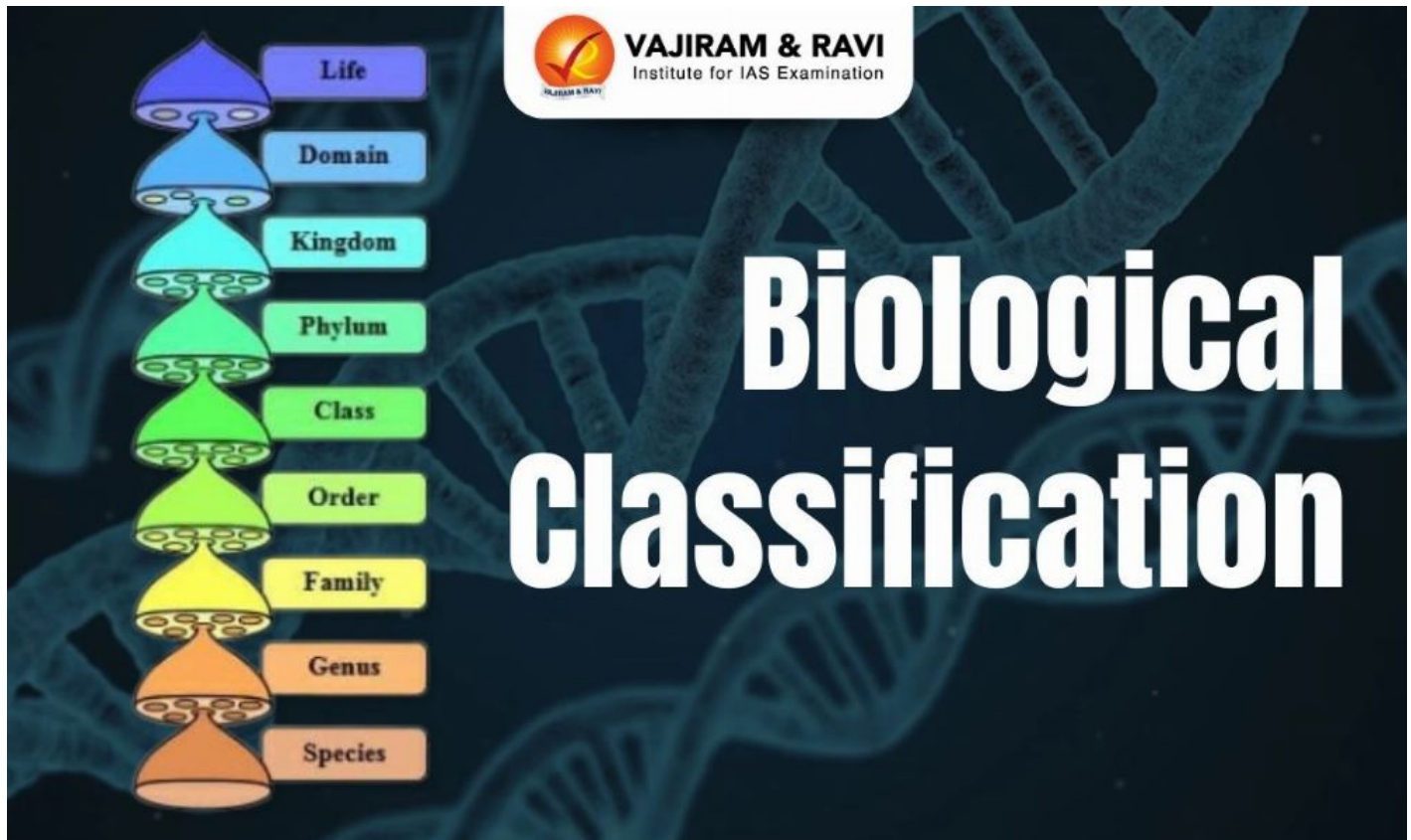


Biological Classification - Five Kingdom Classification

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Biological classification is the process of organising living organisms into **logical hierarchical groups** based on their similarities and differences. The main purpose of classification is to simplify the study of vast biodiversity. Over the years, taxonomists have developed a system consisting of **domains, kingdoms, phyla, classes, orders, families, genera and species** to classify all life forms.

R.H. Whittaker (1969) proposed a five Kingdom Classification. These are **Monera, Protista, Fungi, Plantae and Animalia**.

