



# **GENERAL SCIENCE & TECHNOLOGY**

**For UPSC, State PSC Civil Services & other exams**

**Volume - 1**

**Biology and Environmental Issues**



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# 1

## CHAPTER

# Introduction to Biology



- Biology is the science of life forms and living processes. The living world comprises an amazing diversity of living organisms.
- The word "**Biology**" comes from the **Greek words**:
  - ✓ "**Bios**" = Life
  - ✓ "**Logos**" = Study

Major Branches of Biology	
Field	Study Area
<b>Molecular Biology</b>	Study of biological molecules like <b>DNA, RNA, and proteins</b> in cellular functions.
<b>Evolutionary Biology</b>	Study of the <b>origin, changes, and development</b> of species over time.
<b>Anatomy</b>	Study of the <b>structure and organs</b> of living organisms.
<b>Pathology</b>	Study of <b>diseases</b> , their causes, and effects on the body.
<b>Environmental Biology</b>	Study of organisms in relation to <b>pollution, conservation, and sustainability</b> .
<b>Forensic Biology</b>	Use of biological knowledge in <b>crime investigations</b> (DNA fingerprinting).
<b>Pharmacology</b>	Study of <b>drugs and their effects</b> on biological systems.
<b>Epistemology</b>	The <b>philosophical study</b> of the <b>nature, origin, and limits of human knowledge</b> .

<b>Phenology</b>	The study of <b>seasonal changes</b> in plants and animals, such as <b>flowering, migration, and breeding cycles</b> , in response to <b>climate and environmental factors</b> .
<b>Entomology</b>	The scientific study of <b>insects</b> , their behavior, life cycles, and ecological roles.
<b>Palynology</b>	Study of plant pollen, spores, and microscopic plankton (living & fossil forms).
<b>Herpetology</b>	The study of <b>reptiles and amphibians</b> , including snakes, lizards, frogs, and salamanders.
<b>Ethology</b>	The scientific study of <b>animal behavior</b> in their natural environments.
<b>Dendroclimatology</b>	The study of past <b>climatic conditions</b> using <b>tree rings</b> (dendrochronology) to analyze environmental changes over time.
<b>Phenology</b>	The study of <b>biological events</b> influenced by <b>seasonal and climatic changes</b> , such as bird migration and plant blooming.
<b>Chiropody</b>	The medical field concerned with the <b>diagnosis and treatment of foot disorders</b> (now more commonly referred to as <b>Podiatry</b> ).

<b>Oikology</b>	Greek term used by <b>Ernst Haeckel (1866)</b> for the study of animal relations with organic & inorganic environment (Ecology).
<b>Histology</b>	Study of microanatomy of cells, tissues, and organs under a microscope.
<b>Synecology</b>	Branch of ecology studying structure, development & distribution of ecological communities.
<b>Ornithology</b>	Scientific study of birds.
<b>Mycology</b>	Branch of biology that studies fungi
<b>Founder / Father of Biology, Botany &amp; Zoology</b>	
<b>Field</b>	<b>Father / Founder</b>

<b>Father of Biology</b>	Aristotle (Studied life forms and classified organisms).
<b>Father of Botany</b>	Theophrastus (Wrote <i>Historia Plantarum</i> , first systematic classification of plants).
<b>Father of Zoology</b>	Aristotle (Studied animal anatomy, behavior, and classification).
<b>Father of Genetics</b>	Gregor Mendel (Laws of Inheritance through pea plant experiments).
<b>Father of Modern Taxonomy</b>	Carl Linnaeus (Binomial nomenclature system).
<b>Father of Microbiology</b>	Antonie van Leeuwenhoek (Discovered microorganisms using a microscope).

