom

1. Species -*Panthera leo*, *Panthera pardus*, *Panthera tigris*.
2. Genus- Panthera (Lion, Leopard, Tiger)
3. Family- Panthera and Felis together into Felidae
4. Order - Felidae (cat family) , Canidae (dog family) - Carnivora
5. Class - Carnivora (tiger, cat, dog), Primates (monkeys)- Mammalian
6. Phylum – Pisces, Amphibian, Reptilian, Aves & Mammals
7. Kingdom – Plantae, Animalia.

Taxonomical Aids :

1. Herbarium
2. Botanical garden- NBRI (Lucknow) & IBG (Howrah)
3. Museum
4. Zoological parks.
5. Key (analytical in nature)
6. Monograph (1 family / genera at a time.)
7. Manuals (particular area , family/ genus/ species)
8. Flora (habitat & description of plants in a given area)

Taxonomical aids

- These are the procedures and techniques used to store and preserve information as well as specimens of various plants and animals.
- These help in identification, naming, and classification of organisms.

Herbarium

- It is the storehouse of collected plant specimens.
- Collected plant specimens are dried, pressed, and preserved on sheets and then arranged systematically according to the universally accepted system of classification.
- Herbarium sheet contains label regarding date, place of the collection, scientific name, family, collector's name, etc. of the specimen.

Botanical gardens

- It has the collection of living plant species that are grown for identification and reference.
- Each plant contains labels indicating their scientific name and family.
- Some famous botanical gardens are Indian Botanical Garden, Calcutta (largest in India), Royal Botanical Garden, Kew (largest in world till date) and National Botanical Research Institute.

Museum

- It is the repository that has a collection of various plant and animal specimens that are preserved for study and reference.
- The organisms are preserved either in preservative solution or in the form of dry specimen
- It often has a collection of skeletons of animals also.

Zoological parks

- Wild animals are kept in protected environments.
- Provides opportunity for studying the behaviour and food habits of the animals

Key

- Keys are used for identification of plants and animals based on similarities and dissimilarities.
- Manuals, monographs, and catalogues are other means of recording descriptions.
- Manuals help in the identification of names of various species of organisms in a given area.
- Monograph is a detailed and well-documented work on any particular taxon.

Organisms with their Taxonomic categories:

Man : *Homo sapiens* – Homo – Hominidae – Primate – Chordate - Mammalia

Housefly : *Musca domestica* - Musca – Muscidae – Diptera - Insecta -Arthropoda

Mango : *Mangifera indica* – Mangifera - Anacardiaceae - Sapindales- Dicotyledonae - Angiospermae

Wheat : *Triticum aestivum* – Triticum – Poaceae – Poales - Monocotyledonae - Angiospermae

CHAPTER 2 - BIOLOGICAL CLASSIFICATION

The process of grouping living organisms into convenient categories based on simple characters is known as **Biological classification**.

I. Two kingdom classification.

- Plants. (autotrophs, cell wall, do not move)
- Animals (heterotrophs, no cell wall, can move)

Linnaeus - plantae & Animalia

Later found two kingdom classification was not sufficient because in that

1. Prokaryotes & Eukaryotes were grouped together.
2. Heterotrophs & Autotrophs were together.
3. No difference between unicellular and multicellular
4. Simple organisms were placed along with higher organism.

II. Five kingdom classification. (R.H Whittaker 1959)

Main criteria for classification:

1. Complexity of cell structure (prokaryotes/ eukaryote)
2. Body organization (unicellular/ multicellular)
3. Mode of nutrition (autotrophic / heterotrophic / holozoic)
4. Life style (producers / consumers / decomposers)
5. Phylogenetic relationships (revolutionary history)

Five kingdoms are

1. Kingdom Monera (bacteria) – prokaryotic unicellular
2. Kingdom Protista (amoeba) – eukaryotic unicellular
3. Kingdom Fungi - multicellular eukaryotic
4. Kingdom Plantae - multicellular eukaryotic
5. Kingdom Animalia – multicellular eukaryotic

1. Kingdom Monera (eg. Bacteria)

Habitats- omnipresent

Grouped in to 4 groups based on their shape.

