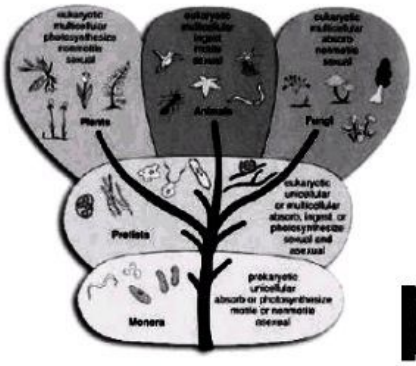


Chapter **2**

Swagatika

Biological Classification

While going through the chapter pay special attention to the following –

Terms and definitions –

1. Phylogenetic relationship
2. Methanogens
3. Thermoacidophiles
4. Halophiles
5. Colicinogenic factor
6. Trichomes
7. Heterocyst
8. Diatomite
9. Capsomeres

At a Glance

- Monera
  - Archaebacteria
  - Bacteria
  - Cyanobacteria
  - Mycoplasma
  - Actinomycetes
- Protista
  - Chrysophytes (Diatoms)
  - Dinoflagellates
  - Euglenoids
  - Slime moulds
- Protozoa
- Fungi
  - Classification of fungi
- Plantae
- Animalia
- Viruses
- Viroids
- Lichens

- Scientists have classified the organism in different kingdoms at different times. Biological classification was first proposed by **Aristotle** who used simple morphological characters to classify plants and animals.
- **Linnaeus** initially separated plants and animals in **two kingdoms** i.e., Kingdom Plantae and Kingdom Animalia. Until recently, it was universally accepted. But later it was found that two-kingdom classification was not sufficient for the following reasons :
  - (i) Prokaryotes and eukaryotes have been grouped together.

    e.g., Bacteria and Cyanobacteria were placed under plant kingdom.
  - (ii) Heterotrophs and autotrophs were placed together.

    e.g., Fungi, which are heterotrophs were placed with plants.

    Euglena, has chlorophyll was placed under protozoa, which are heterotrophs.
  - (iii) It did not differentiate between unicellular and multicellular organisms.

    e.g., Protozoans are unicellular organisms, but were placed with multicellular animals.
  - (iv) Simple organisms were placed with highly complex organisms.

    e.g., Protozoans were placed with human beings in animal kingdom.

    Bacteria (prokaryotes) were placed with highly evolved angiosperms in plant kingdom.
  - (v) Unicellular aquatic organisms are difficult to distinguished as plants and animals.
- In **three kingdom** system, kingdom protista was included along with kingdom plantae and kingdom animalia.
- **Three kingdom** classification was given by **Haeckel**. They placed all unicellular eukaryotes in protista whether they were plants or animals.
- This system was not accepted because it includes both prokaryotic and eukaryotic, chlorophyllous and non-chlorophyllous organisms together.

- **Copeland** classified organisms into **four kingdoms**; Monera (all prokaryotes), Protista (unicellular eukaryotes), Metaphyta (multicellular plants) and Metazoa (multicellular eukaryotes).
- Most accepted system of classification is **five kingdoms** classification which was given by **Whittaker**.

Characteristics of five kingdom system

This system was proposed by **R.H. Whittaker** (1969). Accordingly a separate kingdom has been created for Fungi. Thus, these are – Monera, Protista, Fungi, Plantae and Animalia. The five kingdom classification is based on the following criteria :

- Complexity of cell structure – Prokaryotes or Eukaryotes
- Complexity of organisms body – Unicellular or Multicellular
- Mode of obtaining nutrition – Autotrophs or Heterotrophs
- Phylogenetic relationships

Basic features of all 5 Kingdoms

	Kingdom	Cellular Organisation	Movement	Nutrition	Reproduction
1.	Monera (All Prokaryotes)	Unicellular without nucleus or membranous organelle.	By flagella (tubulin-dynein system)	Absorptive or photosynthetic	Asexual
2.	Protista (Protozoans, unicellular algae)	Unicellular eukaryote with nucleus and membranous organelles.	By flagella, cilia, pseudopodia and mucilage propulsion	Absorptive, photosynthetic & holozoic	Both sexual and asexual
3.	Fungi (Multicellular decomposers)	Multicellular eukaryote, no plastids, cell walls of cellulose, chitin	Non-motile	Absorptive	Asexual and sexual both
4.	Plantae (All plants)	Multicellular eukaryotes of higher organisation, cellulosic cell wall, plastids present	Non-motile	Autotrophic or photosynthetic	Asexual and sexual both
5.	Animalia (All animals)	Multicellular eukaryotes of higher organization, no cell wall and chlorophyll.	Highly motile with all type of motile machinery	Holozoic or saprozoic, heterotrophic	Both sexual and asexual but in higher forms only sexual

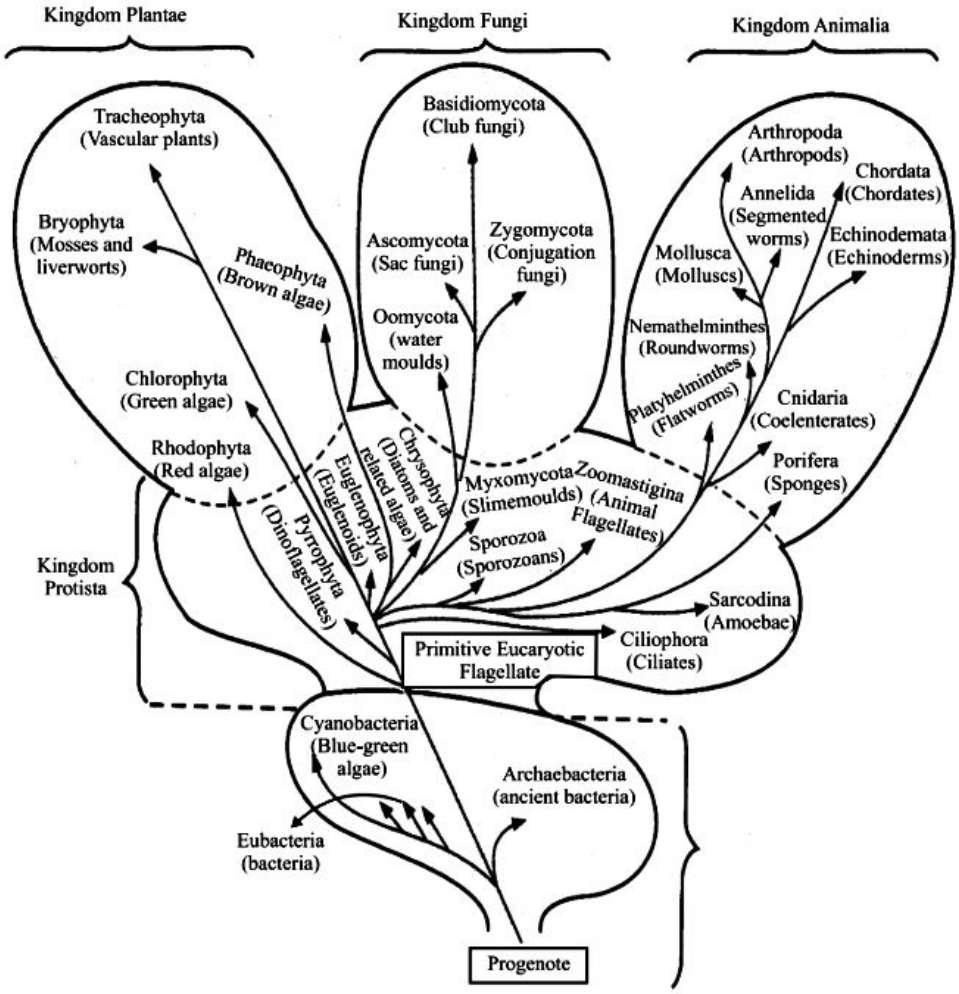


Fig. 2.1 Whittaker's five kingdoms of life with major groups and their phylogenetic relationships.

Connecting Concepts

✦ ***Phylogenetic Relationships :*** The earliest living forms produced procaryotic organisms or monerans. They developed chemoheterotrophy, photoautotrophy, anaerobic respiration and aerobic respiration at different times. Monera gave rise to protista, most probably through association of several types of primitive and advanced monerans. There are several types of protista. Fungi, plants and animals have developed from different types of early protistans.

MONERA (KINGDOM OF PROKARYOTES)

The kingdom includes all prokaryotes – mycoplasma, bacteria, actinomycetes and cyanobacteria or blue green algae.

Characteristics of Monera

- All monerans have evolved from ancient life called **progenote.** They are most primitive and important **decomposers** and **mineralisers** in the biosphere.
- They are unicellular/colonial/multicellular with **prokaryotic** cellular organisation. They are devoid of plastids, mitochondria and advanced (9 + 2) flagella.
- They are without nuclear membrane, nucleoplasm and nucleolus.
- They reproduce asexually by transverse binary fission or budding.
- Protosexual phenomenon is found.
- Cell wall contains peptidoglycan (exceptions are archaebacteria and mycoplasma).
- These organisms are non-motile or move by beating of simple flagella or by gliding.
- They show both autotrophic and heterotrophic mode of nutrition.

Connecting Concepts

✦ Archaebacteria are considered to be **'oldest of living fossils'**.

✦ **Archaebacteria** live under extremely low pH, high temperature, high salinity and high pressure. These properties are being used in modern biotechnology in a number of fields –

(I) Generation of biogas

(ii) Thermophilic enzymes

(iii) Restriction enzymes

(iv) Bioleaching of poor mines

(v) Biosensors

✦ Bacteria were abundant for over 2 billion years before the appearance of eukaryotes in the world. These were responsible for creating the properties of present atmosphere and soil. Further these bacteria make life on earth possible as they perform integral function as decomposers of organic materials.

