Chapter 2

Biological Classification

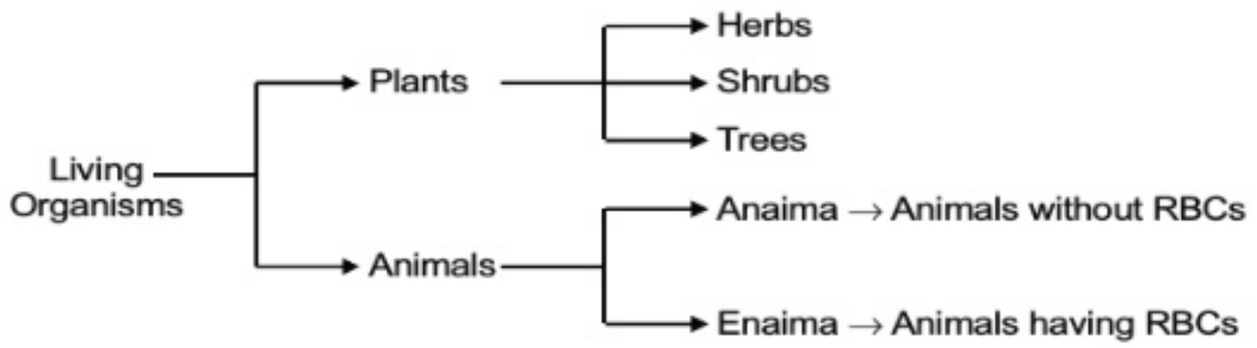
Chapter Contents

Introduction

Biological classification is the scientific procedure to classify the organisms into different groups on the basis of their similarities and dissimilarities and placing the groups in a hierarchy of categories. Since the starting of civilization, many attempts were made to classify the organisms. The criteria of classification used at that time, were not fit in scientific approach. Just for example, one attempt was to classify organisms on the basis of a need to use organisms for our own use like food, shelter and clothing. Over time, an attempt has been made to evolve a classification system which reflects not only the morphological, physiological and reproductive similarities, but is also phylogenetic *i.e.*, based on evolutionary relationships. In this chapter, we will study, the characteristics of kingdoms Monera, Protista and Fungi of the Whittaker system of classification. We will study Kingdom Plantae and Animalia also but in brief.

KINGDOM SYSTEMS OF CLASSIFICATION

The earlier systems of classification of organisms were simple and based on one or two characters. First scientific attempt for classification was performed by Aristotle in following manner :



Aristotle used simple morphological characters to classify plants into herbs, shrubs and trees. He classified animals into **Anaima** and **Enaima**, on the basis of absence and presence of RBCs respectively.

Example 1 : *Who classified plants into trees, shrubs and herbs?*

Solution : Aristotle

Table : Characteristics of the Five Kingdoms

Characters	Five Kingdoms				
	Monera	**Protista**	**Fungi**	**Plantae**	**Animalia**
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	Non-cellulosic (Polysaccharide + amino acid)	Present in some	Present (without cellulose)	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 (chemosynthetic and photosynthetic) and Heterotrophic (saprophytic/parasite)	Autotrophic (Photosynthetic) and Heterotrophic	Heterotrophic (Saprophytic/ Parasitic)	Autotrophic (Photosynthetic)	Heterotrophic (Holozoic etc.)

Example 2 : *Name the kingdom system proposed by R.H. Whittaker.*

Solution : Five Kingdom System

Try Yourself

3. Write the name of five kingdoms which were proposed under Five Kingdom System.
4. Which kingdom includes only photosynthetic organisms w.r.t. Whittaker classification system?

Earlier classification systems included bacteria, blue green algae, fungi, mosses, ferns, gymnosperms and the angiosperms under 'Plants'. The character that unified this whole kingdom was that all the organisms included had a cell wall in their cells. This placed together groups which widely differed in other characteristics. It brought together the prokaryotic bacteria and the blue green algae with other groups which were eukaryotic. It also grouped together the unicellular organisms and the multicellular ones. *Chlamydomonas* and *Spirogyra* were placed together under algae. The classification did not differentiate between the heterotrophic group – fungi and the autotrophic green plants, though they also showed a characteristic difference in their walls composition – the fungi had chitin in their wall while the green plants had a cellulosic cell wall. When such characteristics were considered, the fungi were placed in a separate kingdom – Kingdom **Fungi**.

All prokaryotic organisms were grouped together under kingdom **Monera** and the unicellular eukaryotic organisms were placed in kingdom **Protista**. Kingdom Protista has brought together *Chlamydomonas*, *Chlorella* (earlier placed in Algae within plants and both having cell walls) with *Paramoecium* and *Amoeba* (which were earlier placed in the animal kingdom) which lack it. It has put together organisms which, in earlier classifications, were placed in different kingdoms. This happened because the criteria for classification changed. Such kind of changes will take place in future also. This will depend on the improvement in our understanding of characteristics and evolutionary relationship.

Six kingdom classification : Carl Woese proposed six kingdom classification. These six kingdoms are Kingdom-**Archaebacteria**, Kingdom-**Eubacteria**, Kingdom-**Protista**, Kingdom-**Fungi**, Kingdom-**Plantae** and Kingdom-**Animalia**. He separated the archaebacteria from eubacteria on the basis of some major differences such as the absence of peptidoglycan in the cell walls of the former and the occurrence of branched chain lipids (a monolayer instead of a phospholipid bilayer) in the membrane.

Based on the sequence of 16S ribosomal RNA genes, Woese found that the six kingdoms naturally cluster into three main categories. He called these categories as **domains of life**. These domains are **Bacteria**, **Archaea** and **Eukarya** and are believed to have originated from common ancestor called **progenote**.

Try Yourself

1. Name the group of animals which have red blood cells.
2. Who was the earliest to attempt a more scientific basis for classification?

Linnaeus later classified all living organisms into two kingdoms – Plantae and Animalia. The criteria for classification used by him include cell wall, locomotion, mode of nutrition, response to external stimuli and contractile vacuole.

Features	Kingdom Plantae	Kingdom Animalia
1. Cell wall	Present	Absent
2. Locomotion	Absent	Present
3. Mode of nutrition	Do not eat	Eat
4. Response to external stimulus	Slow	Fast
5. Contractile system	Absent	Present
6. Organisms	Bacteria, algae, fungi, bryophytes, pteridophytes, gymnosperms, angiosperms	Protozoa, vertebrates, invertebrates

This **two kingdom classification** system does not distinguish between – (i) Unicellular and multicellular organisms, (ii) Eukaryotes and prokaryotes and (iii) Photosynthetic (green algae) and non-photosynthetic (fungi) organisms.

There are few organisms like *Chlamydomonas*, *Euglena* and the slime moulds which share the characteristics of both animals and plants. Since there are certain organisms that do not fall naturally into either plant or animal kingdom, it was proposed that a new kingdom is to be established to accommodate such organisms.

Did You Know?

A. Three kingdom classification : Haeckel, suggested that a third kingdom Protista should be created to include all unicellular microorganisms. This includes a wide variety of unicellular, mostly aquatic eukaryotes. Example - Fungi, Protozoa, Algae, Bacteria and Slime moulds.

Thus, he proposed three kingdoms, namely - Plantae, Protista and Animalia.

B. Four kingdom classification : Copeland gave four kingdom of classification and included Monera as fourth kingdom. This kingdom includes all the prokaryotic organisms *i.e.* eubacteria (including cyanobacteria or blue-green algae) and archaebacteria.

R.H. Whittaker (1969) proposed **five kingdom classification**. He divided organisms into kingdom **Monera**, **Protista**, **Fungi**, **Plantae** and **Animalia**, on the basis of following criteria :

1. Cell structure (either prokaryotic or eukaryotic)
2. Thallus organisation (body differentiated or not)
3. Mode of nutrition (autotrophic or heterotrophic)
4. Reproduction
5. Phylogenetic (or evolutionary) relationship

Example 3 : *In which kingdom, all prokaryotic organisms are included?*

Solution : Kingdom Monera

Try Yourself

5. Name the kingdom under which all unicellular eukaryotes are included.
6. *Paramoecium* and *Amoeba* are included under kingdom _____.

EXERCISE

1. Position of bacteria in a kingdom system of classification proposed by Linnaeus is
   (1) Monera (2) Protista
   (3) Plantae (4) Mychota
2. In three kingdom classification, the kingdom Protista includes
   (1) Unicellular eukaryotic organisms only
   (2) Unicellular prokaryotic organisms only
   (3) Wide variety of unicellular, mostly aquatic eukaryotes
   (4) Wide variety of unicellular, mostly terrestrial Prokaryotes
3. Which of the following was given the status of kingdom in the classification system given by Copeland?
   (1) Prokaryotes (2) Myxomycetes
   (3) Eukaryotic algae (4) Protista
4. Which one of the following is not the basis of five kingdom classification?
   (1) Cell type (2) Body organisation
   (3) Reproduction (4) Reserve food materials
5. Multicellular eukaryotic organisms with holophytic mode of nutrition belong to how many kingdoms in Whittaker system?
   (1) One (2) Two
   (3) Three (4) Five
6. In six kingdom classification, Monera was divided into two separate kingdoms on the basis of
   (1) Cell wall composition (2) Lipid nature in plasma membrane
   (3) Absence of sap vacuole (4) Both (1) & (2)
7. Select correct statement w.r.t. monera
   (1) All are autotrophic prokaryotes
   (2) All are chemoheterotrophs
   (3) Unicellular, colonial or filamentous organisms
   (4) Prokaryotes with 70 S ribosome and histonic DNA
8. Multicellular with loose tissue body organisation is a characteristic feature of
   (1) Monera (2) Protista
   (3) Plantae (4) Fungi

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BACTERIAL LIFE PROCESSES

Discussion of bacterial life processes revolves around the study of the prominent metabolic activities like **respiration** and **nutrition**.

A. Respiration: On the basis of mode of respiration, the bacteria are divided into two main groups : *i.e.,* **aerobes** and **anaerobes**. Each group is further of two types *i.e.* **strict** or **obligate** and **facultative.**

(a) Obligate or strict aerobes : These bacteria can live only in presence of oxygen as they possess the enzyme system for aerobic respiration only. In the absence of oxygen, they cannot respire and thus, die, *e.g., Bacillus subtilis.*

(b) Facultative anaerobes : They normally respire aerobically. However, they are capable of switching **over to anaerobic mode** to get energy for their survival, if sufficient oxygen to sustain aerobic respiration is not available in the environment, *e.g.*, *Pseudomonas.*

(c) Obligate or strict anaerobes : These bacteria respire anaerobically only. The growth of such bacteria will certainly be slower as anaerobic respiration liberates much less amount of energy as compared to aerobic respiration. They lack enzymes necessary for carrying out aerobic respiration *e.g.*, *Clostridium botulinum.*

(d) Facultative aerobes : They normally respire anaerobically, but are capable of respiring aerobically as well, if oxygen is available. Most of the photosynthetic bacteria are facultative aerobes *e.g.*, **photosynthetic bacteria** *Chlorobium.*

B. Nutrition : Bacteria is placed in a particular nutritional class based on their primary source of carbon, energy and electron.

(I) Photolithoautotrophic bacteria :

These bacteria are capable of entrapping solar energy and utilizing it for the synthesis of complex food materials due to the presence of pigments like **bacteriochlorophyll (bacteriopurpurin)** and **bacterioviridin.**

Purple sulphur bacteria (*e.g.*, *Thiospirillum*) and **green sulphur bacteria** (*Chlorobium limicola*) are the most familiar examples containing pigment **bacteriochlorophyll**, **bacteriopurpurin** and **bacterioviridin** respectively. Bacterial photosynthesis, however, differs from photosynthesis of higher plants in not liberating oxygen. This type of photosynthesis, characteristic of bacteria, is termed as **anoxygenic**. Normal photosynthesis, occurring in higher plants, is termed as **oxygenic**.

In bacterial photosynthesis **water is not the source of electron** that acts as reducing power to convert CO_2 into glucose. The bacteria obtain reducing power from various compounds such as hydrogen sulphide, thiosulphate or even some organic compounds. No oxygen is evolved as it does **not involve splitting of water**.

Photolithoautotrophic bacteria

Purple sulphur bacteria	**Green sulphur bacteria**
• Bacteriopurpurin pigment • Use inorganic sulphur compounds as e^- and H^+ donor *e.g., Chromatium, Thiospirillum*	• Bacterioviridin pigment or Chlorobium chlorophyll • Use H_2S as e^- and H^+ donor *e.g., Chlorobium*

Hydrogen released by various compounds mentioned above is **picked up by NAD^+** which gets reduced to $NADH_2$ acting as reducing power. $NADH_2$ alongwith ATP, produced generally by entrapping solar energy are used to reduce CO_2 to glucose. Simple equation for anoxygenic photosynthesis may be written as follows :

$$CO_2 + \underset{\substack{\text{(or any other compound acting as } e^- \text{ donor)}}}{H_2S} \xrightarrow[\text{enzymes}]{\text{Solar energy}} \text{Sugar} + (\text{Sulphur or other oxidised compound}) + H_2O$$

9. Cell wall is made of polysaccharide and amino acid in most of the members of
   (1) Monera (2) Protista
   (3) Fungi (4) Animalia
10. Cyclosis is absent in
   (1) Diatoms (2) Eubacteria
   (3) Algae (4) Plantae

KINGDOM : MONERA

Kingdom Monera includes the most ancient, the smallest, the simplest and the most abundant micro-organisms. These organisms are most primitive. They were the first inhabitants of the earth, and they still continue to flourish. Bacteria are the sole members of this kingdom. They occur almost everywhere. Hundreds of bacteria are present in a handful of soil. They also live in extreme habitats such as hot springs, deserts, snow and deep oceans where very few other life forms can survive. Many of them live in or on other organisms as parasites.

Characters of Monera

1. They are unicellular, colonial or filamentous, prokaryotic organisms without nuclear membrane, nucleolus, chromatin and histone proteins.
2. Nucleoid or incipient nucleus is composed of naked DNA, RNA and non-histone proteins. DNA is circular and double stranded.
3. Cell wall is made up of peptidoglycan (Amino acids + Sugar) except in Archaebacteria and Mycoplasma.
4. Membrane bound cell organelles are absent.
5. Ribosomes are of 70S type.
6. Some of the bacteria are autotrophic but vast majority are heterotrophic.
7. Respiratory enzymes are found associated with plasma membrane.
8. Reproduction is asexual type.
9. Bacteria show both autotrophic and heterotrophic nutrition. Autotrophic nutrition involves synthesis of organic material from inorganic substances with the help of light energy (photosynthetic autotrophic) or chemical energy (chemosynthetic autotrophic). Majority of them show heterotrophic nutrition which involves the obtaining of readymade organic nutrients from outside sources. It is of three types – saprotrophic, symbiotic and parasitic.

On the basis of their shape, bacteria are grouped under four categories :

1. The spherical Coccus (pl.: Cocci),
2. The rod-shaped Bacillus (pl.: Bacilli),
3. The comma-shaped Vibrium (pl.: Vibrio), and
4. The spiral Spirillum (pl.: Spirilla)

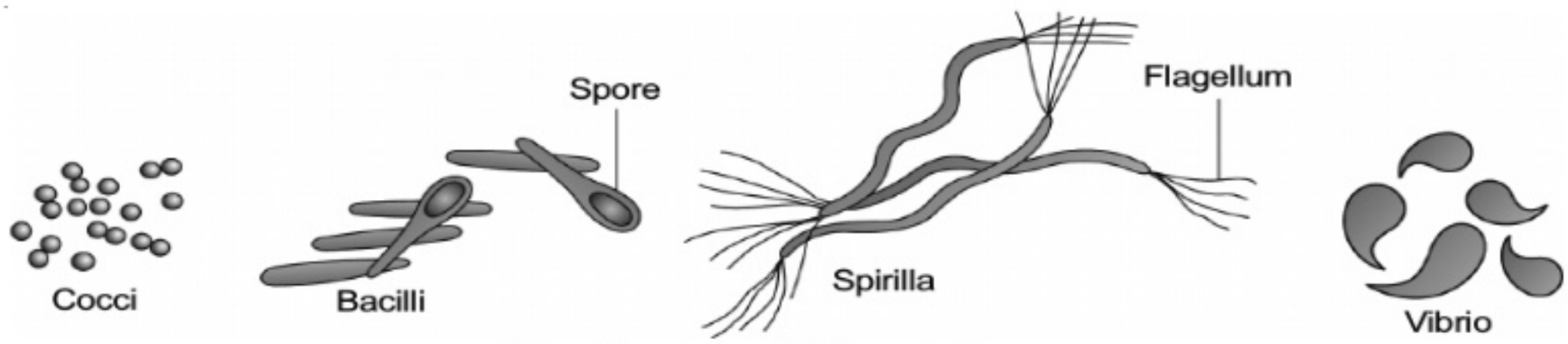

Fig. : Bacteria of different shapes

(II) Photoorganoheterotrophic bacteria :

Some photosynthetic bacteria use organic matter as their electron donor and carbon source.

Photoorganoheterotrophic bacteria

Purple non-sulphur
- Bacteriopurpurin pigment
- Use nonsulphur aliphatic organic compounds as e^- and H^+ donor

e.g., Rhodospirillum, Rhodopseudomonas

Green non-sulphur
- Bacterioviridin pigment
- Use non sulphur aliphatic organic compounds as e^- and H^+ donor

e.g., Chloronema, Chloroflexus

Most of the photosynthetic bacteria are **anaerobes** (facultative aerobes).

(III) Chemosynthetic autotrophic bacteria :

Bacteria belonging to this category obtain energy for the synthesis of food by oxidising certain inorganic substances like ammonia, nitrates, nitrites, ferrous ions, etc. Thus, they **do not utilise light as energy source**. The chemical energy thus obtained, is trapped in ATP molecules. This energy is then used in carbon assimilation with the help of hydrogen from some source other than water, *e.g.,* hydrogen bacteria, nitrifying bacteria, sulphur bacteria, etc. They play a great role in recycling nutrients like nitrogen, phosphorous, iron, sulphur.

(a) Hydrogen bacteria. *Hydrogenomonas.*

(b) Nitrifying bacteria. *Nitrosomonas, Nitrococcus, Nitrobacter* and *Nitrocystis*

(c) Sulphur bacteria. *Thiobacillus thioxidans, Beggiatoa*

(d) Iron bacteria. *Ferrobacillus, Leptothrix*

(IV) Chemoorganotrophic heterotrophic bacteria :

These bacteria are incapable of synthesizing their own food from simple raw materials. They obtain nourishment either from dead and decaying organic matter or directly from a living host. They are segregated into three main categories, *i.e.*, **saprophytic, symbiotic** and **parasitic** forms.

(i) Saprophytic bacteria : They are free living bacteria, obtaining nourishment from organic remains such as dead animals, animal excreta, fallen leaves, decaying vegetables, fruits, bread and other products of animal and plant origin.

These bacteria secrete digestive enzymes into the substrate and the complex insoluble substances are converted into simple soluble compounds like water, hydrogen sulphide, ammonia, CO_2 etc. Some of the simpler substances are absorbed and assimilated by the bacteria, whereas the others are added to the soil and atmosphere to complete the nature's material cycle.

(ii) Symbiotic bacteria : They are mainly Gram negative type. A familiar example of symbiotic bacteria is *Rhizobium leguminosarum*, associated with roots of leguminous plants. They are capable of fixing atmospheric nitrogen as ammonia, inside the nodule only and not in free state. However, some bacteria like *Azotobacter, Beijerinckia, Klebsiella* are free living, **aerobic** and capable of nitrogen fixation in free state, enriching the soil. *Clostridium pasteurianum* is **anaerobic N_2 fixing** bacteria.

(iii) Parasitic bacteria : These bacteria draw nourishment and obtain special organic compounds required for growth from living organisms, either plants or animals, called **hosts**. The disease causing bacteria are termed pathogenic and the ones not causing any disease are termed as non-pathogenic.

REPRODUCTION

Bacteria reproduce mainly by asexual method and also show sexual recombination **(True sexual reproduction is absent).**

A. Asexual Reproduction : Bacteria produce several types of asexual spores like, sporangiospores, oidia, conidia and endospores. However, the **most common mode of asexual reproduction** is binary fission.

Under favourable conditions of nutrient availability, moisture and temperature, daughter cells may repeat binary fission many times and may forms a large population. Fortunately, such a rapid rate is seldom achieved. The process gradually slows down and ultimately stops because of :

(II) Photoorganoheterotrophic bacteria :

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Photoorganoheterotrophic bacteria

Purple non-sulphur	**Green non-sulphur**
• Bacteriopurpurin pigment	• Bacterioviridin pigment
• Use nonsulphur aliphatic organic compounds as e^- and H^+ donor	• Use non sulphur aliphatic organic compounds as e^- and H^+ donor
e.g., Rhodospirillum, Rhodopseudomonas	*e.g., Chloronema, Chloroflexus*

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Griffith concluded that something passed from heat killed S-III to R-II bacteria, so that non virulent strain changed or transformed into virulent bacterial strain.

Avery, MacLeod and McCarty (1944) repeated this experiment using various enzymes and **proved that the transformation principle is DNA** of heat killed S-III strain. **They proved that DNA is a genetic material.**

(b) Conjugation : Lederberg and Tatum (1946) demonstrated in *E. coli* that during conjugation, one cell containing F-plasmid acts as donor (F^+ or male) cell and the other lacking F-plasmid as recipient (F^- or female) cell. The plasmid contains fertility factor or F gene which produces protrusions termed **sex pili**. These help the donor F^+ cell in attaching to the recipient cell. The plasmid replicates and a replica is transferred to recipient cell, changing it into F^+. Often the plasmid integrates with bacterial chromosome, converting it into **Hfr** (High frequency of recombination) **cell or super male** and a part or whole of bacterial chromosome is transferred to recipient cell through conjugation tube. Such association of episome with the endogenote increases the efficiency of genetic transfer. **The number of genes transferred depends upon the time** for which the two cells remain joined together.

When F^- conjugates with super male, the frequency of recombination increases by 1000 times, that is why it is called as Hfr (super male).

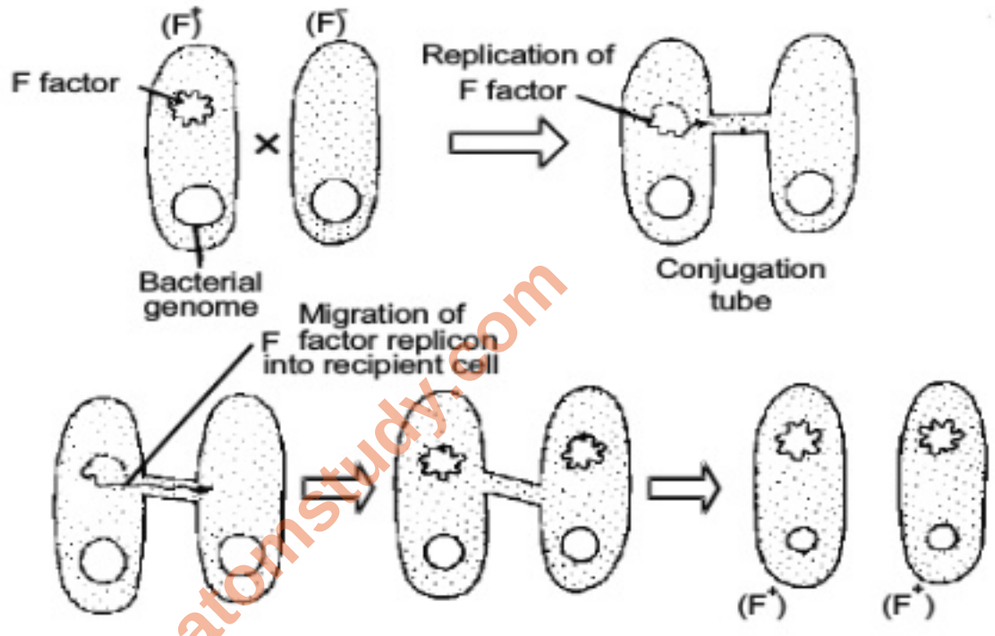


Fig. : Schematic diagram of the conjugation experiment of Lederberg showing conjugation between F^+ and F^- cells

(c) Transduction : During transduction, a small double stranded piece of DNA is transferred from donor to recipient by a bacteriophage. This mode of genetic recombination in bacteria was first demonstrated by **Zinder and Lederberg** (1952) while working with ***Salmonella typhimurium***.

Some viruses have the ability to integrate their DNA with bacterial DNA, which is replicated at the same time as the host DNA and is passed from one bacterial generation to the next. Such bacteria carrying phage (viral) DNA with their own DNA are called **lysogenic bacteria**. Occasionally, the phage DNA becomes active and codes for the production of new virus particles. A number of phage particles are synthesised followed by the destruction of the host cell and release of phage particles. **Upon release**, the phage particles attack sensitive bacterial cells, multiply and release more phage particles. However, sometimes faulty detachment of phage DNA from bacterial DNA results in the incorporation of a small amount of bacterial DNA into the phage DNA. Subsequent infection of another bacterium with this aberrant phage called **transducing phage**, introduces the piece of foreign bacterial DNA into the recipient's chromosomes, producing a genetic change.

Types of transduction : The ability of the bacteriophage to carry the genetic material from any region of bacterial DNA is called **generalised transduction**, *e.g.*, T_4-phage. On the other hand, there are bacteriophages such as **lambda phage** (λ) of *E. coli* which can carry only a **specific region** of the bacterial DNA to a recipient. This is called **specialised transduction** (or **restricted transduction**). Sometimes, the DNA brought by the phage does not integrate with the genome of the recipient bacterium and is lost after one or two generations. Such a transduction is called **abortive transduction.**

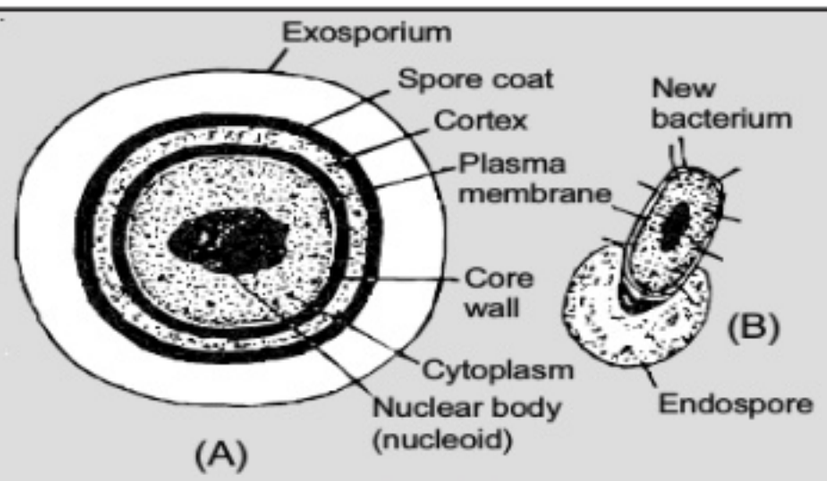


Fig. : Endospores : (A) Structure of an endospore, **(B)** Germination of endospore

The endospores are formed probably upon induction by the exhaustion of nutrients (unfavourable conditions). During endospore formation, a part of the protoplast containing nuclear body undergoes dehydration, stores food material and gets separated from rest of the protoplast to form endospore. It gets surrounded by different layers. These can withstand temperature as high as 100°C or as low as -100°C, so these can remain **unharmed during pasteurisation**. The remarkable resistance shown by endospores is due to :

(i) Thick and impermeable spore coat

(ii) Low water content

(iii) Low metabolic activity

(iv) **Ca-DPA Complex**

Under favourable conditions, endospore absorbs water, becomes metabolically active, ruptures thick spore coat and the bacterium surrounded by thin cell wall emerges out. Endospores are actually the **means of perennation and not reproduction** as only one endospore is formed per cell and subsequently each endospore grows into single bacterium cell after the commencement of favourable conditions.

B. Sexual Recombination (Genetic Recombination) : The bacteria exhibit a primitive form of sexual reproduction which differs from eukaryotic sexual reproduction because there is **no gamete formation and fusion**. However, the essential feature of sexual reproduction, *i.e.*, exchange of genetic material does take place and is called **genetic recombination**.

Three methods are known by which genetic recombination is achieved by bacteria. In the order of their discovery, these are transformation, conjugation and transduction.

(a) Transformation : Griffith (1928) worked on the effect of *Diplococcus* or *Streptococcus pneumoniae* bacteria on mice and discovered the process of transformation.

In transformation, the donor and recipient do not come in contact. The donor cell releases a piece of DNA which is actively taken up by the recipient cell from the solution. This ability to pick up DNA from the solution is called **competence.**

Two strains of *D. pneumoniae* are :

Capsulated or S-III (Virulent strain) and Non-capsulated or R-II (non-virulent strain).

