

BIOLOGICAL CLASSIFICATION

Aristotle's classification

- Aristotle was the earliest to attempt a more scientific basis for classification of organisms.
- He classified plants to **trees, shrubs & herbs** and animals into 2 groups- those **with red blood & without red blood**.

Linnaeus's Two-kingdom classification

- **Linnaeus** (1758) classified organisms into **Two Kingdoms**- Kingdom **Plantae** & Kingdom **Animalia**.

Drawbacks of 2-kingdom classification:

- ♦ **Prokaryotes** (Bacteria, cyanobacteria) and **eukaryotes** (fungi, mosses, ferns, gymnosperms & angiosperms) were included under 'Plants' based on the presence of cell wall. But they are widely differed in other characteristics.

- ♦ It included the unicellular and the multicellular organisms in same group. E.g. *Chlamydomonas* and *Spirogyra* were placed under algae.
- ♦ It did not differentiate between the heterotrophic fungi and the autotrophic green plants. Fungi have chitinous cell wall while the green plants have cellulosic cell wall.

Five Kingdom Classification

- It is proposed by **R.H. Whittaker (1969)**.
- It includes Monera, Protista, Fungi, Plantae & Animalia.
- This is based on cell structure, thallus organization, mode of nutrition, reproduction and phylogenetic relationships.

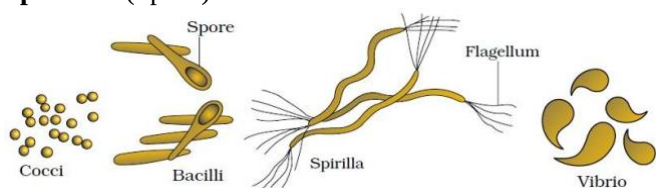
Three-domain system: It divides Kingdom Monera into two domains. Eukaryotic kingdoms are included in third domain. Thus it is **six-kingdom classification**.

Characteristics of the five kingdoms

Characters	Monera	Protista	Fungi	Plantae	Animalia
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	Non-cellulosic (poly-saccharide + amino acid)	Present in some	Present (Chitin & polysaccharides)	Present (Cellulose)	Absent
Nuclear membrane	Absent	Present	Present	Present	Present
Body organisation	Cellular	Cellular	Multicellular, loose tissue	Tissue/organ	Tissue/organ/organ system
Mode of nutrition	Autotrophic (photosynthetic & chemosynthetic) and heterotrophic (saprophyte/parasite)	Autotrophic (photosynthetic) and heterotrophic	Heterotrophic (saprophytic or parasitic)	Autotrophic (photosynthetic)	Heterotrophic (holozoic, saprophytic etc.)

1. KINGDOM MONERA (BACTERIA)

- Bacteria are the most abundant microorganisms.
- Hundreds of bacteria are present in a handful of soil.
- They also live in extreme habitats such as hot springs, deserts, snow & deep oceans. Many are parasites.
- Based on shape, bacteria are 4 types: **Coccus** (Spherical), **Bacillus** (Rod-shaped), **Vibrium** (Comma-shaped) & **Spirillum** (Spiral).



- Some bacteria are **autotrophic** (synthesize food from inorganic substrates). Majority are **heterotrophs** (they do not synthesize food but depend on other organisms or on dead organic matter for food).

I. Archaeobacteria

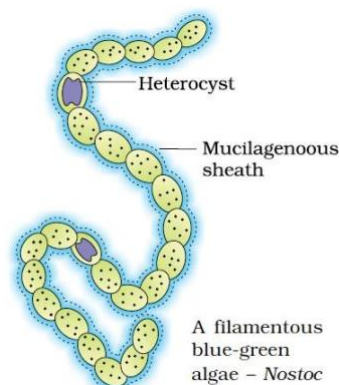
- They live in harshest habitats such as extreme salty areas (**halophiles**), hot springs (**thermoacidophiles**) and marshy areas (**methanogens**).
- Archaeobacteria have a different cell wall structure for their survival in extreme conditions.
- **Methanogens** are present in the guts of ruminant animals (cows, buffaloes etc). They produce **methane (biogas)** from the dung of these animals.