✦ ***Microorganisms*** are small-sized microscopic organisms with a size of 1 mm or less. They cannot be observed with the naked eye. Microorganisms belong to several taxonomic groups – viruses, bacteria, algae, fungi, protistans and metazoa.

Archaebacteria

- Archaebacteria is one of the most primitive group of bacteria.
- They are found in most harsh habitats. Such as extreme salty areas **(halophiles),** hot springs **(thermoacidophiles)** and marshy areas **(methanogens).**
- Their cell wall is adapted to tolerate extreme conditions (peptidoglycan is absent in their wall instead the wall contains protein and non-cellulosic polysaccharides. Pseudomurein are found in some methanogens.
- The cell membranes are characterised by the presence of branched chain lipids that makes it highly resistant to heat and low pH.
- Three main groups of archaebacteria are :

  (i) **Methanogens :** These are an **anaerobic** bacteria and mainly occur in **muddy areas** and also in **stomach of ruminant animals like cattle**, where cellulose is fermented by microbes. They produce methane gas (CH_4) in bio-gas plants, because they have capacity to produce CH_4 from CO_2 or formic acid (HCOOH). They are autotrophic which obtain energy as well as carbon for assimilation from end products of decomposition. Typical methods of carbon assimilation are absent.

  (ii) **Halophiles :** These are also **anaerobic** bacteria, which occur in **extreme saline** or salty conditions (upto 35% of salt or NaCl in culture medium). Halophiles are able to live comfortably in this high salt concentration because their intracellular salt concentration is equally high. The enzymes and ribosomes of halophiles also function efficiently only at high intracellular salt concentration. A purple pigmented membrane containing **bacteriorhodopsin** is developed in sunlight in these bacteria, which utilizes light energy for metabolic activities (different from photosynthesis).

  (iii) **Thermoacidophiles :** These are **aerobic** bacteria which are found in **hot sulphur springs** (upto 80°C). They have the capacity to oxidize sulphur to H_2SO_4 at high temperature and high acidity (*i.e.*, pH 2.0), hence given the name **thermoacidophiles,** *i.e.*, temperature and acid loving. Some of these bacteria are able to reduce sulphur to H_2S under anaerobic conditions.

Bacteria

- **Anton van Leeuwenhoek** (1683), a Dutch, observed small or tiny animalcules in sewage water, saliva and tooth scum under his crude microscope and these animalcules were later known as **bacteria**.
- **Louis Pasteur** gave **germ theory of diseases** as he reported that certain diseases in plants and animals are caused by bacteria.
- **Robert Koch** first of all cultured bacteria.
- **John Lister** started **antiseptic surgery** using carbolic acid as disinfectant.
- The branch which deals with study of bacteria is known as **bacteriology**.
- **Anton van Leeuwenhoek** is the **father of bacteriology**.
- The term bacterium (plural-bacteria) was coined by German microbiologist, **C.G. Ehrenberg** in 1828.
- Bacteria are the simplest, most primitive unicellular organisms.
- They are found everywhere (air, water, soil, food, inside our body, etc.). They are distinguished by the following characteristics :
  - They are prokaryotes. They lack nucleus and other cell organelles of complex cells. Bacteria has prokaryotic ribosome (70 S).
  - Like plants, they possess cell wall. Made up of **sugar derivatives** which are not present anywhere else, *i.e.*, **N-acetyl glucosamine (NAG)** and **N-acetyl muramic acid (NAM)**.

- They are mostly unicellular but may be in the form of colonies or filaments of independent cells.
- Each bacterial cell contains a **single chromosomes** (nuclear material) that is not enclosed in a nuclear membrane. Primitive type of nucleus is present which is known as **nucleoid, genophore** or **incipient nucleus**.

- Besides nuclear DNA, in some bacteria **extranuclear** or **extrachromosomal DNA** are present which is known as **plasmid**. The plasmids are small, circular, double-stranded DNA molecules that are exist separate from genomic chromosome and replicate independently.

There are three types of plasmids which are as following :

(1) **F-factor or fertility factor :** It is responsible for transfer of genetic material.

(2) **R-factor or resistance factor :** It provides resistance against drugs.

(3) **Colicinogenic factor :** It produces **'colicines'** which kill other bacteria.

- According to shape, bacteria are grouped into four types – **Coccus** or spherical shaped, **bacillus** or rod-shaped bacteria, **spirillum** or spiral/curved shaped bacteria, **vibrio** or comma-shaped bacteria.

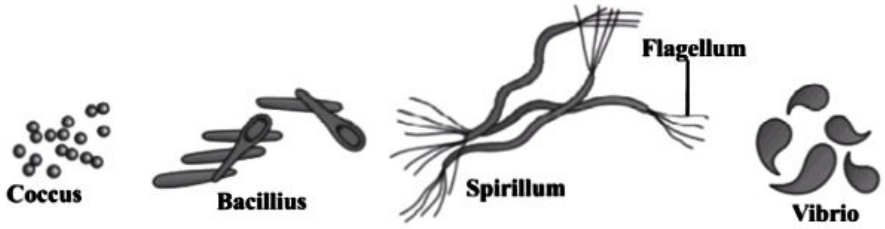


Fig. 2.2 Different forms of bacteria

Connecting Concepts

✦ In donor cell, ***F-factor*** may unite with main genome or nuclear DNA and this donor cell is called ***Hfr-donor*** cell (high frequency donor cell) and here transfer of DNA is rapid.

✦ *E. coli* bacteria is important research material due to its short life cycle, haploid nature and genetic recombinations. The mechanism of gene action and protein synthesis, regulation of operon model was performed in *E.coli*.

✦ It is an ideal host in genetic engineering experiments.

- Most bacteria are immotile *i.e.*, they cannot move. However, some bacteria such as bacilli and spirilla can move on their own. Such bacteria can have a single polar flagellum at one end of a cell, or they can have clusters or many flagella at one or both ends.
- Bacteria show autotrophic as well as hetero-trophic mode of nutrition.
  - **Autotrophic nutrition** means synthesis of organic materials from inorganic raw materials with the help of energy obtained from outside sources. It is of two types, **chemosynthesis** and **photosynthesis**. The bacteria performing these modes of nutrition are respectively called **chemoautotrophs** and **photo-autotrophs**.
  - **Photoautotrophic Bacteria :** The bacteria possess photosynthetic pigments of two types, **bacteriochlorophyll** and **bacteriophaeophytin**.
  - These pigments occur in the membranes of chromatophores dispersed in cytoplasm as chloroplasts are absent.
  - No oxygen is evolved in bacterial photosynthesis. Such type of photosynthesis is known as **anoxygenic photosynthesis**.
  - **Heterotrophic nutrition** involves obtaining of readymade organic nutrients from outside sources.
  - **Chemoautotrophic Bacteria :** The bacteria which are able to manufacture their organic food from inorganic raw materials with the help of energy derived from exergonic chemical reactions involving oxidation of an inorganic substance present in the external medium. The chemical energy obtained from oxidation reaction is trapped in ATP molecules.
- Respiration in bacteria can be **aerobic** in the presence of atmospheric oxygen or **anaerobic** *i.e.*, in the absence of atmospheric oxygen.

Connecting Concepts

✦ The bacterial spore or endospore is perhaps the ***most resistant*** living structure in biosphere.

✦ **Endospore** is highly resistant to very high and very low temperature, strong chemicals and acids, etc., due to calcium, dipicolinic acid and peptidoglycan in cell wall. Dipicolinic acid (DPA) helps in stabilizing its proteins. DPA and Ca ions provide resistance to heat.

- Bacteria reproduce both **asexually** as well as **sexually**. Asexual reproduction in bacteria is by **binary fission** which takes place in favourable conditions or by **endospore formation**. True sexual reproduction is absent in bacteria, but there occurs **genetic recombination**, *i.e.*, bringing together of genetic material of two bacterial cells. There are 3 main methods of genetic recombination :

  (1) Transformation

  (2) Transduction

  (3) Conjugation

  (1) **Transformation :** In transformation genetic material of one bacterial cell moves into another bacterial cell by some unknown mechanism and it converts one type of bacterium into another type (Non-capsulated to capsulated form).

  - It was first studied by **Griffith** (1928) in *Diplococcus pneumoniae* and hence is known as **Griffith effect**. Later on it was studied in detail by **Avery, McCarty** and **McLeod**.