# 2

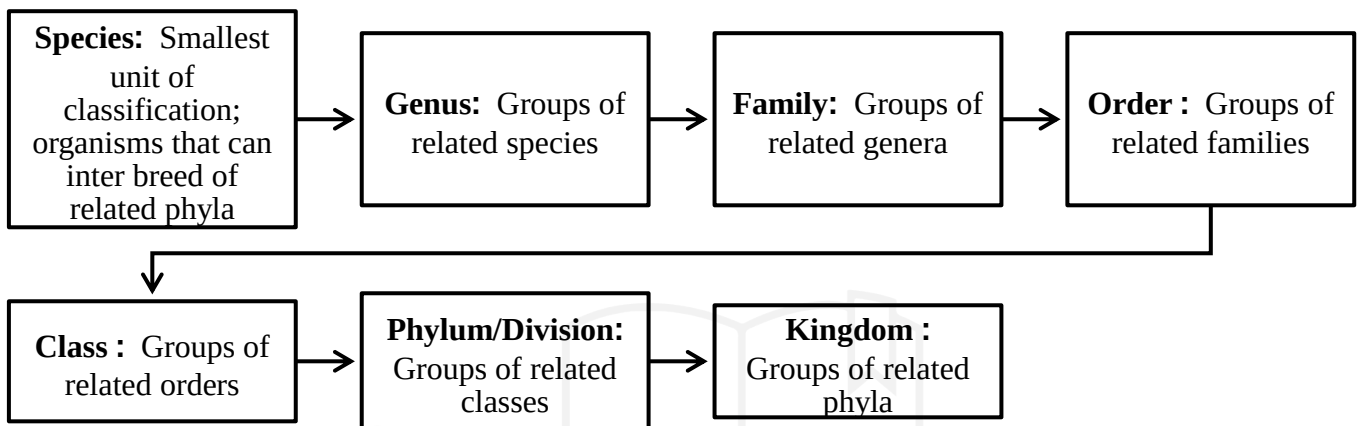
## CHAPTER

# Classification of Living Being (Bacteria and Others)



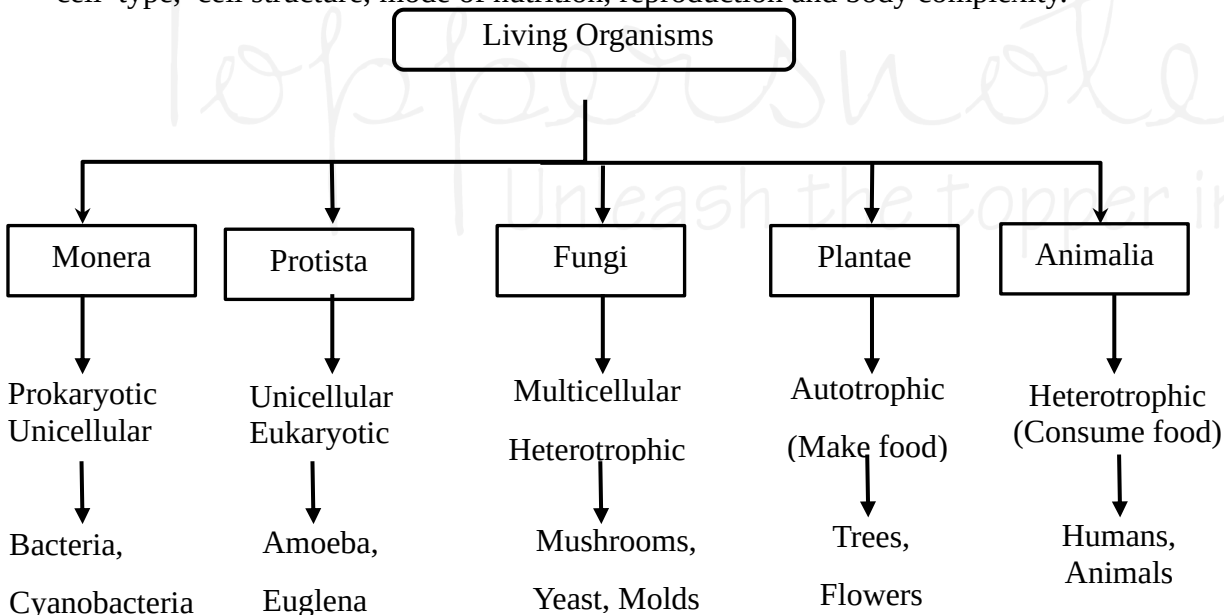
### Classification:

- **Classification** is the scientific grouping of organisms based on **similarities and differences**.
- Each group is a **taxon**, arranged in a **taxonomic hierarchy** given by **Carolus Linnaeus (1751)**, the **Father of Taxonomy**, who introduced **binomial nomenclature** (Genus + Species), e.g., *Homo sapiens*.



### Classification of Living Organism:

- **RH Whittaker (1969)** proposed a five-kingdom classification system based on certain criteria like cell type, cell structure, mode of nutrition, reproduction and body complexity.



### Monera (Kingdom that includes bacteria):

- **Kingdom Monera**, proposed by **Ernst Haeckel (1866)**, includes all **unicellular prokaryotes** (no true nucleus). It contains **Archaeobacteria, Eubacteria, Cyanobacteria, and Mycoplasma**.
- **The Mycoplasma (Joker of Microbiology)** are organisms that completely lack a cell wall and these are **prokaryotic organisms contain both RNA and DNA**. It was discovered in **1889** by **Albert Frank**. (PPLo: **Pleuro Pneumonia Like Organism; Size of PPLo** in Mycoplasma – About **0.1 µm**.)

- Bacteria can be **autotrophic** or **heterotrophic**, and many act as **decomposers**.
- **Bacteria** are the sole members of the Kingdom Monera.
- **Archaeobacteria (Ancient Bacteria)** These are a group of prokaryotes and are also known as **living fossils**. Examples: **Methanogens, Halophiles, Thermophiles**.
- **Eubacteria**
  - ✓ Eubacteria are true bacteria first observed by Leeuwenhoek in 1676 and later named as bacteria by Ehrenberg in 1928.
  - ✓ They are prokaryotic organisms characterized by a rigid cell wall containing peptidoglycan, which provides structural support.
  - ✓ They are characterized by the presence of a rigid cell wall Contains **peptidoglycan** (provides structural support).
  - ✓ Note: Staphylococcus aureus has a thick cell wall composed of several layers of peptidoglycan and teichoic acid.
  - ✓ if they are motile, they have flagellum that is a **thin filamentous extensions** from bacterial cell wall and Composed of **three parts**: filament, hook, and basal body; **Longest part of bacterial flagellum – Filament**; it Does not include Torso).

- ✓ **Length of a bacterial cell:** Typically ranges from **0.2 to 10 µm (Generally: 3 to 5 µm)**.
- ✓ **Shapes & Example: Cocci** (spherical) – *Streptococcus pneumoniae*; **Bacilli** (rod-shaped) – *Escherichia coli*; - **Spirilla** (spiral) – *Spirillum volutans (Spiral shape Bacteria)*; **Vibrios** (comma-shaped) – *Vibrio cholerae*.
- ✓ **Beneficial Roles: Nitrogen Fixation** (*Rhizobium*); **Decomposers** (break down organic matter); **Food Industry** (*Lactobacillus* in yogurt, cheese); **Biotechnology** (genetic engineering, antibiotic production).
- The cyanobacteria (also referred to as **blue-green algae**) have chlorophyll similar to green plants and are **photosynthetic autotrophs**.