1. Coccus (spherical)
2. Bacillus (rod)
3. Vibrio (comma)
4. Spirillum (spiral)

Mode of nutrition – autotrophs and heterotrophs.

Kingdom Monera – includes;

1. Archaeobacteria
2. Eubacteria (Cyanobacteria, Chemosynthetic and Heterotrophic)
3. Mycoplasma

a) Archaeobacteria – Harsh habitats → Halophiles (saline) Thermoacidophiles (hot spring), Methanogens (gut of ruminants)

b) Eubacteria – True bacteria - Rigid cell wall - Motile flagellum

Autotrophic bacteria - Cyanobacteria (BGA) have chlorophyll a unicellular, colonial/ filamentous.

Marine /terrestrial habitat/ gelatinous sheath

Form blooms - can fix nitrogen in heterocysts. Eg. Nostoc, Anabaena.

Chemosynthetic bacteria – Oxidise nitrates , nitrites and ammonia release energy (ATP) help in Recycling of nutrients (eg. Pseudomonas, nitrobacter)

Heterotrophic bacteria – Decomposers – making curd from milk, antibiotics, nitrogen fixing (Rhizobium) some are pathogenic (cause diseases) cholera, T.B, diarrhea.

Reproduction by binary fission, spore / sexual reproduction.

c) Mycoplasma. No cell wall – smallest living cell.

Anaerobic – pathogenic in animals and plants.

2. Kingdom protista

Unicellular – Eukaryotic – aquatic

Flagella / cilia - Reproduce sexually / asexually

a) Chrysophyta :

- Planktons diatoms and golden algae (desmids)
- Fresh water/ marine
- Microscopic – photosynthetic
- In diatoms , cell wall is indestructible (silica)form diatomaceous earth, its being gritty used for polishing, filtration of oil and syrups.

- Chief producers in oceans.
1. Dinoflagellates. Marine photosynthetic, yellow, green, blue or red pigments - Cell wall is cellulosic – have 2 flagella - Red dinoflagellate (*Gonyaulax*) forms red tides and toxins are released.
 2. Euglenoid eg. *Euglena*
Fresh water – stagnant water – no cell wall but protein rich layer is present, called pellicle. Pellicle is flexible with flagella – they are Mixotrophic, because Photosynthetic (in light) Heterotrophs (when no light).
Mixotrophs – Mixture of both autotrophs and heterotrophs.
 3. Slime moulds.
Saprophytic – body moves on decaying twigs and leaves
During suitable conditions form aggregation called plasmodium (mass of slime moulds)
Unfavourable conditions form spores and survive for many years.
 4. Protozoans – Heterotrophs – predators/ parasites

There are 4 major groups;

- Amoeboid protozoans. Fresh water, sea and moist soil -pseudopodia – marine forms have silica shells . *Entamoeba* (parasite) cause Amoebic dysentery
- Flagellated protozoans - free living / parasites have flagella – parasites cause diseases – Sleeping sickness (*Trypanosoma*) is a parasite of flagellated protozoans.
- Ciliated protozoans – aquatic cilia, cavity gullet eg. *Paramecium*.
- Sporozoans – Spore stage in their life cycle. *Plasmodium* causes malarial fever.

3.Kingdom Fungi:

- Multicellular – eukaryotic – heterotrophic - cosmopolitan - grow in warm and humid places.
- Fungi are filamentous with long, slender thread like Hyphae and the net work of hyphae is known as Mycelium – They can be septate or non septate (aseptate)
- Multinucleated cytoplasm (coenocytic hyphae)
- Cell wall is chitin.
- Parasitic/ symbionts (Lichens and Mycorrhizae)
- Symbionts of algae and fungi (Lichens) and Pine trees roots and fungi (Mycorrhizae) on roots to absorb water.

