# 2

# Biological Classification

## Biology : Nature and Scope

Biology (L. **bios** – life; **logos** – knowledge) is the branch of science, which deals with the study of living organisms and their life processes. **Aristotle** is called the Father of Biology, but the term 'Biology' was first coined by **Lamarck** and **Treviranus** in 1802. It has two main branches, **i.e.**, Botany (study of plants) and Zoology (study of animals).

- **Father of Botany** **Theophrastus**
- **Father of Zoology** **Aristotle**

## Classification of Living Organisms

Classification is an arrangement of living organisms according to their common characteristics and placing the group within taxonomic hierarchy.

The branch of science which deals with description, nomenclature, identification and classification of organisms is called taxonomy.

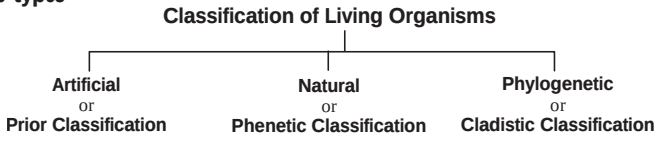
**Some major branches of taxonomy are**

(i) **Numerical taxonomy** It is based on all observable characteristics. Number and codes are assigned to characters and data is processed through computers.

(ii) **Cytotaxonomy** In this taxonomy, the detailed cytological information is used to categorise organisms.

(iii) **Chemotaxonomy** The chemical constituents are taken as the basis for classification of organisms.

**On the basis of reference criteria, the classification of living organisms can be of three types**




## 1. Artificial or Prior Classification

In this system of classification one or very few characters are considered as the key feature of classification. This classification system never throws light on affinities or relationships between the organisms.

## 2. Natural or Phenetic Classification

The classification system in which organisms are classified on the basis of their permanent vegetative characters. In this classification system, the grouping of heterogenous groups (unrelated) of organisms is avoided.

## 3. Cladistic or Phylogenetic Classification

This classification may be monophyletic (**i.e.**, one ancestry), polyphyletic (**i.e.** the organism derived from two ancestors) and paraphyletic (**i.e.**, the organism does not include all the descendents of common ancestor).

**Cladistics** is a method of classification of organisms based upon their genetic and ancestral relationships, which are more scientific and natural.

The most accepted, five kingdom system of classification of living organisms was proposed by **RH Whittaker**. These five kingdoms are **Monera, Protista, Fungi, Animalia** and **Plantae**.

## Other Classification Systems

- Two kingdom system–**Carolus Linnaeus** (Animalia and Plantae).

  **Merits** Photosynthetic organisms were included into plant kingdom and non-photosynthetic organisms were included into animal kingdom.

  **Demerits** Some organisms do not fall naturally either into plant or animal kingdom or share characteristics of both.

- Three kingdom system–**Ernst Haeckel** (Protista, Animalia and Plantae).

  **Merits** Created a third kingdom which includes unicellular eukaryotic microorganisms and some multicellular organisms.

  **Demerits** Monerans were not placed correctly.

- Four kingdom system–**Copeland** (Monera, Protista, Animalia and Plantae).

  **Merits** Monerans were placed separately along with other kingdoms.

  **Demerits** Monerans were not subdivided in Archaebacteria and Eubacteria.

- Six kingdom system–**Carl Woese** (Archaebacteria, Eubacteria, Protista, Fungi, Animalia and Plantae).

  **Merits** Archaebacteria and Eubacteria were separately placed.

## A. **Kingdom–Monera** (Prokaryotic, Unicellular Organisms)

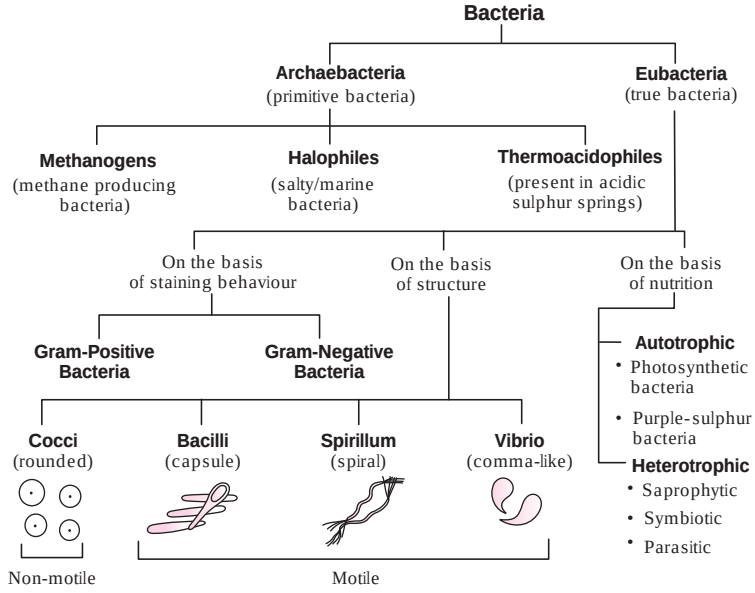
It includes all prokaryotes such as bacteria, archaebacteria, mycoplasma, actinomycetes, cyanobacteria and rickettsia.