### Protista:

- Proposed by **Haeckel (1886)**, includes all **unicellular eukaryotes** that are mostly **aquatic** and have **membrane-bound organelles** like mitochondria and plastids.
- Phytoplankton (Primary Producer) are **photosynthesis**, so they are responsible for the maximum amount of photosynthesis (80 %) occurring on the Earth.

### Key Feature

Organism	Main Characteristics	Special Features
<b>Amoeba</b>	Unicellular organism with no fixed shape; lacks mouth and anus; contains granular nucleus, food vacuoles, and contractile vacuoles in endoplasm	Engulfs food using pseudopodia; forms food vacuole where digestive enzymes digest food
<b>Paramecium</b>	Unicellular organism with definite and fixed shape; commonly found in freshwater	Moves and feeds using cilia
<b>Gonyaulax</b>	Microscopic organism belonging to dinoflagellates	Bioluminescent; produces light through chemical reactions inside the cell

### Fungi:

- Fungi are eukaryotic, heterotrophic organisms belonging to Kingdom Fungi that absorb nutrients from organic matter and show great diversity in morphology and habitat.
- They are cosmopolitan in distribution, found in air, water, soil, and on plants and animals, and grow well in warm and humid conditions (e.g., bread, pickles, leather, clothes).



- Their cell wall is made of chitin instead of cellulose.
- Based on nutrition, fungi may be saprophytic (feed on dead matter), parasitic (obtain nutrients from living hosts), or symbiotic (mutual benefit as in lichens and mycorrhizae).
- Reproduction occurs asexually by spores, budding, or fission, and sexually through fusion of gametes involving plasmogamy, karyogamy, and meiosis.
- Fungi may be unicellular (yeast) or multicellular (mushrooms and other fungi).

## Yeast

- Yeast is a unicellular, eukaryotic fungus of Kingdom Fungi; microscopic and usually oval or spherical in shape, commonly called a “sugar-eating fungus.”
  - It reproduces asexually mainly by budding and sometimes by binary fission, while sexual reproduction occurs under stress conditions through spore formation (sporulation).
  - Yeast is widely used in fermentation, baking, medicine, and biotechnology; *Saccharomyces cerevisiae* is used in bread making and alcoholic fermentation where pyruvate is converted into ethanol and carbon dioxide.
- It is used in producing enzymes, vaccines, insulin, antibiotics, probiotics, and antifungal treatments; yeast with hydrogen peroxide releases oxygen.
  - Fungi secrete enzymes such as cellulases that break down complex organic materials like cellulose, hemicellulose, and lignin into simpler sugars for energy.
  - *Penicillium* is a saprophytic fungus growing on decaying matter, known for producing the antibiotic penicillin (discovered by Alexander Fleming), though some species produce harmful mycotoxins.



ToppersNotes  
Unleash the topper in you

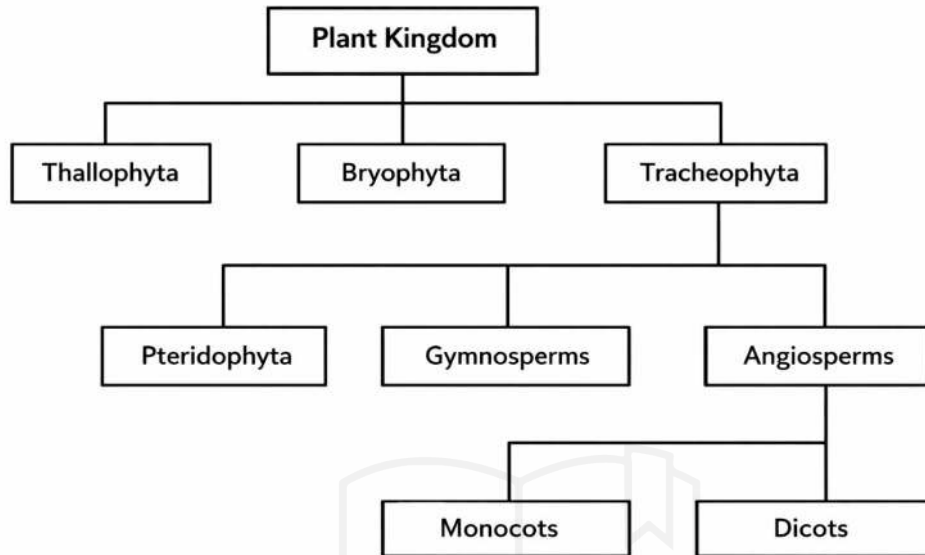
# 3

## CHAPTER

# Plant Kingdom



- Kingdom **Plantae** consists of **multicellular** and **autotrophic organisms** that primarily use **photosynthesis** to produce their own food.



### Thallophyta (Algae):

- Thallophyta are mostly aquatic, simple organisms with an undifferentiated body lacking true roots, stems, and leaves.
- They are mainly autotrophic and perform photosynthesis, commonly represented by algae.
- Their cell walls are made of cellulose and they lack vascular tissues like xylem and phloem.
- The group includes algae, fungi, lichens, bacteria, and slime molds, though fungi and some bacteria are heterotrophic.
- Thallophytes are broadly divided into algae and fungi, and their structure and reproduction were described by F.E. Fritsch (1935).