- Reproduction by fragmentation, fission, budding.
- Asexual reproduction by oospores, ascospores, basidiospores.
- Sexual reproduction steps.

1. Plasmogamy
2. Karyogamy and
3. Meiosis in zygote result in haploid spores – dikaryon

Dikaryophase → Zygote ($2n$ –diploid) →haploid Spores (n – haploid))

Based on morphology of mycelium mode of spore formation, fruiting bodies , there 4 classes;

1. Phycomycetes
2. Ascomycetes
3. Basidiomycetes
4. Deuteromycetes

1. **Phycomycetes** :

- Aquatic decaying wood mycelium is aseptate coenocytic
- asexual reproduction by zoospores (motile) / aplanospores (non motile)
- Eg. Rhizopus, mucor.

2. **Ascomycetes** : (Sac fungi)

- Multicellular (penicillium) / Unicellular (yeast)
- Saprophytic – decomposers – parasitic – coprophilous
- Mycelium is branched and septate –asexual spores are called conidia
- Sexual spores are called ascospores.
- Eg. Aspergillus, Neurospora

3. **Basidiomycetes** : (Eg. Mushroom/ bracket fungi/ puffballs)

- Grow in soil, logs, tree stumps, in plant bodies as parasitic (as rust and smuts)
- Mycelium is branched and septate
- Reproduction by fragmentation
- Dikaryon – basidium –karyogamy
- Eg. Agaricus (mushroom)

4. **Deuteromycetes** :

- Imperfect fungi mycelium is septate and branched.
- Only asexual reproduction by conidial spores
- Saprophytes / parasitic / decomposers
- Help in Mineral cycling
- Eg. Trichoderma, Alternaria

4.Kingdom Plantae :

Autotrophs – size varies from herbs to tall trees. There are different groups;

- Algae
- Bryophytes
- Pteridophytes
- Gymnosperms
- Angiosperms → Monocotyledons and Dicotyledons

5.Kingdom Animalia :

Heterotrophs – locomotory – holozoic / saprophytic / parasitic – cosmopolitans.

It consists of two subkingdom Invertebrata with 9 Phylum and Phylum Vertebrata (Chordata) with 5 Classes.

Virus:

Pasteur coined the term virus, which means Venom / poison. It is made of a outer protein coat and a centre genetic material (RNA / DNA). A virus is a nucleoprotein and the genetic material is infectious. Virus that infect plants have single stand RNA and those infect animals have either single or double RNA or double stranded DNA. Bacteriophages are viruses that infect the bacteria. Viruses cause disease like mumps, small pox, herpes, influenza and AIDS. In plants the symptoms can be mosaic formation, leaf rolling, and curling, yellowing, dwarfing and stunted growth.

Viroids

T.O. Diener discovered a new infectious agent that was smaller than viruses and caused potato spindle tuber disease. It has only a free RNA and lacked the protein coat, so named as viroid.

Lichens

Symbiotic association between algae and fungi. Phycobiont is algal component, which prepare food for fungi and Mycobiont is a fungal component, which provide shelter and absorb mineral nutrients and water for its partner.

CHAPTER – 3 : PLANT KINGDOM

- **Artificial classification** – oldest classification and it is based on few vegetative and sexual characters.
- **Natural classification system** – it is based on natural affinities among the organisms in their external and internal features.
- **Phylogenetic classification system** – it is based on evolutionary relationship
- **Numerical taxonomy** – by using computers numbers and codes are assigned to all the characters and data are processed.
- **Cytotaxonomy** – it is based on cytological information like chromosome number, structure and behavior.
- **Chemotaxonomy** – it is based chemical constituents of the plants.

1.ALGAE :

- Simple, thalloid, autotrophic, aquatic organisms.
- Habitats – grow in moist soil and wood.
- Symbiotic (Lichens) grow on other animals (sloth bear)
- Size ranges from Unicellular colonial (volvox), Filamentous (spirogyra) and Massive bodies (kelp)
- Reproduce vegetatively, asexually and sexually
- Spores are Zoospores (male) → isogamous / anisogamous; Oospores (egg).