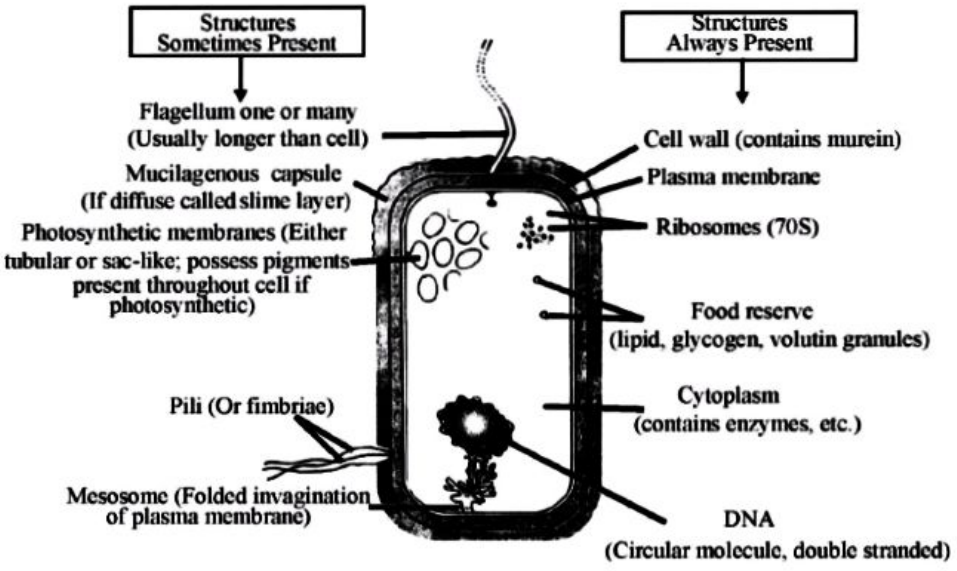


Fig. 2.3 A Typical bacterial cell

  (2) **Transduction :** In this method, genetic material of one bacterial cell goes to other bacterial cell by **bacteriophages** (viruses which infects bacteria).

  - Transduction was first of all reported in *Salmonella typhineurium* by **Zinder** and **Lederberg** (1952).

  (3) **Conjugation :** In conjugation two bacterial cells physically come in contact and genetic material (DNA) of one bacterial cell moves to another cell through conjugation tube which is formed by sex pilli.

  - Conjugation was first reported by **Lederberg** and **Tatum** (1946) in *E. coli* bacteria.
  - Conjugation occurs between donor bacterium and recipient bacterium. Donor is having **sex pilli** and **F-factor** whereas recipient bacterium is lacking both.

- Bacteria have both useful as well as harmful effects.
- They play an important role in nitrogen fixation, decay and putrefaction, used in industries, in curdling of milk, setting of fibres, tanning of leather, in production of vitamins, antibiotics and medicines etc.
- Bacteria cause harmful diseases in plants, animals and humans. Denitrifying bacteria reduce fertility of soil by converting nitrates into free nitrogen.

Some Common Bacterial Diseases

	Human Diseases	
S. No.	**Disease**	**Pathogen**
1.	**Cholera**	*Vibrio cholerae*
2.	**Typhoid**	*Salmonella typhosa*
3.	**Dysentery**	*Shigella dysenteriae*
4.	**Peptic Ulcer**	*Helicobacter pylori*
5.	**Bubonic Plague**	*Yersinia (= Pasteurella) pestis*
6.	**Bacterial Influenza**	*Haemophilus influenzae*
7.	**Whooping Cough**	*Bordetella pertussis*
8.	**Syphilis**	*Treponema pallidum*
9.	**Gonorrhoea**	*Neisseria gonorrhoeae*
10.	**Bacterial Meningitis**	*Neisseria meningitidis*
11.	**Vaginitis**	*Gardnerella vaginalis*
12.	**Tuberculosis (TB)**	*Mycobacterium tuberculosis*
13.	**Leprosy**	*Mycobacterium leprae*
14.	**Diphtheria**	*Corynebacterium diphtheriae*
15.	**Pneumonia**	*Pneumococcus* or *Streptococcus pneumoniae*
16.	**Tetanus**	*Clostridium tetani*
17.	**Boils**	*Staphylococcus aureus*

	Animal Diseases	
S. No.	**Disease**	**Pathogen**
1.	**Anthrax** (Cattle, Sheep)	*Bacillus anthracis*
2.	**Brucellosis** (Cattle, Pig, Goat)	*Brucella melitensis, B. Suis*

	Plant Diseases	
S. No.	**Disease**	**Pathogen**
1.	**Soft Rot of Turnip**	*Erwinia carotovora*
2.	**Fire Blight of Apple, Pear**	*Erwinia amylovora*
3.	**Bacterial Blight of Rice**	*Xanthomonas oryzae*
4.	**Citrus Canker**	*Xanthomonas citri*
5.	**Crown Gall**	*Agrobacterium tumefaciens*
6.	**Angular Leaf Spot of Cotton**	*Xanthomonas malvacearum*

Cyanobacteria

- The new name cyanobacteria has been given to **blue green algae** or **myxophyceae** or **cyanophyceae** class of algae due to their simple prokaryotic organisation like bacteria.
- The cyanobacteria are the largest and most diverse group of photosynthetic bacteria. There are as many as 2,000 or more cyanobacterial species. The cyanobacteria have chlorophyll-a similar to green plants.
- Cyanobacteria may be unicellular, colonial or filamentous. Each filament consists of a sheath of mucilage and one or more cellular strands called **trichomes**.
- Cyanobacterial cells are larger and more elaborate than bacteria. Cell structure is typically procaryotic – one envelope organisation with peptidoglycan wall, naked DNA, 70S ribosomes and absence of membrane bound structures like endoplasmic reticulum, mitochondria, Golgi bodies, plastids, lysosomes, and vacuoles.
- Cyanobacteria reproduce by binary fission, budding, fragmentation and multiple fission. Fragmentation of filamentous cyanobacteria can generate small, motile filaments called **hormogonia**. Some species develop **akinetes**.

Connecting Concepts

✦ ***Pasteurization*** **:** A process named after scientist **Louis Pasteur** which uses application of heat to destroy human pathogens in food. In this process poly β-hydroxybutyrate (PHB) is found in several bacteria as reserve food. It can be used to produce **biodegradable plastics.** Milk is heated at ***62.8°C*** for ***30 min*** or ***71.7°C*** for ***15 sec*** and then immediately cooling it down. This reduces the number of bacteria by killing all non-spore forming bacteria and thus unboiled milk becomes sour earlier than boiled milk.

✦ Lactic acid bacteria unite ***casein*** protein of milk in the form of small droplets and form **curd** and **butter.**

✦ ***Waksman*** was the first person who gave the term **antibiotics** to the chemical substances which are produced by one micro-organisms and which kill other micro-organisms.

✦ The first antibiotic produced was ***penicillin*** (wonder drug) obtained from fungus *Penicillium notatum* by ***Sir Alexander Flemming*** (1923), which checks the growth of Gram +ve bacteria by inhibiting cell wall synthesis or by blocking peptidoglycan synthesis.

✦ The first antibiotic produced from ***bacteria*** by ***Waksman*** was ***thiothricin*** from *Bacillus brewis.*

Connecting Concepts

✦ Genetically engineered strain of *Pseudomonas putida* ***(superbug)*** was developed by Dr. Ananda Mohan Chakraborty (USA) which biodegrade spilled oil.

✦ Mycoplasma are insensitive to penicillin and can be killed by using chloramphenicol, streptomycin and erythromycin.

- **Heterocyst** is a large-sized pale coloured thick-walled cell which occurs in terminal, intercalary or lateral position in filamentous cyanobacteria, e.g., *Nostoc*. It has enzyme **nitrogenase**. Heterocyst is specialised to perform nitrogen fixation.
- About 5–10% cells of a trichome develop into heterocysts, which obtain nutrients from adjacent vegetative cells and contribute fixed nitrogen in the form of amino acid glutamine.
- Cyanobacteria form symbiotic associations with other organisms. They are photosynthetic partners in many lichens, protozoa, liverworts, mosses, gymnosperms and angiosperms.

Mycoplasma

- Mycoplasma are the smallest known aerobic prokaryotes without cell wall. The smallest cell so far discovered is of *Mycoplasma gallisepticum* having a diameter of 0.1 μ.
- Mycoplasma have been reported to cause a number of plants and animal diseases and these have also been reported from urinogenital tract of human beings.
- They lacks cell wall. They have typical colonial appearance and filter through 450 nm bacterial filters.
- As mycoplasma have no cell wall, hence have no definite shape, *i.e.*, **pleomorphic** and thus are called **Jokers of microbiology**. The structure of mycoplasma varies species to species. They are filament form or coccus (round) form.
- On outer side, they have tripartite (3 layered) cell membrane made of lipoproteins.
- In human beings, *Mycoplasma hominis* causes pleuropneumonia, infertility in man and inflammation in genitals. *Mycoplasma pneumoniae* causes Primary Atypical Pneumonia (PAP). Arthritis, respiratory infections and rheumatism are also caused by mycoplasma.
- In plants important diseases caused by *Mycoplasma* are :
  1. Little leaf of brinjal.
  2. Clover dwarf.
  3. Bunchy top of papaya.
  4. Maize stunt.
  5. Mulberry dwarf.
  6. Aster yellows.
  7. Potato witche's broom.

Actinomycetes

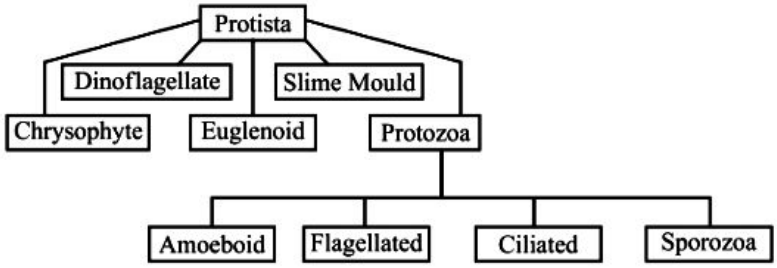
- These are filamentous bacteria (like moulds or fungi).
- These are generally present as **decomposers** in soil. They reproduce asexually by means of **conidia** produced at tips of filaments.
- Most of these secrete chemical substances having antimicrobial activities called **antibiotics** *e.g., Streptomyces* species secrete streptomycin, neomycin, chloromycetin, terramycin, erythromycin, etc.