### Classification of Algae

Feature	Chlorophyta (Green Algae)	Brown Algae (Phaeophyceae)	Red Algae (Rhodophyceae)
Common Name	Green algae	Brown algae	Red algae
Habitat	Freshwater and marine	Mostly marine	Mostly marine
Basic Nature	Chlorophyll-bearing, autotrophic, thalloid organisms	Marine multicellular algae	Marine algae
Pigments	Chlorophyll present (green color)	Fucoxanthin (brown pigment)	Red pigments (phycoerythrin)
Cell Wall	Inner cellulose layer and outer pectose layer	Cellulose with alginates	Cellulose and gelatinous substances
Food Storage	Starch stored in pyrenoids	Laminarin and mannitol	Floridean starch
Organization	Unicellular and multicellular forms	Mostly multicellular	Mostly multicellular

Examples	Chlamydomonas, Spirogyra, Ulva, Cladophora, Chara, Volvox	Sargassum, Laminaria (kelp), Fucus	Gracilaria, Gelidium
Reproduction	Isogamy (Spirogyra), anisogamy (Eudorina), flagellated gametes (Volvox)	Sexual and asexual reproduction	Vegetative reproduction by fragmentation
Economic Importance	Chlorella and Spirulina used as protein-rich food supplements	Produce hydrocolloids used in food and pharmaceutical industries	Produce agar used in food and microbial culture
Special Features	Primary producers; major role in CO <sub>2</sub> fixation; absorb nutrients directly from surroundings	Found in deep, nutrient-rich marine waters	Agar used in jellies, ice-creams, and microbial growth media

### Lichen

- Lichens are slow-growing, colorful organisms commonly found on tree bark and rocks.
- They are formed by a symbiotic association between fungi and algae or cyanobacteria.
- Both partners depend on each other for survival and cannot live independently in nature.
- Lichens help in ecological succession by growing on bare rocks and aiding soil formation.
- They are sensitive to air pollution and are used as pollution indicators; litmus dye is obtained from lichens.

### Bryophyta:

- Bryophytes are small, non-vascular plants called the amphibians of the plant kingdom because they live in moist habitats and require water for reproduction.
- They lack true roots, stems, leaves, and vascular tissues like xylem and phloem.
- Common examples include mosses, liverworts (Marchantia), and hornworts.
- They grow mainly in moist, shady environments such as damp soil, rocks, and forest floors.
- Bryophytes reproduce by spores, and fertilization requires water as flagellated sperm swim to the egg.

### Classification of Bryophyta:

Feature	Liverworts (Marchantiophyta)	Mosses (Bryophyta)
Basic Nature	Non-vascular plants	Non-vascular plants
Habitat	Grow in moist places where conditions support plant growth	Found in moist, shady areas; can survive on land but need water for reproduction
Body Structure	Lack true roots, stems, and leaves	Lack true roots, stems, and leaves; have leaf-like structures and rhizoids
Reproduction	Reproduce through spores	Reproduce through spores; peristome helps in spore dispersal
Special Features	Historically believed to treat liver ailments	Help prevent soil erosion, retain moisture, and provide habitat for small organisms

### Important Mosses Species

Moss Species	Key Features	Habitat / Use
<b>Dawsonia superba</b>	Tallest self-supporting moss, acrocarpous	Found in New Zealand, grows up to 60 cm
<b>Funaria</b>	Small moss with twisted hygrosopic setae ("cord moss")	Found in various terrestrial habitats

<b>Sphagnum (Peat Moss)</b>	Forms dense mats, retains water, provides peat used as fuel, rich in nutrients	Wetlands, bogs; used for domestic heating, energy, and horticulture
<b>Hornwort</b>	Flowerless, spore-producing with horn-like capsule	Moist soils; resembles liverworts in gametophyte stage

## Pteridophyta (Ferns and Allied Plants) :

- Pteridophytes are vascular, flowerless plants that reproduce by spores and possess xylem and phloem.
- They have true roots, stems, and leaves (fronds), representing an important step in plant evolution.
- Common examples include ferns (Pteris, Nephrolepis, Adiantum), Equisetum, Selaginella, and Azolla.
- Spores are produced in sporangia, usually found on the underside of leaves, so they are called cryptogams.
- Some species act as soil binders and have medicinal importance, while Azolla helps in nitrogen fixation in aquatic ecosystems.
- They do not produce flowers or seeds but can grow larger due to well-developed vascular tissues.
- Horsetails (Equisetum) are the only living representatives of **Sphenopsida**, with underground creeping rhizomes giving off aerial and subterranean branches.
- Ferns like Azolla float in water and perform nitrogen fixation in aquatic ecosystems.

## Gymnosperms :

- Gymnosperms are seed-producing vascular plants with “naked seeds,” meaning the ovules are not enclosed within an ovary.
- They are mostly evergreen, woody trees or shrubs, flowerless and fruitless, with seeds formed on cone scales.
- Pollination occurs mainly by wind, and they can survive in extreme climatic conditions.

- Ovules are borne on the surface of sporophylls, which are arranged spirally on the axis of the cone.
  - ✓ They are heterosporous, producing microspores (male pollen grains) and megaspores (female gametophyte).
- Reproduction takes place through cones (strobili), and double fertilisation is absent.
- Major groups include Cycadophyta (Cycas) and Coniferophyta (Pinus, Cedrus, Picea, Sequoia), along with Ginkgophyta and Gnetophyta.
- Common examples are pine, cedar, Cycas, Ginkgo biloba (living fossil), Gnetum, Ephedra, and Welwitschia.
- Sequoia sempervirens (redwood) is the tallest known gymnosperm tree.

## Angiosperms (Magnoliophyta):

- Angiosperms are flowering, vascular plants with seeds enclosed inside fruits; the term means “enclosed seed.”
- Seeds develop within the ovary of a flower, and after fertilization the ovary forms the fruit.
- Flowers act as reproductive organs and help in pollination and fertilization.
- Double fertilization is a unique characteristic feature of angiosperms.
- They are the most abundant and widely distributed plants on Earth.
- Angiosperms are classified into monocots (one cotyledon, parallel venation, fibrous roots) and dicots (two cotyledons, reticulate venation, tap root system).
- Examples include rice, wheat, maize, banana (monocots) and mango, mustard, rose, hibiscus, and bean (dicots).