Economic importance:

1. Porphyra, Laminaria, Sargassum are used as food.
2. Marine brown algae (Algin) and red algae (Carrageen) are used as **Hydrocolloids**, which is a fibrous structure holds water and used to transport seedling.
3. Gelidium, Gracilaria are used to grow microbes, make ice creams and jellies.
4. Chlorella and Spirulina are rich in proteins and used as food supplements.

Algae is divided into 3 main classes;

- a) Chlorophyceae – green algae
- b) Phaeophyceae – brown algae
- c) Rhodophyceae – red algae

a)Chlorophyceae (Green algae):

- Colonial / filamentous / unicellular
- Possess chlorophyll a & b
- Stored with proteins / starch
- Some store oil forms
- Cell wall is rigid and made of inner cellulose and outer pectose

- Vegetative reproduction is by fragmentation / spores
- Asexual reproduction is by flagellated Zoospores
- Sexual reproduction is by isogamous / anisogamous / oogamous

Examples : - Volvox, Spirogyra, Chlamydomonas

b)Phaeophyceae (Brown algae)

- Marine habitats – vary in size and form from simple branched to filamentous form, Kelp (100 m) possess chlorophyll a & c, carotenoid, Xanthophylls and Fucoxanthin.
- Food is stored as carbohydrates in the form of Laminarin / Mannitol
- They have cellulose wass with gelatinous coating of algin.
- They are attached to substratum by Holdfast (root like), Stalk (stipe) and leaf (frond)
- Vegetative reproduction by fragmentation
- Asexual reproduction is by biflagellated zoospores
- Sexual reproduction is by Isogamous / Anisogamous / Oogamous.

Examples :- Laminaria, Srgassum, Ectocarpus, Dictyota, Fucus.

c)Rhodophyceae (Red algae)

- They have red pigment called “r-phycoerythrin”.
- They are marine.
- Food is stored as Floridean starch, which is similar to amylopectin and glycogen in structure.
- Vegetative reproduction is by fragmentation.
- Asexually by non-motile spores.
- Sexually by non-motile gametes.

Examples : - Porphyra, Gracilaria, Gelidium.

II.BRYOPHYTES

- They live in moist shaded areas in the hill.
- It is known as “amphibians of plant kingdom”.
- They occur in damp soil, humid and shaded places.
- Plant body lacks true roots, stem, leaves, they are attached to the substratum by unicellular / multicellular Rhizoids.
- The main plant is haploid and they produce gametes (Gametophyte – dominant).
- The male sex organ is Antheridium (antherozoids)
- The female sex organ is Archegonium (single egg)
- Antherozoids are released in water come into contact with Archegonium to form Zygote.
- Zygote develops into Sporophyte (diploid) undergoes meiosis to form haploid spores germinate to produce Gametophyte.

Economic importance:

- Provide food for herbaceous mammals / birds.
- Sphagnum species (mosses) provide peat, used as a fuel.
- Due to its water holding capacity is used as packing material for trans-shipment of living materials.
- Mosses and Lichens form Pioneer community on bare rocks.
- Form dense mats on soil, so reduce the impact of rain and soil erosion.

Classes: - There are two classes → Liverworts, Mosses.

a) Liverworts :

- Moist, shady habitats, damp soil, bark of trees and deep in the woods.
- Plant body is Thalloid, have a tiny leaf structures.
- Asexual reproduction is by fragmentation / form gemmae (green, multicellular, asexual bodies) they detach from parent body and form as a new individual.
- Sexual reproduction → form male & female sex organs sporophyte is differentiated into a foot, setae and capsule.
- Spore germinate to form gametophyte.