### 1. **Bacteria**

These unicellular, prokaryotic organisms contain cell wall (feature of plant cells only). These are approximately 4000 species of bacteria, with cosmopolitan occurrence. Bacteria can be regarded both friends and foes on the basis of interaction with human beings.

An average weight human (~ 70 kg) has about 2.5 kg of bacteria in the form of gut microflora to supplement the proper digestion and other metabolic functions.

**Details to bacteria can be visualised in a nutshell as**



### (I) Archaebacteria

These are the group of most primitive prokaryotes. They have a cell wall, made up of protein and non-cellulosic polysaccharides. The presence of 16 **sr**RNA, makes them unique and helps in placing in a separate domain called **archaea** between bacteria and eukarya.

Archaebacteria can live under extreme hostile conditions like salt pans, salt marshes and hot sulphur springs. They are also known as **living fossils**, because they represent the earliest form of life on earth.

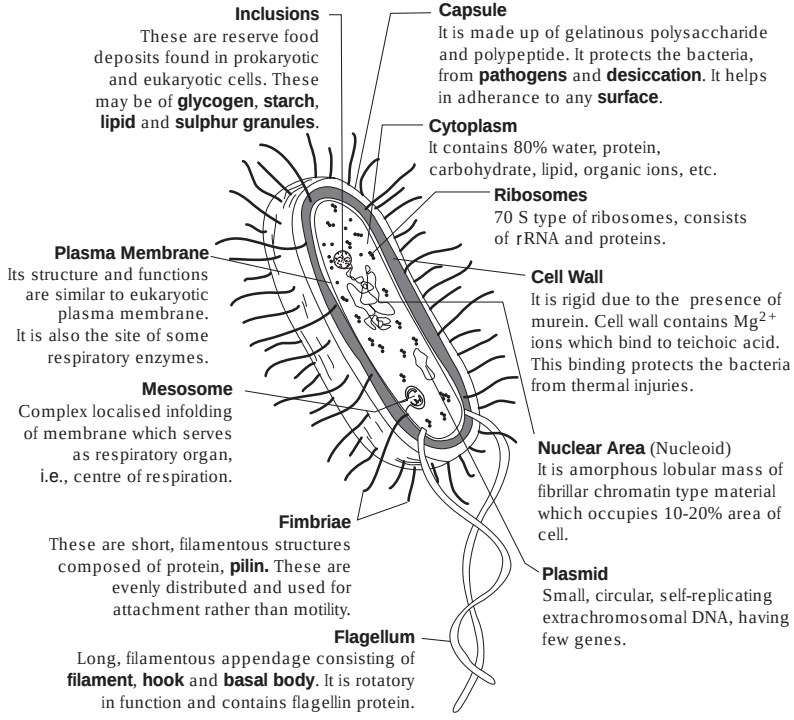
**Archaebacteria can be used for**

(a) Experimentation for absorption of solar radiation.
(b) Production of gobar gas from dung and sewage.
(c) Fermentation of cellulose in ruminants.

### (II) Eubacteria

Eubacteria are 'true bacteria' which lack nucleus and membrane bound organalles like mitochondria, chloroplasts, etc. Eubacteria are usually divided into five phylums– Spirochetes, Chlamydias, Gram- positive bacteria, Cyanobacteria and Proteobacteria.

**The structural detail of a typical eubacterial cell is given as follows**




**Detailed structure of a bacterium**

## Nutrition in Bacteria

The process of acquiring energy and nutrients., is called nutrition. On the basis of mode of nutrition, bacteria are of two types– **autotrophic** and **heterotrophic**. About 1% bacteria show autotrophic mode of nutrition and the rest are of heterotrophic habit. Chemosynthetic bacteria oxidise various inorganic substances such as nitrates, nitrites and ammonia and use the released energy for their ATP production.