## Reproductive Types of Flowers

Type	Description	Examples
<b>Bisexual (Hermaphrodite) Flowers</b>	Contain both <b>male (androecium)</b> and <b>female (gynoecium)</b> reproductive parts in the same flower.	<i>Hibiscus, Mustard</i>
<b>Unisexual Flowers</b>	Have <b>either male (staminate)</b> or <b>female (pistillate)</b> reproductive parts.	<i>Watermelon, Papaya, Pumpkin, Cucumber</i>

<b>Monoecious Plants</b>	Both male and female flowers occur <b>on the same plant.</b>	<i>Maize, Cucumber, Fig, Melon, Coconut</i>
<b>Dioecious Plants</b>	Male and female flowers occur <b>on different plants.</b>	<i>Papaya, Date palm</i>

### Important Flower Families

Family	Flower Type	Key Features	Examples
<b>Fabaceae</b>	Bisexual, zygomorphic	5 sepals, 5 petals, 10 stamens (diadelphous), 1 carpel	Pea, Gram, Beans
<b>Solanaceae</b>	Bisexual, actinomorphic	5 sepals and petals united, 5 stamens	Tomato, Potato, Brinjal
<b>Liliaceae</b>	Bisexual, actinomorphic	6 tepals, 6 stamens, 3 carpels (superior ovary)	Onion, Lily, Aloe
<b>Brassicaceae</b>	Bisexual, actinomorphic	4 sepals, 4 petals, 6 stamens (tetradynamous), 2 carpels	Mustard, Radish, Cabbage
<b>Mimosaceae</b>	Sensitive, compound leaves	Rapid movement on touch (thigmonasty)	Mimosa pudica (Touch-me-not)

### Examples and Botanical Names

Common Name	Scientific Name	Family
Mango	<i>Mangifera indica</i>	Anacardiaceae
Field Mustard	<i>Brassica campestris</i>	Brassicaceae
Wheat	<i>Triticum aestivum</i>	Poaceae
Touch-me-not	<i>Mimosa pudica</i>	Mimosaceae
Rafflesia (largest flower)	<i>Rafflesia arnoldii</i>	Rafflesiaceae

- Anthocyanins are water-soluble pigments responsible for red, purple, and blue colours in flowers, fruits, and vegetables and also act as antioxidants.
- These pigments are stored in the vacuoles of plant cells.
- Herbs are small, soft, green plants with tender, non-woody stems (e.g., grasses, ferns, coriander).
- Shrubs are medium-sized woody plants with branches arising near the base (e.g., China rose, Bougainvillea).
- Trees are tall, woody plants having a single main trunk (e.g., mango, neem, banyan).

# 4

## CHAPTER

# Animal Kingdom



### Phylum - Porifera:

- Named **Zoophyte** by Lamarck (1801) and **Porifera** by Robert Grant (1825); first primitive multicellular, pore-bearing aquatic animals (sponges).
- Mostly **marine**, some freshwater species like *Spongilla*.
- Exhibit **cellular-level organization**, generally **asymmetrical**, with a body full of **pores (ostia)** and a large opening (**osculum**).
- Body wall has two layers — outer pinacoderm, inner choanoderm, separated by mesenchyme with various cells.
- Choanocytes (collar cells) generate water currents for feeding, respiration, and waste removal; their structure resembles choanoflagellates.
- Feed by **trapping food particles** with microvilli collars; respiration occurs by **diffusion**.
- Reproduce **sexually and asexually** (budding or fragmentation).

### Examples

Example	Habitat / Key Feature
<b>Sycon (Scypha)</b>	Marine sponge, cylindrical body, found attached to rocks in shallow waters.
<b>Spongilla</b>	Freshwater sponge found in ponds and slow-moving streams; belongs to the family <i>Spongillidae</i> .
<b>Euspongia (Bath sponge)</b>	Marine sponge used commercially for bathing.
<b>Hydra</b>	<b>Not a sponge</b> ; belongs to <b>phylum Cnidaria</b> , known for regeneration. Included for contrast.

### Phylum-Coelenterata (Cnidaria):

- Includes **corals, jellyfish, sea anemones, hydra, sea pens**, mostly marine, **radially symmetrical** and **diploblastic** with a gastrovascular cavity.

- Body wall has **epidermis, gastrodermis**, and gelatinous **mesoglea**; sac-like body with a single opening for ingestion and excretion.
- Possess **cnidocytes** with **nematocysts** for **prey capture and defense**; respiration and excretion occur by **diffusion**.
- Lack circulatory and excretory systems; rely on **simple body organization** for physiological functions.
- Exhibit **polyp (sessile) and medusa (free-swimming) forms**; reproduction is **sexual and asexual**, often with alternation of generations (e.g., *Obelia*).
- **Aurelia** (moon jellyfish) represents the **medusa stage**, showing typical jellyfish features with umbrella-shaped bodies.
- **Corals** (e.g., *Meandrina – Brain Coral*) are **sessile colonial cnidarians** forming reefs in symbiotic association with **algae (zooxanthellae)** that provide energy via **photosynthesis**.
- **Pennatula (Sea Pen)** is a **bioluminescent colonial cnidarian**, resembling a feather with a central stalk and lateral branches.
- **Adamsia (Sea Anemone)** exhibits a **symbiotic relationship with hermit crabs**, offering protection with its nematocysts.
- Some species show **symbiosis**, like corals with algae (*zooxanthellae*) or sea anemones with hermit crabs (*Adamsia*).
- Notable examples: Hydra, Aurelia, Obelia, Meandrina (Brain Coral), Pennatula, Adamsia.