PROTISTA (KINGDOM OF UNICELLULAR EUKARYOTES)

Haeckel (1886) created the kingdom protista to include all **unicellular eukaryotic microorganisms**. Phylogenetically protists link the prokaryotic kingdom monera with multicellular kingdoms of fungi, plantae and animalia.

- Protists have a typical eukaryotic structure with membrane bound organelles and nucleus.
- Protists are classified into photosynthetic protists slime moulds and protozoan protists.
- **Mesokaryotic** conditions of nucleus are found in dinoflagellates.
- Locomotion is by **flagella** (*Euglena*), **cilia** (*Paramoecium*) and **pseudopodia** (*Amoeba*, slime moulds) and **mucilage propulsion** (diatoms move from one place to another by the secretion of mucilage). Protists like sporozoans and non-flagellate euglenoids move by **wriggling**.
- Flagellate structure possess (9 + 2) microtubular arrangement.

- Protists may be photosynthetic, heterotrophic or mixotrophic (*Euglena).*



Chrysophytes

- They are a group of diatoms or golden algae (*Triceratium, Pieurosigma, Navicula, Cymbella, Amphipleura*) and golden brown photosynthetic microscopic protists. They are basically unicellular but can form pseudofilaments and colonies.
- Diatoms occur in aquatic and moist terrestrial habitat. Diatoms are very good **pollution indicators.**
- The body is covered by a transparent siliceous shell. (silica deposited in cell wall) known as **frustule.** The frustule is made of two valves, **epitheca** and **hypotheca.**
- Diatoms are microscopic unicells of various shapes, *viz.*, circles, semicircles, rectangular, triangular, spindle shaped, boat-shaped, etc. Cells may form zigzag (*e.g., Diatoma*), stellate or fan-shaped colonies. Incipient filaments occur in *Melosira*.
- Depending upon the symmetry, diatoms are of two types— **pennate** (bilateral symmetry, e.g., *Pinnularia, Navicula)* and **centric** (radial symmetry, e.g., *Melosira).*
- They are photosynthetic. They have chlorophyll – *a*, chlorophyll – *c*, α– carotenoids and fucoxanthin (gives brown colour) pigments.
- Each cell has a large central vacuole. The food reserves are oils and **leucosin** (polysaccharide). **Volutin globules** which are proteinaceous in nature also occur.
- Flagella do not occur in somatic cells. However, some diatoms are able to glide by secreting mucilage. Mucilage and oil globules also help the planktonic forms to remain afloat over the surface of water.
- The common mode of multiplication is by **binary fission**. Sexual reproduction varies from isogamy to oogamy. Fertilization produces a zygote which grows in size and forms a rejuvenescent cell called **auxospore.**
- The siliceous cell of diatoms do not decay easily. They pile up at the bottom of water reservoirs and form big heaps called **diatomite** or **diatomaceous earth** or **kieselguhr**.

Economic importance of diatoms

- Diatoms are important sources of food to aquatic animals.
- The oils extracted from some fishes and whales are actually produced by diatoms.
- Diatomite deposits are often accompanied by petroleum fields.
- Diatomite is porous and chemically inert. It is, therefore, used in filtration of sugar, alcohols and antibiotics.
- Diatomite is employed as a cleaning agent in tooth pastes and metal polishes.
- Diatomite is added to paints for enhancing night visibility.
- Diatomite is employed as insulation material in refrigerators, boilers and furnaces.
- Diatomaceous earth is used to make sound proof rooms.

Check Point

Write the causative agent of the following diseases :

(i) Bunchy top of papaya.
(ii) Diphtheria
(iii) Citrus canker
(iv) Syphilis
(v) Bubonic plague

Dinoflagellates

- Dinoflagellate are biflagellate, unicellular golden brown photosynthetic protists which are mainly marine.
- They appear yellow, green, brown, blue or red depending on the pigments present in their cells.
- The cell wall has stiff cellulose plates on the outer surface.
- The dinoflagellate nucleus is very distinctive as it has unusual combination of prokaryotic and eukaryotic characteristics. It is described as **mesokaryon** and has permanently condensed chromosomes. Some species of dinoflagellates have non-condensed chromosomes at some stages in their life cycle.
- Chromosomes are generally membrane attached and nuclear membrane remain intact during mitosis.
- Most of them have two flagella; one lies longitudinally and the other transversely in a furrow between the wall plates.
- Many species of dinoflagellates posses light sensitive organelles known as **eye spot**. Some of them are mere collections of carotenoid containing lipid globules while others have membrane also. It has a pigmented region and a lens like refractive portion.
- Very often, red dinoflagellates (*e.g.*, *Gonyaulax*) undergo such rapid multiplication that they make the sea appear red.
- Dinoflagellates exhibit the phenomenon of **bioluminescence** which is emission of light by living beings. 18 genus of dinoflagellates emit light. They make body glow in dark *e.g.*, *Gonyaulax, Noctiluca, Ceratium, Peridinium*.
- Toxins released by them may even kill other marine animals such as fishes.
- Sometimes they do not kill the animals but accumulate in body of animals like shell fish. Eating such poisoned shell fish causes fatal paralysis in human beings. It affects the neuromuscular transmission and known as **paralytic shell-fish poisoning** or **P.S.P.**

Euglenoids

- It includes *Euglena*-like flagellates which have plant like characteristics (chlorophyll) in addition to some animal characteristics. They ingest food particles and carry out photosynthesis.
- Mostly unicellular and free living, found in fresh water ponds, ditches or in damp soil.
- Instead of a cell wall, they have a protein rich layer called **pellicle** which makes their body flexible. Though they are photosynthetic in the presence of sunlight, when deprived of sunlight they behave like heterotrophs by predating on other smaller organisms.

  Example : *Euglena*.

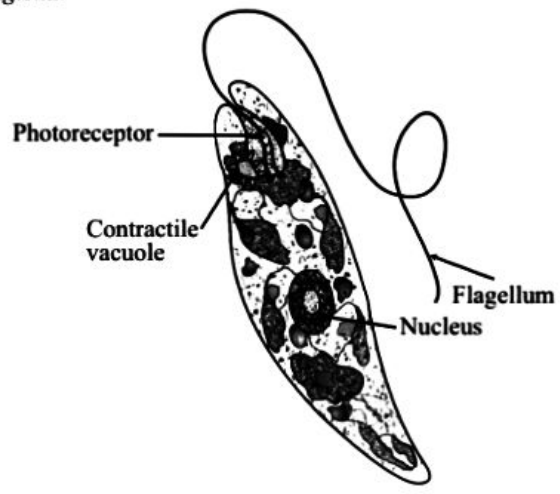


Fig. 2.4 *Euglena*

- They have 'two' tinsel flagella. One is usually reduced. A single long flagellum seems to have two branches at the base with each of which having its own basal granule.
- Euglenoids swim actively in a liquid medium with the help of their long flagellum.
- They can also perform creeping movements by expansion and contraction of their body, the phenomenon is called **metaboly** or **euglenoid movements**.
- The base of flagellum bears a swelling called **paraflagellar body**. A **stigma** occurs attached at the level of paraflagellar body. Both acts as photoreceptor.
- An osmoregulatory **contractile vacuole** is found.
- Nutrition is holophytic (photoautotrophic), saprobic (e.g., *Rhabdomonas)* or holozoic *(e.g., Peranema)*. Even holophytic forms can pick up organic compounds from the outside medium. Such a mode of nutrition is called **mixotrophic** (e.g., holophytic + saprobic).
- The photoautotrophs or holophytic forms possess **chloroplasts** with or without **pyrenoids** (proteinaceous bodies).
- Store carbohydrates as **paramylum bodies.**
- Sometimes, usually under unfavourable conditions, some *Euglenae* come close together, secrete gelatinous covering within which they remain embedded. This condition is called **palmella stage.** On return of favourable conditions, they regenerate their flagella and start their normal life.

Slime Moulds

- They constitute a group of consumer-decomposer organisms which live on decaying organic matter in both terrestrial and aquatic habitats.
- They are unicellular, saprophytic organism which lack cell walls and have the plasma membrane as their outer covering.
- They move through **pseudopodia**.
- The cellular forms are called **plasmodium** while the acellular forms are called **pseudoplasmodium**. They have numerous **diploid nuclei**.
- Their spores having cell wall are produced by reduction division. The spores acts as gametes and are known as **myxamoebae** or **swarm cells**. The zygote undergoes free nuclear division to produce the multinucleate slime mould.
- Slime moulds consist of a spreading slimy mass of protoplasm and share the characters of both animals and fungi. Due to this peculiarity they are commonly called fungus animal. Slime moulds are of two types - **acellular slime moulds** and **cellular slime moulds**.

Acellular Slime Moulds

(i) These slime moulds have a free living diploid somatic phase of one large mass of protoplasm in which there may be thousands of nuclei, lacking cell walls.

(ii) It often appears as a slimy, fan shaped network of living matter. It is called as **plasmodium**.

(iii) This mass flows along in an amoeboid manner on the soil of forest, surface of dead leaves or on a rotting log. As it moves along it engulfs food particles and digests them in food vacuoles.

(iv) Examples of acellular slime moulds *Physarum, Physarella, Fuligo, Dictydium, Lycogala, Tubifera.*

Cellular Slime Mould

(i) They are characterised by the absence of flagellate cells, formation of pseudoplasmodium, absence of a sporangial cover, presence of cellulose wall around spores and anisogamous type of sexual reproduction.

(ii) In cellular slime moulds numerous individuals, amoeboid cells aggregate and move together like a mass of protoplasm. This is called as a **pseudoplasmodium** since individuals are not fused.