II. Eubacteria ('true bacteria')

- They have a **rigid cell wall** and a **flagellum** (if motile).
- They include **Autotrophs** (photosynthetic and chemosynthetic) and **Heterotrophs**.

a. Photosynthetic autotrophs (E.g. Cyanobacteria):

- They have **chlorophyll a** similar to green plants.
- Cyanobacteria (blue-green algae) are unicellular, colonial or filamentous, marine or terrestrial algae.
- The colonies are generally surrounded by **gelatinous sheath**.
- They often form blooms in polluted water bodies.
- Some of them fix atmospheric nitrogen in specialized cells (**heterocysts**). E.g., *Nostoc* & *Anabaena*.



b. Chemosynthetic autotrophs:

- They oxidize inorganic substances such as nitrates, nitrites & ammonia and use the released energy for ATP production.
- They help in recycling nutrients like nitrogen, phosphorous, iron and sulphur.

c. Heterotrophic bacteria:

- They are the **most abundant** in nature.

- The majority are important **decomposers**.

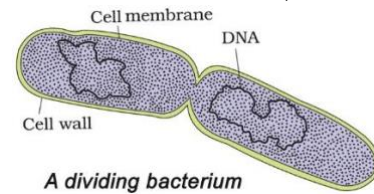
Impacts of Heterotrophic bacteria on human affairs:

- They are used to make curd from milk.
- Production of antibiotics.
- Fixing nitrogen in legume roots etc.
- Some are pathogens causing diseases. E.g. Cholera, typhoid, tetanus and citrus canker.

Reproduction in Bacteria:

- Bacteria reproduce mainly by **fission**.
- Under unfavourable conditions, they produce **spores**.

- They also reproduce by a sort of sexual reproduction (DNA transfer from one bacterium to other).



A dividing bacterium

Mycoplasmas are organisms without a cell wall. They are the **smallest living cells**. They can survive without oxygen. Many are pathogenic in animals and plants.

2. KINGDOM PROTISTA

- It includes **single-celled eukaryotes**.
- The cell contains a well-defined nucleus and other membrane-bound organelles. Some have flagella or cilia.
- Protists are primarily aquatic.
- It is a link with plants, animals and fungi.
- They reproduce asexually and sexually (cell fusion and zygote formation).
- Protista includes **Chrysophytes, Dianoflagellates, Euglenoids, Slime moulds** and **Protozoans**.

I. Chrysophytes

- Found in fresh water and marine environments.
- Microscopic and float passively in water currents (plankton).
- Most of them are photosynthetic.
- It includes **diatoms & golden algae (desmids)**.
- **Diatoms**: They have siliceous cell walls forming two thin overlapping shells, which fit together as in a soap box. The cell wall deposit of diatoms over billions of years in their habitat is known as '**diatomaceous earth**'. This is used in polishing, filtration of oils and syrups.
- Diatoms are the chief 'producers' in the oceans.

II. Dinoflagellates

- Mostly marine and photosynthetic.
- They appear yellow, green, brown, blue or red based on the main pigments present in their cells.
- The cell wall has stiff cellulose plates on the outer surface.
- Most of them have **2 flagella**; one lies longitudinally and the other transversely in a furrow between the wall plates.
- **Red dinoflagellates** (E.g. *Gonyaulax*) undergo rapid multiplication so that the sea appears red (**red tides**). They release toxins that kill marine animals like fishes.

III. Euglenoids

- Mainly fresh water organisms found in stagnant water.
- Instead of a cell wall, they have a protein rich layer called **pellicle**. It makes their body flexible.

- They have **two flagella**, a short and a long one.
- They are **photosynthetic** in the presence of sunlight. In the absence of sunlight, they behave like **heterotrophs** by preying on smaller organisms.
- The pigments are identical to those in higher plants.
- E.g. *Euglena*.