### Phylum – Platyhelminthes

#### (Flatworms):

- Soft-bodied, unsegmented, **dorsoventrally flattened, bilaterally symmetrical**, and **triploblastic** invertebrates; mostly parasitic (~80%), some free-living (e.g., *Planaria*).
- **Acoelomates**: lack a true body cavity; body filled with **parenchyma** for nutrient distribution; organ-level organization but no complex organ systems.

- Digestive system **incomplete**, single opening for mouth and anus; respiration via **diffusion**.
- Specialized excretory structures called **flame cells** (part of protonephridia) handle osmoregulation and nitrogenous waste removal.
- Reproduction **hermaphroditic**, both **sexual (internal fertilization)** and **asexual** via regeneration or fission.
- Remarkable ability for **regeneration**, allowing lost body parts to regrow.
- Notable examples: *Planaria* (free-living), *Fasciola* (liver fluke), *Tapeworm (Cestoda)*.

### Phylum – Nematoda (Roundworms):

- Body **cylindrical in cross-section**, tapering at both ends, giving the name “roundworms.”
- Mostly **free-living** (aquatic or terrestrial) or **parasitic** in plants and animals.
- **Organ-system level** of body organization; **bilaterally symmetrical, triploblastic**, and **pseudocoelomate**.
- **Alimentary canal complete**, with a well-developed **muscular pharynx** for feeding.
- Reproduction is sexual, usually with separate sexes (dioecious).
- **Examples:** *Ascaris* (roundworm), *Wuchereria* (filarial worm), *Ancylostoma* (hookworm), *Enterobius* (pinworm), *Trichinella*.

### Phylum – Annelida (Segmented Worms):

- Segmented worms including **earthworms, leeches, and marine worms**, with ~22,000 species adapted to terrestrial, freshwater, and marine habitats.
- Bodies are **metamerically segmented** with **circular and longitudinal muscles** for locomotion and burrowing.

- Respiration occurs through **moist skin; coelomic fluid** and **circulatory system** transport nutrients and oxygen; earthworms have **5 pairs of hearts**.
- **Well-developed alimentary canal:** pharynx → esophagus → crop → gizzard → intestine; waste removed via **nephridia**.
- **Sensory system** includes cerebral ganglia to detect moisture, heat, light, and vibrations.
- Reproduction: **unisexual or hermaphroditic** depending on species; some, like earthworms and redworms, participate in sexual reproduction, producing gametes for both male and female functions.
- Important roles: **earthworms** improve soil fertility and structure; **redworms (Eisenia fetida)** used in vermicomposting; **leeches** have medicinal uses due to anticoagulants.

### Phylum – Arthropoda (Animals with Jointed Legs):

- Largest animal phylum, including **insects, arachnids, crustaceans, and myriapods**; first described by **Von Siebold (1845)**.
- **Bilateral symmetry, triploblastic, segmented**, and **coelomate** with organ-system level of organization.
- **Jointed appendages** for locomotion and manipulation; body divided into **head, thorax, and abdomen**.
- **Exoskeleton** provides protection and prevents water loss; **open circulatory system** with hemolymph.
- Found in **terrestrial, aquatic, and aerial habitats**; play key ecological roles in **pollination, decomposition, and food chains**.

### Major Classes and Examples

Class	Examples	Key Features
<b>Insecta (largest class)</b>	Honeybee ( <i>Apis</i> ), Butterfly, Termite (White ant), Grasshopper, Mosquito, Housefly	Body divided into <b>head, thorax, abdomen</b> ; <b>6 legs, antennae, compound eyes</b> ; <b>tracheal respiration</b> via spiracles; bees have <b>5 eyes</b> (2 compound + 3 ocelli); grasshopper has <b>tympanum</b> for hearing; termites are <b>not true ants</b>
<b>Arachnida</b>	Scorpion, Spider (Does not have Backbone), Tick, Mite	<b>4 pairs of legs</b> , no antennae; respiration via <b>book lungs</b> ; scorpions are <b>viviparous</b>
<b>Crustacea</b>	Prawn, Crab, Daphnia, Lobster	<b>Body divided into cephalothorax and abdomen</b> ; <b>gills</b> for respiration
<b>Myriapoda</b>	Julus (millipede), Scolopendra (centipede)	<b>Long segmented bodies</b> with numerous legs

## Phylum – Mollusca (Soft-Bodied Animals):

- **Second-largest invertebrate phylum** after Arthropoda, with ~85,000 species; constitutes ~23% of all marine species.
- Soft, **unsegmented bodies**, often protected by a **calcareous shell**; members are called **molluscs**.
- Body divided into **head-foot**, **visceral mass**, and **mantle**; mantle secretes the shell.
- Possess a **mantle cavity** for respiration and excretion; most have a **radula**, a toothed, tongue-like organ for feeding.

### Major Classes of Mollusca

Class	Examples	Key Features
<b>Gastropoda</b>	<i>Snails, Slugs</i>	<b>Largest and most diverse class</b> ; distinct head, coiled shell, muscular foot.
<b>Bivalvia</b>	<i>Oysters, Clams, Pinctada margaritifera</i>	Laterally compressed body with two shells; <b>no radula</b> .
<b>Cephalopoda</b>	<i>Octopus, Squid, Nautilus</i>	Highly developed brain and eyes
<b>Polyplacophora</b>	<i>Chiton (Chatepleura apiculata)</i>	Dorsal shell divided into eight plates; found on rocky surfaces.
<b>Scaphopoda</b>	<i>Dentalium neohexagonum</i>	Tusk-shaped shell; burrowing marine animals.