Connecting Concepts

✦ Diseases caused by zooflagellates are as following :

1. Central african sleeping sickness or Gambian is caused by *Trypanosoma gambiense*. Vector is Tsetsefly *Glossinapalpalis* while east african sleeping sickness or rhodesian is caused by *Trypanosoma rhodesiense*. It is also known as trypanosomiasis. It is transmitted by *Glossina morsitans Trypansoma cruzi* cause chages disease or american trypansomiasis.

2. *Giardia lamblia* or *Giardia intestinalis* is popularly known as **grand old man of intestine** causes giardiasis or black packer's disease.

3. Kala-azar, dumdum fever or visceral leishmaniasis is caused by *Leishmania donovani*. Its vector is blood sucking sandfly *Phlebotomus*.

4. *Leishmania tropica* causes dermal or skin leishmaniasis, also called ***oriental sore*** or ***Delhi sore*** (= Delhi boil). *Leishmania brasiliensis* produces ***mucocutaneous leishmaniasis*** or ***expundia.***

5. ***Polymorphism in Trypanosoma.*** *Trypanosoma* has four forms. Three of them are developmental stages, viz., ***crithidia, leptomonas*** and ***leishmania***. Infective or ***metacyclic*** stage is ***trypanosoma***. In human blood, the adult or trypanosoma type occurs.

✦ ***Plasmodium*** is ***digenetic,*** that is, with two hosts, human beings and females of mosquito *Anopheles*. Female *Anopheles* is the ***primary host*** as sexual reproduction occurs in it. Human being is ***secondary host***. Monkey is ***reservoir host***.

PROTOZOA

- Classification of Protozoa is mainly based on locomotory organelles. Protistan protozoa are divisible into four major groups – zooflagellata, sarcodina, sporozoa and ciliata.

Zooflagellates

- They are protozoan protists which possess one to several **flagella** for locomotion.
- Zooflagellates are generally uninucleate, occasionally multinucleate. The body is covered by a firm pellicle. Cyst formation is also present.
- **Examples of zooflagellates:** *Trichonympha, Lophomonas, Giardia, Trypanosoma, Leishmania* and *Trichomonas. Trichonympha* and *Lophomonas* are cellulose digesting symbionts in the body of termites.

Sarcodines

- They develop **pseudopodia** for locomotion and ingestion of food.
- Pseudopodia are temporary protoplasmic outgrowths. Sarcodines are generally uninucleate, occasionally multinucleate. The body is without periplast (with a covering of only plasmalemma) or have a shell.

Examples of sarcodines :

- *Entamoeba histolytica* – human parasite that resides in the upper part of large intestine and causes the disease known as **amoebic dysentery** or **amoebiasis**.
- *Entamoeba coli* – It inhabits human colon. It is commensal parasite and does not produce any disease.
- *Entamoeba gingivalis or mouth Amoeba* – It is found in tartar of teeth and in pus pockets of bleeding gums. The condition is called as **pyorrhoea**.

Sporozoan

- They are develop from paristic mode of life (usually endoparasites).
- **Locomotory organs (cilia, flagella, pseudopodia etc.)** are absent.
- The body is covered by elastic pellicle or cuticle and have a single nucleus, contractile vacuoles are absent.
- Sporozoans forms occasionally *Amoeba* like stages.

Examples of sprozoan :

- *Plasmodium vivax* – causes **benign tertian fever.**
- *Plasmodium falciparum* – causes **malignant tertian fever** or **cerebral malaria** or **pernicious malaria** or black-water fever.
- *Plasmodium ovale* – causes benign **tertian fever.**

Ciliates

- They are protistan protozoans which possess **cilia** as organelles of locomotion and food capturing.
- Ciliates are mostly free living fresh water protistans. A few are marine. Some are parasites.
- Free living forms are generally motile. A few are sedentary (e.g., *Vorticella*).
- Though unicellular, ciliates have the highest degree of structural and physiological complexity due to specialisation of organelles for skin, muscles, sense organs, kidney, ingestion, egestion, etc.
- Food collecting apparatus consists of an oral groove, vestibule, buccal cavity, cytostome and cytopharynx. A cytopyge or cytoproct is also formed for egestion.
- Two types of nuclei are found, larger metabolism controlling polyploid **macronucleus** and smaller heredity controlling diploid **micronucleus**.
- Asexual reproduction occurs by binary fission, budding and cyst formation.
- Sexual reproduction by conjugation. Autogamy also occurs.
- **Examples** *Paramoecium, Tetrahymena, Vorticella, Balantidium. Tetrahymena* is used in biological research. *Balantidium* coli causes balantidial or ciliary dysentery in humans. Infection comes from faecal contamination of pig.

FUNGI (KINGDOM OF MULTICELLULAR DECOMPOSERS)

Fungi are achlorophyllous, heterotrophic, gametophytic, haploid, multicellular, eukaryotic nucleated, spore producing thallophytes which are surrounded by cell wall of **chitin** (fungus cellulose).

- The fungi were given the status of kingdom by R.H. Whittaker (1969) in his five kingdom system of classification.
- Study of fungi is called ***Mycology*** or **mycetology**.
- **Pier Antonio Micheli** an Italian Botanist is regarded as father of mycology. He wrote *Nova Genera Plantarum*.
- **E. J. Butler** is regarded as father of Indian Mycology and Phytopathology.

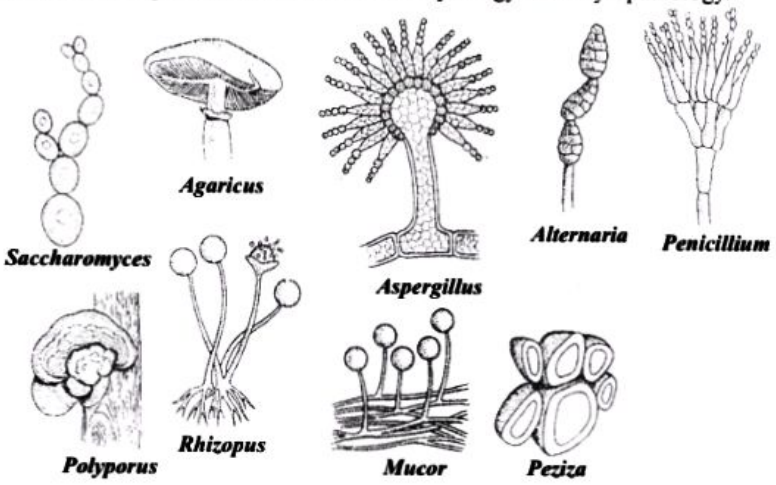


Fig. 2.5 Some Fungi

General Characters

- Fungi are non vascular, non-seeded, non-flowering, multicellular decomposers and mineralisers of organic wastes and help in recycling of matter in the biosphere.
- In true fungi the plant body is **thallus**. It may be non-mycelial or mycelial.
  - **Non Mycelial :** The non-mycelial forms are unicellular; however they may form a pseudomycelium by budding. *e.g.*, Yeast.
  - **Mycelial :** In mycelial form plant body is made up of thread like structures called **hyphae**. Hyphae are usually branched tube like structure bounded by a cell-wall of **chitin**. The hyphae may be septate (higher fungi) or aseptate (lower fungi).
  - Septate hyphae may be of 3 kinds, uninucleate (monokaryotic hyphae), (dikaryotic hyphae) with binucleate cells or multinucleate. Some fungi are aseptate and known as **coenocytic fungi**, with hundreds of nuclei in continuous cytoplasmic mass.
- The cell shows eukaryotic organization but lack chloroplast and Golgi bodies. The genetic material is DNA and mitosis is intracellular **(karyochorisis)**.
- Fungi lack chlorophyll, hence, they do not prepare food by photosynthesis. Thus they can grow where, organic material is available.
- Fungi are **heterotrophs** that acquire their nutrient by absorption. They store their food in the form of **glycogen**.
- The primitive fungi have oogamous type of sexual reproduction where as most advanced ones do not have sexual reproduction.
- Fungi are **achlorophyllus** organisms and hence they live as **heterotrophs** *i.e.*, as parasites and saprophytes.
  - **Parasites :** They obtain their food from a living host. Usually some of their hyphae modified into haustoria.
  - **Saprophytes :** They derive their food from dead and decaying organic matter.

Connecting Concepts

✦ Roman emperor Caesar was poisoned by his wife by *Amanita caesarea*.

✦ In karyochorisis nuclear division involves formation of internal spindle. The latter may be connected with centrioles or spindle pole bodies or SPB. Nuclear envelope persists during nuclear division.

✦ **Obligate parasites :** They thrive on a living host throughtout their life and with the death of host, parasitic fungi dies. Eg., *Puccinia*.

✦ ***Facultative parasites :*** Fungi which lives independent of a host but may occasionally be parasitic under certain conditions. Eg., *Fusarium*.

✦ ***Ectoparasites or ectophytic parasites*** : They grow on the surface of host cells and absorb their food through haustoria.

✦ ***Endoparasites or endophytic parasites :*** They enter into the tissues of the host.

- **Symbionts :** Some fungi live symbiotically with algae (in lichens). Some fungi live in the roots of higher plants e.g., in the roots of *Pinus*. This type of symbiotic relationship is called **mycorrhiza**.
- Some fungi may grow on cow dung (coprophilous fungi).

Reproduction

Fungi have three types of reproduction.