Four steps were performed in experiment :

(i) S-III bacteria $\xrightarrow{\text{Injected into}}$ Healthy mice $\longrightarrow$ Mice died.

(ii) R-II bacteria $\xrightarrow{\text{Injected into}}$ Healthy mice $\longrightarrow$ Mice survived.

(iii) $\underset{\text{(Heat Killed)}}{\text{S – III bacteria}} \xrightarrow{\text{Injected into}}$ Healthy mice $\longrightarrow$ Mice survived.

(iv) R-II (living) + S-III (heat killed) bacteria $\xrightarrow[\text{into}]{\text{Injected}}$ Healthy mice $\longrightarrow$ Mice died.

(But R-II is not virulent and S-III lost its virulent capacity upon heating).

ECONOMIC IMPORTANCE

A. Some Useful Bacteria :

I. Soil fertility / biofertilisers

Free-living N_2-fixing bacteria : *Azotobacter, Clostridium, Klebsiella, Beijerinckia*

Symbiotic N_2-fixing bacteria : *Rhizobium, Frankia, Xanthomonas*

Ammonifying bacteria : *Bacillus vulgaris, B.ramosus*

II. Vinegar production : *Acetobacter aceti*

III. Curd, cheese, yoghurt production : *Lactobacillus, Streptococcus lactis*

IV. Petroleum pollution control : *Pseudomonas putida*

V. Antibiotics production : *e.g.,*

Bacitracin : *Bacillus licheniformis*

Subtilin : *B. subtilis*

VI. Retting of fibres : *e.g., Clostridium perfringens, Pseudomonas fluorescence*

VII. Curing of leaves : To improve the flavour and taste in tea by *Micrococcus candidans* and in tobacco leaves by *Bacillus megatherium*

B. Harmful activities :

(i) *Vibrio cholerae* – Cholera

(ii) *Salmonella typhi* – Typhoid

(iii) *Clostridium tetani* – Tetanus

(iv) *Xanthomonas citri* – Citrus Canker

Let us Discuss various Monerans in detail:

I. Archaebacteria

These archaebacteria are special since they live in some of the most harsh habitats such as extreme salty areas (halophiles), hot springs (thermoacidophiles) and marshy areas (methanogens).

Archaebacteria differ from other bacteria in having a different cell wall structure and this feature is responsible for their survival in extreme conditions. The cell membrane contains branched chain lipids (phytanyl side chains) which decreases membrane fluidity.

Archaebacteria have introns in their genetic sequence.

Archaebacteria are divided into three groups– methanogens, halophiles and thermoacidophiles.

(i) Methanogens : These bacteria are of marshy habitats. They are capable of converting CO_2, methanol and formic acid into methane so named methanogens. These methanogens are present in the guts of several ruminant animals such as cows and buffaloes and they are responsible for the production of methane (biogas) from the dung of these animals. These are chemoautotrophs. **Examples :** *Methanococcus*, *Methanobacterium* etc.

(ii) Halophiles : These bacteria live in extreme saline environment such as salt lakes, sea, brines etc. In strong light, these halophiles develop a pigmented membrane (purple membrane) composed of a pigment called bacterio-rhodopsin (related to the one found in our own eyes) to harness the sun's energy. The light energy is utilised to carry on ATP production but they cannot use this ATP in food synthesis. Hence, they are heterotrophs. **Examples :** *Halobacterium* and *Halococcus*.

(iii) Thermoacidophiles : These are capable of tolerating high temperature as well as high acidity and hence, the name thermoacidophiles. They often live in hot water springs where the temperature is as high as 80°C and the pH as low as 2. They oxidise sulphur to sulphuric acid under aerobic conditions and the energy obtained in this reaction is utilised for the synthesis of organic food. Hence, these are chemosynthetic in nature. The medium becomes highly acidic due to the production of sulphuric acid. Under anaerobic conditions sulphur is reduced to H_2S. **Examples :** *Thermoplasma*, *Thermoproteus* etc.

Example 4 : *Name the group of bacteria, present in the gut of ruminant animals which are responsible for the production of methane from the dung.*

Solution : Methanogens

Try Yourself

7. Which group of bacteria live in extreme salty areas?
8. How can archaebacteria live in harsh conditions?

I. Eubacteria

There are thousands of different eubacteria or 'true bacteria'. Most of them are characterised by the presence of rigid cell wall, and if motile, a flagellum. Eubacteria include several subgroups like Cyanobacteria, *Mycoplasma*, Actinomycetes, Rickettsiae, Chlamydiae, Spirochaetes etc. Let us discuss Cyanobacteria and *Mycoplasma* in detail .

(i) Cyanobacteria : Cyanobacteria are Gram negative photosynthetic prokaryotes, being the most primitive organisms to have **oxygenic photosynthesis.** They added oxygen to the atmosphere, which is indispensible for the existence of aerobic forms of living organisms. They are also known as BGA (Blue green algae) and are classified variously under **cyanophyceae** or **myxophyceae**.

Occurrence : They are mainly fresh water forms, though few are marine. **Red sea** is named so because of abundant occurrence of a cyanobacterium *Trichodesmium erythraeum*, which imparts red colouration to water. They occur in symbiotic association with almost every group of eukaryotes *i.e.* green algae, fungi, bryophytes like mosses and *Anthoceros*, ferns, gymnosperms, angiosperms, sponge, shrimps, mammals etc. *Anabaena azollae* is associated with *Azolla*, an aquatic fern. *Anabaena cycadeae* is associated with coralloid roots of ***Cycas***. In many lichens (symbiotic association of algae and fungi), the algal partner may be a cyanobacterium. When they live **endozoically in protozoans they are called cyanelle.**

Structural Organization : These may be unicelled, filamentous and colonial. Filamentous form consists of one or more cellular strands, called **trichomes**, surrounded by mucilagenous sheath. Cyanobacteria are characterised by the **absence of flagellum throughout life cycle.**

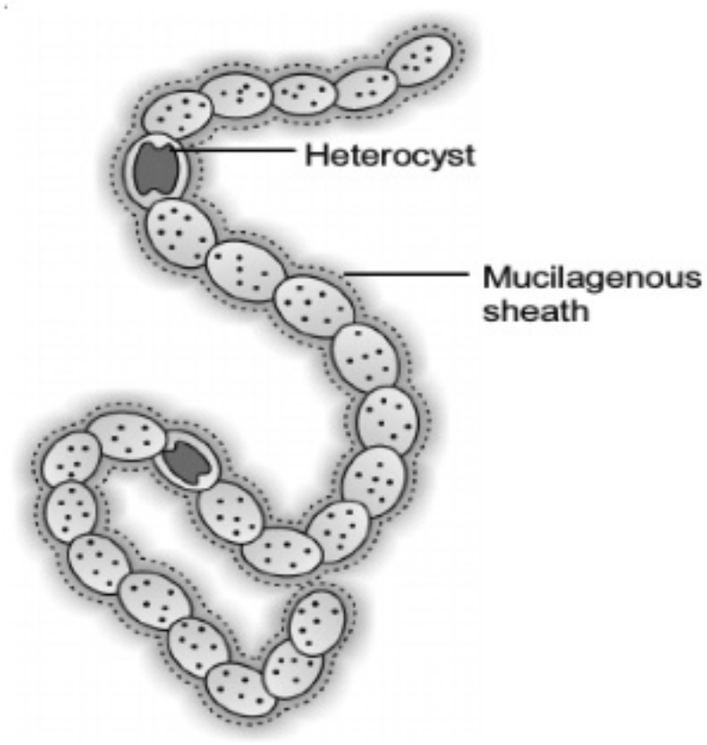


Fig.: A filamentous blue-green algae– *Nostoc*

Cell Structure : The cell structure in cyanobacteria is typically prokaryotic. The cell lacks a well defined nucleus and the chromatin material is centrally located, resembling the bacterial chromosome. The cell wall is 4 layered and is invariably covered by mucilagenous sheath, composed largely of mucopeptides.

Protoplasm in cyanobacterial cell can be distinctly divided into two parts the **centroplasm** and **chromoplasm.** The central colourless **centroplasm** contains the chromatin material. The peripheral protoplasm is coloured or pigmented because of the presence of thylakoids, called as **chromoplasm.** The protoplast lacks membrane-bound organelles like endoplasmic reticulum, golgi bodies, mitochondria, lysosomes, plastids and contains 70S ribosomes. Similar to the mesosome of bacteria, a group of coiled membrane called **lamellasome** is found which connects nucleoid to the cell membrane. It helps in respiration and replication of DNA. The **cell membrane lack sterols**. The **sap vacuoles are absent**. Instead, the cell may contain **gas filled vacuoles** which help to regulate the buoyancy of the organism in water. The characteristic feature of cyanobacterium cell is the presence of a system of photosynthetic lamellae called **thylakoids**. The characteristic photosynthetic pigments present in the thylakoids are **chlorophyll a** and **phycobilins** *i.e.*, phycocyanin (blue coloured), phycoerythrin (red coloured) and allophycocyanin (light blue coloured).

The cyanobacterial cell contains reserve food material in the following forms

(i) Cyanophycean granules (Protein)

(ii) β-granule (Fat droplets)

(iii) Cyano-or myxophycean starch or α-granule (Similar to glycogen but negative to iodine test)

(iv) Volutin body (Reserve phosphate)

(v) Polyhedral body (Rubisco rich)

Knowledge Cloud

Gaidukov's phenomenon or complementary chromatic adaptation – Cyanobacteria or blue green algae can adaptively change their body colour according to different wavelengths of available light, e.g., *Trichodesmium erythraeum*. It is also known as "red sea" causing alga.

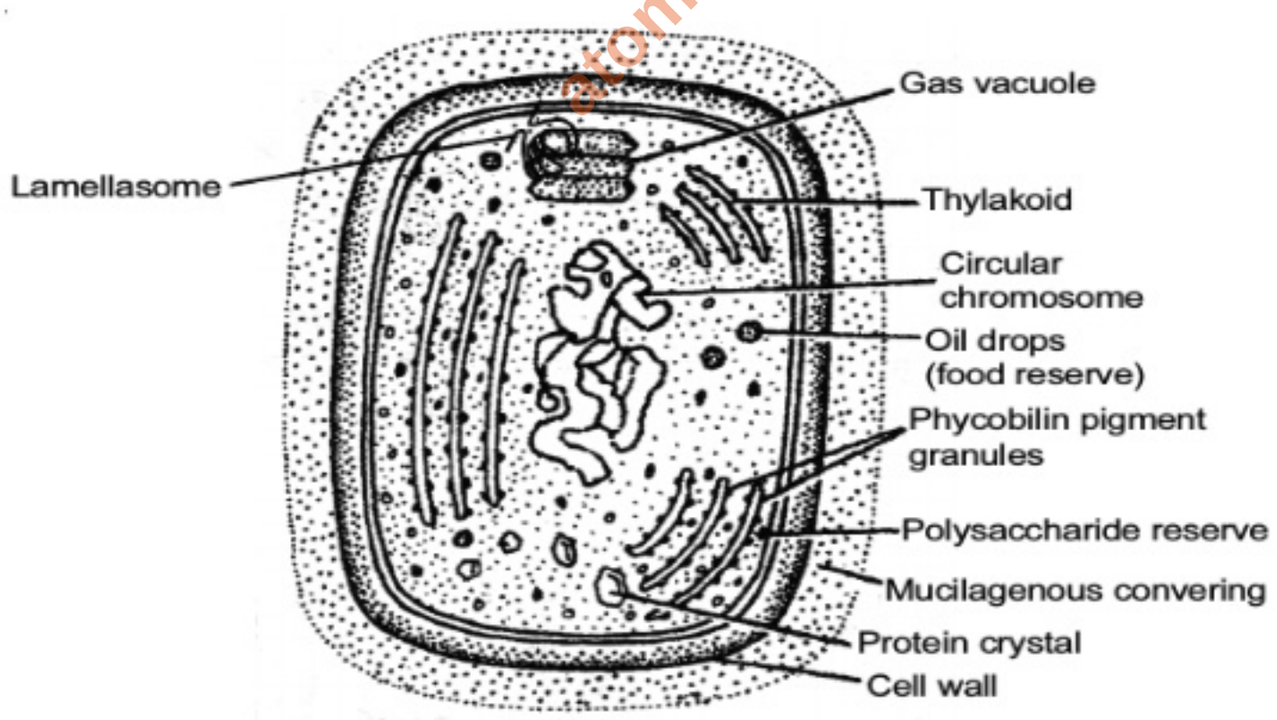


Fig. : Ultrastructure of a cyanophycean cell

Metabolism : They are the **most self-dependent organisms**, because most of these are capable of converting atmospheric nitrogen into ammonium compounds besides utilizing atmospheric CO_2 for synthesis of organic food during photosynthesis. Biological nitrogen fixation is **an anaerobic process** as **nitrogenase enzyme** required for the process acts efficiently in the absence of oxygen. **Nitrogen fixation** under anaerobic conditions occurs mainly in large, specialized cells called **heterocysts** as in *Nostoc*. Heterocyst has terminal pores which at maturity develops a polar granule. Thickened cell wall of these cells is impermeable to oxygen so this creates anaerobic environment in the cell even under aerobic conditions. Besides this, **heterocysts also lack PS II activities and CO_2 fixation is done only by vegetative cells**. Oxygen is not evolved due to absence of PSII. However, PSI remains active in heterocyst which generates ATP required to fix nitrogen.

Besides N_2 fixation heterocyst **promotes fragmentation**. Because of this property of nitrogen fixation, most of the BGA enrich the soil by releasing nitrogenous compounds in the surroundings.

Reproduction : Cyanobacteria reproduce asexually. Typical sexual reproduction is absent.

Asexual reproduction occurs by following methods :

(i) **Binary fission :** It occurs in unicellular forms. The daughter cells formed by amitotic division separate immediately after the division.

(ii) **Fragmentation :** It occurs in filamentous forms. The filament breaks up into short pieces or fragments which grow to form new filaments.

(iii) **Heterocysts :** Under special conditions, the heterocysts germinate to form new filaments.

(iv) **Hormogonia :** Due to the formation of biconcave, mucilage filled dead cells called **necridia**, in between living cells of trichome, the filament breaks into **hormogonia**.

(v) **Akinetes :** Vegetative cells are transformed into thick walled akinetes due to the deposition of food material followed by the thickening of wall. On the arrival of favourable conditions, they germinate to form new filaments.

Importance of Cyanobacteria

(i) They are the most ancient organisms having **oxygenic photosynthesis** and thus, played a significant role in the evolution of aerobic forms of life.

(ii) They convert atmospheric nitrogen into ammonium compounds and excess of these compounds is excreted out, enriching the soil. The death and decay of these also increase the soil fertility, particularly the nitrogen content of the soil. *Tolypothrix* and *Aulosira* fix N_2 non-symbiotically in rice fields.

Cyanobacteria like *Nostoc* and *Anabaena* have been used for **reclaiming usar soils**. As they can live in damp or aquatic habitat, they enrich the root environment in any wetland condition as in rice fields.

(iii) Cyanobacteria are associated in symbiotic relationship with almost every group of plants. They benefit the partner by providing nitrogenous compounds because of their capability of nitrogen fixation.

(iv) Some cyanobacteria serve as food to several aquatic animals. *Spirulina* is edible, non-toxic, fast growing cyanobacterium. It is cultivated in tanks as source of protein rich animal food (SCP).

(v) Extract of *Lyngbya* is used for the manufacture of antibiotic.

(vi) Some cyanobacteria like *Microcystis aeruginosa*, *Anabaena flos–aquae*, *Aphanizomenon flos–aquae* are known to cause **algal blooms** in water bodies. These also secrete toxins into the surroundings, which are harmful to aquatic animals and even to human beings. Water from such sources is harmful and may even prove fatal for organisms drinking it. They also deplete the oxygen from the water reservoir and thereby, cause large scale death of the fishes and other aquatic animals.

II. Mycoplasma

E. Nocard and E.R. Roux (1898)–two French Scientists, discovered these organisms from pleural fluid of cattles suffering from pleuropneumonia. These are **pleomorphic** and were called **PPLO** (Pleuropneumonia Like Organisms) or **Jokers of plant kingdom**. This organism was later on given the name *Asterococcus mycoides* by **Borrel** *et al*. (1910).

Nowak (1929) placed *Asterococcus mycoides* under the genus *Mycoplasma*. All such organisms are now called ***Mycoplasma*,** or MLO's (Mollicutes like organisms). These are sometimes placed in a separate class called **Mollicuta**.

Mycoplasma infects animals (*e.g.,* dog, sheep, mice and man) and plants (*e.g.,* potato, corn, brinjal etc.). They are generally found in soil, sewage water, plants and animals.

Structure : These are unicellular, simplest free living prokaryotes. They do not have cell wall so they are **highly pleomorphic** and can assume various shapes like spherical, granular, filamentous, coccoid etc. Cell membrane is the outermost limiting layer. It is **trilamellar** unit membrane structure. In culture, colonies of *Mycoplasma* show a characteristic **fried egg appearance** with an opaque central area and translucent peripheral zone. The cells are generally **non motile**, but a few are gliding type. The protoplasmic matrix contains ribosomes (70 S type), fatty substances and proteins. Organized nucleus, endoplasmic reticulum,

Example 5 : *What is name of common reproductive unit of Mycoplasma?*

Solution : Elementary bodies

Try Yourself

9. Photosynthetic pigment in cyanobacteria is _____.
10. Name the special cells, where nitrogen fixation takes place in cyanobacteria.

EXERCISE

11. Select incorrect statement w.r.t. eubacteria
    (1) Have very simple structure (2) Peptidoglycan nature of cell wall
    (3) Heterotrophs are most abundant in nature (4) Show most simple metabolic diversity
12. Find odd one w.r.t. phototrophic nutrition
    (1) *Chromatium* and *Chlorobium* (2) *Rhodopseudomonas* and *Thiospirillum*
    (3) *Chloronema* and *Chloroflexus* (4) *Pseudomonas* and *Clostridium*
13. Mark the incorrect option (w.r.t. nitrifying bacteria)
    (1) *Nitrococcus* (2) *Leptothrix*
    (3) *Nitrobacter* (4) *Nitrocystis*
14. Genetic recombination in which a small double stranded piece of DNA is transferred from donor bacterium to recipient bacterium by a bacteriophage was first demonstrated by
    (1) Griffith (2) Lederberg and Tatum
    (3) Zinder and Lederberg (4) Avery *et.al.*
15. Select correct match

	Column-I		**Column-II**
a.	Retting of fibres	(i)	*Pseudomonas putida*
b.	Pollution control	(ii)	*Pseudomonas fluorescence*
c.	Curing of leaves	(iii)	*Bacillus licheniformis*
d.	Bacitracin	(iv)	*Micrococcus candidans*

    (1) a(ii), b(i), c(iv), d(iii) (2) a(ii), b(i), c(iii), d(iv)
    (3) a(i), b(ii), c(iv), d(iii) (4) a(iii), b(i), c(iv), d(ii)
16. Archaebacteria do not show
    (1) Peptidoglycan in cell wall (2) Introns in DNA
    (3) Branched chain lipids in cell membrane (4) Ribosomal proteins with highly acidic nature
17. Thermoacidophiles are capable of withstanding extremely low pH and high temperature due to the
    (1) Presence of branched chain of lipid in cell membrane
    (2) Presence of resistant enzyme which can operate in basic conditions
    (3) Presence of higher concentration of KCl in their cells
    (4) More than one option is correct
18. Which group of monerans played significant role in the evolution of aerobic forms of life?
    (1) *Mycoplasma* (2) Cyanobacteria
    (3) Archaebacteria (4) Actinomycetes

plastids, mitochondria, golgi bodies, lysosomes, centrioles, flagella, etc. are absent. *Mycoplasma* has both **RNA** and **DNA. RNA** is **single stranded**, present in both ribosomes and cytoplasm and **DNA** is **double stranded,** long coiled thread extending almost throughout the cell. Enzymes are present freely in the cytoplasm as well as associated with the plasma membrane. Replicating disc assist in replication and separation of the genetic material.

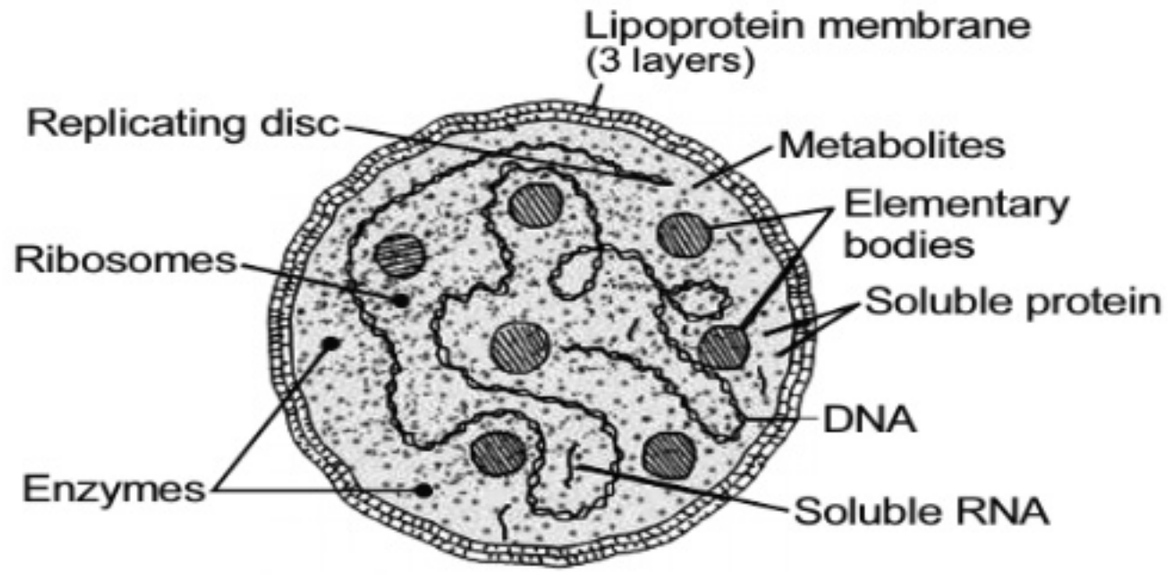


Fig. *Mycoplasma* : Structural details

Nature of *Mycoplasma* : *Mycoplasma* can pass through bacteriological filters and lack cell wall. This shows that they are not bacteria. Since they can multiply in abiotic medium **having sterols**, so they are not considered as virus. Due to many similarities with bacteria they are said to be **"Bacteria with their coats off".**

Mode of nutrition is **heterotrophic.** Some are **saprophytic,** but mostly they are parasitic. They are parasitic because they are unable to synthesize required growth factors, *e.g.*, *M. gallisepticum* (0.3 to 0.5 μm, **smallest prokaryote**). They can survive without oxygen.

Sensitivity to Antibiotics : *Mycoplasma* are **insensitive** to **penicillin** but sensitive to **streptomycin, erythromycin**, **chloramphenicol** (metabolic inhibitors) etc., They are insensitive to penicillin because they are wall less and penicillin interferes in the synthesis of peptidoglycan, a component of cell wall of bacteria.

Reproduction : Much is not known about reproduction of *Mycoplasma* but they mainly reproduce by means of elementary bodies.

From foregoing discussion, it is quite clear that bacterial **structure is very simple** but they are **very complex in behaviour** compared to many other organisms, bacteria as a group show the most extensive metabolic activity.

Knowledge Cloud

1. Cyclosis is absent in bacteria.
2. Flagella consist of flagellin protein.
3. *Bacillus* is most common form.
4. *Pseudomonas putida* - superbug.
5. Methanogens - obligate anaerobes.
6. Thermoacidophiles - Facultative anaerobes.
7. Cell wall of Archaebacteria consists of NAT [N-Acetyltalosamiuronic Acid].
8. Exogenote: Transferred DNA of Hfr is called exogenote and homologous part of F genophore is called endogenote.
9. Mycoplasma: Facultative anaerobes.
10. Hererocyst in BGA: Facultative anaerobe.

19. The characteristic photosynthetic pigments in cyanobacteria are
    (1) Chlorophyll a and c (2) Chlorophyll a and carotenes
    (3) Chlorophyll a and phycobilins (4) Chlorophyll a, carotenoids and phycobilins
20. Smallest wall-less monerans
    (1) Develop fried egg appearance in culture (2) Are motile
    (3) Have definite shape (4) Are mostly saprophytic

KINGDOM : PROTISTA

All unicellular eukaryotes, irrespective of their mode of nutrition, are included in the kingdom **Protista** in Whittaker's system. The term protista was coined by **Ernst Haeckel.** This kingdom forms a link between kingdom Monera on one hand and other three kingdoms *i.e.*, Plantae, Fungi and Animalia on the other hand. Protistans are ancestors of all multicellular eukaryotes (plants, fungi and animals).

Kingdom : Protista includes

Protista

(1) Autotrophic or Photosynthetic organisms	**(2) Consumer – Decomposer organisms**	**(3) Protozoans**
e.g., Dinoflagellates	*e.g.*, Cellular slime moulds	*e.g.*, Zooflagellates
Diatoms	Acellular slime moulds	Sarcodines
Euglenoids		Sporozoans
		Ciliates

General Characteristics of Protista:

1. Unicellular, eukaryotic organisms. Some are colonial without much cellular differentiation. Organisation at tissue level is absent.
2. Mostly aquatic organisms.
3. Cell structure is eukaryotic type having all kinds of membrane bound organelles and **80 S cytoplasmic** ribosomes and cells may possess cellulosic cell wall.
4. Flagella and cilia have **(9+2)** pattern of microtubule organization consisting of **tubulin** protein.
5. Movement by pseudopodia, flagella or cilia where ciliary mode is fastest.
6. Mode of nutrition may be photosynthetic (holophytic), holozoic (ingestive), saprobic or parasitic (absorptive). Some have **mixotrophic** nutrition (photosynthetic and saprobic) as in *Euglena*.
7. Reproduction occurs by asexual and sexual means.
8. Life cycle is of two types– (i) Showing **zygotic meiosis** (ii) Showing **gametic meiosis.**
9. These are decomposers, photosynthetic or parasites. Parasitic protists may cause diseases like dysentery, malaria, sleeping sickness, etc.

Photosynthetic protists and Slime moulds are described below :

(1) Photosynthetic Protists

These are popularly called protistan algae. Protistan algae constitute the major portion of the phytoplanktons.

A. Diatoms : Diatoms are golden brown photosynthetic protists and are called Chrysophytes (**including both diatoms and desmids**). They are both aquatic and terrestrial. Some are marine. They support much of marine life. Their important characters are :

1. These are microscopic organisms possessing varying colours.
2. They are basically unicellular, but may form pseudofilament and colonies, **lacking flagella except in the reproductive stage**. They may be free floating (phytoplanktonic), remaining afloat on surface of water due to presence of light weight lipids.

3. The cell wall is impregnated with silica to form transparent siliceous shell, known as **frustule**. Depending upon the symmetry, diatoms may be **pennate type**, having bilateral symmetry (*e.g.*, *Navicula*) and **centric type**, having radial symmetry (*e.g.*, *Melosira*).
4. The cell wall is characteristic, made up of two halves; one half covering the other **(epitheca** over **hypotheca)** resembling a **soap box**.
5. The cell wall encloses the peripheral layer of cytoplasm (primordial utricle) surrounding a large central vacuole.
6. Nucleus lies in the central vacuole, suspended with the help of cytoplasmic strands.
7. Mode of nutrition is holophytic (photoautotrophic), photosynthetic pigments are **chlorophyll a, chlorophyll c, β-carotene** and special carotenoids containing fucoxanthin; **xanthophylls** like **diatoxanthin**, **diadinoxanthin**.
8. The reserve food is oil and a polysaccharide called leucosin (chrysolaminarin), volutin granules are also present.
9. They are responsible for almost 50% of the total organic matter synthesized in the biosphere.
10. Movement occurs by mucilage propulsion.
11. They mainly undergo asexual reproduction. The common mode of asexual reproduction is binary fission.
12. During binary fission, one-half of the cell wall is retained by each of the daughter cells formed. The other half of the cell wall is secreted afresh.
13. Resting spores are called **statospores** (centric diatoms).
14. They reproduce sexually as well. Sexual reproduction varies from **isogamy** to **oogamy**. It involves gametic meiosis as diatoms are generally diploid (diplontic life cycle).

Did You Know?