Taxonomic Hierarchy

Taxonomy is a branch of science that deals primarily with the description, identification, nomenclature, and classification of organisms. It is essential to classify living organisms into different groups and subgroups.

- **Taxonomy hierarchy:** The process of placing or grouping organisms in different taxonomic groups is known as the taxonomy hierarchy.



- **Domain:** It is the highest level of classification that constitutes three domains of life such as Archaea, Bacteria, and Eukarya.
- **Kingdom:** Each domain is further divided into kingdoms.
 - For example, Eukarya has five kingdoms: **Animalia, Plantae, Fungi, Protista, and Monera.**
- **Phylum:** Within each kingdom, organisms are grouped into phyla based on shared structural body plans and other defining characteristics.
 - For example, **Chordata** is one of the phyla of the Animalia kingdom.
- **Class:** Phyla are divided into classes, which further specify characteristics shared by groups of organisms.
 - For example, **Mammalia** is a class within Chordata.
- **Order:** Classes are divided into orders, representing specific arrangements of families.
 - For example, **Carnivora** is an order of Mammalia.
- **Family:** Orders are divided into families, indicating related groups of genera.
 - For example, **Canidae** is a family of Carnivora.
- **Genus:** Families are divided into genera, representing groups of species that are more closely related.
 - For example, **Vulpe** is a genus under Canidae.
- **Species:** The species is the most specific level and refers to individual organisms that share very similar characteristics and can interbreed to produce fertile offspring.
 - For example, **Vulpe vulpe** is a species (common name - **Red fox**) of the Vulpe genus.

Historic Evolution of Biological Classification Systems

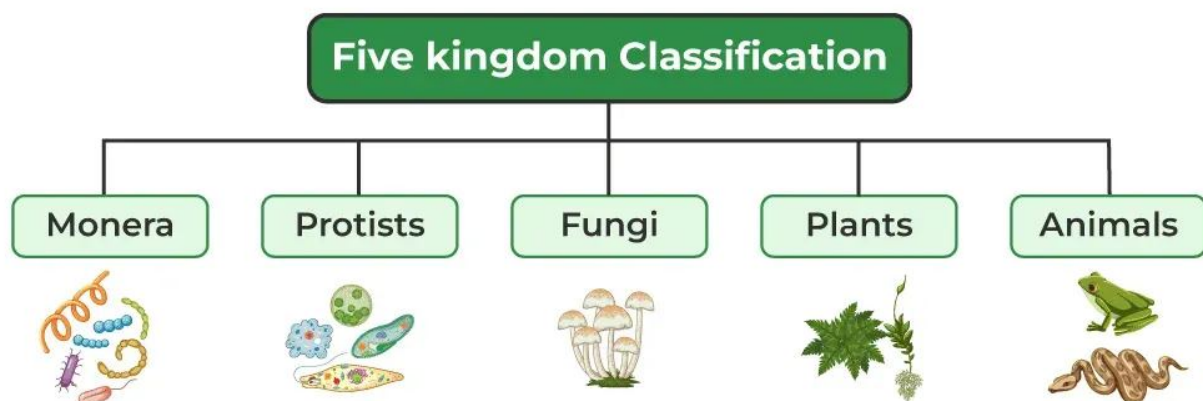
Classification is the process of organizing organisms into groups based on similarities and differences between them. It allows us to better understand the diversity of life on Earth. Biological classification has evolved over centuries, from the time of Aristotle to the six-kingdom classification system used today.

System	Key Features	Limitations
Two Kingdom, Proposed by Aristotle	- Binary split into Plantae (Plants) and Animalia (Animals)	- Failed to account for microscopic organisms.

Three Kingdom, Suggested by Ernst Haeckel	- Added Protista as the third kingdom for unicellular eukaryotes	- Could not resolve dichotomies between multicellular plants, animals and other macroscopic species.
Four Kingdom, proposed by Herbert Copeland	- Distinguished Fungi as separate from Plantae	- The Protista kingdom became saturated with phylogenetically unrelated species.
Five Kingdom, by Robert Whittaker	- Further split unicellular eukaryotes into Protista and prokaryotes into Monera	- Constraints related to integrating molecular taxonomy emerged later.
Six Kingdom, by Carl Woese's three-domain model in 1990.	- Divided Monera into Bacteria and Archaea while subsuming other groups under Eukarya	- Integrating advanced phylogenetic techniques remains ongoing.