### Important Fact:

- **Octopus (Class: Cephalopoda) - Has three hearts** — one systemic and two branchial hearts (for gill circulation).

### Phylum-Echinodermata (Spiny - Skinned Animals):

- Exclusively **marine invertebrates**, found from intertidal zones to deep oceans; ~7,000 species.
- Body covered with **spiny skin** and **calcareous endoskeleton** made of plates or ossicles.
- **Adult echinoderms** exhibit **pentaradial symmetry**, while **larvae** are **bilaterally symmetrical**.
- **Triploblastic, coelomate**, with **organ-system level organization**; body forms can be star-like, rounded, or elongated.
- **Water vascular system**: fluid-filled canals used for **locomotion, feeding, respiration, and excretion**.
- Nervous system is simple, with a nerve ring and radial nerves along arms; no brain.
- **Reproduction**: dioecious, external fertilization; capable of **asexual regeneration** (e.g., starfish regrowing arms).
- Special features include **pigment cells for coloration**, **toxic cells for defense**, and remarkable **regenerative ability** (e.g., starfish, class Asteroidea).

- **Starfish (Class Asteroidea) is a typical example known for its star-shaped body and regeneration capacity.**

### Phylum – Hemichordata:

- Previously considered a subphylum of Chordata, now recognized as a **separate non-chordate phylum**.
- Worm-like, **marine animals** with **organ-system level organization; bilaterally symmetrical, triploblastic, and coelomate**.
- Body cylindrical, composed of **anterior proboscis, collar, and trunk**; collar contains a **stomochord**, a rudimentary structure similar to a notochord.
- Examples: *Balanoglossus* (Acorn Worm), *Saccoglossus*.

### Phylum – Chordata:

- Chordates are characterized by the presence of a notochord, dorsal hollow nerve cord, paired pharyngeal gill slits, and a post-anal tail at some stage of life.

### Vertebrata (Vertebrates):

- Vertebrates (Craniata) have a **backbone (vertebral column)** replacing the notochord in adults; internal skeleton includes a **skull** protecting the brain.
- **Bilateral symmetry, triploblastic, coelomate, metamerically segmented** with organ-system level organization.

- **Well-developed muscular and nervous systems;** dorsal brain and spinal cord enclosed within skull and vertebrae; **closed circulatory system** with a ventral heart.
- Respiration occurs via **gills or lungs;** endoskeleton made of **bone or cartilage;** sexes are separate with mostly **internal fertilization.**
- **Cyclostomata (jawless vertebrates):** lampreys (*Petromyzon*) and hagfishes (*Myxine*), primitive eel-like fishes with **round, jawless mouths.**
  - ✓ Cyclostomata have **slimy, scaleless skin, cartilaginous skeleton, persistent notochord,** and median fins supported by cartilaginous fin-rays.
- They are **ectoparasitic or scavengers,** feeding on the body fluids of other fishes.

### Class Pisces (Fishes):

- Exclusively **aquatic vertebrates** with a **streamlined body,** covered with **scales,** and **fins;** limbs absent.
- **Respiration through gills;** excretion and circulation via distinct organs.
- **Cold-blooded (poikilothermic);** cannot regulate body temperature internally.
- Heart **2-chambered** (1 atrium, 1 ventricle); blood flows through **single circulation.**
- Lay **eggs (oviparous);** all true jawed vertebrates belong to this class.
- Small species often have **high metabolic and respiratory rates** due to large surface area-to-volume ratio.

### Class Amphibia:

- Amphibians (Gr. *Amphi* = dual, *bios* = life) can live **both in water and on land.**
- **Cold-blooded (ectothermic);** mostly found in warm environments.
- Body divided into **head and trunk;** tail may be present or absent; **two pairs of limbs,** fins absent.
- **Skin smooth, moist, glandular, and scaleless;** aids in **cutaneous respiration.**
- Eyes usually have **eyelids;** **tympanum (eardrum)** present; respiration through **gills, lungs, and skin,** depending on stage.
- Heart **three-chambered** (two atria, one ventricle); allows partial mixing of oxygenated and deoxygenated blood; **ten pairs of cranial nerves.**

- Reproduction: sexes separate; mostly **external fertilization** (internal in salamanders); **oviparous** with indirect development via **metamorphosis;** breeding occurs in water.
- Alimentary canal, urinary, and reproductive tracts open into a **common cloaca.**
- Notable examples: **Frog (*Rana*), Toad (*Bufo*), Tree Frog (*Hyla*), Salamander (*Salamandra*), Ichthyophis** (limbless).
  - ✓ **Frog (*Rana*)** – typical amphibian; has **three-chambered heart** and **moist skin** for respiration; Oviparous animal.
  - ✓ **Salamander (*Salamandra*)** – **slender body, blunt snout, tail in adults,** and **short limbs** extending sideways. Belongs to **Order Urodela;** usually has **four front toes** and **five hind toes.**

### Class Reptilia:

- Reptiles are **cold-blooded (ectothermic/poikilothermic)** vertebrates in Phylum Chordata, including **snakes, lizards, turtles, tortoises, and crocodiles.**
- **Dry, scaly skin** covered with **keratinized scales** prevents water loss.
- Terrestrial; body cannot be fully lifted off the ground; **neck present** between head and trunk.
- Limbs with **digits and claws** for gripping and movement; **external ears absent,** internal ear openings present.
- Respiration occurs only through **lungs;** **development is direct** (no larval stage).
- Most reptiles have a **3-chambered heart** (2 atria, 1 ventricle); **crocodiles** have a **4-chambered heart.**
- Cold-blooded: body temperature depends on the environment; some bask in the sun for thermoregulation.
- Reproduction: **sexual, internal fertilization;** mostly **oviparous** with **leathery-shelled eggs.**
- **Temperature-Dependent Sex Determination (TSD)** in some species: higher incubation temperatures produce females, lower produce males.