1. Silica shells of dead diatoms are nearly indestructible and thus, get accumulated at the sea bed. Such huge rock-like deposits of hard shells of diatoms constitute diatomaceous earth, which is mined to obtain a whitish powder called **diatomite** or **kieselguhr** or **diatomaceous earth**. Diatomite is rough and gritty. Because of these features, it is used in filters in brewing industry, sugarcane refineries, in polishes for metals, tooth pastes, for making insulating bricks, in insulation of refrigerators, houses and for making the latter sound proof, in the manufacture of dynamite, water glass or sodium silicate and strong acids. This is added to paint to increase their night visibility.
2. They are very good indicators of water pollution.
   Common examples of diatoms are *Triceratium, Melosira, Navicula, Cymbella.*
3. Auxospores: Zygote formed during sexual reproduction in Diatoms is called Auxospore.

B. Dinoflagellates: Dinoflagellates are **golden brown photosynthetic protists**, belonging to class **Dinophyceae** (**Pyrrophyta**). They are mainly marine, though few are fresh water forms. They may appear red, yellow, green, brown or blue depending upon the main pigment present in cell.

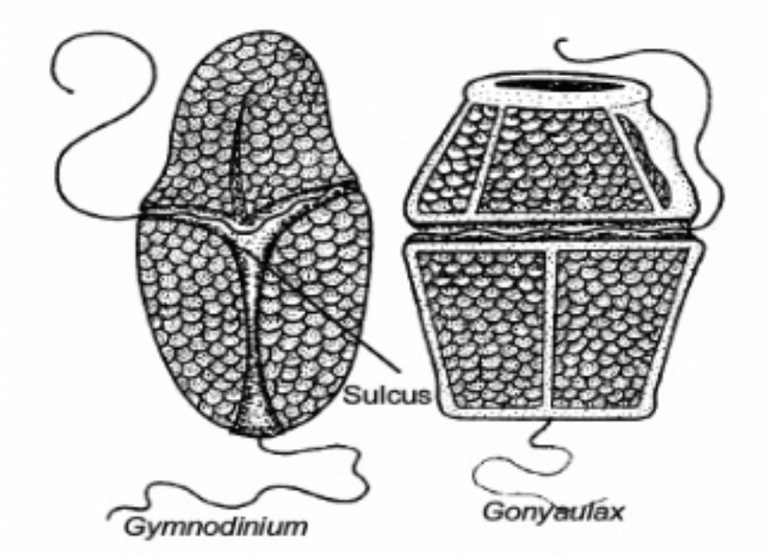


Fig. : Some Dinoflagellates

4. Locomotory organs are flagella.
5. The cell bears a single long tinsel type flagellum **(stichonematic)** arising at the anterior end. Actually, there are two flagella but one of these is reduced. The longer flagellum has two branches at the base each having its own basal granule. **In the area of union of two flagella is present a photosensitive paraflagellar body**.
6. Myonemes are oblique but parallely arranged strips in pellicle. Euglenoids perform creeping movement of contraction and expansion with the help of myonemes which is called **metaboly** or euglenoid movement.
7. The apical end of the cell bears an invagination with three distinct parts, *i.e.*, mouth (**cytostome**), canal (gullet or **cytopharynx**) and **reservoir**. It helps in the ingestion of solid food particles.
8. **Stigma** or an eye spot is attached to the membrane of the reservoir at the level of paraflagellar body and along with it seems to be involved in perception of light stimulus. It contains **photosensitive red-orange pigment called astaxanthin**.
9. A **contractile vacuole** occurs in the anterior end of the cell just below the reservoir, meant for osmoregulation and excretion.
10. Single large nucleus lies near the centre of the protoplast.
11. Nutrition in *Euglena viridis* is photoautotrophic. However, it is capable of getting nourishment from dead and decaying organic matter in the substrate by secreting digestive enzymes (saprophytic nutrition) in the absence of light. This dual mode of nutrition is termed as **mixotrophic**. Holozoic nutrition is absent in *Euglena*. Some forms are holozoic (*Paranema*) or saprobic (*Rhabdomonas*).
12. Photosynthetic pigments are **chlorophyll a**, **chlorophyll b**, xanthophyll and β-carotene.
13. Reserve food material is **paramylon,** stored in cytoplasm in the form of paramylum granules. They are chemically β-1, 3-glucans.
14. Under favourable conditions, they mainly reproduce by longitudinal **binary fission**. During unfavourable conditions, **palmella stage** and **cysts** are formed for perennation. Sexual reproduction is not known to occur in euglenoids, *e.g.*, *Euglena* and *Paranema*.

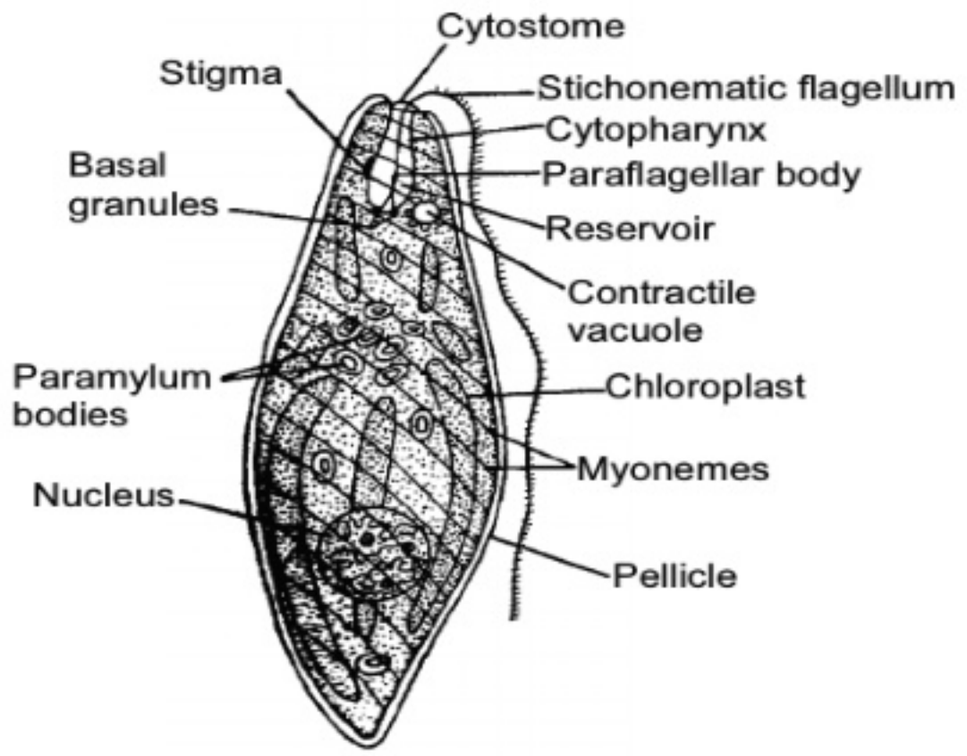


Fig. : *Euglena viridis*

Content Builder

1. *Euglena* is producer-decomposer protist.
2. It is studied as plant as well as animal and is called as plant animal.
3. Plant characters of *Euglena*:
   (i) Presence of chloroplast with photosynthetic pigments.
   (ii) Holophytic nutrition
4. Animal characters of *Euglena*:
   (i) Absence of cell wall and presence of proteinaceous pellicle.
   (ii) Presence of stigma and paraflagellar body.
   (iii) Presence of contractile vacuole.
   (iv) Presence of longitudinal binary fission.

General characters of dinoflagellates are as follows :

1. Unicellular, motile, biflagellate, golden brown photosynthetic protists (some are non-motile, amoeboid, palmelloid or filamentous).
2. They are mostly marine, some are found in fresh water.
3. The body is enclosed by a rigid coat called **theca** or **lorica** consisting of 2 to many articulated or sculptured plates of **cellulose** and **pectin**, hence are also called **armoured dinoflagellates**.
4. Theca has generally two grooves *i.e.,* longitudinal called **sulcus** and transverse called **cingulum** or **annulus** or **girdle.**
5. Flagella are **heterokont** (different). One is longitudinal and other is transverse. The flagella pass out through the pores in the lorica and lie in the grooves. The transverse flagellum lies in the circular groove and the longitudinal flagellum in the longitudinal groove. The **longitudinal flagellum** is narrow, smooth directed posteriorly and the **transverse flagellum** is ribbon like.

   Both are oriented at right angle to each other producing spinning movements. Therefore, these protists are also called '**whirling whips**'.
6. Most of the species have brown, green or yellow chromatophores with **chlorophyll a**, **c**, **β-carotene and α-carotene**, **xanthophyll** (*e.g.,* Peridinin). Plastids are generally surrounded by 3-membrane envelope and contain 3–thylakoid lamellae. They are autotrophic or photosynthetic (*Ceratium*), a few are saprobic or parasitic.
7. **Reserve food** is carbohydrate and oils.
8. Nucleus is relatively larger in size, has condensed chromosomes even in interphase, chromosomes do not have histone. Nuclear envelope and nucleolus remain present even during cell division. This organisation is called **Mesokaryon** (Dodge, 1966).
9. A non-contractile vacuole called **pusule** is present near the flagellar base. It may have one or more vesicle and takes part in **floatation** and **osmoregulation**.
10. Some dinoflagellates possess **trichocysts** and **cnidoblasts** like those of coelentrates.
11. Reproduction is commonly asexual and occurs through cell division.
12. Isogamous and anisogamous sexual reproduction is reported from some dinoflagellates *e.g., Ceratium.*
13. Life cycle involves **zygotic meiosis** (*Ceratium*, *Gymnodinium*). Gametic meiosis occurs in *Noctiluca*.

Did You Know?

1. Some marine dinoflagellates show **bioluminescence**, i.e., emit light, e.g., *Noctiluca, Pyrodinium, Pyrocystis*. Due to phosphorescence the sea glows at night.
2. Some dinoflagellates like *Gonyaulax catenella* produce a toxin called **saxitoxin** into the sea water which is highly poisonous to vertebrates, e.g., fishes and other aquatic animals. Marine shell fish consume dinoflagellates and accumulate the poison which is not harmful to the shell fish (mussel) but upon being consumed causes severe illness in man called **paralytic shell fish poisoning (PSP)** and even prove fatal.
3. Some dinoflagellates proliferate in large number and cause **red tide** of the sea, e.g., *Gonyaulax, Gymnodinium*.

C. Euglenoid (*Euglena*-like) : It is a group of chlorophyllous and non chlorophyllous flagellate protists. Largest genera being *Euglena* amongst them.

1. Euglenoids are unicellular, flagellate protists found in water or damp soil. Majority of them are fresh water organisms found in stagnant water.
2. Body is spindle shaped with blunt anterior end and pointed posterior end.
3. **Cell wall is absent** but a covering periplast or **pellicle** is present which is proteinaceous (elastic) in structure.

(2) Slime moulds or consumer-decomposer protists

They were included in class myxomycetes of fungi in two-kingdom classification. They were called **mycetozoa** by **DeBary** as they are closely related to animals. Mycologists include them in **gymnomycota.** Because of their nature they are called **protistan fungi**.

General characteristics of the slime moulds are :

1. They are usually free-living, creeping over debris like fallen leaves and rotting logs of wood.
2. They have naked protoplast, not covered by any cell wall in vegetative stage.
3. They lack chlorophyll and have **saprobic** or **phagotrophic** mode of nutrition.
4. The body moves along decaying twigs and leaves engulfing organic material. Under favourable conditions, they form an aggregation called plasmodium which may grow and spread over several feet. During unfavourable conditions, the plasmodium differentiates and forms fruiting bodies bearing spores at their tips.
5. During life cycle they are amoeboid and non-cellulosic, but spores have cellulosic wall so that their vegetative phase resembles with animals while reproductive phase resembles with plants.
6. Amoeboid plasmodial stage resembles protozoa and spore forming nature is like fungi.
7. Spores are extremely resistant and survive for many years, even under adverse conditions. The spores are dispersed by air currents.
8. Reproduction is both asexual and sexual.

This group is represented by two separate types of organisms *i.e.* **acellular** and **cellular**.

A. Acellular or Plasmodial Slime Moulds

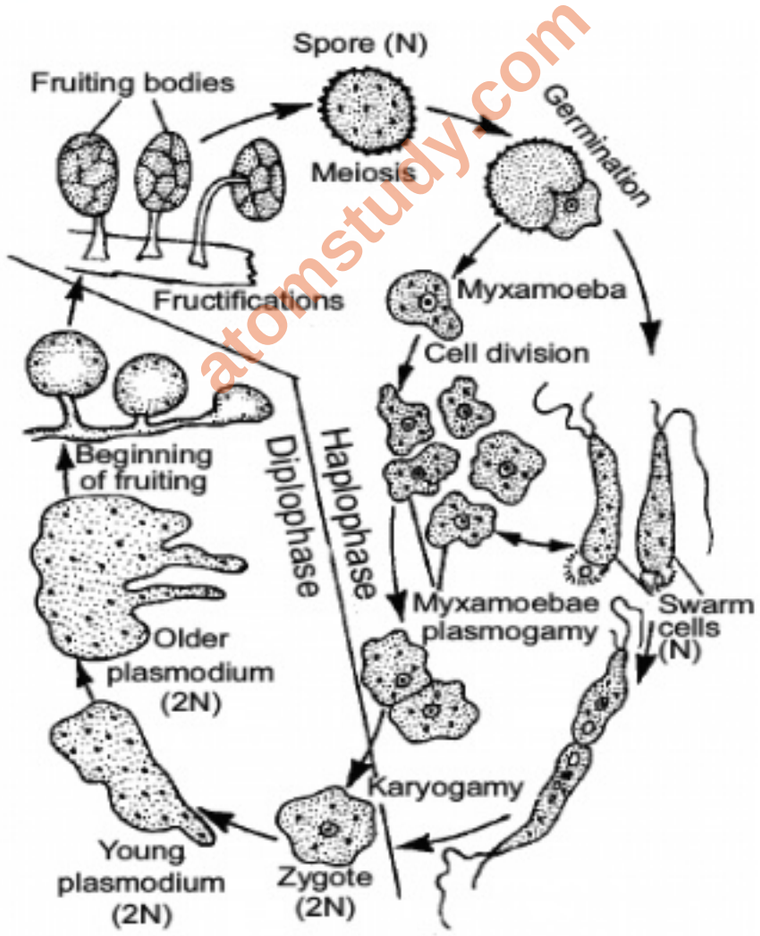


Fig. : Life cycle of an acellular slime mould

General Characters :

1. Slimy masses found on decaying leaves and lumber.
2. Somatic body is free living, multinucleate, naked, diploid mass called **Plasmodium.** Movement occurs by means of **pseudopodia.**
3. During unfavourable conditions, entire plasmodium forms many fructifications/fruting bodies **(polycentric)**. The fruiting body is called sporocarp which contains a stalk having a sporangium at its tip. The wall of sporangium is called **peridium.**
4. Sporangium has an intricate network of cytoplasmic threads called **capillitium.**
5. Diploid protoplast forms **haploid spores by meiosis**

6. Spore wall is double, outer wall is spiny and sculptured.
7. On germination, spores produce biflagellate **swarm cells** or **non-motile myxamoebae** which act as gametes.
8. Sexual reproduction is **isogamous**.
9. Diploid zygote directly forms the plasmodium which becomes multinucleate by repeated mitotic divisions of the diploid nucleus.
10. Chief mode of nutrition is **saprotrophic.**
11. Vegetative reproduction is by fission. *e.g.*, *Physarum*, *Physarella*, *Fuligo*.

B. Cellular slime moulds or communal slime moulds

General characters :

1. Wall less, uninucleate **myxamoebae** present. Complete absence of flagellated cells during life cycle.
2. Sporangia are naked.
3. Spores have cellulosic wall.
4. Sexual reproduction is **anisogamous.**

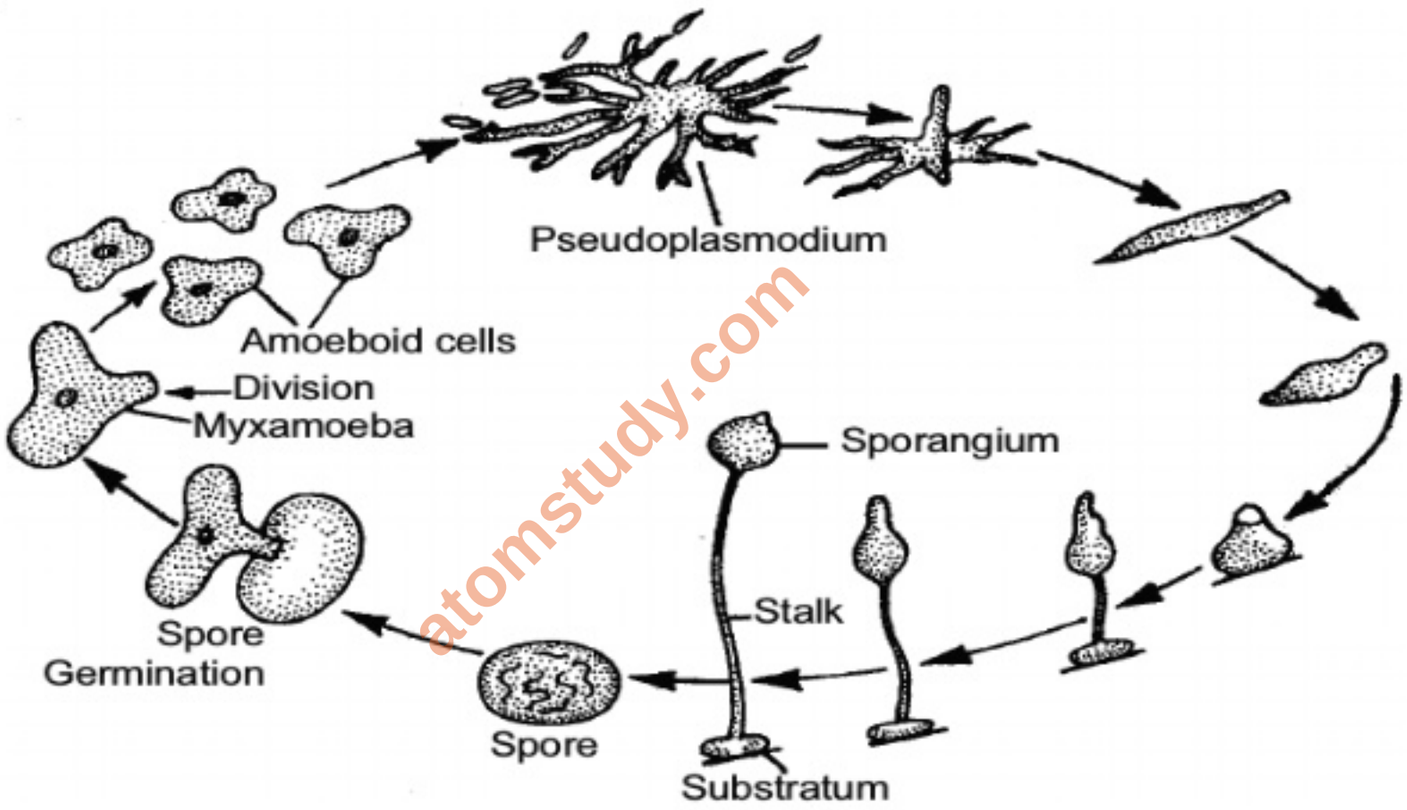


Fig. : Life cycle of Cellular slime moulds (*Dictyostelium*)

Common cellular slime mould, *Dictyostelium,* is a colonial form in which hundreds of uninucleate, haploid amoeboid cells are aggregated without any fusion to form a colony. The colony gives the appearance of single multinucleate mass of protoplasm and thus, called **pseudoplasmodium**.

Under exhausted food supply and stimulation by **cAMP** and chemical **acrasin,** many cells come close together by **chemotactic movement** during the formation of pseudoplasmodium. Pseudoplasmodium exhibits primitive form of **multicellularity and division of labour**. So these are also called as communal slime moulds. On these basis cellular slime moulds are **regarded as advanced protists and primitive fungi**. During unfavourable conditions, the myxamoebae may form a cyst called **microcyst** for perennation and dispersal.

Under dry conditions, the pseudoplasmodium produces stalked **sporocarp**, which may be branched or unbranched, each branch bearing single sporangium terminally **(monocentric)**. Sporangium is wall less. Within the sporangium, amoeboid cells become rounded to secrete a spore wall around. On the approach of favourable conditions, spores are liberated. Each spore germinates by rupturing cellulosic wall to form myxamoeba and the myxamoebae may live independently, multiply by repeated mitotic divisions or get aggregated to form pseudoplasmodium.

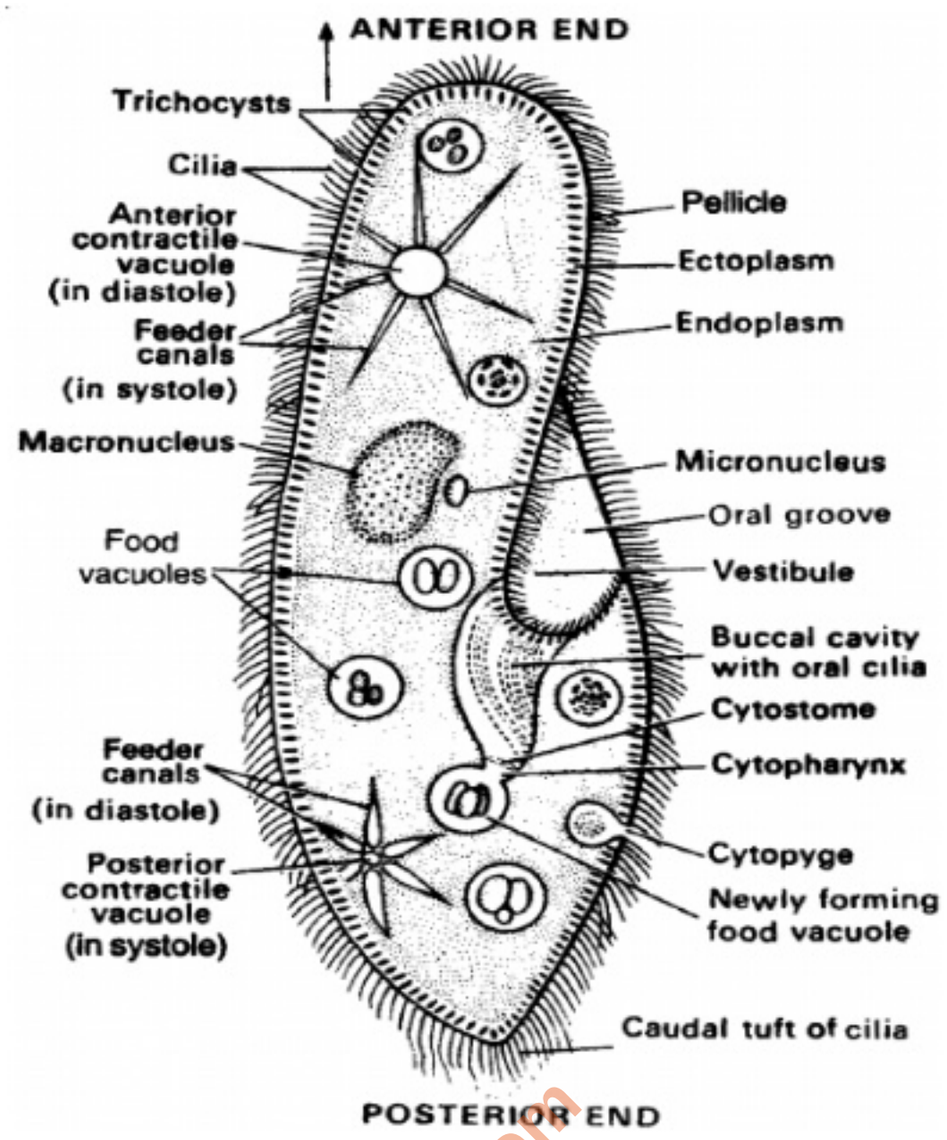


Fig. : *Paramoecium* (a protozoan)

EXERCISE

21. Which kingdom includes nutritionally most diversed group of organisms and has no well defined boundaries?
    (1) Monera (2) Protista
    (3) Fungi (4) Plantae
22. Chrysophytes are
    (1) Diatoms and desmids (2) Diatoms and dinoflagellates
    (3) Slime moulds and desmids (4) Slime moulds and diatoms
23. Which of the following option for diatoms is correct?
    (1) Pecto-cellulosic cell wall (2) Silicified cell wall
    (3) Multicellular eukaryotes (4) Produce saxitoxin
24. The cell wall encloses the peripheral layer of cytoplasm surrounded a large central vacuole in
    (1) *Euglena* (2) Diatoms
    (3) *Amoeba* (4) *Aulosira*
25. Red tide is caused by rapid multiplication of
    (1) *Nostoc* (2) Desmids
    (3) Diatoms (4) *Gonyaulax*
26. Mark the **mis-matched** pair :
    (1) *Pyrocystis* – Bioluminescence
    (2) Whirling whips – Soap box like body structure
    (3) Diatomite – Kieselguhr
    (4) *Gymnodinium* – Zygotic meiosis

Sexual reproduction is **anisogamous** type. During sexual reproduction, a number of myxamoebae form a clump. One of the myxamoeba becomes larger and engulfs the surrounding smaller myxamoebae. The plasmogamy occurs and the fused protoplast secretes a thick wall around to form **macrocyst**. In the macrocyst, karyogamy occurs and it thus, becomes **zygote**. **It is followed by meiosis** and several mitotic divisions to form a large number of haploid myxamoebae, which are released by rupture of macrocyst wall. *e.g., Dictyostelium, Polysphondylium*.

By taking example of slime mould, now we can justify that protista forms a connecting link with plants, animals and fungi.

Fungi like feature : Formation of fruiting bodies.

Plant like feature : Cell wall around spores.

Animal like feature : Plasmodium is without cell wall.

Example 6 : *In which type of slime mould somatic body is free living, multinucleate, naked and diploid?*

Solution : Acellular/Plasmodial slime mould

Try Yourself

11. Give one example of euglenoid.
12. Which type of nutrition *Euglena* shows?

PROTOZOANS

These are unicellular organisms with heterotrophic nutrition. They are believed to be primitive relatives of animals. There are four major groups of protozoans.

Amoeboid protozoans	Flagellated protozoans	Ciliated protozoans	Sporozoans
1. **Habitat and habit**			
Fresh water, sea water or moist soil mostly free living, few parasites.	Free living (aquatic) or parasitic.	Fresh water or marine, few parasite.	All endoparasites
2. **Locomotory structure**			
Pseudopodia (false feet)	Flagella	Cilia	Absent
3. **Special feature**			
Silica shells in some forms.	Rare sexual reproduction with diverse type of associations – commensal, symbiont, parasitic.	Possess definite region of ingestion (gullet) and egestion).	Infectious spore-like stage is present in life cycle.
4. **Example and diseases**			
Amoeba, *Entamoeba* (Dysentery)	*Trypanosoma* (Sleeping sickness)	*Paramoecium*	*Plasmodium* (Most notorious causing malaria)

27. Red-orange photosensitive pigment in *Euglena* is
    (1) Astaxanthin (2) Chlorophyll
    (3) Phycocyanin (4) Phycoerythrin
28. Acellular slime moulds show
    (1) Haploid uninucleate plasmodium (2) Naked sporangia
    (3) Autotrophic nutrition (4) Isogamous type reproduction
29. In acellular slime moulds, sporangium has an intricate network of cytoplasmic threads called
    (1) Peridium (2) Pseudopodia
    (3) Capillitium (4) Trichocyst
30. Mark the **correct** match :
    (1) Amoeboid protozoan – All endoparasite
    (2) Flagellated protozoan – *Paramoecium*
    (3) Sporozoan – Absence of locomotory structure
    (4) Ciliated protozoan – *Entamoeba*

KINGDOM : FUNGI

This kingdom contains achlorophyllous, eukaryotic, heterotrophic, spore producing, thalloid organisms. Fungi include diverse organisms which range in structure from unicellular yeasts to highly complex edible mushrooms, non-edible toad stools. They are cosmopolitan in occurrence being present in air, water, soil and on the animals and plants. They are more abundant in warm and humid areas. So, they show great diversity in morphology and habitat.

Did You Know?

Why we keep food in the refrigerator?

Foods are protected from attack of bacteria and fungi by refrigerating them because at low temperature they become inactive.

General Characters:

(1) They are cosmopolitan and occur in air, water, soil and on animals and plants. They are mostly terrestrial. They prefer to grow in warm and humid places. They may grow on tree bark, dung, wood, burnt wood and keratinous material (*e.g.,* hair, horns) and are called **corticolous (bark)**, **coprophilous (cow dung)**, **epixylic (wood)**, **xylophilous (burnt wood)** and **keratinophilous (keratin)** respectively.

(2) The body is **haploid** (n) and thalloid, *i.e.*, not differentiated into root, stem and leaves. They are multicellular (except **Yeast** and *Synchytrium*). The fungal body is made up of thread like elongated tubular structures, called **hyphae**. These cris-cross with one another to form a network known as **mycelium**.