IV. Slime Moulds

- They are saprophytic protists.
- The body moves along decaying twigs and leaves engulfing organic material.
- Under suitable conditions, they form an aggregation called **plasmodium**. It may spread over several feet.
- Under unfavourable conditions, plasmodium differentiates and forms fruiting bodies bearing **spores** at their tips. Spores have true walls. They are highly resistant and survive for many years. Spores are dispersed by air.

V. Protozoans

They are heterotrophs (predators or parasites).

They are the primitive relatives of animals.

There are 4 major groups of protozoans:

- **Amoeboid protozoans**: They live in fresh water, sea water or moist soil. They move and capture prey by putting out **pseudopodia** (false feet). E.g. *Amoeba*. Marine forms have silica shells on their surface. Some of them are parasites. E.g. *Entamoeba*.
- **Flagellated protozoans**: They are free-living or parasitic. They have **flagella**. The parasitic forms cause diseases like **sleeping sickness**. E.g. *Trypanosoma*.
- **Ciliated protozoans**: They are aquatic, actively moving organisms using thousands of **cilia**. They have a cavity (**gullet**) that opens to outside. By the movement of cilia, the water with food enters gullet. E.g. *Paramecium*.
- **Sporozoans**: They have an infectious spore-like stage in their life cycle. E.g. *Plasmodium* (malarial parasite).

3. KINGDOM FUNGI

- It is a unique kingdom of heterotrophic organisms.
- Fungi are cosmopolitan.
- They grow in warm and humid places.
- E.g. mould on bread & rotten fruits, mushroom, toadstools.
- White spots on mustard leaves are due to a parasitic fungus.
- Some fungi are the source of antibiotics, e.g., *Penicillium*.

- Some unicellular fungi (e.g. yeast) are used to make bread and beer.
- Other fungi cause diseases in plants and animals. E.g. wheat rust-causing *Puccinia*.
- Except yeasts, fungi are filamentous. Their bodies consist of thread-like structures called **hyphae**.

- The network of hyphae is known as **mycelium**.
- Hyphae are 2 types:
 - o **Coenocytic hyphae**: They are continuous tubes filled with multinucleated cytoplasm.
 - o **Septate hyphae**: They have septae or cross walls.
- Fungal cell wall is made of **chitin & polysaccharides**.
- Most fungi are **saprophytes** (absorb soluble organic matter from dead substrates). Some are **parasites**.
- Some live as **symbionts**. E.g. **Lichens** (fungi+ algae), **mycorrhiza** (fungi + roots of higher plants).

Reproduction:

- **Vegetative propagation**: By fragmentation, fission & budding.
- **Asexual reproduction**: By spores such as **conidia**, **sporangiospores** and **zoospores**.
- **Sexual reproduction**: By **oospores**, **ascospores** and **basidiospores**. They are produced in distinct structures called **fruiting bodies**.
- The sexual cycle involves 3 steps:
 - a. Plasmogamy**: Fusion of protoplasm between two motile or non-motile gametes.
 - b. Karyogamy**: Fusion of two nuclei.
 - c. Meiosis** in zygote to give haploid spores.
- When a fungus reproduces sexually, **two haploid hyphae** of compatible mating types come together and fuse.
- In some fungi, the fusion of two haploid cells immediately results in **diploid cells (2n)**.
- In ascomycetes and basidiomycetes, a **dikaryotic stage** or **dikaryophase** ($n + n$ i.e. two nuclei per cell) occurs. Such a condition is called a **dikaryon**. Later, parental nuclei fuse and the cells become diploid.
- The fungi form fruiting bodies in which reduction division occurs, leading to formation of haploid spores.

Based on morphology of mycelium, mode of spore formation & fruiting bodies, Fungi are classified into different classes:

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

I. Phycomycetes (Lower Fungi)

- They occur in aquatic habitats and on decaying wood in moist and damp places or as obligate parasites on plants.
- The mycelium is **aseptate** and **coenocytic**.
- **Asexual reproduction**: By motile **zoospores** or by non-motile **aplanospores**. These are produced in sporangium.
- **Sexual reproduction**: **Zygospores** are formed by fusion of two gametes. These gametes are **isogamous** (similar in morphology) or **anisogamous** or **oogamous** (dissimilar).