**Autotrophic** (**i.e.,** photosynthetic) **bacteria** and **heterotrophic bacteria** with their related details are mentioned in following tables.

**Some Photosynthetic Bacteria**

| Group | Main Habitats | Cell Wall | Representatives |
|---|---|---|---|
| Prochlorobacteria | Live in tissues of marine invertebrates. | Gram-negative | **Prochloron** |
| Purple or green bacteria | Generally anaerobic and reside on sediments of lakes and ponds. | Gram-negative | **Rhodospirillum** and **Chlorobium** |

**Some Heterotrophic Bacteria**

| Group | Main Habitats | Cell Wall | Representatives |
|---|---|---|---|
| Spirochetes | Aquatic habitats, parasites of animals | Gram-negative | **Spirochaeta** and **Treponema.** |
| Aerobic rods and cocci | Soil, aquatic habitats, parasites of animals and plants | Gram-negative | **Pseudomonas, Neisseria, Nitrobacter, Azotobacter** and **Agrobacterium** |
| Facultative anaerobic rods (enterobacteria) | Soil, plants, animal gut | Gram-negative | **Salmonella, Shigella, Proteus, Escherichia** and **Photobacterium** |
| Sulphur and sulphate reducing bacteria | Anaerobic muds, sediments (as in bogs, marshes) | Gram-negative | **Desulfovibrio** |
| Myxobacteria | Decaying plant and animal matter, bark of living trees | Gram-negative | **Myxococcus** and **Chondromyces** |

| Group | Main Habitats | Cell Wall | Representatives |
|---|---|---|---|
| Mycoplasmas | Parasites of plants and animals | Cell wall absent | **Mycoplasma** |
| Gram-positive cocci | Soil, skin and mucous membranes of animals | Gram-positive | **Staphylococcus** and **Streptococcus** |
| Endospore-forming rods and cocci | Soil; animal gut | Gram-positive | **Bacillus** and **Clostridium** |
| Non-sporulating rods | Fermenting plant and animal material, human oral cavity, gut, vaginal tract | Gram-positive | **Lactobacillus** and **Listeria** |
| Chemoautotrophes | Soil, aquatic habitat | Gram-negative | **Halothiobacillus** and **Acidothiobacillus** |

## Respiration in Bacteria

Respiration occurs in the plasma membrane of bacteria. Glucose is broken down into carbon dioxide and water using oxygen in aerobic cellular respiration and other molecules such as nitrate ($NO_3$) in anaerobic cellular respiration.

## Reproduction in Bacteria

Bacteria reproduce **asexually** and **sexually** both.

### Asexual Methods

**Asexually, bacteria reproduce by following methods**

- **Fission** Bacteria divide both laterally and longitudinally.
- **Budding** Vegetative outgrowths result into new organisms after maturity.
- **Spore formation** Non-motile spores like **conidia, oidia** and **endospores** are formed.

### Sexual Methods

Although sexes are not differentiated in bacteria, following methods of genetic recombination are categorised under sexual reproduction in bacteria.

- **Transformation** F Griffith (1928), Genetic material of one bacteria is transferred to other through **conjugation tube**.

- **Conjugation** Lederberg and Tatum (1946), Transfer of genetic material occurs through **sex pili**.
- **Transduction** Zinder and Lederberg (1952), Transfer of genetic material occurs by **bacteriophage**.

## Economic Importance of Bacteria

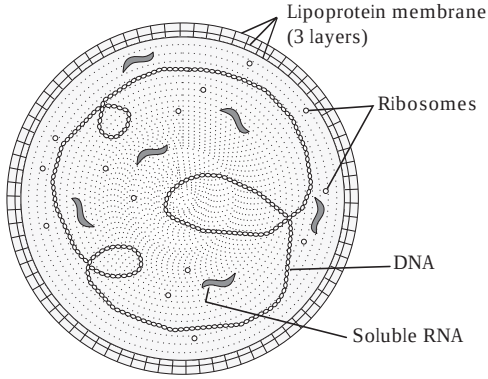
Economically, some bacteria are useful in producing various useful substances like curd, cheese, antibiotics and vinegar, etc. While other bacteria cause several chronic diseases in humans, plants and other animals, etc.