Reptile Group	Unique Adaptations / Characteristics	Additional Notes / Examples
<b>Crocodiles</b>	Semi-aquatic; can live on land and in water; most advanced reptilian heart	<b>Four-chambered heart</b> like birds and mammals; family Crocodylidae
<b>Chameleons</b>	Color-changing ability for <b>thermoregulation and camouflage</b> ; monocular vision allows panoramic view	Eyes move independently
<b>Snakes</b>	Elongated, limbless body covered with scales; adapted for slithering	Example: <i>Xylophis deepaki</i> — non-venomous wood snake, endemic to southern India, feeds on earthworms
<b>Blind Snakes (Typhlops)</b>	Small, cylindrical, burrowing (fossorial); reduced eyes covered by scales; non-venomous	Feed mainly on ants and termites; family Typhlopidae
<b>Turtles</b>	Bony shell developed from ribs acts as protective shield; ectothermic; slow-moving	Terrestrial or aquatic species

### Class Aves (Birds):

- Birds are **warm-blooded (endothermic) vertebrates** of Phylum Chordata; found worldwide from polar regions to deserts.
- Body is **streamlined and covered with feathers**; forelimbs modified into **wings**, hindlimbs adapted for walking, perching, or swimming.
- **Skin is dry**, mostly without glands except the **urophygial (oil) gland**; jaws are **toothless, forming a beak**.
- **Respiration** via lungs connected to **air sacs** for efficient gas exchange during flight.
- **Bony, pneumatic (air-filled) endoskeleton** reduces weight and aids flight.

- **Oviparous**, laying **hard-shelled eggs**; homeothermic with **constant body temperature**.
- **Closed circulatory system**; **four-chambered heart** prevents mixing of oxygenated and deoxygenated blood.
- Birds are **uricotelic**, excreting uric acid to conserve water.
- Notable birds: **Crow (*Corvus*)**, **Peacock (*Pavo cristatus*)**, **Kiwi**, **Ostrich (*Struthio camelus*)**, **Wandering Albatross (*Diomedea exulans*)**, **Hummingbird**, **Bee Hummingbird**.
- Unique adaptations: **flight** (wings), **pneumatic bones**, **specialized beaks**, and **exceptional aerial abilities** (e.g., hovering, long-distance flying).

Bird	Unique Features / Adaptations	Additional Notes
<b>Crow (<i>Corvus</i>)</b>	Common bird	Intelligent, adaptable, found worldwide
<b>Vulture (<i>Neophron</i>)</b>	Scavenger, strong beak for tearing flesh	Plays key role in ecosystem by cleaning carcasses
<b>Parrot</b>	Colorful plumage, strong curved beak	Known for mimicking sounds and social behavior
<b>Peacock (<i>Pavo cristatus</i>)</b>	National Bird of India; four-chambered heart	Males have ornamental tail feathers for courtship displays
<b>Kiwi</b>	Flightless, pear-shaped, long-beaked	Endemic to New Zealand; related to ostrich, emu, cassowary, and rhea
<b>Ostrich (<i>Struthio camelus</i>)</b>	Largest living bird; flightless	Belongs to ratites; two species: common ostrich & Somali ostrich
<b>Wandering Albatross (<i>Diomedea exulans</i>)</b>	Largest flying bird; wingspan up to 3.65 m (12 ft)	Exceptional long-distance flier

<b>Bee Hummingbird</b>	Smallest bird (~57 mm)	Endemic to Cuba; tiny, high metabolism
<b>Hummingbird</b>	Can fly in all directions including backward and hover	Produces humming sound from rapid wing beats

### Class Mammalia:

- Mammals are **warm-blooded (homeothermic) vertebrates** of Phylum Chordata; maintain constant body temperature (endothermic).
- Skin covered with hair or fur for insulation and protection; external ears (pinnae) present.
- Teeth **differentiated** into incisors, canines, premolars, and molars; adapted to diet.
- Two pairs of limbs adapted for **walking, running, climbing, swimming, or flying**.
- Possess **mammary glands** to produce milk for feeding young — defining mammalian trait.
- Most mammals are **viviparous** (give birth to live young); exceptions include monotremes (platypus, echidna) that **lay eggs**.
- **Four-chambered heart** separates oxygenated and deoxygenated blood; high metabolic rate supported by a **diaphragm** for respiration.
- **Three middle ear bones** (malleus, incus, stapes) aid in sound conduction.
- Parental **care** is well-developed in most species.
- **Marsupials:** young born incompletely developed, carried in a pouch (marsupium); examples: kangaroos, koalas, wombats, opossums.
- **Adaptations to cold/polar regions:** shorter appendages (Allen's Rule), fat layers, and specialized fur; examples: polar bears, musk oxen, reindeer, seals, whales.
- **Penguins:** flightless birds adapted to cold oceans, with counter-shaded plumage, flippers for swimming, and spiny tongues for catching prey.
- **Example:**
  - ✓ **Rat** — A typical small mammal found worldwide; warm-blooded, fur-covered, and viviparous.
  - ✓ **Cat** — Warm-blooded animal with high metabolism; surface area/volume ratio helps maintain body temperature.
  - ✓ **Platypus** — Egg-laying mammal (monotreme) with mammary glands.
  - ✓ **Kangaroo** — Marsupial with pouch for carrying young.
  - ✓ **Flying fox (Pteropus)** — Large bat; an example of a mammal capable of sustained flight.