- **Vegetative Reproduction :** Vegetative reproduction in fungi may be of the following types:
  - **(a) Fragmentation :** Multiplication by breakage of mycelium.
  - **(b) Fission :** Simple splitting of vegetative cells into two daughter cells.
  - **(c) Budding :** Some fungi produce small outgrowths *i.e.*, buds from their vegetative body. Eventually the buds are cut off to form new individuals.
  - **(d) Oidium formation :** In some fungi the hyphae break up into numerous small fragments known as Oidia and give rise to new hyphae.
  - **(e) Chlamydospore :** Under unfavourable conditions, the hypha forms thick walled resting resistant spores which on return of favourable conditions germinate to give rise to new individuals. Thus, chlamydospore are organs of perennation.

Connecting Concepts

✦ ***Obligate saprophytes :*** They can not live without dead organic matter.

✦ ***Facultative saprophytes :*** Some fungi which are usually parasitic but after the death of host plant, are able to absorb their food from the decaying body of the plant.

✦ ***Predaceous fungi :*** Some fungi e.g., *Dactylella* derive their food from protozoans, eelworms and rotifers.

✦ **Heterothallism** (GK. heteros – different, thallos – undifferentiated body) is the phenomenon in which the fusing gametes belong to two genetically distinct strains of the same species though there may not be any morphological distinction between the gametes or structures bearing them. It was first discovered by **Blakeslee** in 1904. Since, there is no morphological distinction between the different strains producing compatible gametangia, they are called (+) and (–), A and B or α and α. Heterothallism is a mechanism to introduces variations that are helpful in adapting to diverse habitats, unfavourable environments and toxic chemicals.

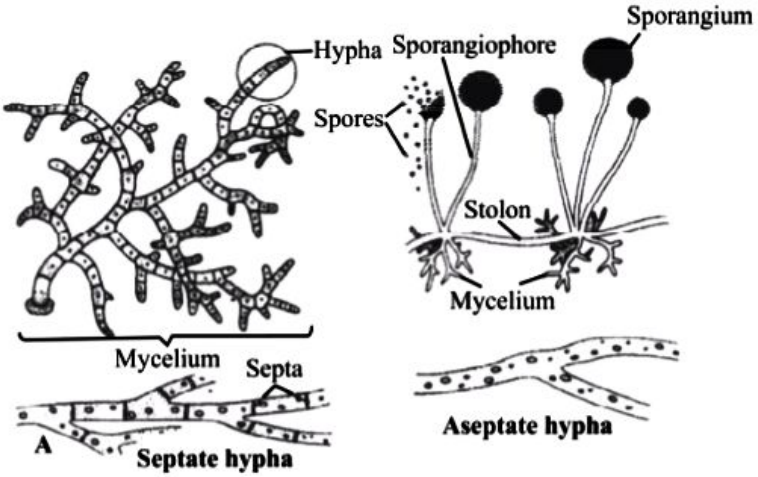


Fig. 2.6 Mycelium of fungus with septate hypa & mycelium of fungus with aseptate hypa

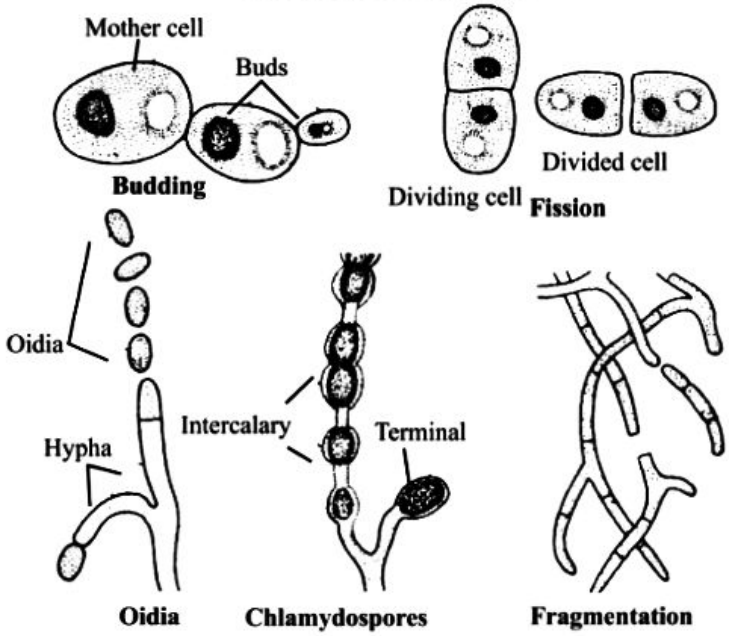


Fig. 2.7 Vegetative reproduction in Fungi

Asexual Reproduction

Asexual reproduction in fungi may be of the following types:

(a) Zoospore formation : Zoospores are thin walled uninucleate, motile structures formed in zoosporangia. They may be uniflagellate (*e.g.*, *Synchytrium*) or biflagellate (*e.g.*, *Saprolegenia*).

(b) Sporangiospores : They are nonflagellate spores that develop inside sporangia, *e.g.*, *Mucor, Rhizopus*. Sporangiospores are usually dispersed by air currents. Therefore, they are produced in large numbers.

(c) Conidia: Conidia are non-motile, thin walled exogenous spores produced on a conidiophore. They are arranged in chains on the conidiophore e.g., *Aspergillus* and *Penicillium*. They may also be produced singly on a conidiophore e.g., *Pythium*.

Sexual Reproduction

Sexual reproduction is reduced in fungi and take place by two fusing gametes. It includes 3 stages:

(a) Plasmogamy or fusion of two protoplasts

(b) Karyogamy or fusion of two nuclei

(c) Meiosis or reduction division

In higher fungi, kayrogamy is delayed and occurs just before meiosis. In the stage intervening between plasmogamy and karyogamy the cells often contain two nuclei or **dikaryons** (n + n). Such cells are called **dikaryotic cells**. The phase is known as **dikaryophase**.

Sexual reproduction of fungi is of the following types :

(i) Planogametic copulation : In this process, fusion of two gametes of opposite sex or strains takes place. This process is usually of two types i.e., isogamy and heterogamy.

(ii) Gametangial contact: In this process, two gametangia come in contact with one another. Both the gametangia never fuse together loosing their identity.

(iii) Gametangial copulation: In this process, entire content of 2 gametangia is fused.

(iv) Spermatization: The uninucleate, nonmotile male gamete called spermatia is transferred to trichogyne of ascogonium (female gametangium). The contents migrate into receptive structure and dikaryotic condition is established.

(v) Somatogamy: This takes place in fungi where formation of gametes is absent. Here two hyphae of opposite strains are involved in fusion thus bringing about dikaryotisation.

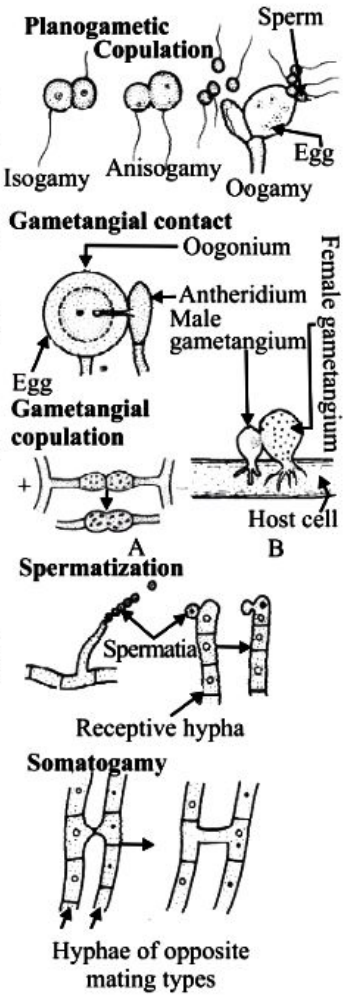


Fig. 2.8 Different types of sexual reproduction in fungi

Classification of Fungi

A number of criteria are used for classifying fungi. The important ones are:

(a) Morphology of mycelium and reproductive structure. Reproductive structure is more important as it exhibit more variation.

(b) Types of spores and their dispersal.

(c) Life cycle.

Kingdom fungi has been divided into two divisions

Division 1: Myxomycotina *e.g.*: Slime moulds. No cell wall.

Division 2: Eumycotina. They are true fungi, cell wall is present. This subdivision has been divided into following 4 classes.

Classes:

- Phycomycetes
- Ascomycetes
- Basidiomycetes
- Deuteromycetes

Phycomycetes (Algal fungi)

- These are aseptate, coenocytic fungus.
- Asexual reproduction takes place by **zoospores** (motile) or by **aplanospores** (non-motile). These spores are endogeneously produced in sporangium. Sexual reproduction occurs by **gametangial copulation** (conjugation) between two similar, multinucleated coenogametangia containing multinucleated coenogametes to produce zygospore (sexual spore). Some common examples are *Mucor*, *Rhizopus* (bread mould) and *Albugo* (parasitic fungi).

Ascomycetes (Sac fungi)

- Mycelium is branched, septate (except yeast which is unicellular).
- Each cell of mycelium is uninucleated (e.g., *Penicillium)* or bi-nucleated or multi-nucleated, cell wall is made up of fungus cellulose **(chitin)**.
- Flagella totally absent, asexual reproduction by **conidia** produced exogenously on branched/ unbranched conidiophore; conidia are brown/green/blue/yellow/pink and provide colour to the mycelium.
- Sexual spores are **ascospores** which are produced endogenously in sac like **asci** (singular *ascus*). These asci are arranged in different types of fruiting bodies called **ascocarps**.
- Ascomycetes include unicellular yeast (*Saccharomyces*), blue mould (*Aspergillus*), green mould (*Penicillium*), pink mould (*Neurospora*), parasitic fungi such as *Erysiphe* which causes powdery mildews, *Claviceps purpurea* which causes ergot of rye.
- *Neurospora* is used extensively in biochemical and genetic work.