## Other Monerans

**These are as follows**

1. **Mycoplasma**

- It was discovered by **Nocard** and **Roux** in 1898. These are cell wall less, aerobic and non-motile organisms. Due to the absence of cell wall and pleomorphic nature, they are commonly called as **jokers of living world**.
- The mycoplasmas are also known as **Pleuro Pneumonia Like Organisms** (PPLO). These are the smallest living cells, yet discovered, can survive without oxygen and are typically about 0.1 μm in diameter.




**Structure of Mycoplasma**

2. **Actinomycetes**

- The members of a heterogeneous group of Gram-positive, are generally anaerobic bacteria noted for a filamentous and branching growth pattern. It results in most forms in an extensive colony or **mycelium.**

- Morphologically, they resemble fungi because of their elongated cells that branch into filaments or hyphae. During the process of composting, mainly thermophilic and thermotolerent **Actinomyces** are responsible for the decomposition of the organic matter at elevated temperature.
- Generally, Actinomycetes grow on fresh substrates more slowly than other bacteria and fungi. During the composting process, the Actinomycetes degrade natural substances such as chitin or cellulose.
- Natural habitats of thermophilic Actinomycetes are silos, corn mills, air conditioning systems and closed stables. Some Actinomycetes are found responsible for allergic symptoms in the respiratory tract, **e.g.,** Extrinsic Allergic Alveolitis (EAA).

3. **Cyanobacteria/Blue-Green Algae** (BGA)

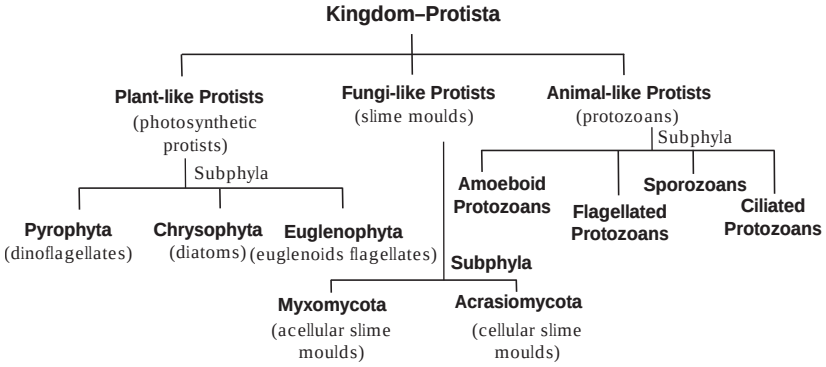
- They are Gram-negative photosynthetic prokaryotes which perform oxygenic photosynthesis. These can live in both freshwater and marine habitats and are responsible for 'blooms' in polluted water (eutrophication).
- They have photosynthetic pigments, **chlorophyll-**a, **carotenoids** and **phycobilins** and food is stored in the form of cyanophycean starch, lipid globule and protein granules.
- Cyanobacteria have cell wall formed of peptidoglycan, naked DNA, 70S ribosomes and the absence of membrane bound organelles like endoplasmic reticulum, mitochondria, Golgi bodies, etc.
- The red sea is named after the colouration provided by red coloured cyanobacteria **i.e., Trichodesmium erythraeum.**
- Cyanobacteria can fix atmospheric nitrogen through a specific structure called **heterocyst**. These are modified cells in which photosystem-II is absent hence, non-cyclic photophosphorylation does not take place. Nitrogen-fixation is performed through enzyme nitrogenase, present in it.

4. **Rickettsia**

- These are small, aerobic and Gram-negative bacteria. They belong to phylum–Proteobacteria, which are capable of growing in low level of nutrients and have long generation time relative to other Gram-negative bacteria.
- Rocky Mountain Spotted Fever (RMSF) is a tick borne human disease caused by **Rickettsia rickettsii**, an obligate, intracellular bacteria.

## B. Kingdom–Protista (Eukaryotic, Unicellular Organisms)

**It includes three broad groups, explained in the following flow chart**




In the view of evolution, the **kingdom–Protista** acts as a connecting link between the prokaryotic kingdom–Monera and multicellular kingdoms like Fungi, Plantae and Animalia. The term 'Protista' was given by German biologist, **Ernst Haeckel** in 1866.

**The group Protista shows following characteristics in common**

(i) These are mostly aquatic.

(ii) Eukaryotic cell of protists possess well-defined nucleus.

(iii) Membrane bound organelles present.

(iv) Protists reproduce both asexually and sexually by a process involving cell fusion and zygote formation.

(v) They may be autotrophic and heterotrophic (**i.e.,** parasitic).