(3) The hyphae may be **aseptate** and multinucleate. Such a hypha is termed **coenocytic**. In most of the fungi, the mycelium is **septate**. The septum, however, is not complete, but has a pore through which continuity of the cytoplasm of the adjoining cells is maintained. The septum may have **simple central pore** as in **ascomycetes**, but in higher fungi (**class basidiomycetes**), the septum is **dolipore septum**, in which central pore possesses a barrel shaped inflation. In septate mycelium, individual cell may contain single nucleus (**monokaryotic** – feature of primary mycelium) or an intermediate phase of two nuclei (**dikaryotic** – feature of secondary mycelium).

(4) The cell wall of the hyphae is made up of **chitin** or **fungal cellulose**, which is a polysaccharide containing nitrogenous compound and it is basically made up of **acetylglucosamine**. In some fungi, the cell wall is made up of **cellulose** (*e.g.*, *Phytophthora*, *Pythium* and other oomycetes). Reserve food material is stored in the form of **oil** and **glycogen**.

(5) Cells have unicisternal golgi bodies.

(6) Mitosis in somatic cells is **Karyochorisis** type (mitosis with intranuclear spindle formation).

(7) Nutrition is heterotrophic which includes saprophytes, parasites and symbionts.

(8) In most of the fungi, there are two distinct phases in the life cycle, the **vegetative or assimilative phase** and the **reproductive phase**. In vegetative phase, fungus is microscopic hidden in the substratum and is hardly visible to the naked eyes. The fungus enters into reproductive phase after attaining maturity in the vegetative phase. In unicellular yeasts, the same cell performs both assimilative and reproductive functions. Such type of fungal bodies in which entire cell gets transformed into reproductive structures are known as **holocarpic**. Fungal body is termed **eucarpic** in which a part of mycelium is used up in the development of reproductive structures.

Reproduction in Fungi

Fungi reproduce by all the three modes, *i.e.*, **vegetative**, **asexual** and **sexual**.

1. Vegetative reproduction:

It occurs by the following methods :

(a) Fragmentation : The mycelium breaks up into two or more fragments due to mechanical injury, decay or some other reasons. Each fragment grows into independent mycelium.

(b) Fission : Here, simple splitting of vegetative cells into two daughter cells takes place by simple constriction.

(c) Budding : Some fungi like yeast produce small outgrowths, *i.e.*, buds from their vegetative body. Eventually, the buds are cut off from parent cell and mature to form new individuals.

2. Asexual reproduction : It occurs through spores. These are single celled specialized structures which separate from the organism, get dispersed and germinate to produce new mycelium after falling on suitable substrate. The spores produced during asexual reproduction in fungi are formed by mitotic division and are thus termed, **mitospores.**

The various means of asexual reproduction are as follows :

(a) Zoospore: Many fungi, especially aquatic members produce these types of spores. Zoospore may be **uniflagellate,** *e.g., Synchytrium* or **biflagellate,** *e.g., Saprolegnia, Pythium* and are **naked uninucleate** structures formed in zoosporangia. They germinate to give rise to new mycelium. Biflagellate zoospores are of two kinds (*e.g.*, *Saprolegnia*) **pear shaped or pyriform** with 2 flagella placed at anterior end (primary zoospore) and **kidney shaped or bean shaped**, bearing two laterally inserted flagella (secondary zoospore). This phenomenon of having two types of zoospores is called **diplanetism**.

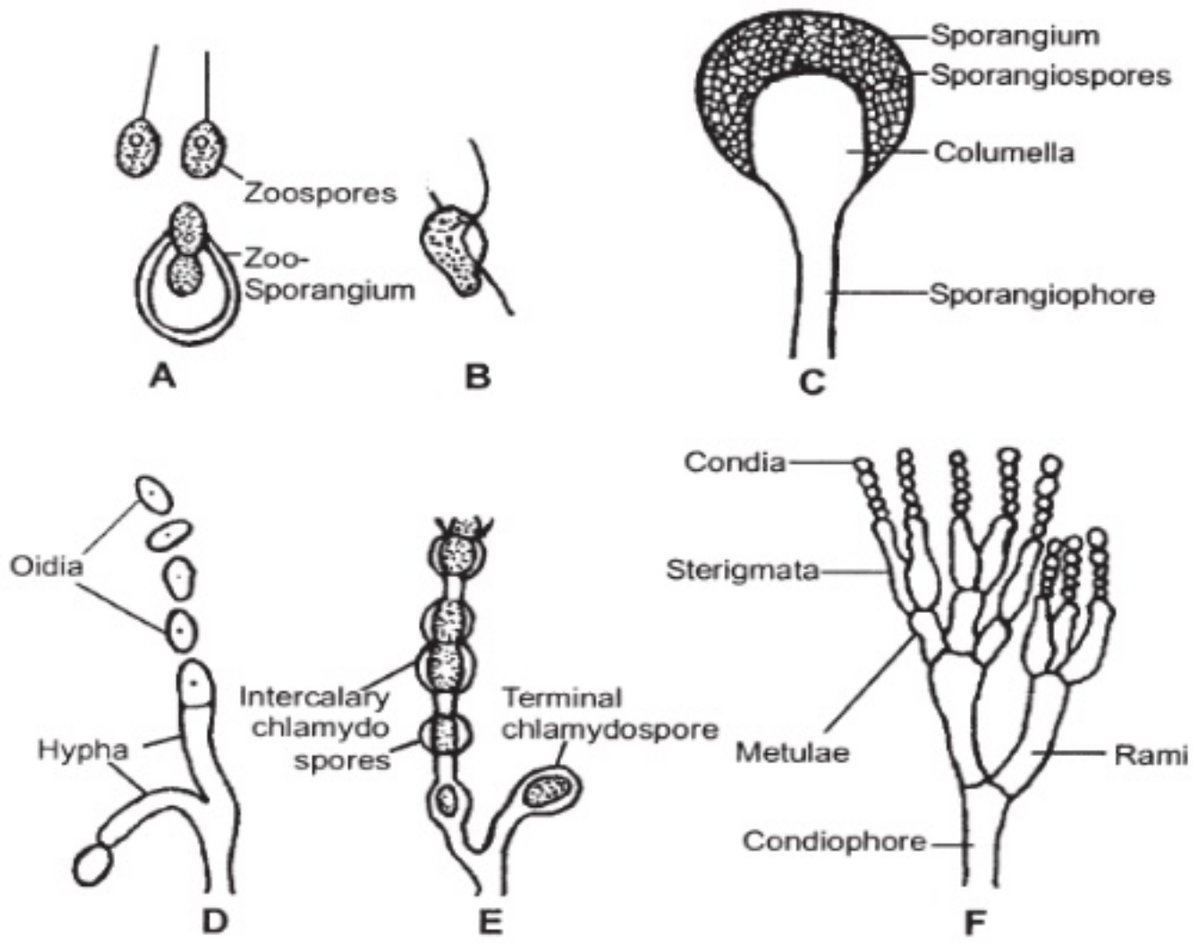


Fig. : A – F. Different modes of asexual reproduction

(b) **Gametangial contact :** In this process two gametangia come in contact with one another. A **fertilization tube** is developed to facilitate the migration of entire contents of male gametangium into the female gametangium. Both the gametangia never fuse together losing their identity, *e.g., Pythium, Albugo* (**Oomycetes**).

(c) **Gametangial copulation :** In this process, direct fusion of entire contents of two gametangia is accomplished by **dissolution** of their common walls resulting in the formation of a single cell, in which protoplasts of two gametangia fuse, *e.g., Mucor, Rhizopus* (**Zygomycetes**).

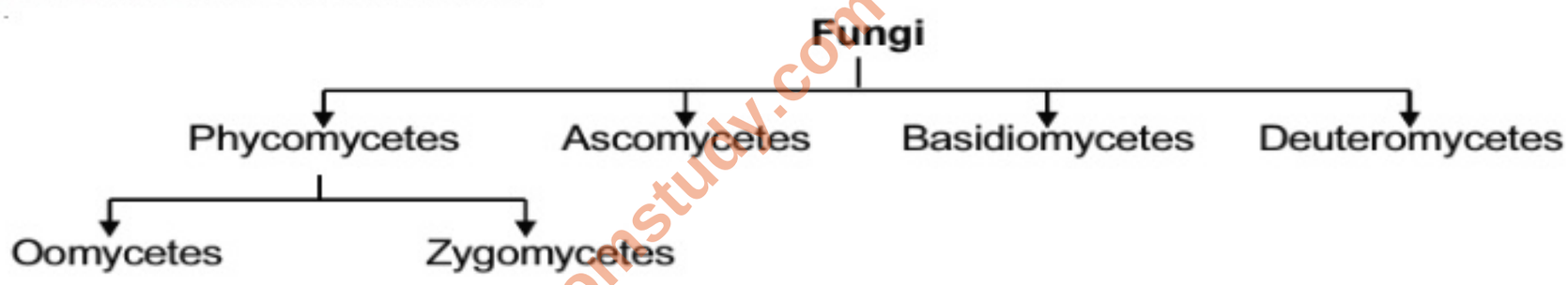
(d) **Spermatization :** Some fungi produce many minute, spore like, single-celled structures called **spermatia** (non motile male gametes) on **spermatiophores** (hyphae). These structures are transferred through agencies like water, wind and insects to special female receptive hyphae (**Basidiomycetes**). The contents migrate into receptive structure. Thus, dikaryotic condition is established, *e.g., Puccinia*.

(e) **Somatogamy :** This takes place in most of the higher true fungi, where formation of gametes is absent. In such fungi, direct fusion of somatic hyphal cells occur to establish dikaryophase, *e.g., Agaricus*.

2. **Karyogamy :** Fusion of two nuclei is called karyogamy. In some fungi, the fusion of two haploid cell immediately results in diploid cells (2n). However, in some fungi (*e.g. Agaricus*, *Aspergillus*), an intervening dikaryotic stage (n + n *i.e.* two nuclei per cell) occurs; such a condition is called a dikaryon and the phase is called dikaryophase. Later, the parental nuclei will fuse and the cells become diploid in karyogamy.

3. **Meiosis :** The fungi form fruiting bodies in which reduction division (meiosis) occurs leading to the formation of haploid spores.

Kingdom fungi is classified on the basis of **Morphology of the Mycelium, Mode of Spore Formation and Fruiting Bodies** into various classes.



Example 7 : *Name the asexual reproductive spores in fungi.*

Solution : Conidia or sporangiospores or zoospores.

Try Yourself

13. What is the basis of classification in kingdom fungi?
14. Name the sexual spores in fungi.

I. Oomycetes : The Algal Fungi

1. Hyphal wall **contains cellulose** and other glucans in many members.
2. The mycelium is **coenocytic** (multinucleate and aseptate).
3. Asexual reproduction involves the formation of spore containing sacs or **sporangia**. In aquatic forms, the sporangia produce zoospores.
4. Zoospores generally have two laterally inserted flagella with **heterokont condition**, in which one flagellum is **smooth** (whiplash) while the other is of **tinsel type** (having fine surface outgrowths called mastigonemes).
5. Sexual reproduction is by planogametic fusion or **gametangial contact**.
6. The product of sexual reproduction and **site of meiosis is oospore**.

(b) **Sporangiospore:** Sporangiospores are thin walled non-motile spores produced **endogenously** in a sporangium during favourable conditions, which after liberation give rise to new mycelium, *e.g., Rhizopus, Mucor*.

(c) **Conidia**: Conidia are non motile, thin walled **exogenous spores** produced at the tips of erect hyphae called **conidiophore**. They are arranged in chains upon the conidiophore, *e.g., Aspergillus* and *Penicillium*.

(d) **Chlamydospore**: In some fungi the hyphae under unfavourable conditions, forms **thick walled resting resistant spores** which later get separated from each other. They may be terminal or intercalary. They may remain viable for several years. On return to favourable conditions they germinate to give rise to new individuals. Thus, chlamydospores are structures for perennation also, *e.g., Rhizopus*.

(e) **Oidia:** Non-motile thin walled spores developing under sugar rich conditions in medium. Their budding condition is called **torula stage**.

3. **Sexual reproduction:** It occurs through **oospores, ascospores and basidiospores.** The various spores are produced in distinct structures called fruiting bodies. The fruiting bodies are ascocarps and basidiocarp which contain asci and basidia respectively. The ascospores are a type of non-motile spores which are produced inside special sacs called asci (singular-ascus). Basidiospores are non-motile which are formed exogenously (*i.e.* outside the body) on short outgrowths of club-shaped structure called basidium.

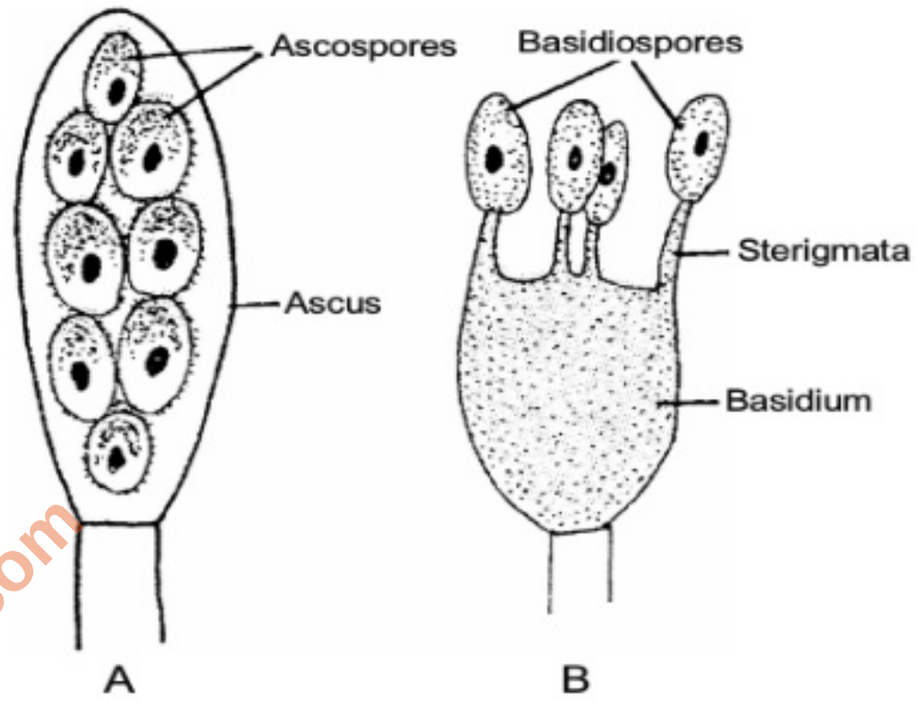


Fig. : A. Ascospores, **B.** Basidiospores

Sexual cycle involves three steps :

1. **Plasmogamy:** There is union of protoplasm between two haploid hyphae of compatible mating type or gametes.

Plasmogamy occurs by the following methods :

(a) **Planogametic copulation / Gametic fusion :** This is the simplest form of sexual reproduction. In this process, fusion of two gametes of opposite sex or strains takes place. One or both of the fusing gametes are motile. It results in the formation of a diploid zygote, *e.g., Allomyces*.

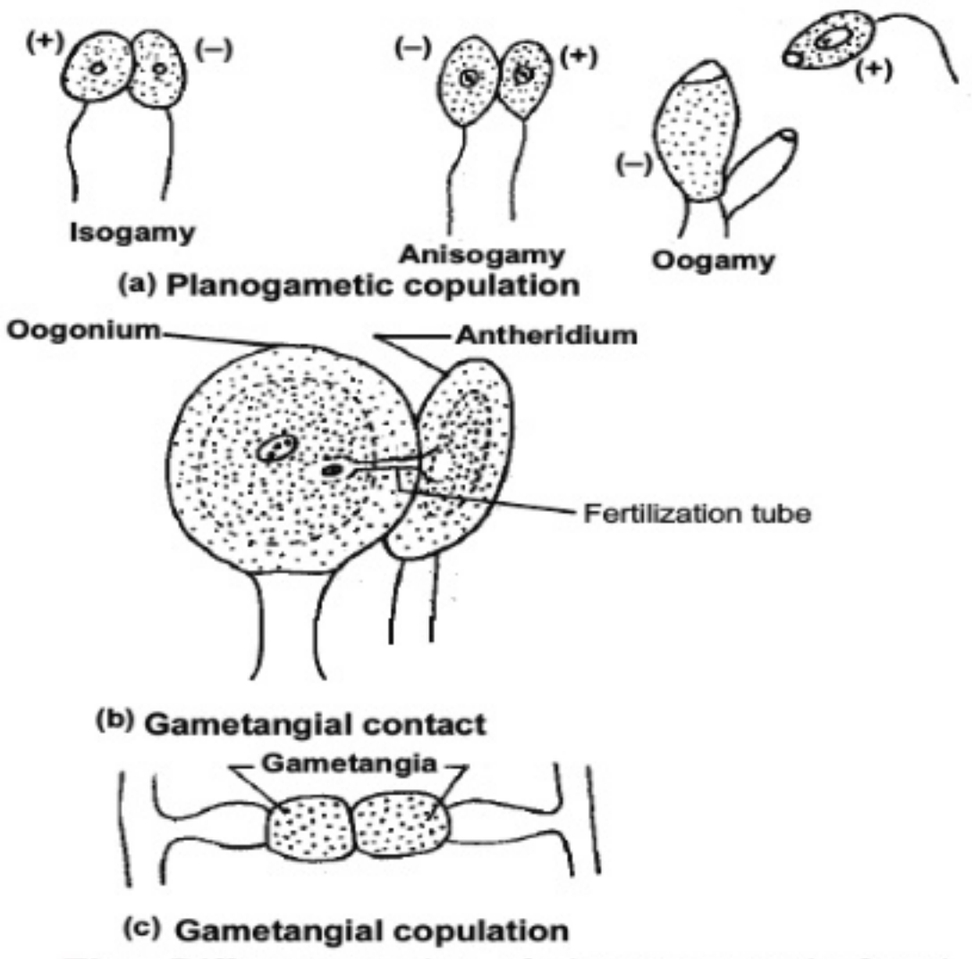


Fig.: Different modes of plasmogamy in fungi

This process is usually of three types : **Isogamy, Anisogamy, Oogamy**.

Knowledge Cloud

(i) *Phytophthora infestans* causes **late blight of potato** and occasionally of tomato as well. Great Irish famine of 1845 – 1847 was due to late blight of potato.

(ii) *Albugo candida (Cystopus candidus)* causes **white rust of crucifers** and is characterised by the appearance of irregular white blisters on the leaves and stems.

(iii) *Pythium debaryanum* causes **damping off** disease in seedlings of tomato, chillies, castor, mustard.

(iv) *Sclerospora graminicola* causes **downy mildew in cereals** particularly, *Pennisetum typhoides* (vern. Bajra) green ear disease.

(v) *Peronospora parasitica* causes **downy mildew** in a number of plants, such as pea, mustard, spinach, onion etc.

(vi) *Saprolegnia* causes salmon disease of gills in fishes.

II. Zygomycetes : The Conjugation Fungi

1. It is class of terrestrial fungi which are mostly saprotrophic and rarely parasitic.
2. Hyphal wall contains **chitin** or fungal cellulose.
3. The mycelium is **coenocytic** (multinucleate, aseptate) like the one found in Oomycetes.
4. Motile cells (zoospores or planogametes) are **absent**.
5. Mitospores are non motile. They are called **sporangiospores** as the spores are formed inside **sporangia** that are borne at the tips of special hyphae called **sporangiophores**.
6. Sexual reproduction occurs through **gametangial copulation** or **conjugation**. Because of it, zygomycetes are also called **conjugation fungi**.
7. The gametes are commonly multinucleate and are called **coenogametes**.
8. Sexual reproduction produces a **resting diploid spore called zygospore**. Because of the presence of zygospore, the group of fungi is called zygomycetes. **Zygospore differs from oospore** in that, for its formation a distinct food laden, non motile, large female gamete is not produced.
9. Zygospore is the **site of meiosis** and does not give rise to new mycelium directly. Instead it produces a new sporangium called **germ sporangium** (previously called zygosporangium). Germ sporangium forms meiospores called germ spores.
10. Sometimes, gametangia fail to fuse. Gametangia become surrounded by a thick wall resulting in formation of **azygospore** (parthenogenetically produced zygospore).

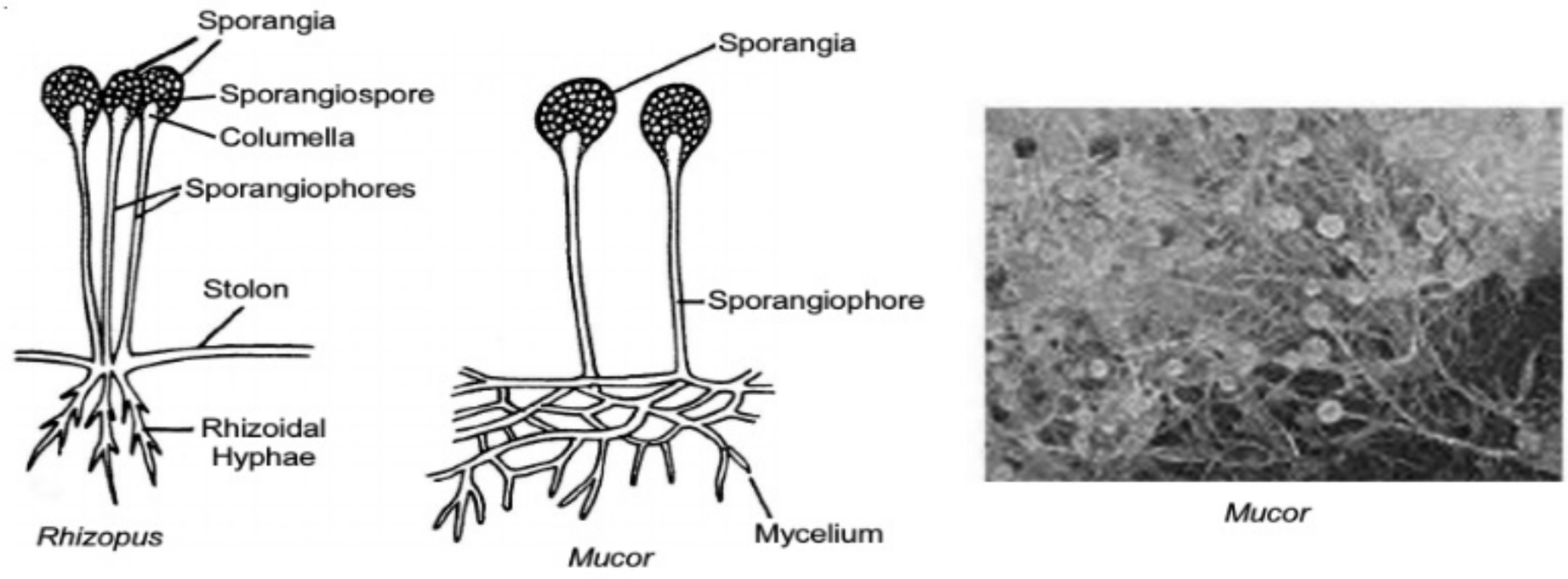


Fig. : Common Phycomycetes

Knowledge Cloud

(i) *Rhizopus stolonifer* (= *R. nigricans*) is popularly known as **black bread mould**. *M. mucedo* is called **dung mould** or **pin mould**. *Rhizopus* and *Mucor* are the common saprotrophic fungi that attack a variety of food stuffs. **Soft rot** or leek disease of strawberry, apple, jack fruit, sweet potato etc. is due to *Rhizopus*. Mucor pusillus causes infection of internal organs in human beings. *Absidia corymbifera* causes **bronchomycosis**.

(ii) Ramysin (antibiotic) is obtained from *Mucor ramannianus*.

III. Ascomycetes : The Sac Fungi

1. The mycelium consists of **septate** hyphae. (Yeasts are an exception in that they are basically unicellular).
2. They are saprophytic, decomposers, parasitic or coprophilous (growing on dung).
3. The septa possess central pores called **septal pores**. The pores allow communication and transport between adjacent cells.
4. Cell wall contains **chitin**.
5. **Motile structures do not occur in the life cycle.**
6. In majority of ascomycetes, the common mode of asexual reproduction is through the formation of **conidia**. Conidia are borne on branched or unbranched hyphae called **conidiophores**, *e.g.*, *Penicillium*, *Aspergillus*.

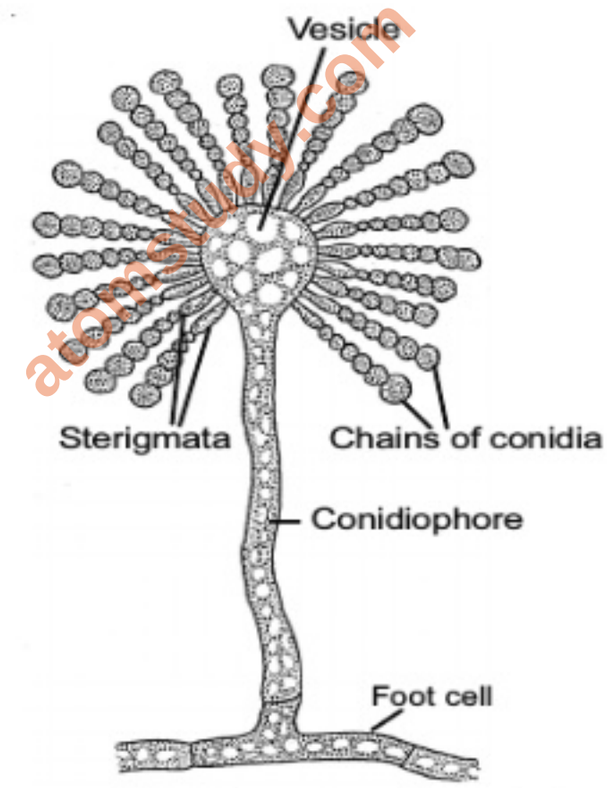


Fig. : *Aspergillus*. A mature conidiophore bearing sterigmata and chains of conidia

7. Female sex organ is called ascogonium.
8. Plasmogamy occurs by means of :
   (i) Gametangial contact (*e.g.*, *Pyronema*)
   (ii) Conjugation (*e.g.*, Yeast)
   (iii) Spermatization (*e.g., Ascobolus*)
   (iv) Somatogamy (*e.g.*, *Peziza*) (v) Autogamy (*e.g., Morchella*).
9. Karyogamy is delayed after plasmogamy. A new transitional phase appears in the life cycle. It is called **dikaryophase**. The cells of dikaryophase are called dikaryotic cells. Each such cell possesses two different nuclei (Dikaryon). **This forms a shorter phase of life cycle**.
10. Once a cell becomes dikaryotic, it transfers the nucleus to other cells by the **crozier method** (method of dikaryotization) to make them dikaryotic.

Example 8 : *What is the name of bread mould?*

Solution : *Rhizopus*

Try Yourself

15. Write the name of an unicellular fungi.
16. What are coprophilous fungi?

IV. Basidiomycetes : The Club Fungi

1. They are the **most advanced** and **most commonly seen fungi**. Their fructifications are often large and conspicuous, *e.g.*, mushrooms, toadstools, puff balls, bracket fungi etc.
2. Basidiomycetes are among the best **decomposers of wood**. They are able to decompose both cellulose and lignin. Lignin is not metabolised by most other fungi and even bacteria. *Ganoderma* species causes decay of wood even on standing trees.
3. **Motile structures or cells are absent.**
4. Mycelia are of two types, primary and secondary. Primary mycelium contains monokaryotic cells and is short lived.
5. Monokaryotic phase or primary mycelium may multiply by oidia, conidia-like spores and pycniospores.
6. Secondary mycelium is long lived and **dominant phase of life cycle**. It is represented as **dikaryophase**. It consists of profusely branched septate hyphae.
7. Septa possess **dolipores** or central pores with barrel-shaped outgrowths (except rusts and smuts).
8. Handle like outgrowths are found on the sides of septa. They are called **clamp connections**. Clamp connections are meant for proper distribution of dikaryons at the time of cell division.