- E.g. *Mucor*, *Rhizopus* (bread mould) and *Albugo* (parasitic fungi on mustard).

II. Ascomycetes (sac-fungi)

- They are unicellular (e.g., yeast, *Sacharomyces*) or multicellular (e.g., *Penicillium*).
- Mycelium is branched and septate.
- They are saprophytic, decomposers, parasitic or coprophilous (growing on dung).
- **Asexual reproduction**: By **conidia** produced exogenously on the special mycelium called **conidiophores**. Conidia germinate to produce mycelium.
- **Sexual reproduction**: By **ascospores** produced endogenously in sac like asci (sing. ascus). The asci are arranged to form fruiting bodies called **ascocarps**.
- E.g. *Aspergillus*, *Claviceps* and *Neurospora*.
- *Neurospora* is used in biochemical and genetic work.
- Morels & truffles are edible.

III. Basidiomycetes

- Includes **mushrooms, bracket fungi or puffballs**.
- They grow in soil, on logs and tree stumps and in living plant bodies as parasites (e.g. rusts and smuts).
- The mycelium is branched and septate.
- The asexual spores are generally not found, but **vegetative reproduction** by fragmentation is common.
- The sex organs are absent, but **plasmogamy** occurs by fusion of two vegetative or somatic cells of different strains or genotypes. The resultant structure is dikaryotic which gives rise to **basidium**. Karyogamy and meiosis take place in basidium producing four **basidiospores** exogenously. Basidia are arranged in fruiting bodies (**basidiocarps**).
- E.g. *Agaricus* (mushroom), *Ustilago* (smut) and *Puccinia* (rust fungus).

IV. Deuteromycetes

- Commonly known as **imperfect fungi** because only their asexual or vegetative phases are known.
- When perfect (sexual) stages were discovered, they were often moved to ascomycetes or basidiomycetes.
- It is also possible that **asexual and vegetative stage** have been given one name placing under **deuteromycetes** and the **sexual stage** another name placing under **another class**. When the linkages were established, the fungi were correctly identified and moved out of deuteromycetes.
- They reproduce only by asexual spores (**conidia**).
- The mycelium is septate and branched.
- Some are saprophytes or parasites. Majority are decomposers of litter and help in mineral cycling.
- E.g. *Alternaria*, *Colletotrichum* and *Trichoderma*.

4. KINGDOM PLANTAE (PLANT KINGDOM)

- Plants are **eukaryotic chlorophyll**-containing organisms with **cellulosic cell wall**.
- Some are partial heterotrophs (e.g. insectivorous plants like bladderwort & Venus flytrap) or parasites (e.g. *Cuscuta*).
- Plantae includes **algae, bryophytes, pteridophytes, gymnosperms** and **angiosperms**.

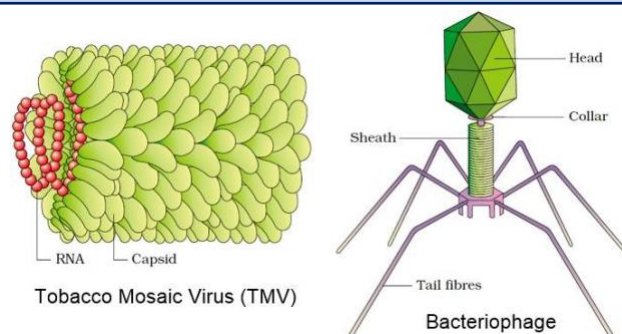
- Life cycle of plants has 2 phases: **Diploid sporophytic & haploid gametophytic**. These phases alternate with each other. This is called **alternation of generation**.
- Among different plant groups, length of the haploid & diploid phases is varied. Also, these phases are free living or dependent on others.