**The detailed descriptions of protistan groups are as follows**

### Plant-like Protists (Photosynthetic)

**These can be**

#### 1. Dinoflagellates

The group of 1000 species of photosynthetic protists, belongs to the division–**Pyrophyta** and class–**Dinophyceae.** They are unicellular, motile and biflagellate, golden-brown coloured protists. They form the important components of phytoplanktons.

Their macronuclei possess condensed chromosomes, even in interphase, called as **mesokaryon** (Dodge; 1966). Sometimes they exhibit the phenomenon of bioluminescence.

### 2. Chrysophytes

These include **diatoms** and **desmids.** Diatoms are mostly aquatic and sometimes present in moist terrestrial habitat. They are very **good pollution indicator**.

The diatoms do not decay easily as their body is covered by **siliceous shell.** They pile up at the bottom of water body and form **diatomite** or **diatomaceous earth** (can be used as fuel after mining).

### 3. Euglenoids

These are **Euglena** like unicellular flagellates found mostly in stagnant freshwater. Instead of a cell wall, they have a protein rich layer called **pellicle**, which makes their body flexible.

**They have two types of flagella**

(i) **Long** Whiplash

(ii) **Short** Tinsel

The food is stored in proteinaceous granules called **pyrenoids**. Photosynthetic euglenoids, behave like heterotrophs in dark, this mode of nutrition is called **mixotrophic.**

The chief member of this group, **i.e., Euglena** is regarded as connecting link between animals and plants.

## Fungi-Like Protists (Slime Moulds)

They possess the characters of both animals and fungi therefore, combinedly called as **fungus-animals.** They show saprophytic food habit and consume organic matter. Under suitable conditions, they form **Plasmodium**. **On the basis of occurrence of Plasmodium, these are of two types**

(i) **Acellular/Plasmodial slime moulds**, **e.g., Physarum**, **Fuligo septica,** etc.

(ii) **Cellular slime moulds**, **e.g., Dictyostelium, Polysphondylium,** etc**.**

## Animal-Like Protists (Protozoans)

The most primitive relatives of animals, protozoans are heterotrophic (predator or parasitic) organisms, **divided into four major groups**

(i) **Amoeboid protozoans** They live in freshwater, moist soil and salt water as parasite. They move with the help of **pseudopodia** as in **Amoeba.**

**Other members of this group are**

**Entamoeba histolytica** and **E. gingivalis** cause various digestive and oral diseases when engulfed through polluted water.

(ii) **Flagellated protozoans** They are either free-living or parasitic in nature. **Chief members are**

(a) **Trypanosoma** sp.–carried by **tse-tse fly** and causes **African sleeping sickness**.

(b) **Leishmania** sp. carried by **sand fly** and causes **kala-azar** or **dum-dum fever**.

(c) **Giardia** sp. causes **giardiasis**.

(d) **Trichomonas vaginalis** causes **leucorrhoea**.

(iii) **Ciliated protozoans** They are aquatic and move actively due to the presence of cilia. They show nuclear dimorphism (macro and micronucleus), **e.g., Paramecium**, etc.

(a) **Macronucleus/Vegetative nucleus** Controls metabolic activities and growth.

(b) **Micronucleus/Reproductivenucleus**Controls reproduction.

(iv) **Sporozoans** They have an infectious, spore-like stage in their life cycle. All are endoparasites. Locomotory organs are cilia, flagella and pseudopodia, **e.g., Plasmodium**, **Monocystis**, etc.

## C. Kingdom–Fungi (Eukaryotic, Heterotrophic Organisms)

Fungi are a group of eukaryotic, achlorophyllous, non-photosynthetic and heterotrophic organisms.

**The basic features of fungi include**

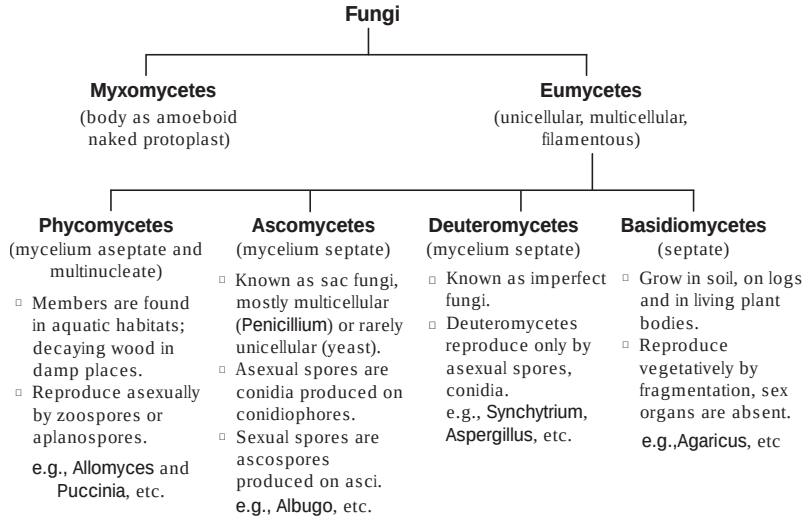
(i) Fungi lack chlorophyll, hence they are heterotrophic.