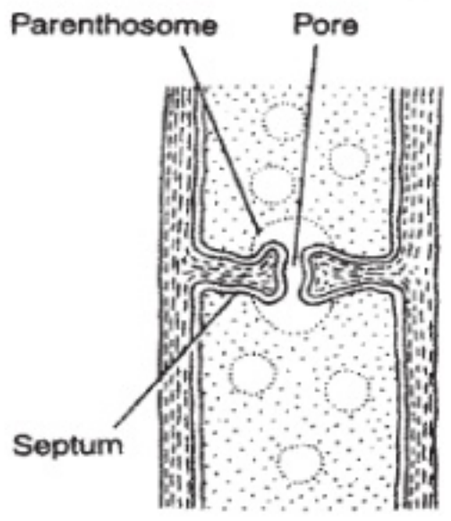


Fig. : Dolipore septum

9. Secondary mycelium can perennate in the soil or wood by means of **sclerotia** or **rhizomorphs**.
10. Dikaryophase or secondary mycelium may multiply by different types of spores– **chlamydospores**, **aecidiospores**, **uredospores**, **teleutospores** etc.
11. There is often differentiation of two mating types (+) and (–) in thallus.
12. Sexual reproduction does not involve sex organs. Instead fusion occurs between basidiospores and other monokaryotic spores, between a spore or spermatium and a hypha or between two hyphal cells of primary mycelia.
13. **Karyogamy and meiosis** occur in club-shaped structures known as **basidia** (singular – basidium). The name of the class is based after them.

11. Some dikaryotic cells function as **ascus mother cells**. This converts the cells into **asci** (singular – ascus). Ascus is a sporangial sac peculiar to Ascomycetes. **Ascus is the site of karyogamy and meiosis**. 4 to 8 haploid meiospores named **ascospores** are produced **endogenously** in each ascus. In most of the cases, half the number of ascospores belong to one mating type(+) while the other half belong to the second mating type (–).
12. Ascospores may be arranged linearly (*Neurospora*) or unorderly (yeast).
13. The asci may occur freely or get aggregated into specific fructifications called **ascocarps**. Ascocarps are of many types : cup-like (**apothecium**, *e.g.*, *Peziza*), flask-shaped (**perithecium**, *e.g.*, *Neurospora, Claviceps*), elongated with a slit (**hysterothecium**), closed (**cleistothecium**, *e.g.*, *Penicillium*) cushion like, chambered (**Ascostroma**, *e.g., Pleospora*). The fructifications of some ascomycetes are edible, *e.g.*, morels, truffles.

Knowledge Cloud

Members of this class are said to be our worst fungal enemies.

(i) **Morels** (sponge mushroom) are Ascomycetes with edible ascocarps having fleshy sponge-like conical cap or pileus and a stalk like stipe, *e.g., Morchella esculenta* (vern. Guchhi), *M. deliciosia.*

(ii) **Truffles :** They are edible tuber-like subterranean ascocarps, e.g., *Tuber aestivum*.

(iii) *Claviceps purpurea* causes **ergot of rye** and *C. microcephala* causes ergot of bajra in which ears are filled with **sclerotia** of the fungus. Eating of infected cereals produces **ergotism.** (It produces an alkaloid called ergotine which causes abortion, if eaten, unknowingly). This is used as a drug to promote expulsion of foetus).

(iv) *Neurospora crassa* (Pink bread mould), is often employed in biochemical and genetic work (experimental genetics), **so is called *Drosophila* of plant kingdom**.

(v) **Erisyphe :** The fungus produces **powdery mildew** (fungal disease in which pathogen results in a powdery coating of spores on the surface of the host), e.g., *Erysiphe graminicola.*

(vi) *Penicillium chrysogenum* is used in commercial production of the antibiotic **penicillin.** The later was the first commercial antibiotic. It was discovered from *P. notatum*. The fungus is employed in ripening of cheese, *e.g., P. roqueforti* and *P. camemberti.*

(vii) ***Aspergillus* :** It is common green smoky mould which not only contaminates laboratory cultures (hence called **weed of laboratory**), but also various food stuffs including bread, butter etc. *Aspergillus flavus* is highly poisonous due to the presence of **aflatoxins.** *A. oryzae* is the source of diastase enzyme.

(viii) **Brewing Industry :** Under anaerobic conditions, sugary solutions inoculated with yeasts are converted into alcoholic beverages, *e.g.,* beer, wine, cider, toddy. The two common yeasts used by brewing industry are *Saccharomyces cerevisiae* (Beer or Baker's yeast) and *S. ellipsoidens* (Wine yeast).

(ix) **Gibberellins:** They were first discovered in the extracts of *Gibberella fujikuroi* growing on rice (bakanae disease of rice). It is the perfect stage of fungus *Fusarium moniliforme* (Deuteromycete). Gibberellins are natural plant growth hormones.

***Penicillium* : Important characters**

(i) Facultative parasite and saprophytic fungi.

(ii) Mycelium is branched septate, with simple septal pore and each cell is uni or multinucleate depending upon the species.

(iii) Asexual reproduction occurs by **conidia**. Conidiophores are often branched. The first branch level is called **rami** and second or ultimate branches are called **metulae** having bottle shaped **sterigmata**. Each sterigmata produces a chain of conidia. The conidia in chain are arranged in **basipetal order**. Each conidium is uninucleate, non motile, two layered, dispersed by air and germinates to form new mycelium.

(iv) **Sexual reproduction :** It exhibits dikaryophase and produces ascocarp. The ascocarp is **cleistothecium** type. Each ascus has 8 ascospores. Ascospore germinates to form new mycelium.

14. A basidium commonly produces four meiospores or basidiospores **exogenously** at the tips of fine outgrowths called **sterigmata** or directly on the basidium.
15. The fungi may or may not produce fructifications called **basidiocarps**. The basidiocarps vary from microscopic forms to large macroscopic structures. Some puff balls and brackets can be over 50 cm in diameter.

Knowledge Cloud

(i) **Smuts :** They produce thick-walled, black-coloured resting spores called **smut spores.** Smuts are of two types, **covered** and **loose**. In covered smut, the spore mass remains within the membranous covering of sorus, e.g., *Ustilago hordei* (**covered smut of barley**), *Ustilago maydis* (**smut of corn**). In loose smut the spores are exposed while attached to the host, e.g., *Ustilago nuda tritici* (**loose smut of wheat**), *U. avenae* (**loose smut of oat**).

(ii) **Mushrooms :** They are edible and non edible Agaricales which possess umbrella like basidiocarp. Common examples of edible mushrooms are *Agaricus campestris*, *A. bisporous*, *Volvariella volvacea* (**Paddy straw mushroom**), *Pleurotus ostreatus* etc.

(iii) **Toadstools :** Toadstools are poisonous mushrooms which generally have white spores. *Amanita caesarea* (**Caeser's mushroom**) was used in poisoning Roman emperor Caesar. The other toadstools are *Amanita phalloides* (**Death cup**), *A. muscaria* (**Fly agaric**) and *Gynomitra esculenta* (heat labile carcinogenic toxin).

(iv) **Rusts :** They are characterised by the formation of rusty pustules containing the spores.

(a) *Puccinia graminis tritici* – Black rust of wheat.

(b) *Puccinia glumarum* or *P. striiformis* – Yellow rust of wheat.

(c) *P. recondita* - Brown rust of wheat

(v) (a) *Puccinia* is heteroecious obligate parasite which completes its life cycle on two hosts;

Primary host – wheat

Secondary or alternate host – Barberry

(b) It has macrocyclic life cycle with five types of spores: uredospores (n + n), teleutospores (n + n) on wheat plant, basidiospore (n) in soil, pycniospores (n) and aeciospores (n + n) on barberry leaf.

(vi) **Hallucinogens :** *Psilocybe mexicana* (**Sacred mushroom**) has hallucinating properties similar to LSD. It is used by Mexican Indians during certain religious ceremonies.

(vii) ***Armillaria* (largest fungi):** *A. mellea* (**Honey mushroom**) is a serious root parasite of both hardwoods and conifers. The fungus develop rhizomorphs into the phloem of the host and hence, blocks the food supply.

(viii) **Puffballs :** The basidiocarp is a stalked rounded structure which, upon ripening, releases out puffs of spores. The fructification may grow above or below the substratum, *e.g., Lycoperdon oblongisporum, L. giganteum*.

(ix) **Bracket fungi (Shelf fungi) :** They are basidiomycetes whose basidiocarps or fructifications appear on tree trunks, logs, lumber etc. just as brackets or shelves, *e.g., Fomes applanatus, Polyporus sulphureus, Ganoderma*.

(x) **Predator fungi :**, *e.g., Dactylaria, Arthrobotrys.*

(xi) **Stink horn**. *Phallus impudicus* (Dead man's finger). Spore mass produces a stinking odour to attract flies.

Life History of a Mushroom

Agaricus campestris is the common field mushroom which has edible basidiocarp. The fungus is **saprotrophic**. The vegetative or assimilative part of mycelium is subterranean. It is found in moist humus rich soil of open fields, grassland, piles of straw or within rotting logs.

The mycelium multiplies by **fragmentation**; occasionally by oidia and chlamydospores.

Life cycle of mushroom contains two types of mycelia, **primary** and **secondary**. **Sex organs do not differentiate.** Primary mycelium is short lived. It consists of septate hyphae having monokaryotic cells. The

mycelia are **heterothallic**, [having two mating types, (+) and (–)]. The hyphae of two mating types come in contact and show **somatogamy**. However, only plasmogamy occurs at this time. It gives rise to a dikaryotic cell that grows, divides and produces a long-lived and extensive dikaryotic or **secondary mycelium**. The hyphae of secondary mycelium show **clamp connections** and **dolipore septa**. Its cells possess two haploid nuclei instead of single diploid nucleus.

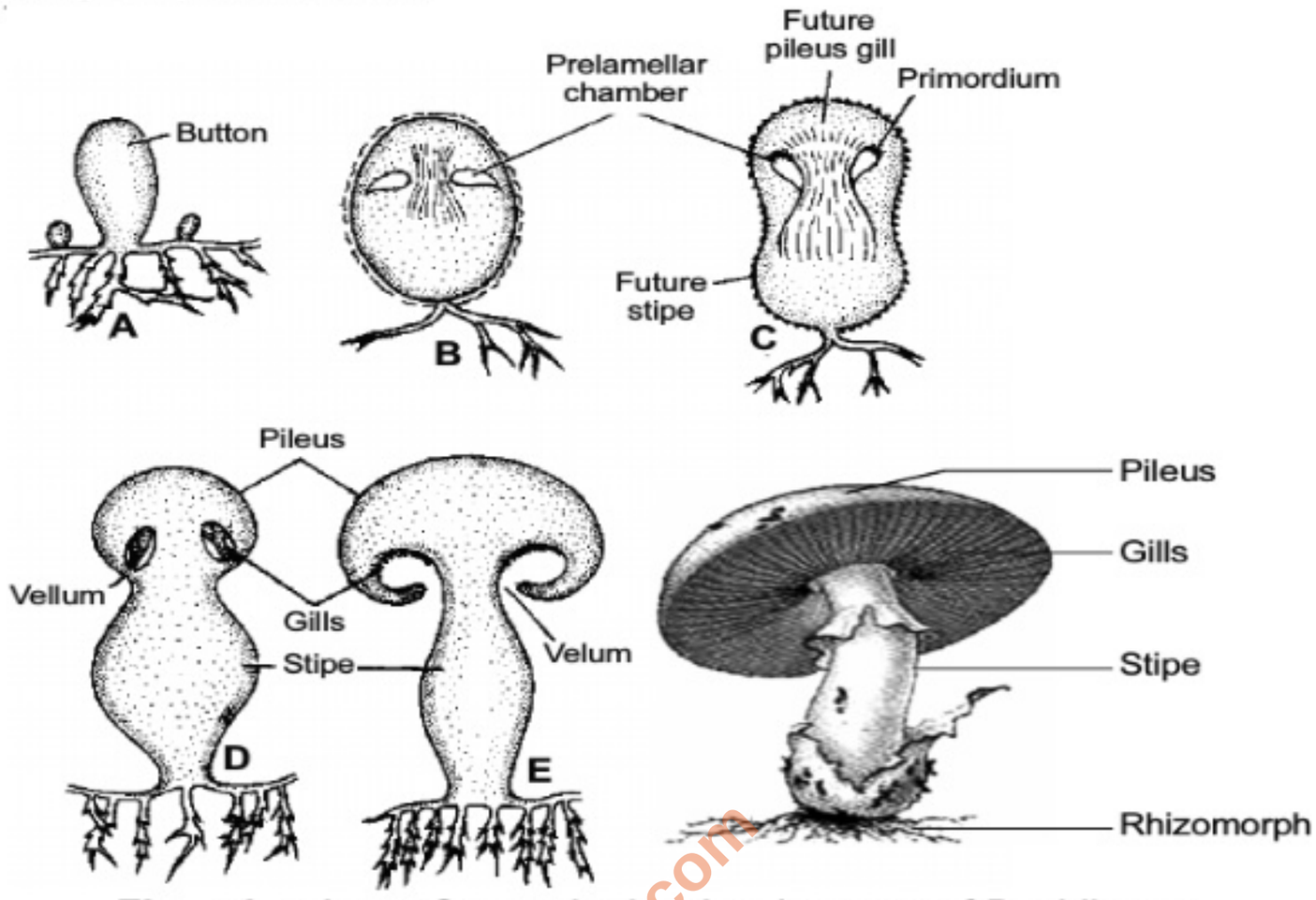


Fig. : *Agaricus* : Stages in the development of Basidiocarp

Under favourable conditions, hyphae of secondary mycelium collect at places and give rise to rounded or pyriform compact masses of hyphae called **buttons**. The buttons enlarge and produce aerial fructifications or basidiocarps. The latter are popularly termed as **mushrooms**. In contrast the secondary mycelium, from which mushrooms develop, is known as **spawn**. The basidiocarps or mushrooms often lie in rings. The latter are called as **fairy rings**, its diameter increases centrifugally every year.

Each basidiocarp or mushroom is cream to pinkish brown in colour and consists of two parts, **stipe** and **pileus**. The stipe or stalk is fleshy. It is slightly swollen at the base. Pileus is umbrella-like cap of the mushroom. In the button stage, the pileus is connected to stipe by membrane called **veil** or **velum**. It ruptures during growth of pileus. However, its remains can be seen on the upper part of stipe as **annulus**. The pileus is circular in outline. Its upper surface is more or less convex. The under surface is flat or concave. It bears 300-600 radiating rows of vertical plates named **gills** (lamellae).

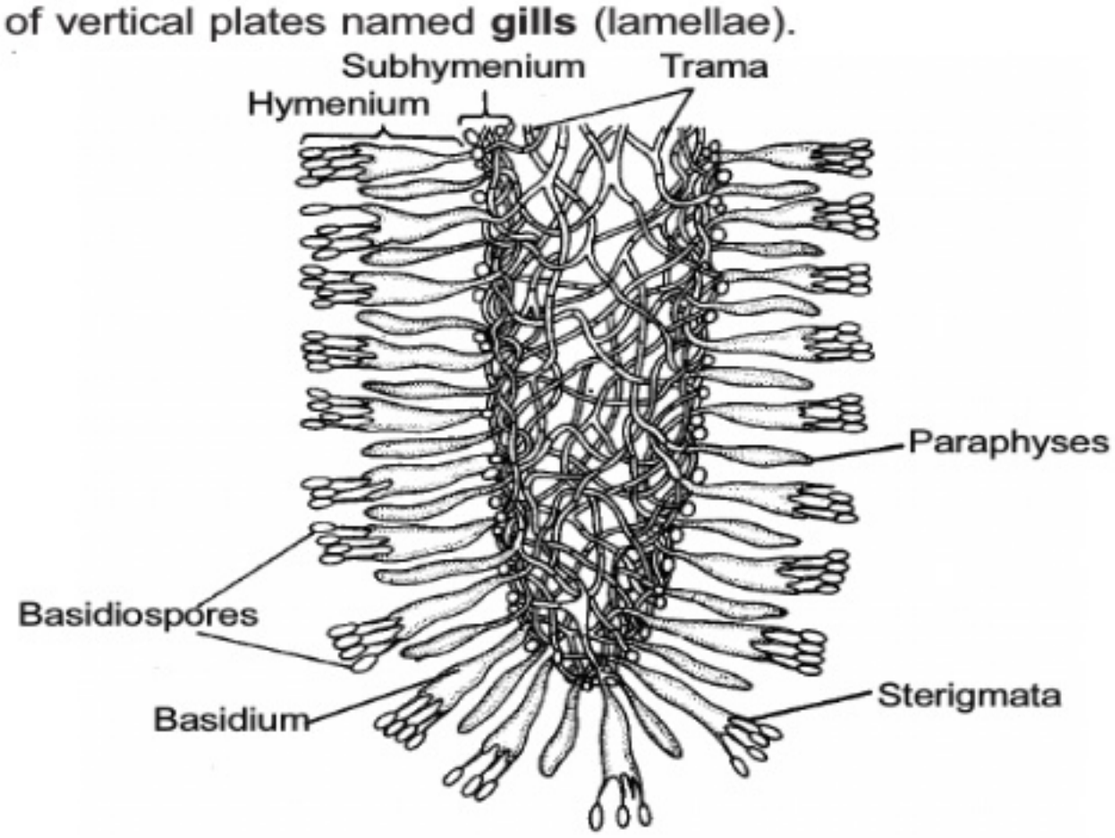


Fig. : *Agaricus*: Internal structure of Gill

Example 10 : *Name the asexual reproductive bodies of Deuteromycetes.*

Solution : Conidia.

Try Yourself

19. Name the main groups in which fungi are classified.
20. Give three examples of deuteromycetes.

After this discussion, we can easily differentiate between various classes of fungi.

Features	Phycomycetes	Ascomycetes	Basidiomycetes	Deuteromycetes
1. Mycelium	Aseptate/coenocytic	Septate, branched	Septate, branched	Septate, branched
2. Asexual spore	Zoospore (Planospore)/ Sporangiospore (Aplanospore)	Conidia	Generally absent	Conidia
3. Sexual spore	Zygospore/Oospore	Ascospore	Basidiospore	Absent
4. Fruiting bodies	Absent	Ascocarp	Basidiocarp	Absent

READ & DIGEST

Common names of some Fungi :

Fungus/Group	Common names
Rhizopus	Black/Bread mould
Morchella	Morels (sponge mushroom)
Saccharomyces	Yeasts (sugar fungus)
Phallus	Stink horns
Hydnum	Tooth fungi (Hedge hog fungi)
Ganoderma, Polyporus	Wood / Bracket / Shelf fungi
Aspergillus flavus	Guinea pig of plant kingdom
Mucor mucedo	Dung mould
Penicillium	Blue/green mould
Peziza	Cup fungi
Lycoperdon, Clavatia	Puff balls
Cyathus	Bird's nest fungus
Clavaria	Coral fungi
Amanita	Toad stool
Tremella	Jelly fungi/Trembling fungi
Pleurotus ostreatus	Oyster mushroom
Agaricus bisporus	Button mushroom
Neurospora crassa	*Drosophila* of plant kingdom

The two sides of vertically placed gills are lined by thousands of club-shaped **basidia** alongwith sterile **paraphyses**. The two, together constitute the fertile layer or **hymenium** of the gill. Hymenium is subtended by compact **subhymenium**. The centre consists of interwoven hyphae called **trama**. Each basidium functions as the **site for both karyogamy and meiosis**. The two nuclei fuse to form a short-lived diploid **synkaryon**. The latter, then divides meiotically giving rise to four haploid nuclei, two of (+) strain and two of (–) strain. The free end of the basidium now develops four peg-like outgrowths called **sterigmata**. Each sterigmata bears an ovoid pinkish-purple meiospore termed as **basidiospore**. A droplet appears at the tip of sterigmata which creates tension and hanging basidiospores are carried away by air currents. The basidiospores are liberated successively for several days. After falling on a suitable substratum, each basidiospore germinates to produce monokaryotic primary mycelium.

Example 9 : *What is the name of rust fungus?*

Solution : *Puccinia*.

Try Yourself

17. Name the group to which bracket fungi belong.
18. Where karyogamy and meiosis take place in basidiomycetes?

V. Deuteromycetes : The Fungi Imperfecti

There is only asexual and vegetative phase known so these are commonly regarded as imperfect fungi. It is also possible that the asexual and vegetative stage have been given one name (and placed under deuteromycetes) and the sexual stage another (and placed under another class).

By the establishment of linkages, the perfect stage (or sexual form) discovered in these fungi, they are moved out of deuteromycetes to ascomycetes and basidiomycetes. The deuteromycetes reproduce only by asexual spores known as conidia. The mycelium is septate and branched in these fungi. Some of them are saprophytes or parasites while a large number of them are decomposers of litter (organic matter) and help in mineral cycling.

Examples : *Alternaria*, *Colletotrichum* and *Trichoderma*.

Knowledge Cloud

(i) **Leaf spot of rice** : *Helminthosporium oryzae* causes leaf spot disease of rice commonly called **brown leaf spot of rice**. It caused Bengal famine in 1942-43.

(ii) **Early blight** : *Alternaria solani* causes early blight of potato. The leaves develop small oval brown spots with concentric rings (**target board symptom**).

(iii) **Tikka disease**: Circular necrotic dark brown or blackish leaf spots develop in groundnut due to *Cercospora personata*.

(iv) **Red rot** : *Colletotrichum falcatum* produces red rot of sugarcane.

(v) **Wilts**: Many economically important plants (e.g., cotton, pigeon pea) show sudden signs of wilting due to blockage of tracheary elements by growth of fungus, *Fusarium* especially *F. oxysporum, F. udum*.

(vi) Ringworm of foot/**Athlete's foot** is caused by *Trichophyton interdigitate*.

Did You Know?

Common Fungicides and their composition

1. Bordeaux mixture – ($CuSO_4$: $Ca(OH)_2$: H_2O). First fungicide discovered by RMA Millardet
   – Commonly known as **holy water of plant pathology**
2. Burgandy mixture (Soda Bordeaux) – Mixture of $CuSO_4$ + Na_2CO_3 + H_2O was discovered by Mass
3. Chestnut mixture – Ammonium carbonate + copper sulphate

MYCORRHIZA (FUNGAL ROOTS)

The mutual beneficial or symbiotic association of a fungus with roots of higher plants (gymnosperms and angiosperms) represents mycorrhiza.

Benefits to fungi	Benefits to plant
1. Nourishment from root cortical cells. 2. Shelter	1. Surface area for absorption increases. 2. Enhanced supply of H_2O, N, P, S.

The mutually beneficial or symbiotic association of a fungus with the roots of higher plants is termed **mycorrhiza**. Mycorrhizal roots differ in shape from normal roots and often show a wooly covering. **These roots lack root cap and root hairs**. A fungus may get associated with roots of a number of plants and a particular plant may form association with a number of fungi. Depending upon the location of the fungus, the mycorrhiza is of two types, *i.e.*, **ectomycorrhiza** and **endomycorrhiza**.

In **ectomycorrhiza**, the fungal hyphae are mainly external, forming a wooly covering on external surface of root and forms network of mycelium (**Hartig net**) in the intercellular spaces of the cortex. Fungal partner is commonly basidiomycetes like *Boletus*, *e.g.*, *Pinus* roots

In **endomycorrhiza**, the fungal hyphae enter the tissue of the root, spreading intercellularlly and intracellularly. The fungus is able to break the cell wall in a limited way and is restricted to cortical region of the root. Some hyphae send small projections into cortical cells without destroying them. Such fungi are termed **VAM (Vesicular Arbuscular Mycorrhiza)**, *e.g.*, Orchid roots.

Mycorrhizal association is a **symbiotic relationship** as both the partners are mutually beneficial to each other. The fungal partner obtains nourishment from the cortical cells of the root and depends upon the plant for shelter. The root cells excrete sugars and other soluble gradients which are used by fungal hyphae spreading in intercellular spaces. The hyphae may get nourishment from the cells directly and also by sending small projections into cortical cells. The fungus seems to be essential for the growth of the plant having mycorrhiza. The plant also gets benefit from the association as the fungal hyphae spreading in soil substantially increases the surface area of absorption, thereby **enabling the plant to get enhanced supply of water, nitrogen, phosphorus and other minerals** from the soil. Orchids seldom occur without mycorrhiza. Certain forest trees like pines, birches show stunted growth if their roots are not associated with fungus.

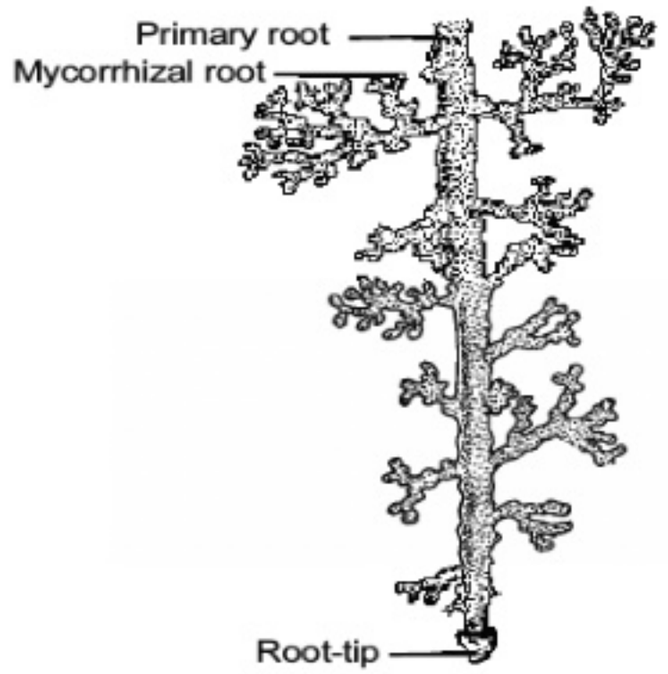


Fig. : Ectomycorrhiza on *Pinus* roots

KINGDOM : PLANTAE

All eukaryotic chlorophyll containing organisms commonly called plants are included under kingdom plantae. Few of them are partially heterotrophic such as insectivorous plants (*e.g.* Bladderwort and Venus fly trap) or parasites (*e.g., Cuscuta*). The plant cells have an eukaryotic structure with prominent chloroplasts and cell wall which is mainly made up of cellulose.

Kingdom **Plantae** includes algae, bryophytes, pteridophytes, gymnosperms and angiosperms. In plants, life cycle has two distinct phases *i.e.* the diploid sporophytic and haploid gametophytic that alternate with each other. This phenomenon is called alternation of generation. The lengths of haploid and diploid phases, and whether these phases are free living or dependent on others, vary among different groups in plants.

KINGDOM : ANIMALIA

The members of this kingdom are multicellular and their cells lack cell walls. They directly or indirectly depend on plants (autotrophs) for nutrition. In these members, the digestion of food takes place in an internal cavity and they store their food reserves in the form of glycogen or fat. Their mode of nutrition is holozoic by ingestion of food. They follow a definite growth pattern and grow into adults that have a definite shape and size. Most of them are capable of locomotion. Higher forms of kingdom animalia show elaborate sensory and neuromotor mechanism.

Example 11 : *Give two examples of insectivorous plant.*

Solution : Bladderwort and Venus fly trap.

Try Yourself

21. Members of kingdom animalia store food reserves in the form of _____.
22. Which mode of nutrition is found in kingdom animalia?

EXERCISE

31. Mark the odd one (w.r.t. fungi)
    (1) Unicisternal golgi bodies
    (2) Show a great diversity in morphology and habitat
    (3) Most of the members are aquatic
    (4) Reverse food material is stored in the form of oil and glycogen
32. Select **incorrectly** matched pair :
    (1) *Rhizopus* – Sporangiospore
    (2) *Penicillium* – Ascocarp
    (3) *Mucor* – Dikaryophase
    (4) *Aspergillus* – Conidia
33. Coenocytic dimorphic vegetative mycelium is found in
    (1) *Neurospora*
    (2) *Rhizopus*
    (3) *Penicillium*
    (4) *Ustilago*

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34. Choose **incorrect** match w.r.t. different classes of fungi
    (1) Oomycetes – zoospore – gametic copulation
    (2) Zygomycetes – sporangiospore – zygophore
    (3) Ascomycetes – conidia – monokaryotic aseptate mycelium
    (4) Phycomycetes – algal and conjugation fungi – coenocytic mycelium
35. Asci are not organised into ascocarps in
    (1) True yeast (2) *Drosophila* of plant kingdom
    (3) Pigmented mould (4) Morels
36. Ultimate branches of conidiophore in *Penicillium* is
    (1) Rami (2) Phialide
    (3) Sterigmata (4) Metulae
37. The common type of asexual spore in sac fungi is
    (1) Uninucleate and motile (2) Unilayered and non-motile
    (3) Two layered and non-motile (4) Multinucleate, two layered and motile
38. The name of the class is based on sexual structure as the site of karyogamy and meiosis in
    (1) Phycomycetes and Actinomycetes (2) Deuteromycetes and Zygomycetes
    (3) Ascomycetes and Basidiomycetes (4) Basidiomycetes and Actinomycetes
39. In *Agaricus*, clamp connections and dolipore septa are shown by the hyphae of
    (1) Primary mycelium (2) Secondary mycelium
    (3) Monokaryotic mycelium (4) Coenocytic mycelium
40. Select correct statement w.r.t. mycorrhizal roots
    (1) They do not differ in shape from normal roots
    (2) Often show a wooly covering
    (3) Possess root cap but lack root hairs
    (4) Fungal partner is commonly a member of Ascomycetes

VIRUSES, VIROIDS AND LICHENS

In the five kingdom classification of Whittaker, there is no mention of some acellular organisms like viruses, viroids and lichens. These are briefly introduced here.