Five Kingdom Classification

In 1969, R.H. Whittaker proposed a five-kingdom classification system for living organisms based on differences in their cell structure, body organization, mode of nutrition, reproduction and phylogenetic relationships. The five kingdoms he defined were:



Kingdom Monera

Monera includes all prokaryotic organisms like bacteria.

Kingdom Monera - Main characteristics

- Lack of a **true nucleus** and **membrane-bound cell organelles**
- They have **unicellular body** organisation.
- Cell wall made of **peptidoglycan, polysaccharides and lipids**
- They reproduce asexually by **fission, budding, fragmentation or spore formation.**
- They have **circular DNA** located directly in the cytoplasm.
- They evolved around 3.5 billion years ago and were the first life forms on Earth.

- Monerans have adapted to survive in diverse environments like soil, water, extreme temperatures, salinity and acidity.
- They exhibit a range of nutritional modes including photosynthesis, decomposition, symbiosis and parasitism.
- Bacteria in Kingdom Monera can be classified based on different criteria:

Based on the shape:

Shape	Examples
Spherical (coccus)	Staphylococcus
Rod-shaped (bacillus)	Lactobacillus
Comma-shaped (vibrio)	Vibrio cholera
Spiral (spirillum)	Spirochaetes

Based on the Nutrition:

Mode	Examples
Autotrophic	Nitrobacter, Sulphur bacteria
Saprotrophic	Clostridium
Symbiotic	Rhizobium
Parasitic	Mycoplasma

Based on the respiration:

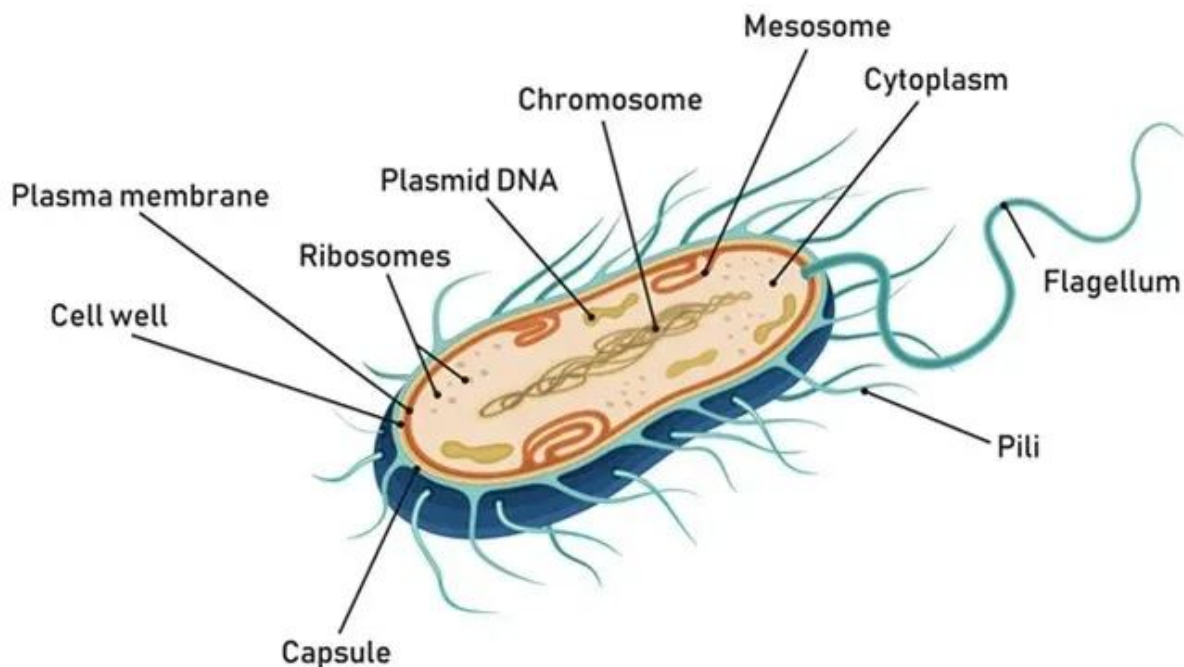
Type	Examples
Aerobic	Pseudomonas
Anaerobic	Clostridium
Facultative anaerobic	E.coli

Archaeobacteria and Eubacteria

Monerans are further divided into:

- **Archaeobacteria:** They differ in cell wall and lipid structure from other bacteria and can live in extreme conditions of temperature, salinity and acidity. Examples include:
 - **Methanogens:** They produce methane gas found in the guts of ruminants like cows.
 - **Halophiles:** They are found in very salty waters.
 - **Thermoacidophiles:** They thrive in hot acidic environments.
- **Eubacteria:** All other 'true' bacteria. They have a thicker cell wall and include photosynthetic cyanobacteria, chemosynthetic bacteria, decomposers and disease-causing forms.
- **Structure of a Bacterial Cell:**

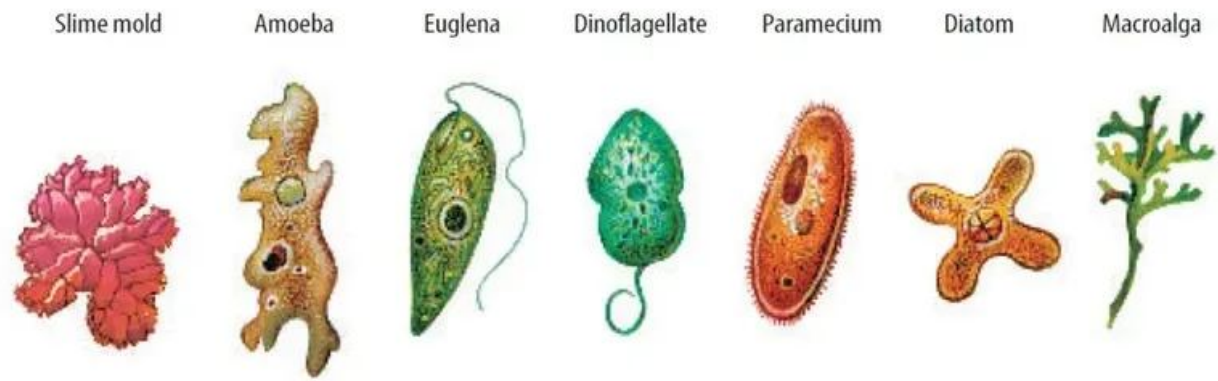
STRUCTURE OF A BACTERIAL CELL



- A typical bacterial cell has the following parts:
 - **Cell wall:** Made of peptidoglycan
 - **Cell membrane:** phospholipid bilayer with proteins
 - **Cytoplasm:** Contains circular DNA, ribosomes, nutrients
 - **Pili:** For attachment
 - **Flagellum:** For movement
 - **Capsule:** Protective layer in some bacteria

Kingdom Protista

They include all eukaryotic unicellular organisms. Some key features are:



Kingdom Protista

- They include all eukaryotic unicellular organisms. Some key features are:

- **Eukaryotic cell structure** with membrane-bound organelles.
- Either **free-living unicellular** forms or **parasites**.
- They occur mainly in aquatic habitats.
- Reproduce by cell division and sexually by fusion of cells.
- Includes chrysophytes, dinoflagellates, euglenoids, slime moulds and protozoans.

Chrysophytes



- These are **microscopic unicellular aquatic organisms**.

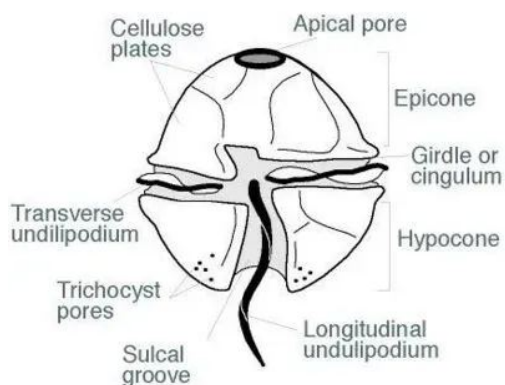
- They contain **chlorophyll** for photosynthesis.

- These cell walls contain **silica in diatoms** giving them a shell-like covering.

- They help in detecting water pollution based on species distribution.