(ii) They cannot ingest solid food, but absorb it after digestion. The digestive enzymes are secreted on food, then they (fungi) absorb it.

(iii) On the basis of food sources, they may be saprophyte or parasites. Cell wall in fungi is made up of nitrogen containing polysaccharides, chitin. Reserved food material is glycogen or oil. Along with certain bacteria, saprotrophic fungi function as the main decomposers of organic remains.

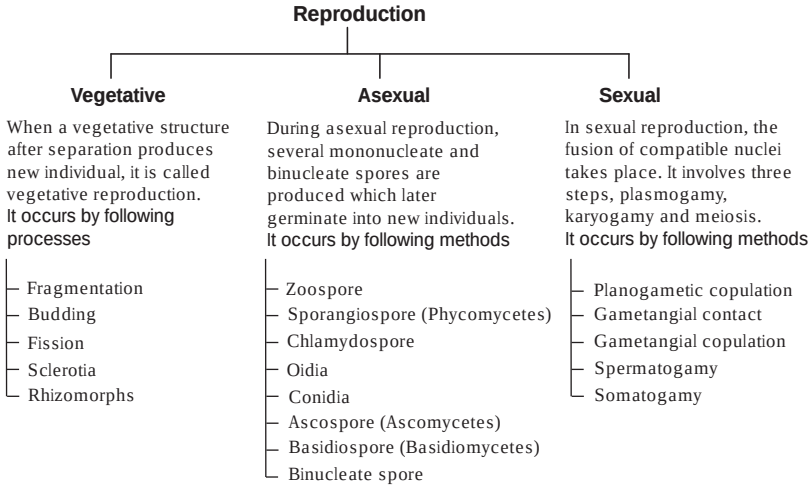
With the exception of yeasts (unicellular, fungi and filamentous), fungi bodies consist of long, slender, thread-like structures called **hyphae.** Mycelium is the network of hyphae. Some are called coenocytic hyphae (continuous tubes filled with multinucleated cytoplasm) and others have cross walls (septae) in their hyphae. Cell walls of fungi are composed of chitin and polysaccharides.