VIRUSES

Viruses are infectious agents, with simple, acellular organisation. They are exception to the cell theory. The study of virus is called virology. Viruses are connecting link between living and non-living entities. They have the properties of both living and non-living things. Viruses can reproduce only within living cells and are obligatory intracellular parasites.

Non-living Nature of Virus:

1. Lacking protoplast.
2. Ability to get crystallized, *e.g.,* TMV, poliomyelitis virus.
3. Inability to live independent of a living cell. (Lack functional autonomy)
4. High specific gravity which is found only in non living objects
5. Absence of respiration.
6. Absence of energy storing system.
7. Absence of growth and division.

(a) DNA containing viruses are called deoxyviruses. These are of two types :

(i) Double stranded DNA (dsDNA) virus *e.g.* Pox virus, Cauliflower mosaic virus, Herpes virus.

(ii) Single stranded DNA (ssDNA) *e.g.* Coliphage $\phi \times 174$, M13 phage.

(b) RNA containing viruses or riboviruses are of two types :

(i) Double stranded RNA (dsRNA) virus *e.g.* Reovirus, Wound tumour virus.

(ii) Single stranded RNA (ssRNA) virus *e.g.* TMV, Influenza virus, Foot and Mouth disease virus, Retroviruses (HIV).

On the basis of host specificity viruses are divided into three groups :

Group	Common type of genetic material
1. Phytophagineae/Plant viruses	1. ssRNA
2. Zoophagineae/Animal viruses	2. ss or dsRNA or dsDNA
3. Bacteriophages/Bacterial viruses	3. dsDNA

Structure of Some Viruses

1. **Tobacco Mosaic Virus (TMV)** is elongated rod like, 3000 Å long, 180 Å in diameter with molecular weight 39.4×10^6 dalton. 2130 capsomeres are arranged helically to form the capsid. RNA strand is helical. ssRNA consists of 6400 nucleotides. Thus, the ratio of nucleotides : capsomeres = 3 : 1

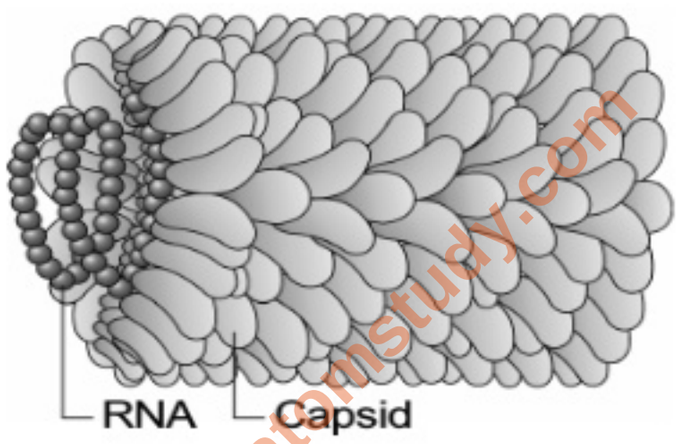

Fig. : Tobacco Mosaic Virus (TMV)

2. **Bacteriophage** (or bacterial viruses) are the viruses that infect the bacteria. Bacteriophages usually have double stranded DNA. **T_4 Bacteriophage** has a tadpole like structure with polyhedral head connected to a helical tail (binal). The head consists of nucleic acid surrounded by a protein coat or capsid. Nucleic acid is double stranded DNA. Tail is proteinaceous tube-like, core surrounded by sheath. At one end, tube is joined to the head by thin collar. At the other end, it has a hexagonal base plate with six small tail pins and six tail fibres which help in attachment of the phage to the host cell.

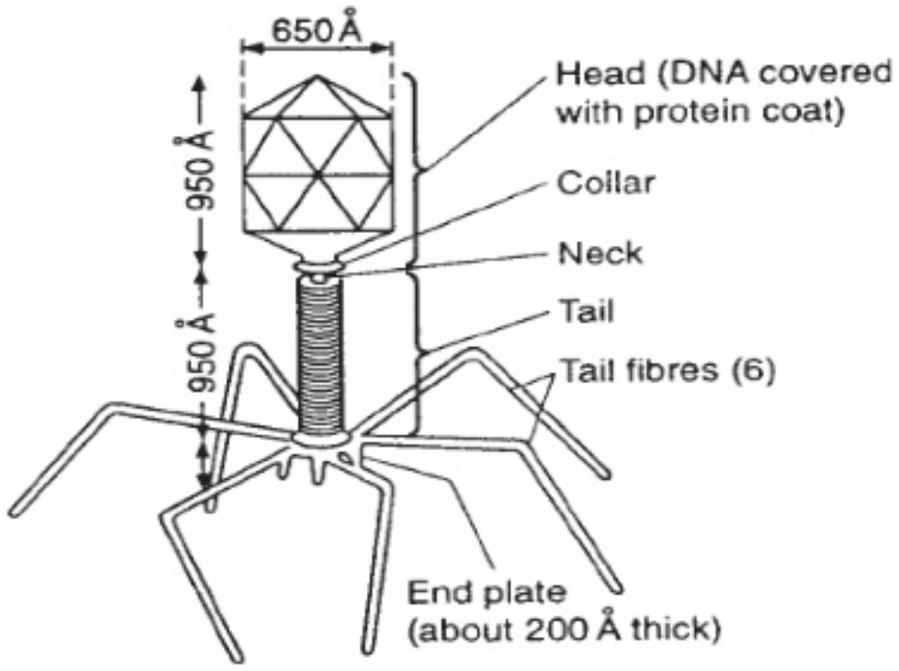

Fig. : Structure of T_4 bacteriophage

Living Nature of Virus :

1. Being formed of organic macromolecules.
2. Presence of genetic material.
3. Ability to multiply.
4. Occurrence of mutations.
5. Occurrence of certain enzymes like, neuraminidase (first discovered), transcriptase and lysozyme in certain viruses.
6. Infectivity and host specificity.
7. Viruses can be 'killed' by autoclaving and ultraviolet rays.
8. They take over biosynthetic machinery of the host cell and produce chemicals required for their multiplication.
9. Viruses are responsible for a number of infectious disease like common cold, epidemic influenza, chicken pox, mumps, poliomyelitis, rabies, herpes, AIDS, SARS etc.

Discoveries of Virology :

- Term virus (means venom or poisonous fluid) was coined by **Pasteur** (1880).
- **D.J. 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. Beijerinck** (1898) demonstrated that the extract of the infected plants of tobacco could cause infection in healthy plants and called this fluid as *Contagium vivum fluidum* (infectious living fluid).
- **W.M. Stanley** (1935) crystallised TMV (Tobacco mosaic virus) for the first time. He showed that viruses could be crystallised and crystals consists largely of proteins.

Note : • *Viruses are obligate parasite and are inert outside their specific host cell.*
• *An inert virus is called virion.*

Viruses did not get place in classification because they are not truely living. To understand living organisms, they should have cell (fundamental unit of life) but viruses does not follow it. Viruses do not have their own cellular machinery. When they enter (or infect) a cell then these take over the cellular machinery of host to replicate themselves.

Example 12 : *Name the connecting link between living and non-living.*
Solution : Viruses.

Try Yourself

23. Who coined the term 'Virus'?
24. Who demonstrated that the extract of the infected plants of tobacco could cause infection in healthy plants?

Structural Components of Viruses

The structural components of viruses are envelope, capsid and nucleoid:

1. **Envelope :** It is the outer thin loose covering composed of proteins (from virus), lipids and carbohydrates (both from host). This layer may or may not be present. Envelope is present in HIV, Herpes virus.
2. **Capsid :** It is the outer protein coat made up of small subunits called capsomeres for the protection of nucleic acid (their genetic material).
3. **Nucleoid :** Viruses contain either DNA or RNA :

Reproduction

It is of two main types: **Phagic** and **Pinocytic**

(a) Phagic Reproduction : Only nucleic acid of virus enters the host cell. It is further of two types :

(i) Lytic cycle : Occurs in virulent phages, *e.g.*, T_4 bacteriophages.

(ii) Lysogenic cycle : Occurs in temperate viruses such as λ phage.

(b) Pinocytic Reproduction : It is found in viruses like TMV, HIV, Hepatitis B etc., in which whole of virus particle enters host cell except envelope (if present).

List of some Diseases caused by viruses

Table : Viral diseases of Man

Name of the disease	Causal agent
1. Influenza	1. Influenza virus
2. Small pox	2. Variola virus
3. Mumps	3. Paramyxovirus
4. AIDS	4. Retroviruses
5. Poliomyelitis	5. Polio virus
6. German measles	6. Rubella virus
7. Measles	7. Measles virus

Table : Viral diseases of Plants

Name of the disease	Causal agent
1. Tobacco mosaic	1. TMV
2. Cucumber mosaic	2. Cucumber mosaic virus
3. Potato leaf roll	3. Potato leaf roll virus
4. Bunchy top of banana	4. Banana bunchy top virus

Note : *In plants, the viral symptoms can be mosaic formation, leaf rolling and curling, yellowing and vein clearing, dwarfing and stunted growth.*

Knowledge Cloud

Interferons: Small group of glycoprotein released by virus infected animal cells which prevent non-infected cells from infection.

Example 13 : *Name the genetic material found in viruses.*

Solution : DNA or RNA.

Try Yourself

25. Viruses that infect the bacteria are called _____.

26. Name five diseases caused by viruses in man.

Sub-viral Agents :

These are viruses which lack one of the essential component, *e.g.*, viroids, virusoids, prions :

The bulk of lichen body is formed by fungal partner called **mycobiont**. It includes the surface, medulla (or interior) and rhizines (attaching devices). The algal partner or **phycobiont** constitutes hardly 5% of the lichens body. It is generally restricted to a narrow zone (algal zone) below the surface.

Relationship

The fungus performs following functions :

(i) Body structure and covering.

(ii) Anchoring

(iii) Absorption of water and minerals. It can absorb water from wet air (atmosphere), dew and rain. Minerals are picked up both from substratum and atmosphere. Special chemicals are excreted by the fungal partner of the lichen to dissolve minerals from the substratum.

(iv) Sex organs and fruitifications are of fungal origin.

The major function of alga is photosynthesis.

The cyanobacterial alga additionally takes part in nitrogen fixation. The alga picks up water and mineral salts from the fungus while the fungus obtains part of the food manufactured by the alga. Therefore, in a lichen the association between alga and fungus is that of mutual benefit (mutualism) popularly called **symbiosis**.

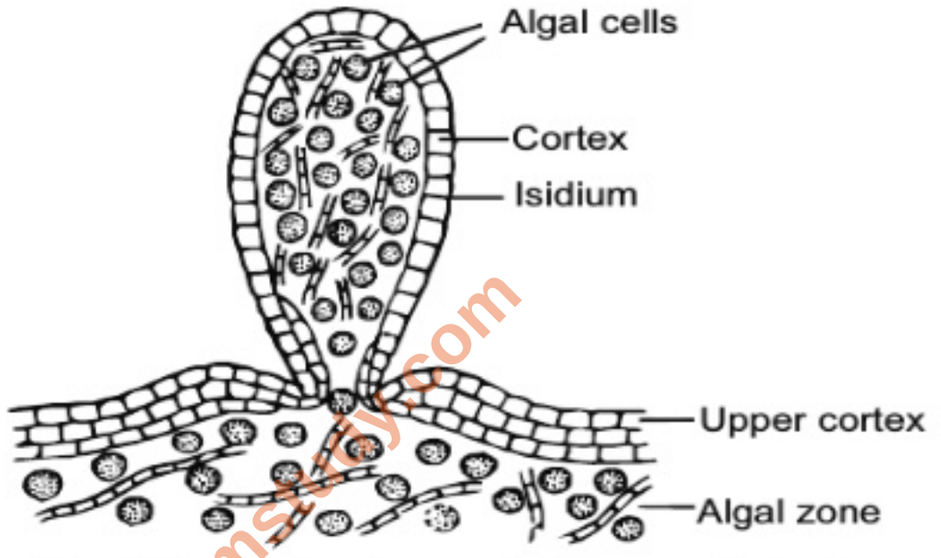

Fig. : V.S. of lichen showing an isidium and algal zone

Reproduction

Lichens multiply by four methods :

(i) **Progressive death and decay** resulting in the separation of a lichen thallus into two or more parts.

(ii) **Fragmentation** caused by mechanical injury, due to wind or animal bites.

(iii) **Isidia** are superficial outgrowths of the lichens which are primarily meant for increasing surface area and photosynthetic activity. At time, they are broken off. Each isidium is capable of forming a new lichen because it has a core of a few algal cells surrounded by a sheath of fungal hyphae.

(iv) **Soredia.** These are **most efficient means of asexual reproduction.** They are microscopic lichen propagules which are produced in large numbers inside sori called pustules. Soredia are dispersed by air currents. After falling on a suitable substratum each soredium gives rise to a lichen, because it has a few algal cells surrounded incompletely by a weft of fungus.

Did You Know?

Special structures in the thallus of lichen :

(i)	Cyphellae	:	Help in exchange of gases, present in lower cortex.
(ii)	Cephalodia	:	Help to retain moisture and its algal partner fix nitrogen also.
(iii)	Breathing pores	:	For aeration, present in upper cortex of thallus.

(1) Viroids (L. *virus* – poison, *eidos* – diminutive) : They are the smallest self replicating particles which were discovered by **Diener** (1971). Viroids are infectious RNA particles which are devoid of protein coat. They are obligate parasites. Molecular weight of a viroid is low. The RNA is tightly folded to form circular or linear structures. Viroids are known to cause diseases (some 20) in plants only, *e.g.,* Potato spindle tuber disease (PSTD), *Chrysanthemum* stunt and *Citrus* exocortis.

(2) Virusoids : Discovered by **Randle** *et. al.*, these are RNA viruses but inside the capsid of other larger virus. They replicate within the host and do not cause any infection.

(3) Prions : Discovered by **Alper *et al.***

Proteinaceous infectious particles, causing certain diseases like

(i) Kuru disease (laughing death disease in humans)

(ii) Bovine spongiform encephalopathy (BSE or Mad cow disease)

(iii) Scrapie disease in sheep

(iv) Creutz Feldt Jakob disease

LICHENS

Lichens are **dual (composite) organisms** or entities which contain a permanent association of a fungal partner or **mycobiont** and an algal partner or **phycobiont**. **Mycobiont** is dominant partner and mostly belongs to ascomycetes (Ascolichens–, *e.g., Graphis, Cladonia, Parmelia, Usnea, etc.*) or sometimes basidiomycetes (Basidiolichens–, *e.g., Corella, Cora, etc.*). **Phycobiont** is mostly a member of Chlorophyceae (*e.g., Chlorella, Trebouxia, Protococcus, Palmella,* etc.) or can be a BGA (*e.g., Nostoc, Chlorococcus, Scytonema,* etc.). The term lichen was coined by **Theophrastus** (370 – 285 B.C.), also **called Father of Botany**. Lichens often grow in most inhospitable and uninhabited places like barren rocks (saxicolous), soil (terricolous), icy tundra or alpines, sand dunes, roofs, walls, wood (lignicolous), tree bark (corticolous), leaves, etc. They commonly live under humid and exposed conditions but can tolerate extreme desiccation. However, **lichens, cannot tolerate air pollution, especially due to sulphur dioxide** (so are considered indicators of SO_2 pollution).

Lichens are perennial. Their growth is slow. Lichens have greyish, yellowish, greenish, orange, dark brown or blackish colouration.

Structure

Based upon external morphology, the lichens are of three types :

(i) Crustose : Crust like, closely appressed to the substratum and attached to it at several places, *e.g., Graphis, Lecanora, Rhizocarpon.*

(ii) Foliose : The body of the lichen is flat, broad, lobed and leaf-like, which is attached to the substratum at one or a few places with the help of rhizoid like structures called **rhizines**, *e.g., Parmelia, Peltigera.*

(iii) Fruticose : The lichen is branched like a bush and attached to the substratum by means of a disc, *e.g., Cladonia, Usnea, Evernia, Bryonia.*

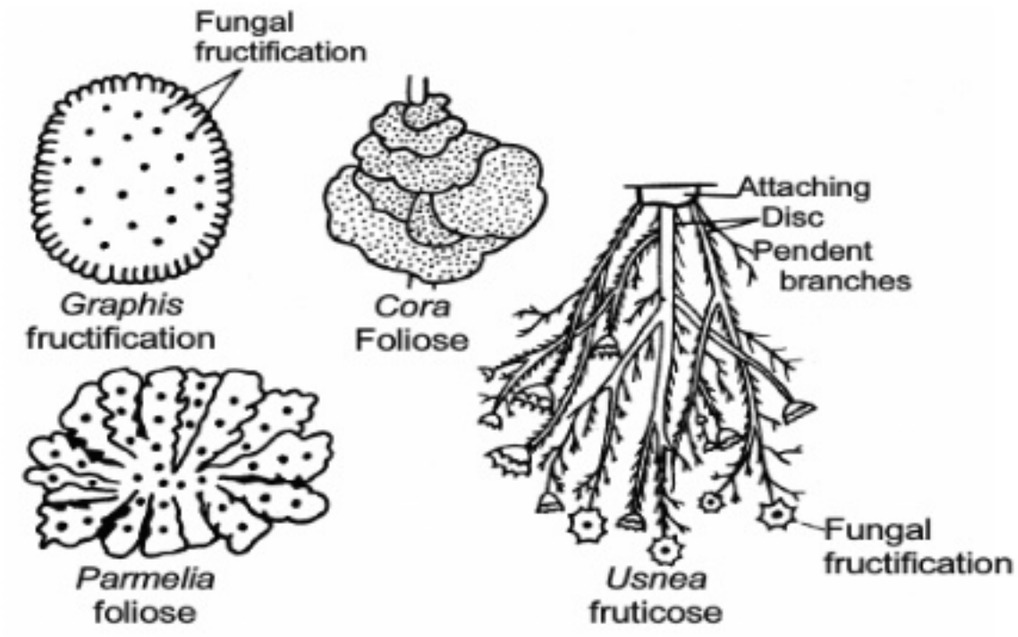

Fig. : Forms of Lichens

Knowledge Cloud

(i) **Early Colonisers :** Lichens are early or **pioneer colonisers** of barren rocks, cliffs, mountains and new terrains. During their growth, lichens stick to the rocks and cliffs by secreting acids. It produces minute crevices where organic matter accumulates. It paves the way for growth of mosses.

(ii) **Food :** In tundra, *Cladonia rangifera* **(Reindeer Moss)** constitutes the staple food of reindeer, caribou, musk ox, etc. *Cetraria islandica* **(Iceland Moss)** is used as a food article in Iceland, Sweden and Norway. *Lecanora esculenta* is regarded as **bread of heaven** by Jews. *Parmelia* **(Rock Flower)** is also a table delicacy. *Dermatocarpon miniatum* (**Stone Mushroom**) is a vegetable in Japan.

(iii) **Dyes :** Orchil is obtained from *Rocella tinctoria*. The latter was also the source of litmus *(R. montagnei)* before the advent of synthetic products. Litmus is a pH indicator.

(iv) **Perfumes :** Scented incense is got from species of *Ramalina and Evernia*.

(v) **Medicines :** Usnic acid got from *Usnea* **(Old Man's Beard)** and *Cladonia* has antibiotic properties. It is used in preparation of ointment for burns and wounds.

(vi) **Air Pollution :** Decrease in lichen population of an area is indicative of SO_2 pollution.

(vii) **Fires :** In hot season, *Usnea* may produce forest fires.

EXERCISE

41. Lichens growing on tree bark are called
(1) Lignicolous (2) Terricolous
(3) Corticolous (4) Saxicolous

42. Common mycobionts and phycobionts of lichen body are respectively
(1) Ascomycetes, Chlorophyceae (2) Ascomycetes, Cyanophyceae
(3) Basidiomycetes, Chlorophyceae (4) Basidiomycetes, Cyanophyceae

43. Foliose lichens are attached to the substratum at one or few places with the help of
(1) Branched, multicellular rhizoids (2) Holdfast
(3) Rhizines (4) Rhizomorph

44. Specialised structure in the thallus of lichen for nitrogen fixation and retaining moisture is
(1) Cyphellae (2) Isidia
(3) Cephalodia (4) Soredia

45. Which of the following feature is not related with virus?
(1) Infectivity and host specificity (2) Presence of genetic material
(3) Occurrence of certain enzymes (4) Presence of respiration

46. Most of the viruses are/have
(1) Enveloped nucleo-protein structure (2) Non-enveloped nucleo-protein structure
(3) Infectious protein particles (4) Double stranded DNA as well as dsRNA

47. Select incorrect statement w.r.t. T_4 bacteriophages
(1) Have polygonal prismatic head (2) Motile organisms
(3) Six tail fibres (4) ds-DNA as the genetic material

(a) DNA containing viruses are called deoxyviruses. These are of two types :

(i) Double stranded DNA (dsDNA) virus *e.g.* Pox virus, Cauliflower mosaic virus, Herpes virus.

(ii) Single stranded DNA (ssDNA) *e.g.* Coliphage $\phi \times 174$, M13 phage.

(b) RNA containing viruses or riboviruses are of two types :

(i) Double stranded RNA (dsRNA) virus *e.g.* Reovirus, Wound tumour virus.

(ii) Single stranded RNA (ssRNA) virus *e.g.* TMV, Influenza virus, Foot and Mouth disease virus, Retroviruses (HIV).

On the basis of host specificity viruses are divided into three groups :

Group	Common type of genetic material
1. Phytophagineae/Plant viruses	1. ssRNA
2. Zoophagineae/Animal viruses	2. ss or dsRNA or dsDNA
3. Bacteriophages/Bacterial viruses	3. dsDNA

Structure of Some Viruses

1. **Tobacco Mosaic Virus (TMV)** is elongated rod like, 3000 Å long, 180 Å in diameter with molecular weight 39.4×10^6 dalton. 2130 capsomeres are arranged helically to form the capsid. RNA strand is helical. ssRNA consists of 6400 nucleotides. Thus, the ratio of nucleotides : capsomeres = 3 : 1

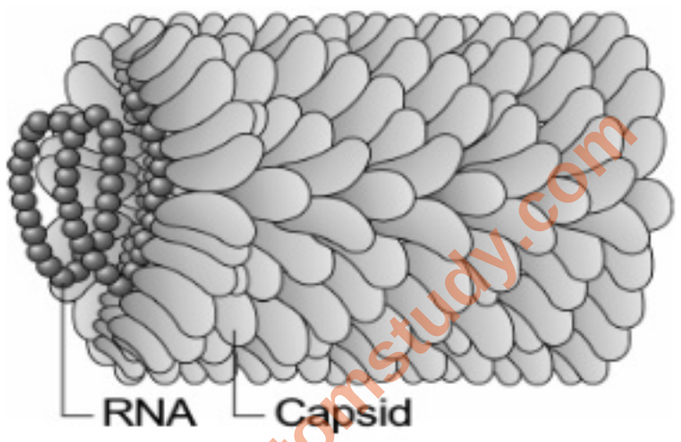

Fig. : Tobacco Mosaic Virus (TMV)

2. **Bacteriophage** (or bacterial viruses) are the viruses that infect the bacteria. Bacteriophages usually have double stranded DNA. **T_4 Bacteriophage** has a tadpole like structure with polyhedral head connected to a helical tail (binal). The head consists of nucleic acid surrounded by a protein coat or capsid. Nucleic acid is double stranded DNA. Tail is proteinaceous tube-like, core surrounded by sheath. At one end, tube is joined to the head by thin collar. At the other end, it has a hexagonal base plate with six small tail pins and six tail fibres which help in attachment of the phage to the host cell.

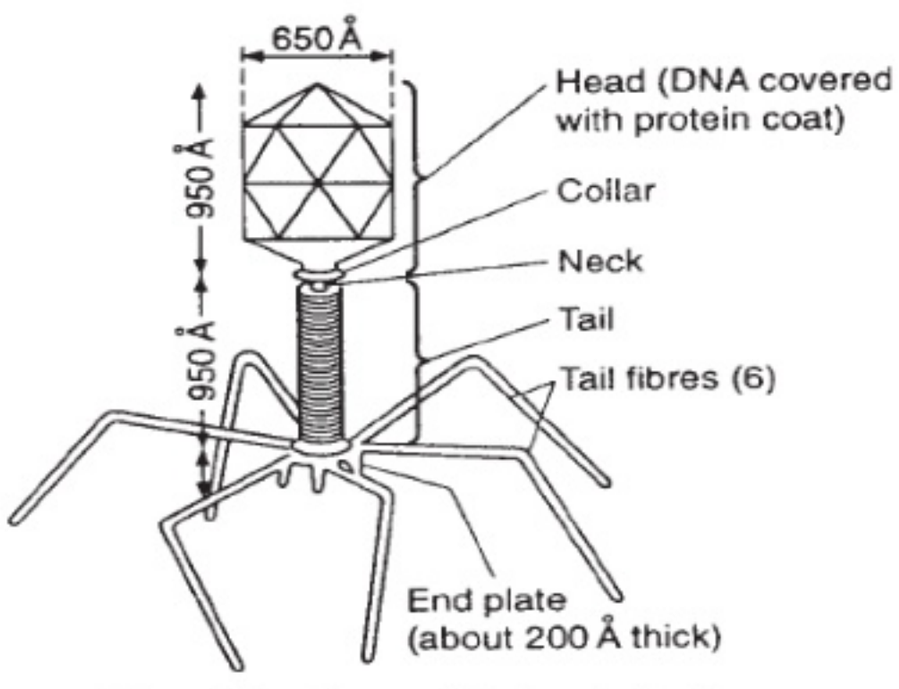

Fig. : Structure of T_4 bacteriophage

48. TMV is
    (1) ds Ribovirus
    (2) ds Deoxyvirus
    (3) ss Ribovirus
    (4) Ribovirus with 6400 capsomeres

49. Infectious RNA particles without protein coat
    (1) Have high molecular weight
    (2) Were discovered by Alper
    (3) Known to cause disease in plants
    (4) More than one option is correct

50. Mark the odd one (w.r.t. prions)
    (1) CFJ disease
    (2) Mad cow disease
    (3) Potato leaf roll
    (4) Scrapie disease

Some Important Definitions

- **Anaima :** Animals without RBCs.
- **Enaima :** Animals having RBCs.
- **Phylogenetic :** Evolutionary inter-relationship.
- **Heterocysts :** Specialised cells in cyanobacteria for N_2 fixation.
- **Saprophytes :** Are organisms which obtain (absorb) their food from dead and decaying substances.
- **Parasites :** Depend on living plants and animals for nutrition.
- **Plasmogamy :** Fusion of protoplasm between two motile or non-motile gametes, called plasmogamy.
- **Mycelium :** The network of hyphae.
- **Phycobiont :** Algal component of lichens.
- **Mycobiont :** Fungal component of lichens.

Quick Recap

1. Aristotle classified plants into herbs, shrubs and trees and animals into Anaima and Enaima.
2. Linnaeus was the founder of two kingdom system of classification. These two kingdoms were Plantae and Animalia.
3. Whittaker proposed five kingdom classification.
4. Monerans are unicellular prokaryotes.
5. Protists are unicellular eukaryotes.
6. Fungi are multicellular eukaryotes having chitinous cell wall.
7. Plants are multicellular, eukaryotic having cellulosic cell wall.
8. Viruses are the connecting link between living and non-living.
9. In the five kingdom classification there is no mention of viruses, viroids and lichens.

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Knowledge Cloud

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Assignment

(SET - 1)

School/Board Examinations

Students are required to solve and write the solutions in their exercise book.

For referring solutions to the assignment (Set-1), please visit our Library at the Centre or log on to our website: www.aakash.ac.in

SECTION - A

School/Board Exam. Type Questions

Very Short Answer Type Questions :

1. What are monerans?
2. Why some fungi are called 'fungi imperfecti'?
3. Who coined term virus?
4. Name the chemical substance present in the bacterial cell wall.
5. Expand TMV.
6. Who classified plants into herbs, shrubs and trees?
7. Who classified animals into Anaima and Enaima?
8. Red tide causing organism belongs to which group of photosynthetic protists?
9. First scientific approach to classify the organisms was done by _____.
10. Give the mode of nutrition in fungi.