- **Examples:** Cymbella, Navicula, Coscinodiscus sp

Pyrrophyta: The Dinoflagellates



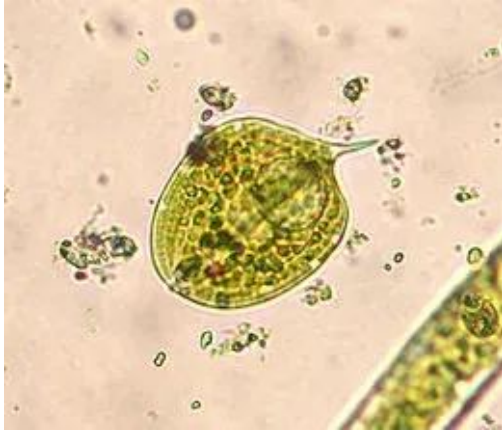
- They are mainly marine organisms and appear in different colours.

- They have **two flagella** for movement.

- Some show blooms or population explosions forming red tides which can kill other marine life.

- **Examples:** Noctiluca, Peridinium and Gonyaulax

Euglenophyta: Euglenoids



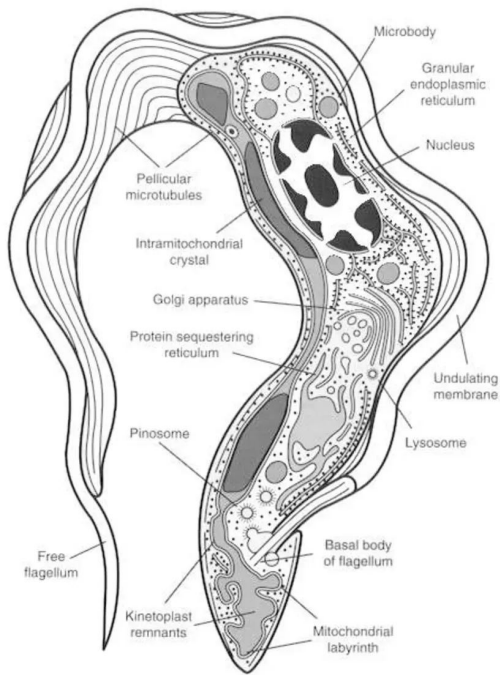
- They are freshwater organisms found in stagnant water.
- They have **flagella** and a **protein-rich flexible pellicle**.
- They can be **autotrophic** in sunlight or **heterotrophic** in darkness.
- **Examples:** Eugleana, Phacus, Astasia, Trachelomonas

Slime Moulds



- **Saprophytic protists** feeding on bacteria found in decaying material.
- They can form aggregates called **plasmodium** containing the large multi-nucleate mass of protoplasm.
- They can survive extreme environmental conditions.
- There are two groups of slime moulds-
 - **Acellular or plasmodial slime moulds:** class Myxomycetes.
 - **Cellular slime moulds:** class Acrasiomycetes.

Protozoans



- Microscopic heterotrophic protists acting as predators or parasites

- Classified based on locomotory organs as:

- **Amoeboid:** Pseudopodia for movement
- **Flagellated:** Flagella for movement
- **Ciliated:** Rows of cilia for movement

- They act as disease vectors and human parasites.

Examples of common protozoans:

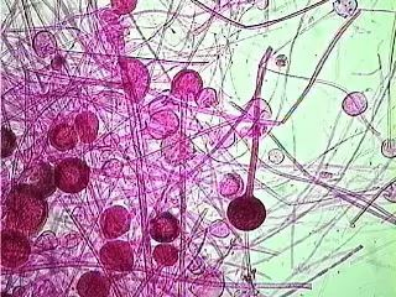
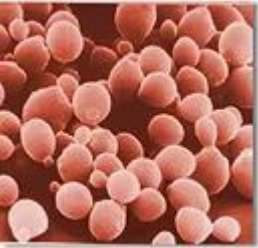
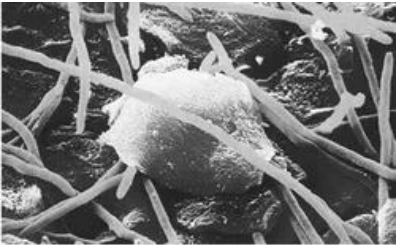
Type	Examples	Characteristics
Amoeboid	Entamoeba histolytica	- It causes amoebiasis dysentery
Flagellated	Trypanosoma	- It causes sleeping sickness
Ciliated	Paramecium	- Model lab organism with food vacuoles

Kingdom Fungi

Fungi comprise **eukaryotic, saprophytic** organisms which may be **unicellular or multicellular**. Key features include:

- Cell walls are made of **chitin** and **polysaccharides**.
- Body organised as slender filaments called **hyphae**.
- Networks of hyphae form thick bundles called **mycelium**.
- They reproduce by **spores** and sexually by **cell fusion**.
- They occur as **saprophytes, decomposers or parasites**.
- The phyla of Kingdom Fungi are classified based on reproductive and morphological characteristics:

Phylum	Examples	Key Features
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Phycomycetes 	Mucor, Rhizopus	- Aseptate hyphae produce zoospores.
Ascomycetes 	Aspergillus and yeast	- Septate hyphae produce sexual spores called ascospores.
Basidiomycetes 	Agaricus, Puccinia	- Club-shaped basidia produce external basidiospores.
Deuteromycetes 	Alternaria	- Only reproduces asexually through conidia.

- Examples of important fungi:
 - **Penicillium** is used for producing antibiotics.
 - **Saccharomyces** species are used in the baking industry.

- **Mucor** and **Rhizopus** are used for fermentation processes.
- **Agaricus** and **Morchella** are used as food sources.
- **Ustilago** and **Puccinia** act as plant parasites.

Kingdom Plantae

These include all eukaryotic photosynthetic organisms commonly called plants. Key points about Kingdom Plantae include:

- These are **eukaryotic cells** with cell walls made of **cellulose**.
- They contain **chloroplasts** with **chlorophyll pigment**.
- They exhibit alternation of generations between **diploid sporophyte** and **haploid gametophyte stages**.
- They consist of five major divisions:
 - **Algae:** aquatic photosynthetic organisms
 - **Bryophytes:** small herbaceous plants
 - **Pteridophytes:** seedless vascular plants
 - **Gymnosperms:** produce naked seeds
 - **Angiosperms:** flowering plants producing fruits and seeds
- Some examples of plants with unusual nutrition:
 - **Insectivorous plants (heterotrophic):** Venus fly trap, bladderwort
 - **Parasitic plants (heterotrophic):** Cuscuta