Example :- Marchantia

b) Mosses :

- Gametophyte shows two stages → Protonema (spores) and Leafy stage (Secondary protonema)
- Attached to the soil by Rhizoids
- Vegetative reproduction is by fragmentation / budding
- Sexual reproduction is by antheridia and archegonia
- Zygote develops into sporophyte and form capsule and it contains spores (haploid)

Example :- Sphagnum, Funaria

III. PTERIDOPHYTES (first land plants):

They are used for medical purpose, ornamental and as soil binders and first terrestrial plants.

- They grow in cool, damp, shady places
- Possess vascular tissues (xylem and phloem)
- Main plant body is Sporophytes
- The body is differentiated into true roots, stem and leaves.

- Leaves may be small (microphylls – selaginella) or large (macrophylls – ferns) and bear sporangia and form sporophylls (leaf carrying spores).
- Sporangia produce spores by meiosis.
- Spore germinates to form gametophyte, called Prothallus.
- They need water for fertilization.
- Gametophyte bear male & female sex organs called Antheridia and Archegonia respectively.
- Gamete fusion results in zygote formation. Zygote develops into sporophytes (dominant phase).
- If all the spores are similar kind, it is called *Homospores*.
- Selaginella produce two kinds of spores, Macro and micro spores, hence known as *Heterosporous*.
- Macro and micro spores develop into female and male gametophytes respectively.
- Female gametophyte retained on sporophyte. It leads to the development of seed habit.

Classes: - There are four classes in Pteridophtae;

- a) Psilopsida – Ex. *Psilotum*
- b) Lycopsidea – Ex. *Selaginella*
- c) Sphenopsida – Ex. *Equisetum*
- d) Pteropsida – Ex. *Pteris*

IV. GYMNOSPERMS (Naked seeds)

- They are seed bearing plants.
- The ovules are not enclosed in an ovary, so no fruits.
- Tallest gymnosperm is Sequoia (red wood tree)
- Plant body is differentiated into roots, stems and leaves
- Roots are tap root – associated with other organisms like Pinus roots with Mycorrhizae and Cycas roots with Cyanobacteria like Nostoc and Anabaena (nitrogen fixing microbes)
- Stem can be branched / unbranched
- Leaves are simple / needle like – leaves show Xerophytic adaptation
- Gymnosperms are heterosporous, produce microspores and megaspores
- They form male cones & female cones
- Both cones can occur on some plant / different.
- Fertilization results in Zygote and embryo develops.
- Ovules form seeds.
- Gymnosperms show diplontic life cycle.
- They show Alternation of generation.

Examples ; - Pinus, Cycas, Cedrus

V. ANGIOSPERMS (flowering plants)

- They are flowering plants
 - Seeds are covered by fruits – live in wide range of habitats.
 - Size varies from tiny microscopic *Wolffia* to tall trees *Eucalyptus*.
 - Provide food, fodder, fuel and medicine.
 - There are two classes → Dicotyledons and Monocotyledons.
 - Male sex organ is Stamen and female is Pistil.
 - Ovules have embryo sac; it undergoes meiosis and form egg apparatus with one egg and 2 synergids, 3 antipodal cells and 2 polar nuclei.
 - Polar nuclei fuses to form secondary polar nucleus.
 - Pollen dispersal is by pollination – pollen tube grows in to stigma and style of pistil, one male gamete fuses with egg and form zygote and other male gamete fuses with secondary polar nucleus ($2n$) to form Primary Endosperm Nucleus (PEN - $3n$).
 - Due to two fusions, it is called Double fertilization.
- a) Zygote → Embryo
 - b) PEN → Endosperm (and nourishes embryo)
 - c) Synergids and antipodal cells → degenerate
 - d) Ovules → seeds
 - e) Ovary → Fruits
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CHAPTER – 4 : ANIMAL KINGDOM

Levels of organization :

1. Body symmetry
2. Nature of coelom (cavity)
3. Body plan
4. Pattern of development
5. Segmentation of the body
6. Presence/absence of notochord

1.Level of organization

- Cellular level - organ level
- Tissue level – organ system level (open and closed circulation)
- Complete/incomplete digestive system. (hydra)