Short Answer Type Questions

11. According to two kingdom classification system, differentiate kingdom Plantae and Animalia in terms of cell wall, locomotion, nutrition and response to external stimuli.
12. Write down three drawbacks of two-kingdom classification system.
13. In which kingdom, Whittaker placed *Chlamydomonas* and *Chlorella*? What was the earlier position of these organisms in two-kingdom system?
14. Why do we expect the criteria of classification to change in the future?
15. Which type of similarities are reflected in existing classification system?
16. What are the sole members of the kingdom Monera and mention about their habitat?
17. Give a characteristic feature of kingdom Monera, in terms of their nucleus and cell wall (composition).
18. Which type of nutrition and reproduction is found in kingdom Monera?
19. How are bacteria grouped on the basis of their shape?
20. Why Archaebacteria are special?
21. Which feature of Archaebacteria allow them to survive in extreme conditions?
22. Give two example of Methanogens, Halophiles and Thermoacidophiles.
23. How are bacteria classified on the basis of their mode of nutrition?
24. Why are cyanobacteria called photosynthetic autotrophs?
25. In which habitat cyanobacteria exist? Give their effect on aquatic animals.
26. Why chemosynthetic bacteria oxidise inorganic substances?
27. Write a note on the uses of heterotrophic bacteria.
28. Mention the damage caused by pathogenic bacteria to human beings.
29. Write a note on *Mycoplasma*.
30. Discuss the habitat and mode of nutrition of chrysophytes.

Long Answer Type Questions

31. Give five features of dinoflagellates and their impact on marine ecosystem.
32. (a) Write a note on the mode of nutrition in *Euglena*.
    (b) Explain the reproduction in *Euglena*.

4. Name the type of ribosomes present in Monerans.
5. Carl Woese divided bacteria into two groups. Name them.
6. What is the habitat of halophiles?
7. Name the group of bacteria under which methanogens, halophiles and thermoacidophiles are included?
8. Which group of bacteria are characterised by the presence of rigid cell wall?
9. How can we say that cyanobacteria are photosynthetic autotrophs?
10. In which way, heterotrophic bacteria are useful for human being?

Short Answer Type Questions : **[2 Marks]**

11. In what way sexual reproduction of bacteria is different from eukaryotic organisms?
12. Which essential feature of sexual reproduction is not performed by bacteria?
13. Mention the type of reproduction in Protists.
14. What is pellicle and what is its advantage in Euglenoids?
15. What are basidiocarps?

Short Answer Type Questions : **[3 Marks]**

16. Explain the structure of cell wall in diatoms.
17. How diatomaceous earth is formed? Write its advantage.
18. What is the reason of keeping food into refrigerator?
19. How asexual reproduction takes place in fungi?
20. (a) Name the common forms of basidiomycetes.
    (b) What is the habitat of basidiomycetes?
    (c) Which type of mycelium do they have?
21. (a) In what way *Neurospora* is useful?
    (b) Edible morels and truffles belong to which group of fungi?
    (c) What is *Contagium vivum fluidum*?

Long Answer Type Questions : **[5 Marks]**

22. (a) Give the symptoms of plant diseases caused by viruses.
    (b) Name a disease caused by viroid.
    (c) How algae and fungi take benefit from each other in association as lichens?
23. (a) What are heterocysts?
    (b) Write a note on dikaryophase.
    (c) Differentiate kingdom Protista and Fungi in terms of their nutrition.

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(a) How do slime moulds aggregate?

(b) How do slime moulds form fruiting bodies and how they are extremely resistant?

(a) Mention the diversity of fungi.

(b) Give an account of their habitat.

(c) Why they are regarded as heterotrophs?

(d) In what way they are useful?

(e) What is mycorrhiza?

(a) Discuss fragmentation, budding and fission in fungi.

(b) What is coenocytic hyphae?

Explain sexual reproduction in Basidiomycetes and give three examples of this group.

(a) Why some fungi were grouped under Deuteromycetes?

(b) Why the fungi imperfecti were moved into classes Ascomycetes and Basidiomycetes?

(c) How these fungi reproduce asexually?

(d) What is the mode of nutrition in members of Deuteromycetes and how some of them help in mineral cycling?

(a) Explain alternation of generation in kingdom Plantae.

(b) Do few members of kingdom Plantae have partially heterotrophic mode of nutrition, if yes, then give example?

(c) Differentiate between kingdom Plantae and Animalia on the basis of growth pattern.

Give the contribution of D.J. Ivanowsky, M.W. Beijerinck and W.M. Stanley for studying viruses.

(a) What is bacterial virus?

(b) What is advantage of capsomeres?

(c) Do viruses have their own genetic material?

(d) Name the infectious part of virus.

Tabulate the characteristics of five kingdom, on the basis of cell type, cell wall, nuclear membrane, body organisation and mode of nutrition.

(a) Write a short note on methanogens.

(b) Write the shape of Coccus, Bacillus, Vibrio and Spirillium type of bacteria.

What are halophiles?

Write an explanatory note on thermoacidophiles.

Write a note on :

(a) Mycorrhiza

(b) Sac fungi

(c) Imperfect fungi

SECTION - B

Model Test Paper

Short Answer Type Questions : **[1 Mark]**

Who proposed six kingdom system of classification?

What name was given to animals having RBCs by Aristotle?

What is the mode of nutrition in kingdom Animalia?

Assignment

(SET - 2)

NEET & AIIMS

(Competitive Entrance Exams.)

SECTION - A

Objective Type Questions

1. **Statement-1 :** Linnaeus classified plants into trees, shrubs and herbs, on the basis of morphological characters.

   Statement-2 : Aristotle divided animals into group - Anaima and Enaima.

   (1) Only statement-1 is correct

   (2) Only statement-2 is correct

   (3) Both statement-1 and statement-2 are correct

   (4) Both statement-1 and statement-2 are incorrect

2. In members of which kingdom, nuclear membrane is absent?

   (1) Monera (2) Protista

   (3) Fungi (4) Plantae

3. In five kingdom classification, the kingdom that includes the blue-green algae, nitrogen-fixing bacteria and methanogenic archaebacteria, is

   (1) Monera (2) Protista

   (3) Fungi (4) Plantae

4. Which one of the following is not the basis of five kingdom classification?

   (1) Cell structure

   (2) Body organisation

   (3) Reproduction

   (4) Reserve food material

5. Position of bacteria in the kingdom system of classification proposed by Linnaeus is

   (1) Monera (2) Protista

   (3) Plantae (4) Animalia

6. Who was the founder of five kingdom system of classification?

   (1) C. Linnaeus (2) R.H. Whittaker

   (3) Aristotle (4) T.O. Diener

7. According to five kingdom system, gymnosperms and angiosperms are grouped under the kingdom

   (1) Monera (2) Protista

   (3) Fungi (4) Plantae

8. Which organisms are not included in the five kingdom system of classification?

   (1) Protozoans (2) Viruses

   (3) Lichens (4) Both (2) & (3)

9. Who for the first time classified organisms on the basis of scientific approach?

   (1) Aristotle (2) Linnaeus

   (3) Whittaker (4) Pasteur

10. Aristotle classified animals in two groups on the basis of presence or absence of RBC. The group which does not have RBCs is

    (1) Anaima (2) Enaima

    (3) Ovipera (4) Vivipera

11. Heterotrophic, eukaryotic, multicellular organisms lacking a cell wall are included in the kingdom.

    (1) Protista (2) Fungi

    (3) Plantae (4) Animalia

12. Match the following

	Column-I (Group of bacteria)		**Column-II (Their shape)**
a.	Coccus	(i)	Rod-shaped
b.	Bacillus	(ii)	Spherical
c.	Spirillum	(iii)	Spiral
d.	Vibrium	(iv)	Comma-shaped

    (1) a(i), b(ii), c(iii), d(iv) (2) a(ii), b(i), c(iii), d(iv)

    (3) a(i), b(ii), c(iv), d(iii) (4) a(ii), b(i), c(iv), d(iii)

13. During favourable conditions bacteria mainly reproduce by

    (1) Budding (2) Fragmentation

    (3) Sporulation (4) Fission

14. Select the **correct** statement.

    (1) Cholera, typhoid, tetanus are well-known diseases caused by viruses

    (2) Dinoflagellates, euglenoids and slime moulds are placed under kingdom Monera

    (3) Members of kingdom Protista are primarily aquatic

    (4) Dinoflagellates are the chief 'producers' in the oceans

15. Select the **incorrect** statement.

    (1) *Nostoc* and *Anabaena* have heterocysts for nitrogen fixation

    (2) Cyanobacteria often form blooms in polluted water bodies

    (3) Heterotrophic bacteria are more abundant in nature

    (4) The cell wall of *Mycoplasma* are made up of chitin

31. Vegetative reproduction by fragmentation is common in
(1) *Agaricus*
(2) *Saccharomyces*
(3) *Euglena*
(4) *Gonyaulax*

32. Select the **incorrect** match.

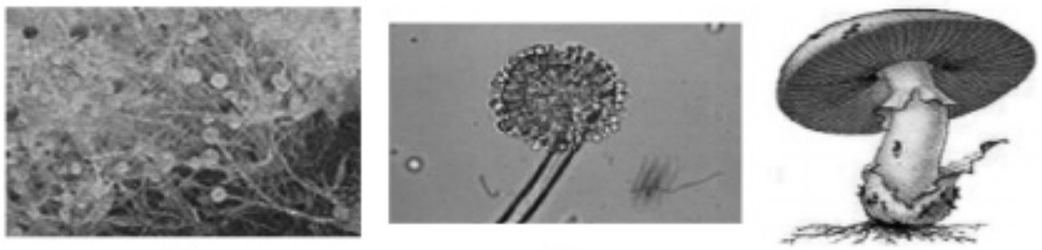
	Class		Member
(1)	Phycomycetes	–	*Albugo*
(2)	Basidiomycetes	–	*Claviceps*
(3)	Ascomycetes	–	*Penicillium*
(4)	Deuteromycetes	–	*Trichoderma*

33. Haploid sexual spore produced exogenously is
(1) Ascospore
(2) Basidiospore
(3) Oospore
(4) Zygospore

34. Coenocytic mycelium is found in
(1) Deuteromycetes (2) Phycomycetes
(3) Ascomycetes (4) All of these

35. The members of which group are commonly known as sac fungi?
(1) Phycomycetes
(2) Deuteromycetes
(3) Basidiomycetes
(4) Ascomycetes

36. Identify A, B and C in given diagram.



A B C
(1) A = *Mucor*, B = *Aspergillus*, C = *Agaricus*
(2) A = *Mucor*, B = *Agaricus*, C = *Aspergillus*
(3) A = *Agaricus*, B = *Mucor*, C = *Aspergillus*
(4) A = *Agaricus*, B = *Aspergillus*, C = *Mucor*

37. Which one is **correctly** matched?
(1) *Agaricus* - Smut
(2) *Ustilago* - Mushroom
(3) *Puccinia* - Insectivorous plant
(4) Deuteromycetes - Imperfect fungi

38. Which of the following statement is **incorrect** about viruses?
(1) Viruses contain either RNA or DNA
(2) Viruses do not have their own metabolic system
(3) Bacteriophages are usually double stranded DNA viruses
(4) TMV contains both RNA and DNA as their genetic material

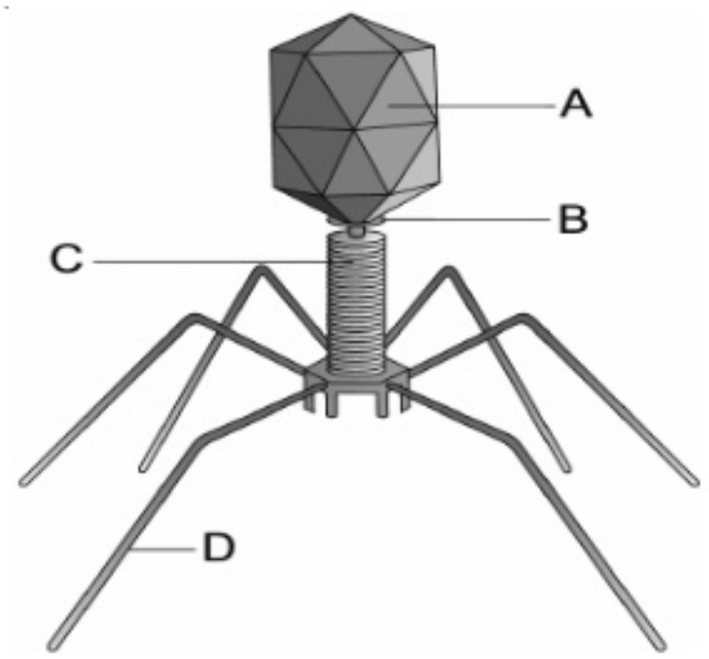
39. Viruses that infect the bacteria are termed as
(1) Cyanophages
(2) Bacteriophages
(3) Mycophages
(4) Both (1) & (2)

40. Who demonstrated that the extract of the infected plants of tobacco could cause infection in healthy plants?
(1) Pasteur
(2) M.W. Beijerinek
(3) D.J. Ivanowsky
(4) W.M. Stanley

41. The protein coat called capsid made of small subunits called capsomeres are present in
(1) Viruses (2) Bacteria
(3) Fungi (4) Gymnosperms

42. Select the incorrect match w.r.t. genetic material.
(1) Herpes virus – ssDNA
(2) Bacteriophage – dsDNA
(3) TMV – ssRNA
(4) Influenza virus – ssRNA

43. Identify A, B, C and D parts in this diagram of bacteriophage.



16. Heterocysts present in *Anabaena* is specialised for
(1) Nitrogen fixation (2) Food storage
(3) Fission (4) Sexual reproduction

17. Mark the odd one w.r.t. cell wall.
(1) Halophiles (2) Methanogens
(3) Thermoacidophiles (4) Cyanobacteria

18. Primitive bacteria living in salty areas are called as
(1) Methanogens (2) Thermoacidophiles
(3) Heliophytes (4) Halophiles

19. Select the non-protistan group.
(1) Slime moulds
(2) Dinoflagellates
(3) Phycomycetes
(4) Chrysophytes

20. Which of the following is **correct**?
(1) All slime moulds are haploid
(2) Protozoans lack cell wall
(3) Dinoflagellates are non-motile
(4) Pellicle is absent in *Euglena*

21. Which is not a feature of dinoflagellates?
(1) They cause red tides
(2) Their cell wall has stiff cellulose plates on the outer surface
(3) They release toxins
(4) These are mostly fresh water and non-photosynthetic

22. _____ are saprophytic protists, whose body moves along decaying twigs and leaves engulfing organic material.
(1) Euglenoids (2) Dinoflagellates
(3) Chrysophytes (4) Slime moulds

23. Being photosynthetic, which organism in absence of sunlight behave like heterotrophs?
(1) Slime moulds (2) Euglenoids
(3) Sporozoans (4) Ciliated protozoans

24. Which is the **incorrect** statement regarding fungi?
(1) Wheat rust causing agent is *Puccinia*
(2) *Penicillium* is a source of antibiotic
(3) The cell wall of fungi are composed of peptidoglycans
(4) Fungi prefer to grow in warm and humid places

25. **Statement-1 :** Yeast is a multicellular fungus.
Statement-2 : *Penicillium* is an unicellular fungus.
Statement-3 : *Albugo* is a parasitic fungus on mustard.
(1) Only statement-1 and statement-2 are correct
(2) All the above statements are incorrect
(3) Only statement-3 is correct
(4) Both statement-1 and statement-3 are correct

26. Mark the **correct** statement.
(1) Phycomycetes include mushrooms, bracket fungi or puff balls
(2) The mycelium of basidiomycetes is branched and septate
(3) *Neurospora* is used extensively in biochemical and genetic work, it belong to group basidiomycetes
(4) Morels and truffles are non-edible

27. With respect to fungal sexual cycle, choose the **correct** sequence of events.
(1) Karyogamy, plasmogamy and meiosis
(2) Meiosis, plasmogamy and karyogamy
(3) Plasmogamy, karyogamy and meiosis
(4) Meiosis, karyogamy and plasmogamy

28. Mark the odd one w.r.t. kingdom fungi.
(1) They reproduce asexually and sexually
(2) They show a great diversity in structure and habitat
(3) Most of fungi are saprophytic in their mode of nutrition
(4) They do not reproduce by zoospores

29. The sex organs are absent, but plasmogamy is brought about by fusion of two vegetative or somatic cells of different genotypes. It is the feature of
(1) Phycomycetes (2) Basidiomycetes
(3) Ascomycetes (4) All of these

30. The fungi form fruiting bodies in which _____ division occurs, leading to formation of _____ spores.
(1) Mitotic, diploid
(2) Reduction, haploid
(3) Mitotic, haploid
(4) Reduction, diploid

(1) A – Head, B – Sheath, C – Collar, D – Tail fibres
(2) A – Head, B – Collar, C – Sheath, D – Tail fibres
(3) A – Head, B – Collar, C – Tail fibres, D – Sheath
(4) A – Head, B – Sheath, C – Tail fibres, D – Collar

44. Select the **correct** statement.
(1) Viroids have double stranded RNA
(2) RNA of viroids have high molecular weight than viruses
(3) Mumps and Herpes are viral diseases
(4) The name virus was given by D.J. Ivanowsky

45. Lichens show symbiotic relationship between
(1) Algae and fungi
(2) Algae and bacteria
(3) Fungi and bacteriophage
(4) Algae and bacteriophage

46. Which is **correct** w.r.t. lichens?
(1) Mycobiont is autotrophic component
(2) Phycobiont is heterotrophic component
(3) They are good pollution indicators
(4) They do not grow in non-polluted areas

47. The association of fungi with the roots of higher plants is called
(1) Lichens (2) Mycorrhiza
(3) Slime mould (4) *Neurospora*

48. Select the **incorrect** statement.
(1) *Cuscuta* is a parasitic plant
(2) Bladderwort and Venus fly trap are examples of insectivorous plants.
(3) Plantae includes algae, bryophytes, pteridophytes, gymnosperms and angiosperms
(4) The mode of nutrition in plants is holozoic

49. In which group of organisms, reserve food is stored in the form of glycogen and fat?
(1) Man and Monkey
(2) *Cuscuta* and Dog
(3) Bladderwort and *Cuscuta*
(4) Bladderwort and Venus fly trap

50. Diatomaceous earth is formed due to which substance?
(1) Phosphorus (2) Calcium
(3) Silicon (4) Copper

SECTION - B

Objective Type Questions

1. Which kingdom was introduced in four kingdom classification and who proposed it ?
(1) Protista and Copeland
(2) Plantae and Linnaeus
(3) Monera and Whittaker
(4) Monera and Copeland

2. Select **correct** match w.r.t. Whittaker' system of classification
(1) Monera : Unicellular, osmotrophs, producers and decomposers, true cellulosic cell wall
(2) Protista : Unicellular, eukaryotic, photoautotrophs and chemoautotrophs
(3) Fungi : Multicellular/loose tissue, eukaryotic, osmotrophs, chitinous wall
(4) Animalia : Multicellular, eukaryotic, organ or organ system, holozoic, no saprobic

3. Domain Eukarya includes how many kingdoms (w.r.t. six kingdom system)?
(1) 2 (2) 3
(3) 1 (4) 4

4. Bacteria are considered primitive organisms because they
(1) Possess incipient nucleus
(2) Are small, microscopic plants, which are not seen by the naked eyes
(3) Cause serious diseases to human being, domesticated animals and crop plants
(4) Produce endospores which are very resistant to adverse conditions

5. 70S ribosomes, chromatophores and circular DNA, are found in
(1) All eukaryotes
(2) All prokaryotes
(3) Some prokaryotes
(4) Some eukaryotes and some prokaryotes

6. There is no alternation of generation in *Escherichia coli* because of the absence of
(1) Syngamy (2) Reduction division
(3) Conjugation (4) Both (1) & (2)

7. Branched chain lipids occur in the cell membranes of
   (1) *Methanobacterium* (2) *Mycoplasma*
   (3) *Actinomycetes* (4) *Streptomyces*
8. Cyanobacteria do not possess
   (1) Gene recombinations (2) Flagella
   (3) Plasmids (4) Pigments
9. Bacterial cell divides every one minute. It takes 15 minutes a cup to be one-fourth full. How much time will it take to fill the cup?
   (1) 30 minutes (2) 45 minutes
   (3) 60 minutes (4) 17 minutes
10. Highly resistance nature of endospore is due to the presence of
   (1) Dipicolinic acid and peptidoglycan in spore coat
   (2) Peptidoglycan in exosporium
   (3) Dipicolinic acid and Ca in cortex
   (4) Dipicolinic acid and Ca in cell membrane
11. Endospores formed by certain bacteria are actually the means for
   (1) Reproduction (2) Perennation
   (3) Bioluminescence (4) Red snow formation
12. Select an incorrect statement for F^+ bacteria
   (1) It has F plasmid
   (2) Only somatic pili are present
   (3) It is considered as donor bacterium
   (4) It cannot conjugate with another F^+ form
13. Sea water glows during night mainly due to occurrence of
   (1) *Gonyaulax* (2) *Noctiluca*
   (3) *Euglena* (4) *Cyclotella*
14. Rejuvenescent spore of diatom is
   (1) Haploid and exospore
   (2) Diploid and statospore
   (3) Haploid and statospore
   (4) Diploid and auxospore
15. Leucosin (Chrysolaminarin) is a carbohydrate which is stored as reserve food in case of
   (1) Diatom
   (2) *Euglena*
   (3) Dinoflagellates
   (4) *Paramoecium*
16. Flagellation in *Euglena* is
   (1) Uniflagellation and stichonematic
   (2) Isokont and whiplash type
   (3) Heterokont and whiplash type
   (4) Heterokont and stichonematic
17. Special type of red pigment present in the eye-spot of *Euglena* and Crustacea is called
   (1) Phycoerythrin
   (2) Astaxanthin
   (3) Carotene
   (4) Xanthophyll
18. Paraflagellar body of *Euglena* helps in
   (1) Locomotion (2) Photoreception
   (3) Reproduction (4) Osmoregulation
19. The structure formed in the life cycle of cellular slime-mould due to chemotactic movement is
   (1) Pseudoplasmodium (2) Swarm cells
   (3) Macrocyst (4) Capillitia
20. Myxamoeba are formed in the life cycle of
   (1) *Physarum* (2) *Amoeba*
   (3) *Entamoeba* (4) Diatoms
21. Difference between a red sea and red tide is
   (1) Red tide takes place in red sea
   (2) Associated with a cyanobacteria and protist respectively
   (3) One is by virus and other by bacteria
   (4) Associated with Rhodophyceae and diatoms respectively
22. Consider the following statements and select correct set of features w.r.t. the life cycle of acellular slime moulds
   a. Haploid vegetative stage as myxamoebae
   b. Diploid vegetative stage as plasmodium
   c. Capillitium
   d. Photosynthetic protists
   e. Sporic meiosis
   f. Isogamous sexual reproduction
   g. Anisogamous sexual reproduction with zygotic meiosis
   (1) a, c, g (2) b, c, g
   (3) b, d, e, f (4) b, c, e, f

35. Read the following statements carefully and identify **correct** statements w.r.t. Lichens

a. The association cannot tolerate air pollution, especially due to sulphur dioxide

b. Lichens are annuals and their growth is slow

c. The fungal partner mostly belongs to ascomycetes.

d. Soredia are most efficient means of asexual reproduction

e. Orchids seldom occur without this association

f. Foliose lichens are pioneers of succession in a water body.

(1) c, d, f

(2) a, c, d, f

(3) a, b, e

(4) a, c, d

SECTION - C

Previous Years Questions

1. Which one of the following is **wrong** for fungi? **[NEET (Phase-2) 2016]**

(1) They are eukaryotic

(2) All fungi possess a purely cellulosic cell wall

(3) They are heterotrophic

(4) They are both unicellular and multicellular

2. Methanogens belong to **[NEET (Phase-2) 2016]**

(1) Eubacteria

(2) Archaebacteria

(3) Dinoflagellates

(4) Slime moulds

3. Select the **wrong** statement. **[NEET (Phase-2) 2016]**

(1) The walls of diatoms are easily destructible

(2) 'Diatomaceous earth' is formed by the cell walls of diatoms

(3) Diatoms are chief producers in the oceans

(4) Diatoms are microscopic and float passively in water

4. Select the **wrong** statement

(1) Bacterial cell wall is made up of peptidoglycan

(2) Pili and fimbriae are mainly involved in motility of bacterial cells

(3) Cyanobacteria lack flagellated cells

(4) *Mycoplasma* is a wall-less microorganism

5. Which one of the following statements is **wrong**? **[NEET-2016]**

(1) Phycomycetes are also called algal fungi

(2) Cyanobacteria are also called blue-green algae

(3) Golden algae are also called desmids

(4) Eubacteria are also called false bacteria

6. Chrysophytes, Euglenoids, Dinoflagellates and Slime moulds are included in the kingdom **[NEET-2016]**

(1) Animalia (2) Monera

(3) Protista (4) Fungi

7. One of the major components of cell wall of most fungi is **[NEET-2016]**

(1) Hemicellulose (2) Chitin

(3) Peptidoglycan (4) Cellulose

8. The primitive prokaryotes responsible for the production of biogas from the dung of ruminant animals, include the **[NEET-2016]**

(1) Eubacteria (2) Halophiles

(3) Thermoacidophiles (4) Methanogens

9. Which of the following statements is **wrong** for viroids? **[NEET-2016]**

(1) Their RNA is of high molecular weight

(2) They lack a protein coat

(3) They are smaller than viruses

(4) They causes infections

10. Choose the **wrong** statement **[Re-AIPMT-2015]**

(1) Yeast is unicellular and useful in fermentation

(2) *Penicillium* is multicellular and produces antibiotics

(3) *Neurospora* is used in the study of biochemical genetics

(4) Morels and truffles are poisonous mushrooms

23. Find the correct match

Column I	Column II
a. Gill fungi	(i) Salmon disease
b. Cup fungi	(ii) Trama
c. Black mould	(iii) Penicillin
d. Blue / green mould	(iv) Zygophore
	(v) Apothecium

(1) a(ii), b(iii), c(i), d(v) (2) a(ii), b(v), c(iv), d(i)
(3) a(ii), b(v), c(iv), d(iii) (4) a(ii), b(iii), c(i), d(iv)

24. Select incorrectly matched pair
(1) *Mucor mucedo* - Coprophilous
(2) *Albugo candida* - Facultative parasite
(3) *Agaricus bisporus* - Edible basidiocarp
(4) *Puccinia graminis* - Black rust fungi

25. Fungi differs from bacteria in
(1) Mode of nutrition
(2) Having NAG in cell wall
(3) Flagella structure
(4) Reserve food material as glycogen

26. Fruiting body in *Aspergillus* (or *Penicillium*) is known as
(1) Cleistothecium (2) Apothecium
(3) Perithecium (4) Ascus

27. The famous Irish famine is related to a disease of potato known as
(1) Late blight of potato (2) Early blight of potato
(3) Dry rot of potato (4) Potato scab

28. A dolipore septum is a characteristic feature of
(1) Phycomycetes (2) Ascomycetes
(3) Basidiomycetes (4) Zygomycetes

29. Which one of the following combination of characters is correct for the given fungal group?
(1) Algal fungi : Coenocytic, cellulosic wall, zoospore, zygospore, dikaryophase present
(2) Conjugating fungi : Septate mycelium, chitinous wall, sporangiospore, shorter (n + n) phase
(3) Sac fungi : Septate mycelium, Ascogonium, Crozier stage, meiospores as ascospores, shorter dikaryophase
(4) Club fungi : Shorter primary mycelium stage, No sex organs, dominant dikaryophase, zygosporic meiosis

30. Find set of edible basidiocarps.
(1) *Agaricus, Pleurotus* (2) *Agaricus, Morchella*
(3) *Volvariella, Tuber* (4) *Amanita, Morchella*

31. Read the statements carefully
a. Hartig net is the network of intracellular mycelium of *Boletus*
b. Ectomycorrhiza forms ten percent of total mycorrhiza
c. Fungal partner of endomycorrhiza belongs to zygomycetes or phycomycetes
(1) Only a & c are correct
(2) Only b & c are correct
(3) Only c is correct
(4) All are correct

32. Symptom not seen in plants due to viruses is
(1) Mosaic formation
(2) Leaf rolling and curling
(3) Yellowing, vein clearing
(4) Root knot

33. Viruses possess all the following properties, *except*
(1) They are non-cellular organisms
(2) Possess both DNA and RNA
(3) Capsid protects nucleic acid
(4) Have inert crystalline structure outside living cells

34. Identify A and B given below:

A B

(1) A - DNA virus - Cauliflower mosaic virus
B - RNA virus - Pox virus
(2) A - RNAvirus - T.M.V
B - DNA virus - T_4 bacteriophage
(3) A - RNA virus - Hepatitis B virus
B - Reterovirus - T.M.V
(4) A - Reterovirus - Hepatitis B virus
B - RNA virus - T_4 bacterophage