Connecting Concepts

✦ ***'Guinea Pig' of Plant Kingdom.*** *Aspergillus flavus.* ***'Drosophila' of plant Kingdom.*** *Neurospora.*

✦ ***Biobleaching.*** Fungus *Phanerochaele chrysosporium* can bleach paper pulp better than bleaching powder.

Basidiomycetes (Club Fungi)

- Class basidiomycetes include *Agaricus* (mushroom), *Puccinia* (rusts) and *Ustilago* (smuts). It is commonly called club fungi because the basidia are club shaped.
- These are most evolved, most complex and most advanced fungi and **best decomposers of wood**.
- These are most commonly seen fungi as their fruiting bodies are large and easily visible e.g., mushrooms, puff ball, rusts, smuts and predaceous fungi do not produce fruiting bodies.
- The mycelium is branched and septate.
- The asexual reproduction are generally absent, but vegetative reproduction by fragmentation is common.
- The sex organs are absent, but plasmogamy is brought about by fusion of two vegetative or somatic cells of different strains or genotypes. The resultant structure is **dikaryotic** which ultimately gives rise to **basidium**. **Karyogamy** and **meiosis** take place in the basidium producing four **basidiospores**. The basidiospores are exogenously produced on the basidium (Pl. :basidia). The basidia are arranged in fruiting bodies called **basidiocarps**.
- Some common members are *Agaricus* (mushroom), *Ustilago* (smut) and *Puccinia* (rust fungus).

Deuteromycetes (Fungi imperfecti)

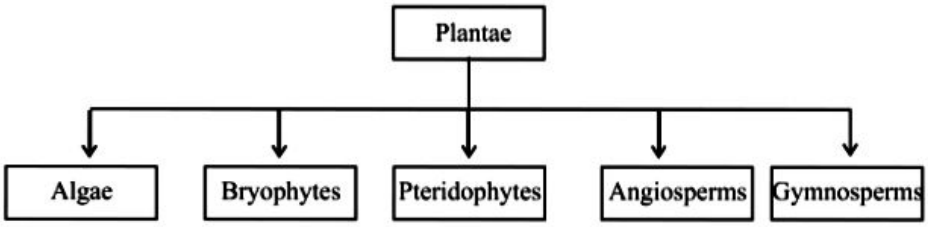
- The **perfect stage (sexual stage)** is either **absent** or not reported and hence called **fungi imperfecti**.
- Some members are saprophytes or parasites while a large number of them are decomposers of litter and help in mineral cycling.
- Mycelium is septate, branched. Asexual reproduction by **conidia** produced on **conidiophores**. These conidiophores may occur isolated or aggregated to form complex structures like **acervulus, synnema, sporodochium** and **pycnidium**.
- Acervulus (called asexual fruitification) is a aggregation of hyphae developed beneath the surface of host plant. These hyphae produce short conidiophores packed closely to form a flat bed like mass on the surface of host conidia are not covered by fungal tissue.

- Conidiophores are free from each other and bear conidia *e.g., Colletotrichum*.
- Some examples are *Alternaria*, *Colletotrichum* and *Trichoderma*.

PLANTAE (KINGDOM OF PLANTS)

- Members are multicellular, eukaryotic, photosynthetic organisms.

  Main characters of the members of this kingdom are :
  - Cellulosic cell wall.
  - Non-motile, excepts some aquatic forms.
  - Presence of chloroplasts.
  - Photosynthetic mode of nutrition **(oxygenic photosynthesis)**, e.g., different types of algae (green, brown, red algae), bryophytes, pteridophytes, gymnosperms and angiosperms.
  - Growth is usually indefinite.
  - Some of the plants are **heterotrophic**. They are mostly parasitic. A few are saprobes. A small group of autotrophic plants catch small animals and insects for obtaining nitrogen. They are called **carnivorous or insectivorous plants**.
  - Reproduction is both asexual and sexual. Accessory spores are present in lower plants. An embryo stage is absent in the algal group but present in others.



ANIMALIA (KINGDOM OF ANIMALS)

- These are multicellular eukaryotic organisms.
- The cells do not contain cell wall, but contain only cell membrane.
- They do not perform photosynthesis and have heterotrophic nutrition.
- They have the power of locomotion.
- They show increased sensitivity through the nervous system.

VIRUSES

- Study of virus – virology.
- The term 'virus' has been derived from latin, which means poison or venom or viscous fluid.
- These are defined as, **infectious nucleo-proteins**.
- These are submicroscopic organisms generally less than 200 mμ.
- They are **obligate parasites**, *i.e.*, can live inside living host only.
- **Ivanowsky** (1892) recognised certain microbes as causal organism of the **mosaic disease of tobacco**. These were found to be smaller than bacteria because they passed through bacteria-proof filters.
- **M.W. Beijerinek** (1898) demonstrated that the extract of the infected plants of tobacco could 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 **crystallised**. They are inert outside their specific host cell.
- They have either **RNA** or **DNA**.

Check Point

Give the scientific term for

(a) A cell with two haploid nuclei of different mating types.

(b) The symbiotic association of a fungus with the root of higher plant.

(c) Fruiting body of ascomycetes.

(d) Uninucleate non motile gamete transferred to female gametangium.

(e) Aggregration of hypae developed beneath the surface of host plant produces conidia without fungal covering.

- They have characteristic mode of multiplication, *i.e.*, once a virus enters into the host cell, it takes control of whole biochemical machinery of host cell and orders the metabolic machinery to synthesize their own (viral) components.
- They have character of both living and non-living.
- **Non-living characters of virus**
  - No protoplasm
  - No enzyme system
  - No respiration
  - They can be crystallized
  - Do not grow in culture medium
- **Living characters of virus**
  - They contain nucleic acid as a result of which they are capable of synthesizing proteins.
  - They can multiply inside living host cell.
  - They cause disease in humans, plants and animals.
- **Bacteriophage :** Bacterial viruses or bacteriophages (viruses that infect the bacteria) are usually double stranded DNA viruses.

Types of bacteriophages

Broadly of two types :

1. **Prophages or non-virulent phages or non-infective phages :** The phages which do not cause lysis of bacteria soon after their formation inside the bacterial cell are called **prophages**. Such bacterial cells which are having prophages inside them are called **Lysogenic bacteria**.
2. **Virulent phages or infective phages :** The phages which cause lysis of bacterial cell at once are called virulent phages.

   Most studied series of bacteriophages is **T-series**, *i.e.*, T_2, T_4, T_6, etc.

Structure of bacteriophages

- Having tadpole-like structure, i.e., with head and tail. Nucleic acid generally DNA is present inside the head.

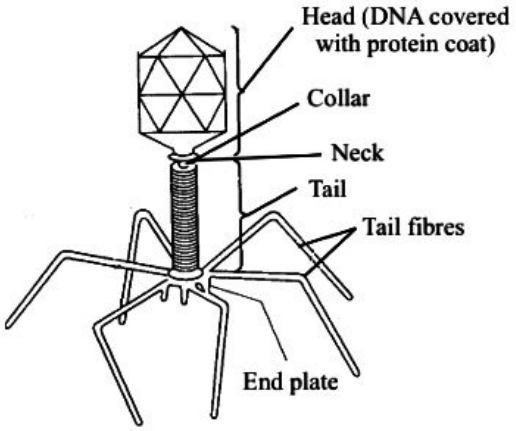


Fig. 2.9 Structure of bacteriophage

- Head is **hexagonal** having length 950Å and breadth 650Å. Tail is joined to head by neck and collar.
- Tail is having hollow core and is surrounded by tail sheath. At the end of tail, end plate is present to which tail fibres are attached.

Multiplication

Viruses multiply by lytic or lysogenic cycle.

Lytic Cycle

The main steps of **lytic cycle** are :

1. **Adsorption :** Bacteriophage is attached to bacterial cell surface with the help of tail fibres.
2. **Penetration :** Only nucleic acid of phage enters into the bacterial cell through the lysis of bacterial cell by **lysozyme** secreted by tail fibres. Protein coat is left outside, which is known as **ghost** or **doughnut**.
3. Virus nucleic acid control the metabolic activities of bacterial cell and forms new phage components, which unite to form **100-300 new phages** with 15-20 minutes.
4. **Lysis** of bacterial cell to release new phages.