2.Body symmetry

- A symmetry – Ex. Sponges
- Symmetrical → Bilateral symmetry (Annelids and Arthropods) and Radial symmetry (Ctenophora, Coelenterate and Echinoderms)

3.Nature of Coelom (Body cavity)

- Coelomate – body cavity with ecto, endo and mesoderms - Ex. Annelids, Molluscs, Arthropods, Echinoderms, hemichordates and chordates.
- Pseudocoelomate – no mesoderm, have only ectoderm and endoderm layers - Ex. Aschelminthes (round worms)
- Acoelomate – no body cavity - Ex. Platyhelminthes (flat worms)

4.Body plan

- Cell aggregate plan
- Blind sac body plan

5.Embryonic germinal layers

- Diploblastic (Coelenterates) – only ectoderm and endoderm
- Triploblastic organization (Platyhelminthes to Chordates)- ectoderm, endoderm and mesoderm

6.Segmentation- Metameric segmentation – true segmentation (metamerism) – Ex. - Earthworm

7.Notochord

- It is a mesodermal origin – rod like structure – animals with notochord are chordates and without that are non-chordates.

CLASSIFICATION OF ANIMALS:

1. Phylum - Porifera - Ex. Sponges.

- Marine , asymmetrical, cellular level of organization
- Have water canal system
- Ostia → Spongocoel → Osculum
- Choanocytes/ collar cells line in the spongocoel
- Digestion is intracellular
- Skeleton made up of spicules/ sponging fibres
- Hermaphrodite –male and female organs present on the same body.
- Reproduce asexually by fragmentation
- Sexually by gametes
- Fragmentation is internal and development is indirect
Eg. Sycon, spongilla.

2. Phylum Coelenterata (cnidaria) - Ex. Hydra

- Aquatic / marine
- Sessile (fixed) / free swimming
- Radially symmetrical
- Have cnidoblasts / cnidocytes, stinging capsule on tentacles
- Used for defense, anchorage and to capture the prey
- Tissue level of organization diploblastic
- Mouth on hypostome.
- Digestion extracellular and intracellular
- Corals have skeleton made of calcium carbonate.
- Exhibit 2 basic forms called polyp and medusa.
- Polyp is sessile cylindrical (hydra)
- Medusa is umbrella shaped free living (jelly fish)
- They show alternation of generation (metagenesis) where polyp forms medusa asexually and medusa forms polyp sexually. Ex. Obelia
- Ex. - Hydra, Physalia, Sea anemone, Sea pen, Sea fan, Brain coral.

3. Phylum - Ctenophora (sea walnuts/comb jellies)

- Marine , radially symmetrical diploblastic
- Tissue level of organization
- Body bears 8 rows ciliated comb plates help in locomotion
- Digestion by intra and extra cellular
- Bioluminescence is well developed
- Sexes are not separate (monoecious)
- Reproduce by sexual reproduction
- Fertilization is external and indirect development.
Ex. - Pleurobrachia and ctenoplana

4. Phylum – Platyhelminthes (flat worms)

- Dorso-ventrally flattened body
 - Endoparasites, bilaterally symmetrical
 - Organ level of organization
 - Triploblastic - acocelomate
 - Hooks and suckers are present
 - Flame cells for excretions
 - Sexes are not separate - fertilization is internal and development is through many larval stages
 - Have high regeneration capacity
- Ex.- Tape worm, Planaria, Liver fluke

5. Phylum - Aschelminthes (round worms)

- Free living, aquatic, terrestrial parasitic
 - Organ system level of body organization
 - Bilaterally symmetrical and triploblastic
 - Pseudocoelomate
 - Digestive system is complete (mouth and anus)
 - Sexes are separate (dioecious)
 - Fertilization is internal and development is direct.
- Ex. Ascaris, Wuchereria (filarial worm) and Ancylostoma (hookworm)