## Classification of Fungi (Martin; 1961)




## Reproduction in Fungi

### Three types of reproduction occur in fungi

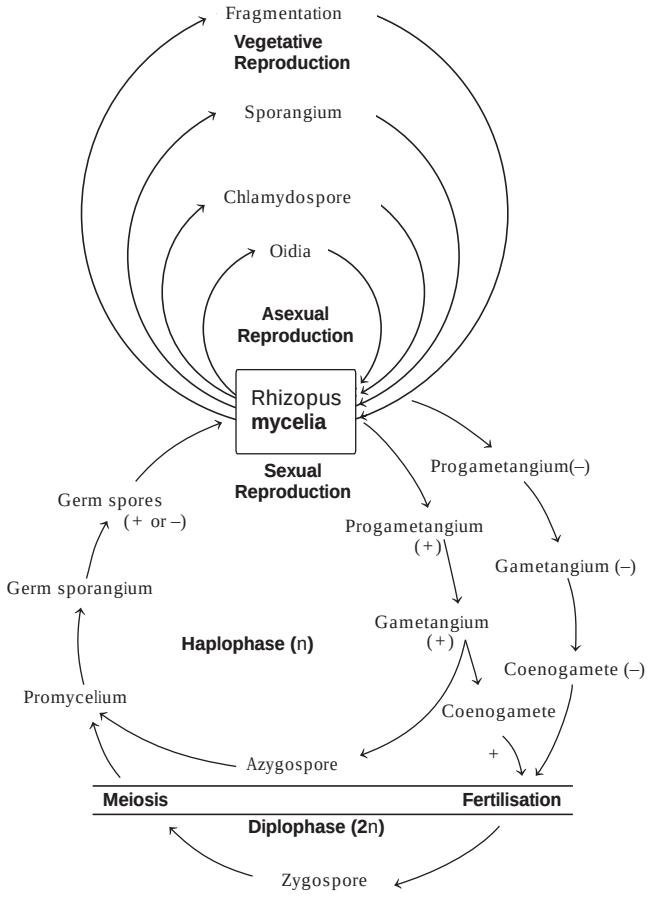


## Life Cycles of Some Fungi

**These can be described as follows**

### (i) **Life Cycle of** Rhizopus

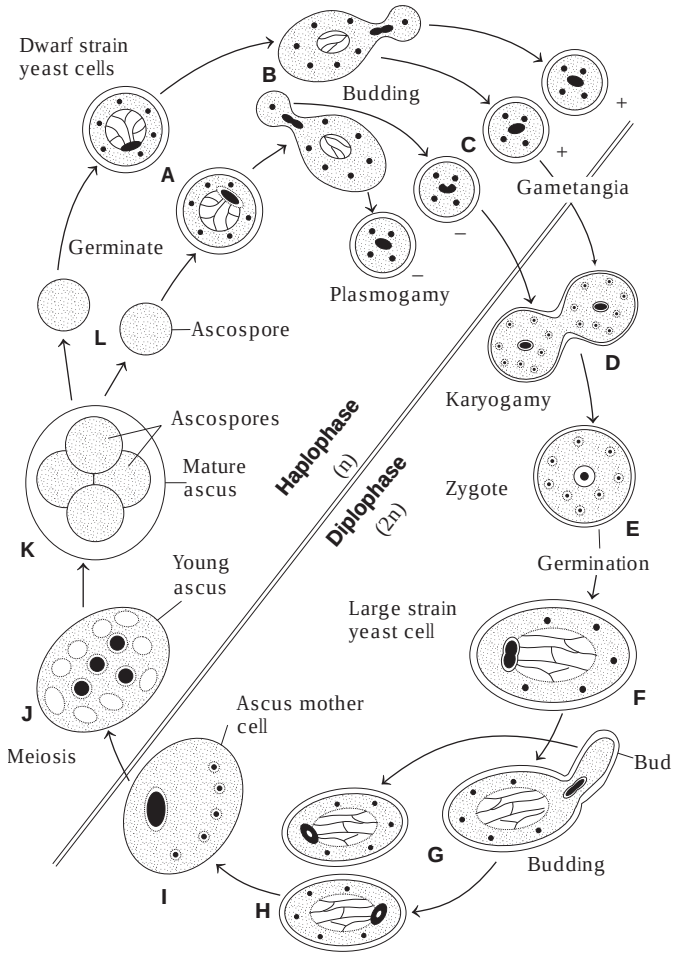
**The structural representation (sexual and asexual) of life cycle of Rhizopus is as follows**




**Life cycle of Rhizopus**

### (ii) Life Cycle of Yeast

**The diagrammatic representation of sexual cycle of Saccharomyces cerevisiae is as follows**




**Life cycle of Saccharomyces cerevisiae**

## Heterothallism

The phenomenon of having two genetically different and compatible sexual strains in two different thalli is called heterothallism. It was discovered by **Blakeslee** in **Mucor.**

### Mushroom and Fairy Rings

**Agaricus compestris** is an edible mushroom. It is also called **white button mushroom**. The fruiting body of **Agaricus**, arises in concentric rings (called fairy rings or fungal flowers) from the mycelium present in the soil.

## Lichens

They have composite structure and consist of two dissimilar organisms forming a symbiotic relationship between them.

**Lichens are formed by**

- Algal Part — Phycobiont — Provide food to fungi
- Fungal part — Mycobiont — Provide shelter to algae

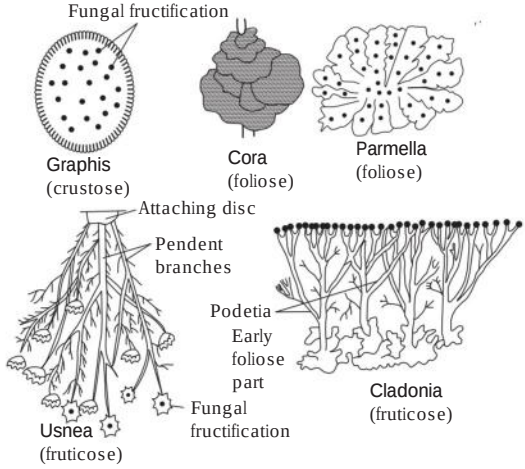
**Lichens are of three types on the basis of their structure**

(i) **Crustose lichens** These are point-like, flat lichens, **e.g., Caloplaca.**

(ii) **Foliose lichens** These lichens have leafy structure, **e.g., Hypogymnia physodes**.