Plant



Equiseta



Lycopodia



Gymnosperms



Angiosperms

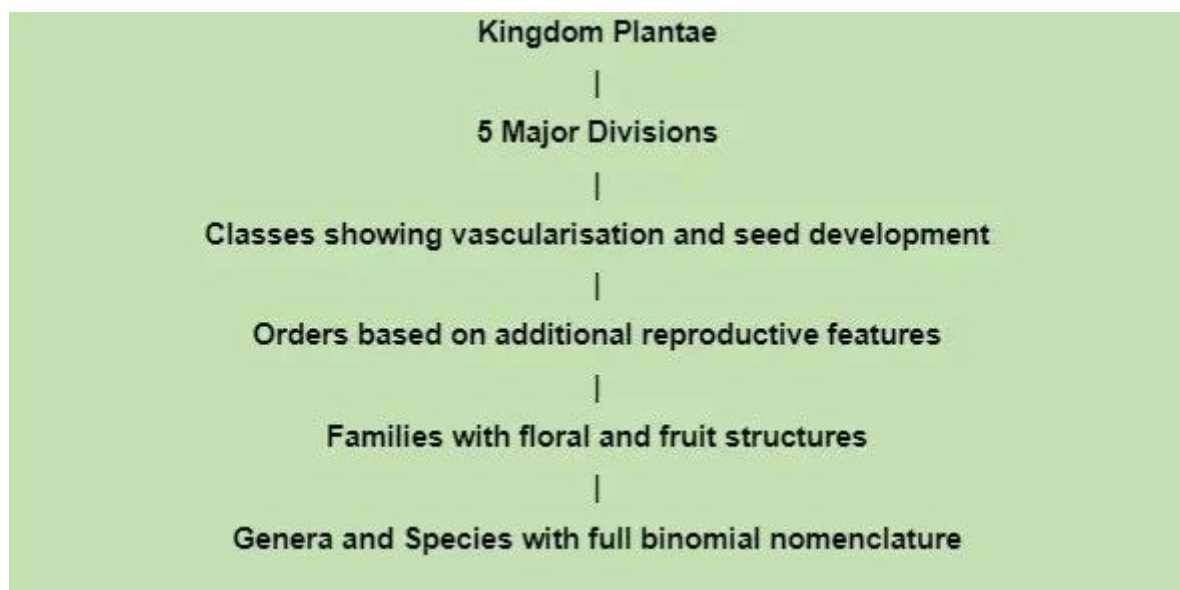


Ferns



Mosses

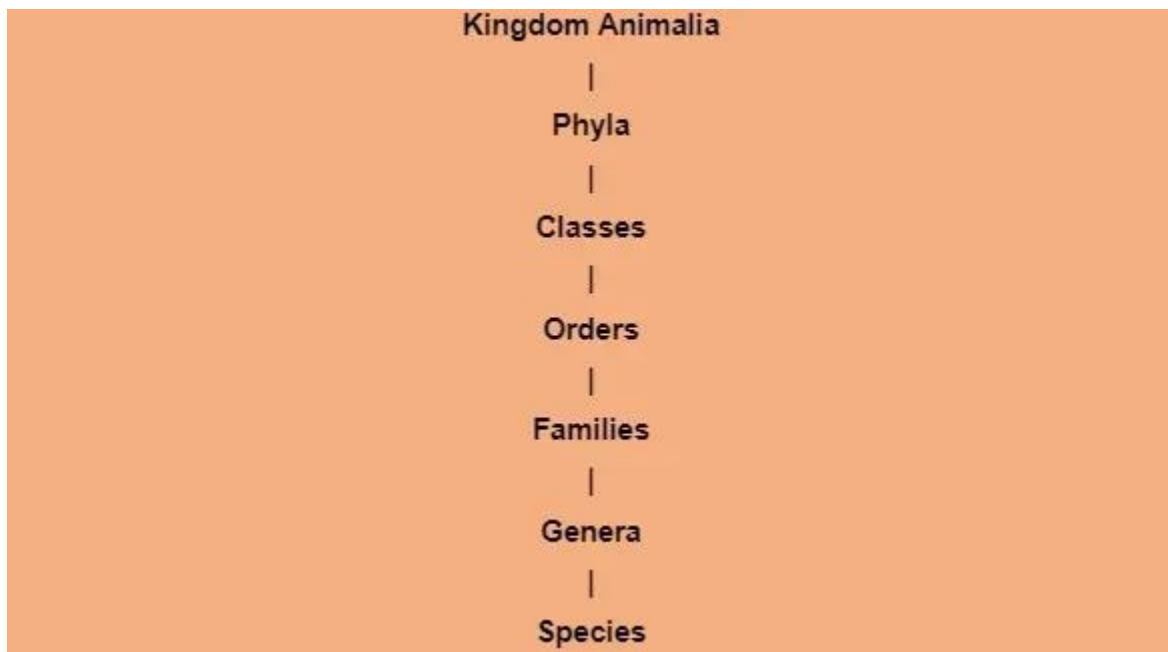
- The plant kingdom is classified into different divisions, classes, orders, families, genera and species based on characteristics like **vascular tissue**, **seed formation** and **embryo development**. A simplified framework is given below:



Kingdom Animalia

This kingdom includes all **heterotrophic, multicellular eukaryotic organisms** which lack cell walls. Some salient features are:

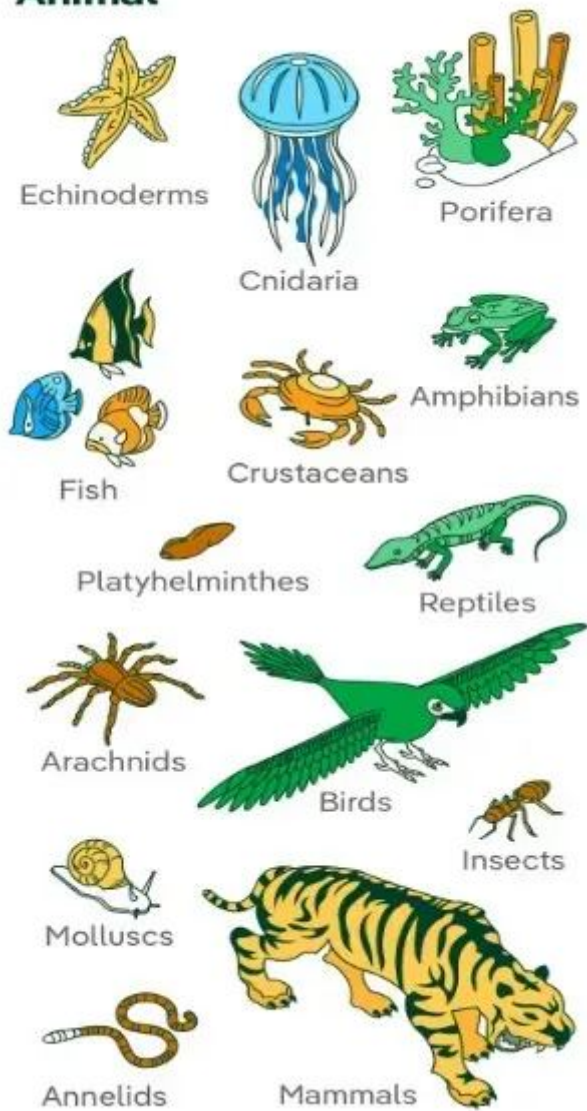
- Lack of **cell walls and chloroplasts**.
- They obtain nutrition by ingestion - **holozoic nutrition**.
- The **diploid stage** dominates the life cycle.
- They exhibit **elaborate sensory, nervous and locomotory** systems.
- Reproduction is sexual with a population of separate males and females.
- Kingdom Animalia is classified hierarchically based on **morphology, anatomy and embryology** into various taxa illustrated below:



Some well-known **animal phyla**:

Phylum	Examples	Characteristics
Porifera	Sponges	Asymmetric pores throughout the body
Coelenterata	Jellyfish, corals	Sac-like body with a single opening
Platyhelminthes	Tapeworms, liver flukes	Dorsoventrally flattened body
Annelida	Earthworms, leeches	Metamerically segmented body
Mollusca	Snails, bivalves	Calcereous shell, rasping tongue
Arthropoda	Insects, spiders	The chitinous exoskeleton, jointed legs
Echinodermata	Starfish, sea urchins	Endoskeleton of calcareous plates
Chordata	Fish, frogs, birds	Bilateral symmetry, notochord, dorsal nerve cord

Animal



Significance of the Five Kingdom Classification

The five-kingdom classification introduced by Whittaker has the following advantages:

- **Broad framework for taxonomic studies:** It divided the entire spectrum of life forms into five kingdoms providing a standard framework for biodiversity research.
- **Distinguish prokaryotes from eukaryotes:** The identification of Monera accommodated prokaryotes like bacteria separately from eukaryotic organisms.
- **Resolved issue of unicellular eukaryotes:** The Protista kingdom was created for unicellular eukaryotes, while multicellular eukaryotes were kept in separate kingdoms.
- **Based on natural affinities:** Related organisms were grouped based on body designs, structure, and reproductive mechanisms indicating their evolutionary relationships.
- **Comprehensive coverage of biodiversity:** All known life forms like archaeobacteria, protists, fungi, plants and animals were covered under this five-kingdom system exhaustively.

Limitations of the Five Kingdom Classification

While the five-kingdom classification system is extensively used, it has some limitations:

- **Does not reflect the latest taxonomic developments:** Recent advances in cytology, genetics and molecular biology have led to modifications in classifications that are not covered here.
- **Position of viruses unclear:** Being non-cellular, viruses do not appropriately fit into any kingdom, necessitating separate taxonomic treatment.
- **Overlap between Protista and other kingdoms:** Many unicellular algae and fungi-like organisms classified under Protista have a closer affinity to Plantae and Fungi kingdoms respectively.
- **Archaeobacteria requires separate treatment:** Though placed in Monera, Archaeobacteria are now considered a separate domain - Archaea.
- **Kingdom names not fully standardized:** Naming conventions used for the five kingdoms are not consistent, unlike other taxonomic ranks.

Other Aspects of Biological Classification

Certain lifeforms possess unusual characteristics requiring specialised taxonomic considerations:

Entity	Description	Classification Approach
Viruses	- Infective acellular particles containing genetic material (RNA or DNA) wrapped in a protein coat.	- Based on the type of genetic material, presence of envelope, morphology and host infection.
Viroids	- Small circular infectious RNA particles causing diseases in plants without a protein coat.	- Grouped under subviral agents along with virusoids and satellites which depend on helpers to replicate.
Prions	- Infectious pathogenic entities composed entirely of misfolded proteins acting as templates inducing abnormalities.	- Classified under conformational disorders causing transmissible <i>spongiform encephalopathies</i> .
Lichens	- Composite organisms formed through the symbiotic association between a fungus (mycobiont) and a photosynthetic partner (phycobiont) like algae.	- Named and grouped under fungal partners into Classes like Ascomycetes or Basidiomycetes .

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