6. Phylum – Annelida (annulus little ring)

- Aquatic/terrestrial
- Freelifving/ parasites
- Organ system level of body organization
- Bilaterally symmetrical
- Triploblastic
- Metamerically segmented – coelomate
- Metameres/body is segmented
- Marine Nereis possess parapodia
- Possess longitudinal and circular muscles help in locomotion
- Closed circulatory system
- Nephridia help in osmoregulation and excretion
- Dioecious (sexes are separate)
- Earthworm and leeches are monoecious
- Reproduction is sexual

Eg. Nereis, Pheretima (earth worm) and Hirudinaria (blood sucking leech)

7. Phylum – Arthropoda – (jointed legs)

- Largest phylum 2/3 are insects
- Organ system level of body organization
- Bilaterally symmetrical

- Segmented and coelomate
- Chitinous exoskeleton.
- Body has head thorax and abdomen.
- Have jointed appendages(organs for locomotion) respiratory organs are gills/book gills/Book lungs / tracheal system
- Open circulatory system.
- Sense organs are antennae, eye, statocysts (balance organs)
- Fertilization is internal.
- Excretion by malpighian tubules.
- Sexes are separate (Dioecious)
- Oviparous
- Development may be direct/ indirect
- Economic importance-
 - Honey bees (*Apis*)
 - Silkworm worm (*Bombyx*)
 - Vectors. Mosquito, Housefly
 - Aquatic –crab, prawn, lobster

7.Phylum - Mollusca: (soft bodied and shelled)

- Second largest phylum
- Terrestrial and aquatic
- Organ system level of body organization
- Bilaterally symmetrical
- Triploblastic and Coelomate
- Calcereous shell and unsegmented body with head muscular foot and visceral hump
- Soft spongy layer of skin forms a mantle over the visceral hump
- Gills for respiration and excretion
- Head has sensory tentacles
- Mouth has file like rasping organ for feeding radula
- Sexes are separate (Dioecious)
- Oviparous
- Indirect development
Eg. Oyster, snail, squid, devil fish

8.Phylum - Echinodermata: (spiny skinned)

- Spiny skin has exoskeleton which is calcareous ossicles
- Marine organ level of body organization
- Radially symmetrical
- Coelomate
- Triploblastic
- Mouth of the lower side and anus on the upper side.

- Have water vascular system, help in locomotion, to capture and transport of food and for respiration
- Excretory system is absent
- Dioecious and fertilization is external, development is indirect with free swimming larva
Ex. Starfish, sea urchin, sea lily, sea cucumber

9. Phylum – Hermichordata

- Under non chordate
- Worm like marine animals
- Organ system level of organization
- Bilaterally symmetrical, triploblastic
- Coelomate – body has anterior proboscis, a collar and a long trunk
- Circulatory system is open type
- Respiration is through gills
- Excretory organ is proboscis gland
- Sexes are separate
- Fertilization is external
- Development is indirect
Ex. Balanoglossus

10. Phylum – Chordata

- Presence of notochord dorsal hollow spinal cord – nerve cord and paired pharyngeal gill slits
- Bilaterally symmetrical and triploblastic
- Coelomate organ system level of organization
- Have post and tail
- Closed circulatory system

Chordates

1. Notochord present
2. Central nervous system is dorsal hollow and single
3. Gills are present
4. Heart is ventral
5. Tail is present

Non chordates

1. Notochord is absent
2. Central nervous system is ventral, solid and double
3. Gills are absent
4. Heart is dorsal
5. Tail is absent

Chordata - Urochordata, Cephalochordate and Vertebrata (protochordates)

Urochordata – notochord present in larval tail eg. Ascidia, salpa

Cephalochordate – notochord extends from head to tail eg. Amphioxus

1. Subphylum – Vertebrata:

- Possess notochord (replaced by vertebral column)
- All vertebrates are chordates but not all chordates are vertebrates (all vertebrates have vertebral column, but all chordates do not have vertebral chord).