5. KINGDOM ANIMALIA (ANIMAL KINGDOM)

- Animals are **multicellular, heterotrophic, eukaryotic** organisms **without cell wall**.
- They directly or indirectly depend on plants for food.
- They digest their food in an internal cavity and store food reserves as glycogen or fat. Their mode of nutrition is **holozoic** (by ingestion of food).
- They have a definite growth pattern and grow into adults that have a definite shape and size.
- Higher forms show sensory and neuromotor mechanism.
- Most of them are capable of locomotion.
- The sexual reproduction is by copulation of male and female followed by embryological development.

VIRUSES, VIROIDS, PRIONS AND LICHENS

- In the five-kingdom classification, acellular organisms (viruses, viroids & prions) and lichens are not mentioned.
- Viruses are non-cellular and not truly 'living'. So they are not included in five-kingdom classification.
- Viruses have an inert crystalline structure outside the living cell.
- Viruses are **obligate parasites**.
- When they infect a cell, they take over the machinery of the host cell to replicate themselves, killing the host.
- **Louis Pasteur** gave the name **virus** (means venom or poisonous fluid).
- **D.J. Ivanowsky (1892)** discovered virus. He recognized certain microbes that cause mosaic disease of tobacco. They were smaller than bacteria because they passed through bacteria-proof filters.
- **M.W. Beijerinck (1898)** demonstrated that the extract of the infected tobacco plants cause infection in healthy plants and called the fluid as *Contagium vivum fluidum* (infectious living fluid).
- **W.M. Stanley (1935)** showed that viruses could be crystallized and crystals consist largely of proteins.
- A virus is a **nucleoprotein**, i.e., it has a **protein coat (capsid) & genetic material (RNA or DNA)**.
- The genetic material is infectious.
- No virus contains both RNA & DNA.
- Generally, plant viruses have single stranded RNA. Animal viruses have either single or double stranded RNA or double stranded DNA. **Bacteriophages** (viruses that infect bacteria) usually have double stranded DNA.
- The **capsid** made of small subunits (**capsomeres**) protects nucleic acid. Capsomeres are arranged in **helical or polyhedral geometric** forms.



- Viruses cause diseases like **mumps, small pox, herpes, influenza & AIDS**. In plants, the symptoms can be mosaic formation, leaf rolling and curling, yellowing and vein clearing, dwarfing and stunted growth.
- **Viroid**: It is an infectious agent with a free low molecular weight RNA and no protein coat. These are smaller than viruses. It is discovered by **T.O. Diener (1971)**. He found that it caused **potato spindle tuber disease**.
- **Prions**: These are **abnormally folded protein** that cause some infectious neurological diseases. These are similar in size to viruses. They cause **bovine spongiform encephalopathy (BSE) or mad cow disease** in cattle and its analogous variant **Cr-Jacob disease (CJD)** in humans.

LICHENS

- Lichens are symbiotic associations (mutually useful associations) between **algae & fungi**.
- The algal component is called **phycobiont** (autotrophic) and fungal component is **mycobiont** (heterotrophic).
- Algae prepare food for fungi and fungi provide shelter and absorb mineral nutrients and water for its partner.
- Lichens are very good **pollution indicators**. They do not grow in polluted areas.

MODEL QUESTIONS

- Based on the relationship, fill in the blanks.

a) Sac fungi: Ascomycetes	Imperfect fungi:
b) Ciliated Protozoans: Paramecium	Flagellated Protozoans:
c) Spherical shaped bacteria:	Rod shaped bacteria: Bacillus
- Louis Pasteur named virus which means venom or poisonous fluid.

a. Who crystallized virus for the first time?	b. Name one plant disease caused by virus.
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- Arrange the organisms given in brackets under two categories, prokaryotes and Eukaryotes.
(*Rhizopus*, *Amoeba*, *Chlamydomonas*, *Nostoc*, *Bacteria*, *Yeast*, *Paramecium*, *Mycoplasma*, *Anabaena*)
- Select the odd man. Justify your answer.

a) Chrysophytes, Dinoflagellates, Mycoplasma, Euglenoids	b) Oscillatoria, Spirulina, Ascomycete, Nostoc
c) Oospores, ascospores, zoospores, basidiospores	
- Differentiate between ascomycetes and basidiomycetes.
- Viruses are not included in five-kingdom classification. Why?