(iii) **Fruticose lichens** These are branched lichen, form filamentous branching, **e.g., Cladonia evansii**, **Usnea australis**, etc.

**Various forms of lichens are given below**




**Forms of lichens**

## Mycorrhiza

It is a symbiotic association between a fungus and a plant. Plants prepare organic food and supply them to fungus and in return, fungus supplies water and mineral nutrients to plants.

## D. Kingdom–Plantae (Eukaryotic, Chlorophyllous Organisms)

These are chlorophyllous and embryo forming organisms. Mostly non-motile and function as the producers in **ecosystem** as they can fix solar energy into chemical energy through the process of photosynthesis. The cell wall in plants is cellulosic and stored food material is in the form of starch.

**A detailed account of plant kingdom is given in chapter** 6.

## E. Kingdom–Animalia (Multicellular, Eukaryotic Organisms)

The heterotrophic, eukaryotic organisms which are multicellular and lack cell wall, present in this kingdom. Animals have advanced level of tissue organisation, in which the division of labour is highly specific. The two main groups among animals are Non-chordata and Chordata, divided on the basis of the presence of notochord in them.

**A detailed account of animal kingdom is** given in chapter 7.

# Viruses and Viroids

## 1. Viruses

The term 'Virus' means **poisonous fluid**. The word was coined by **Louis Pasteur**. Viruses are very small (0.05-0.2 μm), infective, nucleoprotein particles, which can be called as **living** because of the presence of nucleic acid as genetic material and ability to produce their own copy-viruses. They show only some properties of living beings, otherwise they behave like non-livings. Hence, these are referred to as the **connecting link between living and non-living**.

**On the basis of nature of genetic material, the viruses are of two types**

(i) **Adenovirus** DNA containing, **e.g.,** HIV, etc.
(ii) **Retrovirus** RNA containing, **e.g.,** Rous sarcoma virus, etc.

**On the basis of their host, the viruses can be categorised as**

(i) **Animal virus** (Zoophagineae), **e.g.,** HIV, sarcoma, etc.
(ii) **Plant virus** (Phytophagineae), **e.g.,** TMV, etc.
(iii) **Bacterial viruses** (Phagineae), **e.g.,** $T_4$ phage, etc.

## Characteristics of Viruses

**Characteristics of viruses are as follows**

**Living**

- They can replicate.
- In host body, they can synthesise protein.
- They cause diseases like other living organisms.
- Similar gene mutation as living organism.

### Non-living

- Do not have protoplasm, and do not perform metabolism.
- These can be crystallised.
- They do not respire.
- **In vitro** culture is not possible.

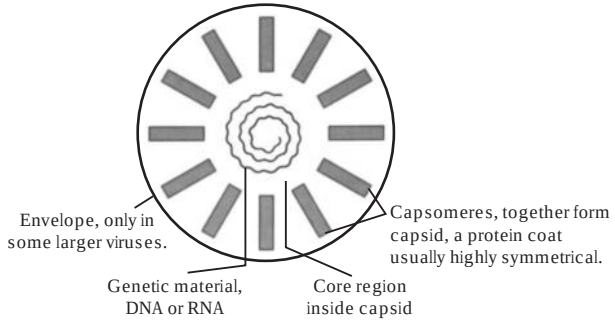
## Structure of Viruses

(i) Viruses are non-cellular and ultramicroscopic.

(ii) **Virus has two components**

(a) A core of nucleic acid called **nucleoid**.

(b) A protein coat called **capsid**.




**Structure of a virus (generalised)**

## 2. **Viroids** (RNA without a Capsid)

**TO Diener** (1917) introduced the term as 'Subviral pathogens'. Viroids are 100 times smaller than smallest virus. They are known to be infectious for plants only (no animal), **e.g.,** potato spindle tuber caused by viroids.

### Virion

An intact, inert, complete virus particle capable of infecting the host lying outside the host cell in cell free environment is called **virion.**

### Virusoids

These are like viroids, but located inside the protein coat of a true virus. Virusoid RNA can be circular or linear. These are non-infectious as they are replicated only in their host.

### Prions/Slow Virus

The prions are smallest, proteinaceous infectious particles, **i.e.,** disease causing agents that can be transmitted from one animal to another.