- Ventral muscular heart
- Excretion by kidneys
- Fins / limbs for locomotion

a)Super class – Agnatha (without jaw)

Class – Cyclostomata

- Ectoparasites on some fishes.
- Elongated body with 6-15 pairs of gill slits
- Sucking circular mouth without jaw
- Body is devoid of scales – paired fins
- Cranium and vertebral column are cartilaginous
- Circulation is closed –marie but migrate to fresh water for spawning
- After spawning they die
- Larvas, metamorphosis and return to the ocean

Ex. Lamprey, Hagfish

b)Super class - Gnathostomata (with jaw)

- Jaws are present
- Paired lateral appendages

There are six classes:

Class – Chondrichthyes:

- Cartilage fish, endoskeleton is cartilage
- Body is stream lined
- Pelvic fins in male with claspers
- 5-7 pairs of gills.
- No operculum
- Mouth in ventral with teeth.
- Jaws are powerful
- Air bladder is absent
- Heart is 2 chambered (1 auricle and one ventricle)
- Some possess electric /poison stings
- Poikilothermous (cold blooded)
- Body has placoid scales
- Unisexual
- Viviparous and fertilization is internal

Eg. Shark, sting rays.

Class – Osteichthyes - boney fish

- Endoskeleton is bone. Skin is covered by cycloid scales.
- Four pairs of gill slits with operculum, mouth is terminal, air bladder is present and help in buoyancy.

- Heart is two chambered (1 auricle and 1 ventricle)
- Poikilotherms (cold blooded)
- Sexes are separate ,fertilization is external and oviparous
Ex. Angel fish, Clown fish, Rohu, Katla, Tilapia, Hippocampus.

Class – Amphibia - dual life

- Live on land and move to water for breeding
- Body has head and trunk
- Tail is in larval stage – two pairs of limbs
- Digits without claws.
- Poikilotherms – eyes are with nictitating membranes
- Skin is smooth and moist with mucous glands
- Tympanum is ear drum
- Heart is three chambered (two auricle and one ventricle)
- Respiration by gills in larva and by lungs and skin in adults.
- Digestive system
- Urinary tract and reproductive tract open into a common cloacal chambers and the
Opening is called cloacal aperture.
- Sexes are separate
- Oviparous
- Fertilization is external and development is indirect with tadpole larva
Ex. Toad, Frog

Class – Reptilia

- Skin is dry without glands.
- Covered by horny epidermal scales (scutes)
- Tympanum is small no external opening
- 12 pairs of cranial nerves
- Trunk bears two pairs of pentadactyl limbs with claws.
- Heart with three and half chambered (two auricle, one which is incompletely partitioned ventricle)
- Only Crocodiles have four chambered heart
- Respiration is by lungs.
- Fertilization is internal.
- Oviparous and egg is covered by hard calcareous shells
Ex. Snake, Tortoise, Turtle, Viper, Lizard

Class – Aves

- Streamlined body and covered with feathers
- Jaws are modified into beaks, teeth absent , various shapes and sizes of beaks
- Digestive system has two structures – crop and gizzard (grinding the food)
- Forelimbs form wings.

- Hind limbs modified for perching, swimming, running, etc.
- Voice box called syrinx is present
- Respiration is by lungs.
- Skin is dry with oil glands, at the base of tail.
- Bones are pneumatic bones (air cavities) helps to make the body light.
- Homeiothermous
- Heart is 4 chambered
- Oviparous and egg is with calcareous shells.
- Fertilization is internal.

Ex. Pigeon, Crow, Sparrow, Ostrich.

Class- Mammalia

Aquatic/aerial/terrestrial

Body has head, neck, trunk and tail

Have mammary glands in females

External ear (pinna) is present

Skin has sweat glands and sebaceous glands

Heart is 4 chambered

Respiration is by lungs.

Body has hair

Excretion is by kidneys (ureotelic – urea)

Sexes are separate

Viviparous (give birth young ones)

Few are ovoviviparous – egg laying mammals (Platypus)

Few are marsupials – pouched mammals with brood pouches (Kangaroo)

Ex. *Canis macaca*, *Camelus*, *Dolphin*.