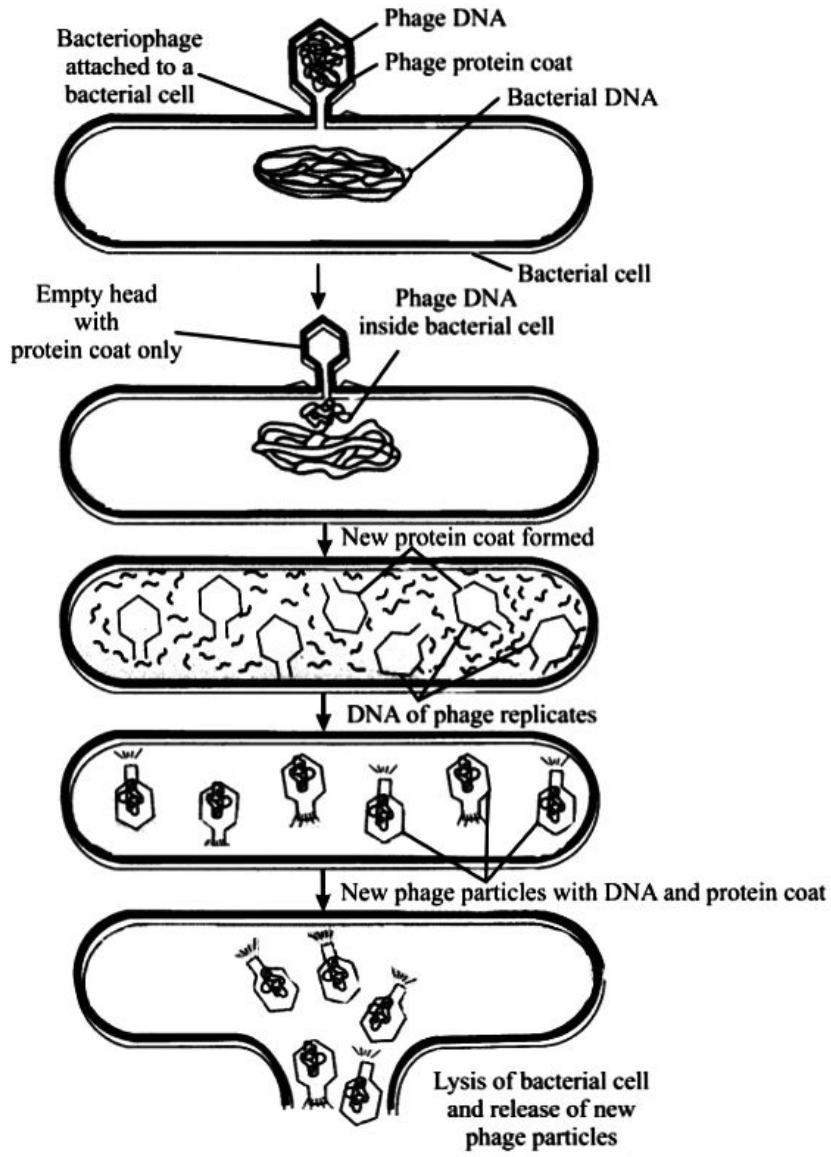


Fig. 2.10 Lytic cycle of T_2 Bacteriophage

Lysogenic cycle

It is a mode of viral multiplication in which the virus does not cause immediate lysis of the host cell nor produce phage particles immediately. It has following stages.

Check Point

Fill in the blanks :

(1) The phages which do not cause lysis of bacteria soon after their formation inside the bacterial cell is known as _____.

(2) Virus which attack bacteria are called as _____.

(3) _____ is the protein covering of TMV.

(4) AIDS virus contains _____.

(5) The integrated viral genome is called _____.

(i) **Entry of viral genome in bacterial cells :** The virus attaches to the surface of host cell. The viral genetic material passes into the host by the help of lysozyme.

(ii) **Formation of prophage** : The virus genome produces a **repressor** and an **integrase**. The repressor does not allow the viral genome to take over the metabolic machinery of the host cell. Enzyme integrase fuses the viral genome with DNA of the host cell at a specific site. The integrated viral genome is called **prophage** or **provirus**. In this state the virus remains **non-virulent**. It is also called **temperate stage**.

(iii) **Lysogeny :** The condition of host cell carrying a prophage is called lysogeny. The prophage multiplies along with the multiplication of the host cell without harming the latter. This mode of multiplication is called lysogenic cycle.

(iv) **Conversion into lytic phage :** Occasionally, repressor formation is inhibited. Certain physical factors (*e.g.* UV radiations), chemicals (*e.g.*, nitrogen gas, mustard gas) and stresses inhibit its formation. The viral genome separates from the genome of the host cell and becomes **virulent** or **lytic**. It takes over the machinery of the host cell, undergoes replication and forms viral proteins and assemble virus particles. The host cell undergoes lysis to liberate the virus particles.

- The inert particle of virus, outside its host, is called **virion**.

Importance of bacteriophages

1. Used in studying viral infection mechanism.
2. Used in control of certain bacterial diseases (as phages are very specific in relation to their host).
3. Purity of holy Ganges is due to presence of bacteriophages.

TMV (Tobacco Mosaic Virus) :

- It is a rod-shaped virus. The rod has a core which contains helically coiled single stranded **RNA .**
- There is a protective covering of protein called **capsid** around the infective part. Capsid consists of 2130 subunits called **capsomeres** and has antigenic property.
- TMV causes mosaic disease to tobacco leaves and some other plants.
- There is loss of chlorophyll in young leaves. Later on non-green and green patches are found on mature leaves as well. Green areas grow in thickness and give blistered appearance.
- The infected leaves also show curling and distortions.

HIV (Human Immunodeficiency virus, AIDS virus)

- It is round retrovirus of about 100 nm in diameter.
- The surface is covered by host derived envelope which bears spikes which have protein components known as **peplomers** complementary to CD_4 or T_4 antigen receptor present on the surface of helper T-cells, monocytes, macrophages, etc.
- Inner to envelope, viral wall is present which is made of two layers.
- The core contains two single strands of genomic RNA, protein, reverse transcriptase enzyme etc.
- HIV causes AIDS for which no remedy has been found.
- Generally in plant viruses, RNA is present but in **cauliflower mosaic virus,** DNA is present.
- Generally in animal viruses, DNA is present but in following animal viruses, RNA is present:
  - (i) Influenza virus : Single stranded RNA.
  - (ii) Rous sarcoma virus : Single stranded RNA.
  - (iii) AIDS virus : Single stranded RNA.
  - (iv) Poliomyelitis virus : Single stranded RNA.
  - (v) Reovirus : Double stranded RNA.

- Single stranded RNA viruses *(e.g.,* AIDS virus) which carry **reverse transcriptase** enzyme (which copies RNA into DNA, *i.e.,* reverse transcription), are called **retroviruses**.
- In bacteriophages, generally DNA is present but in **MS_2, F_2, r-17 bacteriophages**, RNA is present.
- Generally DNA is double stranded but in **ϕ 174 bacteriophage** and **S/3. *E. coli* phage,** DNA is single stranded.
- Generally RNA is single stranded but in **reoviruses, wound tumour viruses** and **rice dwarf virus,** RNA is double stranded.
- Total number of genes is about a hundred for a large virus, *e.g., Vaccinia* (cowpox virus) or 3 or 4 for the smallest virus.
- In some **mammalian viruses,** outside the capsid there is another membrane which is known as **limiting membrane** or **mantle**.
- **Coliphage** is the virus infecting *E. coli* bacteria (discovered by F.H.d' Herelle).
- **Cyanophages** are viruses infecting blue-green algae or **cyanophyceae** or **cyanobacteria.** (The first cyanophage or algal virus was discovered and isolated from 3 blue-green algal genera: *Lyngbya, Phormedium* and *Plectonema,* hence called **LPP-I).**
- **Safferman and Morris** (1963) discovered cyanophages and these are having double stranded DNA.
- Viruses infecting fungi are called **mycophages**. Mycophages were first of all discovered by **Sinden** (1957) in *Agaricus bisporus*. These are having double stranded RNA and are spherical or polygonal in shape.
- During latent mode of replication virus genome is not affected because it possess 5 hydromethyl cytosine (5–HMC) instead of cytosine. Viral genome modify bacterial nucleoid which produce modified enzymes, modified mRNAs and ribosomes that take part in replication and transcription of viral genome.
- **Economic importance of virus :**
- Viruses cause diseases like mumps, small pox, herpes, rabies, chicken pox, poliomyelitis, hepatitis, Bird or Avian flu (H5NI), swine flu (HINI) and influenza. **AIDS** in humans is also caused by a virus.
- In plants, the symptoms can be mosaic formation, leaf rolling and curling, yellowing and vein clearing, dwarfing and stunted growth.

VIROIDS

- **T.O. Diener** (1971) discovered some new infections agents, which are smaller than viruses.
- These sub-viral infections agents are called viroids.
- Viroids contain only very low molecular weight **RNA** and protein coat.
- Viroids cause **potato spindle tuber disease (PSTV), Chrysanthemum stunt, Citrus exocortis, cucumber pale fruit** etc.
- Viroids cause persistent infections, *i.e.*, never recovered.

LICHENS

- Lichens constitute a small and distinct group of plants having about 400 genera.
- In lichens, there are 2 components; *i.e.*, algal partner called **phycobiont** and fungal partner called **mycobiont**.
- Lichens have distinct structure different from algal and fungal partner.
- **Internal structure of lichen :** The major portion of lichen body is formed of fungus. Photosynthetic or algal symbiont constitutes hardly 5% of the body.
- There is an upper or outer cortex, algal zone, medulla, lower cortex and rhizines.
- Rhizines are attaching devices made of fungal hyphae.

Connecting Concepts

✦ ***Viroid genome*** is rod shaped circular RNA which appears double stranded due to complementary base pairing interspersed by unpaired regions forming loops. It does not code for any protein because of absence of initation codon. A viroid can multiply by two methods – DNA dependent and RNA dependent.

✦ **Prions** are non-nucleic infectious entities which are formed by modification of a neuronal protein. The can multiply by converting normal neuronal protein into prion form.

✦ On accumulation, prions cause degeneration of neuronal tissue, e.g., scrapie of sheep, mad cow disease, kuru, Cruetzfeldt-Jakob disease (CJD).

✦ Prions are resistant to proteases, nucleases, high temperature of autoclave, UV rays, formaldehyde and other disinfectants except diethyl pyrocarbonate. The diseases caused by prions are, therefore, incurable.

✦ Eating meats of animals suffering from a prion disease can cause a similar disease in humans .