11. In which group of organisms the cell walls form two thin overlapping shells which fit together? **[Re-AIPMT-2015]**

(1) Slime moulds
(2) Chrysophytes
(3) Euglenoids
(4) Dinoflagellates

12. Choose the **wrong** statement **[Re-AIPMT-2015]**

(1) Mosaic disease in tobacco and AIDS in human being are caused by viruses
(2) The viroids were discovered by D.I. Ivanowski
(3) W.M. Stanley showed that viruses could be crystallized
(4) The term *Contagium vivum fluidum* was coined by M.W. Beijerinek

13. The imperfect fungi which are decomposers of litter and help in mineral cycling belong to: **[Re-AIPMT-2015]**

(1) Ascomycetes
(2) Deuteromycetes
(3) Basidiomycetes
(4) Phycomycetes

14. Pick up the **wrong** statement **[Re-AIPMT-2015]**

(1) Nuclear membrane is present in Monera
(2) Cell wall is absent in Animalia
(3) Protista have photosynthetic and heterotrophic modes of nutrition
(4) Some fungi are edible

15. Which one of the following matches is correct? **[AIPMT-2015]**

(1)	*Agaricus*	Parasitic fungus	Basidiomycetes
(2)	*Phyto-phthora*	Aseptate mycelium	Basidiomycetes
(3)	*Alternaria*	Sexual reproduction absent	Deuteromycetes
(4)	*Mucor*	Reproduction by conjugation	Ascomycetes

16. The guts of cow and buffalo possess **[AIPMT-2015]**

(1) Cyanobacteria (2) *Fucus* spp.
(3) *Chlorella* spp. (4) Methanogens

17. Five kingdom system of classification suggested by R.H. Whittaker is not based on **[AIPMT-2014]**

(1) Presence or absence of a well defined nucleus
(2) Mode of reproduction
(3) Mode of nutrition
(4) Complexity of body organisation

18. Archaebacteria differ from eubacteria in **[AIPMT-2014]**

(1) Cell membrane structure
(2) Mode of nutrition
(3) Cell shape
(4) Mode of reproduction

19. Which of the following shows coiled RNA strand and capsomeres? **[AIPMT-2014]**

(1) Polio virus (2) Tobacco mosaic virus
(3) Measles virus (4) Retrovirus

20. Viruses have **[AIPMT-2014]**

(1) DNA enclosed in a protein coat
(2) Prokaryotic nucleus
(3) Single chromosome
(4) Both DNA and RNA

21. The motile bacteria are able to move by: **[AIPMT-2014]**

(1) Fimbriae (2) Flagella
(3) Cilia (4) Pili

22. Pigment-containing membranous extensions in some cyanobacteria are **[NEET-2013]**

(1) Basal bodies (2) Pneumatophores
(3) Chromatophores (4) Heterocysts

23. Which statement is wrong for viruses? **[AIPMT (Prelims)-2012]**

(1) They have ability to synthesize nucleic acids and proteins
(2) Antibiotics have no effect on them
(3) All are parasites
(4) All of them have helical symmetry

24. The cyanobacteria are also referred to as **[AIPMT (Prelims)-2012]**

(1) Slime moulds (2) Blue green algae
(3) Protists (4) Golden algae

25. Which one single organism or the pair of organisms is correctly assigned to its or their named taxonomic group? **[AIPMT (Prelims)-2012]**

(1) Yeast used in making bread and beer is a fungus

(2) *Nostoc* and *Anabaena* are examples of protista

(3) *Paramecium* and *Plasmodium* belong to the same kingdom as that of *Penicillum*

(4) Lichen is a composite organism formed from the symbiotic association of an algae and a protozoan

26. How many organisms in the list given below are autotrophs?

Lactobacillus, Nostoc, Chara, Nitrosomonas, Nitrobacter, Streptomyces, Saccharomyces, Trypanosoma, Porphyra, Wolfia

[AIPMT (Mains)-2012]

(1) Four

(2) Five

(3) Six

(4) Three

27. In the five-kingdom classification, *Chlamydomonas* and *Chlorella* have been included in

[AIPMT (Mains)-2012]

(1) Protista (2) Algae

(3) Plantae (4) Monera

28. Which one of the following organisms is not an example of eukaryotic cells?

[AIPMT (Prelims)-2011]

(1) *Amoeba proteus*

(2) *Paramecium caudatum*

(3) *Escherichia coli*

(4) *Euglena viridis*

29. Membrane-bound organelles are absent in

[AIPMT (Prelims)-2010]

(1) *Plasmodium* (2) *Saccharomyces*

(3) *Streptococcus* (4) *Chlamydomonas*

30. Single-celled eukaryotes are included in

[AIPMT (Prelims)-2010]

(1) Monera

(2) Protista

(3) Fungi

(4) Archaea

31. Virus envelope is known as

[AIPMT (Prelims)-2010]

(1) Core (2) Capsid

(3) Virion (4) Nucleoprotein

32. Algae have cell wall made up of

[AIPMT (Prelims)-2010]

(1) Cellulose, hemicellulose and pectins

(2) Cellulose, galactans and mannans

(3) Hemicellulose, pectins and proteins

(4) Pectins, cellulose and proteins

33. Some hyperthermophilic organisms that grow in highly acidic (pH = 2) habitats belong to the two groups **[AIPMT (Prelims)-2010]**

(1) Liverworts and yeasts

(2) Eubacteria and archaea

(3) Cyanobacteria and diatoms

(4) Protists and mosses

34. Infectious proteins are present in

[AIPMT (Prelims)-2010]

(1) Satellite viruses (2) Gemini viruses

(3) Prions (4) Viroids

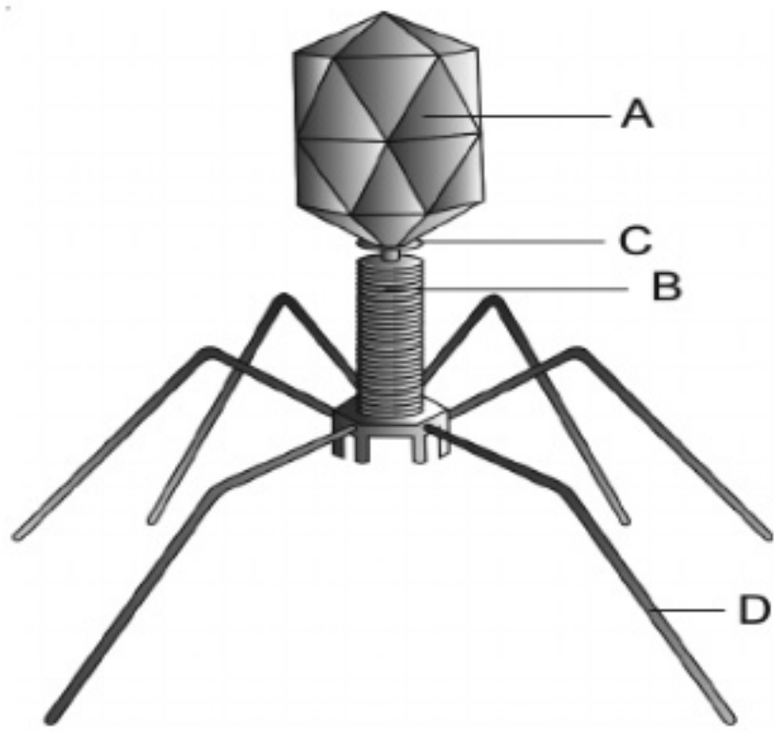
35. Black (stem) rust of wheat is caused by :

[AIPMT (Mains)-2010]

(1) *Alternaria solani* (2) *Ustilago nuda*

(3) *Puccinia graminis* (4) *Xanthomonas oryzae*

36. Given below is the diagram of a bacteriophage. In which one of the options all the four parts A, B,C and D are correct?



46. Which one of the following is a slime mould?
[AIPMT (Prelims)-2007]
(1) *Anabaena* (2) *Rhizopus*
(3) *Physarum* (4) *Thiobacillus*

47. Which one of the following statements about *Mycoplasma* is wrong? **[AIPMT (Prelims)-2007]**
(1) They cause disease in plants
(2) They are also called PPLO
(3) They are pleomorphic
(4) They are sensitive to penicillin

48. Which pair of the following belongs to Basidiomycetes? **[AIPMT (Prelims)-2007]**
(1) *Morchella* and Mushrooms
(2) Birds' nest fungi and Puffballs
(3) Puffballs and *Claviceps*
(4) *Peziza* and Stink horns

49. Ergot of rye is caused by a species of
[AIPMT (Prelims)-2007]
(1) *Claviceps*
(2) *Phytophthora*
(3) *Uncinula*
(4) *Ustilago*

50. The thalloid body of a slime mould (Myxomycetes) is known as **[AIPMT (Prelims)-2006]**
(1) Protonema (2) Plasmodium
(3) Fruiting body (4) Mycelium

51. The bacterium (*Clostridium botulinum*) that causes botulism is **[AIPMT (Prelims)-2006]**
(1) A facultative anaerobe
(2) An obligate anaerobe
(3) A facultative aerobe
(4) An obligate aerobe

52. Which of the following environmental conditions are essential for optimum growth of *Mucor* on a piece of bread ?
A. Temperature of about 25°C
B. Temperature of about 5°C
C. Relative humidity of about 5%
D. Relative humidity of about 95%
E. A shady place
F. A brightly illuminated place
Choose the answer from the following options :
[AIPMT (Prelims)-2006]
(1) A, C and E only
(2) A, D and E only
(3) B, D and E only
(4) B, C and F only

53. Curing of tea leaves is brought about by the activity of: **[AIPMT (Prelims)-2006]**
(1) Bacteria
(2) Mycorrhiza
(3) Viruses
(4) Fungi

54. What is common about *Trypanosoma*, *Noctiluca*, *Monocystis* and *Giardia* ? **[AIPMT (Prelims)-2006]**
(1) These are all unicellular protists
(2) They have flagella
(3) They produce spores
(4) These are all parasites

55. Barophilic prokaryotes **[AIPMT (Prelims)-2005]**
(1) Grow slowly in highly alkaline frozen lakes at high altitudes
(2) Occur in water containing high concentrations of barium hydroxide
(3) Grow and multiply in very deep marine sediments
(4) Readily grown and divides in sea water enriched in any soluble salt of barium

56. Auxospores and hormocysts are formed, respectively, by **[AIPMT (Prelims)-2005]**
(1) Several diatoms and a few cyanobacteria
(2) Several cyanobacteria and several diatoms
(3) Some diatoms and several cyanobacteria
(4) Some cyanobacteria and many diatoms

Options :

	A	B	C	D
(1)	Tail fibres	Head	Sheath	Collar
(2)	Sheath	Collar	Head	Tail fibres
(3)	Head	Sheath	Collar	Tail fibres
(4)	Collar	Tail fibres	Head	Sheath

37. Select the correct combination of the statements (a-d) regarding the characteristics of certain organisms

(a) Methanogens are Archaebacteria which produce methane in marshy areas.

(b) *Nostoc* is a filamentous blue-green alga which fixes atmospheric nitrogen.

(c) Chemosynthetic autotrophic bacteria synthesize cellulose from glucose.

(d) Mycoplasma lack a cell wall and can survive without oxygen.

The correct statement are **[AIPMT (Mains)-2010]**

(1) (b), (c)

(2) (a), (b), (c)

(3) (b), (c), (d)

(4) (a), (b), (d)

38. T.O. Diener discovered a

[AIPMT (Prelims-2009) & (Mains-2010)]

(1) Free infectious DNA

(2) Infectious protein

(3) Bacteriophage

(4) Free infectious RNA

39. Which one is the wrong pairing for the disease and its causal organism? **[AIPMT (Prelims)-2009]**

(1) Black rust of wheat – *Puccinia graminis*

(2) Loose smut of wheat – *Ustilago nuda*

(3) Root-knot of vegetables – *Meloidogyne*

(4) Late blight of potato – *Alternaria solani*

40. Which of the following is a symbiotic nitrogen fixer? **[AIPMT (Prelims)-2009]**

(1) *Azotobacter*

(2) *Frankia*

(3) *Azolla*

(4) *Glomus*

41. *Thermococcus, Methanococcus* and *Methano--bacterium* exemplify **[AIPMT (Prelims)-2008]**

(1) Bacteria that contain a cytoskeleton and ribosomes

(2) Archaebacteria that contain protein homologous to eukaryotic core histones

(3) Archaebacteria that lack any histones resembling those found in eukaryotes but whose DNA is negatively supercoiled

(4) Bacteria whose DNA is relaxed or positively supercoiled but which have a cytoskeleton as well as mitochondria

42. Cellulose is the major component of cell walls of

[AIPMT (Prelims)-2008]

(1) *Saccharomyces*

(2) *Pythium*

(3) *Xanthomonas*

(4) *Pseudomonas*

43. In the light of recent classification of living organisms into three domains of life (bacteria, archaea and eukarya), which one of the following statements is true about archaea?

[AIPMT (Prelims)-2008]

(1) Archaea completely differ from prokaryotes

(2) Archaea resemble eukarya in all respects

(3) Archaea have some novel features that are absent in other prokaryotes and eukaryotes

(4) Archaea completely differ from both prokaryotes and eukaryotes

44. Bacterial leaf blight of rice is caused by a species of **[AIPMT (Prelims)-2008]**

(1) *Erwinia*

(2) *Xanthomonas*

(3) *Pseudomonas*

(4) *Alternaria*

45. Biological organisation starts with:

[AIPMT (Prelims)-2007]

(1) Atomic level

(2) Submicroscopic molecular level

(3) Cellular level

(4) Organismic level

57. All of the following statements concerning the actinomycetous filamentous soil bacterium *Frankia* are correct except that *Frankia* :

[AIPMT (Prelims)-2005]

(1) Can induce root nodules on many plant species

(2) Can fix nitrogen in the free-living state

(3) Like *Rhizobium*, it usually infects its host plant through root hair deformation and stimulates cell proliferation in the host's cortex

(4) Forms specialized vesicles in which the nitrogenase is protected from oxygen by a chemical barrier involving triterpene hopanoids

58. Which of the following unicellular organism has a macronucleus for trophic function and one or more micronuclei for reproduction?

[AIPMT (Prelims)-2005]

(1) *Euglena* (2) *Amoeba*

(3) *Paramoecium* (4) *Trypanosoma*

59. For retting of jute the fermenting microbe used is:

[AIPMT (Prelims)-2005]

(1) *Helicobacter pylori* (2) *Methophilic* bacteria

(3) *Streptococcus lactin* (4) Butyric acid bacteria

Questions asked prior to Medical Ent. Exams. 2005

60. In the five kingdom system of classification, which single kingdom out of the following can include blue-green algae, nitrogen fixing bacteria and methanogenic archaebacteria?

(1) Plantae (2) Protista

(3) Monera (4) Fungi

61. In five kingdom system, the main basis of classification is

(1) Structure of nucleus

(2) Mode of nutrition

(3) Structure of cell wall

(4) Asexual reproduction

62. In which kingdom would you classify the archaea and nitrogen-fixing organisms, if the five-kingdom system of classification is used ?

(1) Plantae

(2) Fungi

(3) Protista

(4) Monera

63. Maximum nutritional diversity is found in the group

(1) Monera (2) Plantae

(3) Fungi (4) Animalia

64. Specialized cells for fixing atmospheric nitrogen in *Nostoc* are

(1) Akinetes (2) Heterocysts

(3) Hormogonia (4) Nodules

65. Nuclear membrane is absent in

(1) *Volvox* (2) *Nostoc*

(3) *Penicillium* (4) *Agaricus*

66. The most abundant prokaryotes helpful to humans in making curd from milk and in production of antibiotics are the ones categorised as

(1) Chemosynthetic autotrophs

(2) Heterotrophic bacteria

(3) Cyanobacteria

(4) Archaebacteria

67. Organisms called Methanogens are most abundant in a

(1) Hot spring (2) Sulphur rock

(3) Cattle yard (4) Polluted stream

68. Which of the followings is mainly produced by the activity of anaerobic bacteria on sewage?

(1) Marsh gas (2) Laughing gas

(3) Propane (4) Mustard gas

69. A peculiar odor that prevails in marshy areas and cow-sheds is on account of a gas produced by

(1) Mycoplasma (2) Archaebacteria

(3) Slime moulds (4) Cyanobacteria

70. Organisms, which fix atmospheric nitrogen in the soil, fall under the category of

(1) Bacteria (2) Green algae

(3) Soil fungi (4) Mosses

71. Transduction in bacteria is mediated by

(1) Plasmid vector (2) Phage vector

(3) Cosmid (4) F-factor

72. Many blue-green algae occur in thermal springs (hot water springs). The temperature tolerance of these algae have been attributed to their

(1) Mitochondrial structure

(2) Importance of homopolar bonds in their proteins

(3) Cell wall structure

(4) Modern cell organization

73. For the first time, the bacteria were observed by
(1) Robert Koch (2) A.V. Leeuwenhoek
(3) W.H. Stanley (4) Louis Pasteur

74. A large number of organic compounds can be decomposed by
(1) Photoheterotorphs (2) *Pseudomonas*
(3) Photolithotrophs (4) Chemoheterotrophs

75. What are the sex organs provided in some bacteria?
(1) Sex pili (2) Plasmid
(3) Circular DNA (4) Gametes

76. BGA (blue green algae) are included in which of the following groups?
(1) Bryophytes (2) Prokaryotes
(3) Protista (4) Fungi

77. Which type of DNA is found in bacteria?
(1) Circular DNA
(2) Membrane bound DNA
(3) Straight DNA
(4) Helical DNA

78. A few organisms are known to grow and multiply at temperatures of 100-105°C. They belong to
(1) Thermophilic sulphur bacteria
(2) Hot spring blue-green algae
(3) Thermophilic subaerial fungi
(4) Marine archaebacteria

79. The DNA of *E.coli* is
(1) Double stranded and linear
(2) Double stranded and circular
(3) Single stranded and linear
(4) Single stranded and circular

80. Photosynthetic bacteria have pigments in
(1) Chromoplasts (2) Chromatophores
(3) Leucoplasts (4) Chloroplasts

81. What is true for Archaebacteria?
(1) All are halophiles
(2) All are photosynthetic
(3) All are fossils
(4) Oldest living beings

82. What is true for cyanobacteria?
(1) Oxygenic with nitrogenase
(2) Oxygenic without nitrogenase
(3) Non oxygenic with nitrogenase
(4) Non oxygenic without nitrogenase

83. Organisms which obtain energy by the oxidation of reduced inorganic compounds are called
(1) Photoautotrophs (2) Chemoautotrophs
(3) Saprozoic (4) Coproheterotrophs

84. Which statement is correct for bacterial transduction?
(1) Transfer of some genes from one bacteria to another bacteria through virus
(2) Transfer of genes from one bacteria to another bacteria by establishing contact
(3) Bacteria obtained its DNA directly from mother cell
(4) Bacteria obtained DNA from other external source

85. Chromosomes in a bacterial cell can be 1 in number and
(1) Are always circular with more G ≡ C content
(2) Are always linear with more G ≡ C content
(3) Can be either circular or linear, but never both within the same cell
(4) Can be circular as well as linear within the same cell

86. Viruses that infect bacteria and cause their lysis, are called
(1) Lysozymes (2) Lipolytic
(3) Lytic (4) Lysogenic

87. The most thoroughly studied bacteria plant interactions is the
(1) Cyanobacterial symbiosis with some aquatic ferns
(2) Gall formation on certain angiosperms by *Agrobacterium*
(3) Nodulation of *Sesbania* stems by nitrogen fixing bacteria
(4) Plant growth stimulation by phosphate-solubilising bacteria

88. What is true for photolithotrops?
(1) Obtain energy from radiations and hydrogen from organic compounds
(2) Obtain energy from radiations and hydrogen from inorganic compounds
(3) Obtain energy from organic compounds
(4) Obtain energy from inorganic compounds

89. The protists have
(1) Only free nucleic acid aggregates
(2) Membrane bound nucleoproteins lying embedded in the cytoplasm
(3) Gene containing nucleoproteins condensed together in loose mass
(4) Nucleoprotein in direct contact with the rest of the cell substance

106. An example of endomycorrhiza is
(1) *Nostoc* (2) *Glomus*
(3) *Agaricus* (4) *Rhizobium*

107. Satellite RNAs are present in some
(1) Plant viruses
(2) Viroids
(3) Prions
(4) Bacteriophages

108. A cell-coded protein that is formed in response to infection with most animal viruses, is called
(1) Histone
(2) Antibody
(3) Interferon
(4) Antigen

109. Tobacco mosaic virus *(TMV)* genes are associated with
(1) Single stranded RNA
(2) Double stranded DNA
(3) Single stranded DNA
(4) Double stranded RNA

110. The tailed bacteriophages are
(1) Motile on surface of bacteria
(2) Non-motile
(3) Motile on surface of plant leaves
(4) Actively motile in water

111. Viruses posses
(1) Ribosomes to synthesize protein
(2) Organelles for its vital mechanisms
(3) Either DNA or RNA
(4) None of these

112. Enzymes are generally not found in
(1) Fungi
(2) Algae
(3) Virus
(4) Cyanobacteria

113. Viruses are living, because they
(1) Multiply in host cells
(2) Carry anaerobic respiration
(3) Carry metabolic activities
(4) Cause infection

114. Viruses are no more "alive" than isolated chromosomes because
(1) They require both RNA and DNA
(2) They both need food molecules
(3) They both require oxygen for respiration
(4) Both require the environment of a cell to replicate

115. Tobacco mosaic virus is elongated rod like with size
(1) 300 × 10 nm
(2) 300 × 5 nm
(3) 300 × 18 nm
(4) 700 × 30 nm

116. Which one of the following statements about viruses is correct ?
(1) Viruses possess their own metabolic system
(2) All viruses contain both RNA and DNA
(3) Viruses are obligate parasites
(4) Nucleic acid of viruses is known as capsid

117. Which of the following statements is not true for retroviruses?
(1) DNA is not present at any stage in the life cycle of retroviruses
(2) Retroviruses carry gene for RNA-dependent DNA polymerase
(3) The genetic material in mature retroviruses is RNA
(4) Retroviruses are causative agents for certain kinds of cancer in man

118. The causative agent of mad-cow disease is a
(1) Virus (2) Bacterium
(3) Prion (4) Worm

119. Which one of the following statement about lichens is wrong?
(1) These grow very rapidly (2 cm per day)
(2) They show fungal and algal symbiotic relationships
(3) Some of its species are eaten by reindeers
(4) These are pollution indicators

120. Most of the lichens consist of
(1) Green algae and ascomycetes
(2) Brown algae and higher plant
(3) Blue green algae and basidiomycetes
(4) Red algae and ascomycetes

90. Which of the following organism possesses characteristics of a plant and an animal?
(1) *Euglena*
(2) *Paramoecium*
(3) Bacteria
(4) *Mycoplasma*

91. Capillitium is present in the sporangium of
(1) *Dictyostelium*
(2) *Polysphondylium*
(3) *Physarum*
(4) *Navicula*

92. Which one of the following is true for fungi?
(1) They are phagotrophs
(2) They lack a rigid cell wall
(3) They are heterotrophs
(4) They lack nuclear membrane

93. When there are two haploid nuclei per cell in some fungi before the formation of diploid, this stage is called
(1) Diplotene
(2) Diplophase
(3) Dikaryophase
(4) Dikaryote

94. Which one of the following is linked to the discovery of Bordeaux mixture as a popular fungicide?
(1) Black rust of wheat
(2) Bacterial leaf blight of rice
(3) Downy mildew of grapes
(4) Loose smut of wheat

95. The black rust of wheat is a fungal disease caused by
(1) *Albugo candida*
(2) *Puccinia graminis tritici*
(3) *Ustilago nuda*
(4) *Cleviceps purpurea*

96. The smut of maize is caused by
(1) *Ustilago avenae*
(2) *Ustilago nuda*
(3) *Ustilago hordei*
(4) *Ustilago maydis*

97. *Puccinia* forms uredia and
(1) Telia on wheat leaves
(2) Aecia on barberry leaves
(3) Pycnia on barberry leaves
(4) Aecia on wheat leaves.

98. Columella is a specialized structure found in the sporangium of
(1) *Spirogyra* (2) *Ulothrix*
(3) *Rhizopus* (4) *Penicillium*

99. Dikaryotisation occurs in *Puccinia* on
(1) Upper surface of Barberry leaf
(2) Lower surface of Barberry leaf
(3) Upper surface of wheat leaf
(4) Lower surface of wheat leaf

100. Adhesive pad of fungi penetrate the host with the help of
(1) Mechanical pressure and enzymes
(2) Hooks and suckers
(3) Softening by enzymes only
(4) Only by mechanical pressure

101. Which fungal disease spreads by seed and flowers?
(1) Loose smut of wheat
(2) Corn smut
(3) Covered smut of barley
(4) Soft rot of potato

102. Which of the following secrete toxins during storage conditions of crop plants?
(1) *Aspergillus* (2) *Penicillium*
(3) *Fusarium* (4) *Colletotrichum*

103. Mycorrhiza exhibits the phenomenon of
(1) Parasitism (2) Symbiosis
(3) Antagonism (4) Endemism

104. Mycorrhiza is correctly described as
(1) Parasitic association between roots and some fungi
(2) Symbiotic relationship between fungi and roots of higher plants
(3) Symbiosis of algae and fungi
(4) Relation of ants with the stem of some trees

105. VAM is an example of
(1) Endomycorrhiza (2) Ectoparasitism
(3) Endoparasitism (4) Ectomycorrhiza

121. Which of the following is the use of lichens in case of pollution?
(1) They promote pollution
(2) Lichens are not related with pollution
(3) They treat the polluted water
(4) They act as bioindicators of pollution

122. Lichens are well known combination of an alga and a fungus where fungus has
(1) A saprophytic relationship with the alga
(2) An epiphytic relationship with the alga
(3) A parasitic relationship with alga
(4) A symbiotic relationship with alga

123. There exists a close association between the alga and the fungus within a lichen. The fungus
(1) Provides protection, anchorage and absorption for the algae
(2) Provides food for the alga
(3) Fixes the atmospheric nitrogen for the alga
(4) Releases oxygen for the alga

124. What is the genetic material in Influenza virus?
(1) Double helical DNA (2) RNA
(3) Single helix DNA (4) None of these

125. The sexual reproduction is absent in
(1) *Spirogyra* (2) *Nostoc*
(3) *Ulothrix* (4) *Volvox*

126. Which one of the following fungi contains hallucinogens?
(1) *Morchella esculenta* (2) *Amanita muscaria*
(3) *Neurospora* sp. (4) *Ustilago* sp.

127. Anoxygenic photosynthesis is characteristic of
(1) *Rhodospirillum*
(2) *Spirogyra*
(3) *Chlamydomonas*
(4) *Ulva*

128. A location with luxuriant growth of lichens on the trees indicates that the
(1) Trees are very healthy
(2) Trees are heavily infested
(3) Location is highly polluted
(4) Location is not polluted

SECTION - D

Assertion - Reason Type Questions

In the following questions, a statement of assertion (A) is followed by a statement of reason (R)

(1) If both Assertion & Reason are true and the reason is the correct explanation of the assertion, then mark **(1)**.
(2) If both Assertion & Reason are true but the reason is not the correct explanation of the assertion, then mark **(2)**.
(3) If Assertion is true statement but Reason is false, then mark **(3)**.
(4) If both Assertion and Reason are false statements, then mark **(4)**.

1. A : Slime moulds have the characters of both plants and animals.
R : Reproductive phase is animal like and vegetative phase is plant like.

2. A : Methanogens can show symbiotic association with eukaryotic organisms.
R : They are used for the production of biogas.

3. A : Lichens do not grow in polluted area having SO_2.
R : Lichens secrete carbonic acid and oxalic acid on barren rocks.

4. A : Secondary mycelium of *Agaricus* is binucleated.
R : Secondary mycelium is formed by somatogamy of primary mycelium.

5. A : Phycobiont is dominant parent in lichens.
R : Algal component in the dual organisms can be eukaryotic only.

6. A : Unicellular eukaryotes are included in Monera.
R : Unicellular eukaryotes have 70S cytoribosomes.

7. A : Slime moulds form fruiting bodies under unfavourable conditions.
R : Naked plasmodium is formed during favourable conditions.

8. A : DNase can inhibit the process of transformation.
R : Transformation is absorption of DNA segment from the surrounding medium by a living bacterium.

9. A : MLOs are pleomorphic and non-motile monerans.
R : They are resistant to antibiotics like penicillin.

10. A : Majority of bacteria are autotrophs.
R : Chemoheterotrophic nutrition is absent in bacteria.

11. A : Holophytic protistans are important phytoplanktons and they contribute 80% of the total photosynthesis.
    R : They lack chemosynthetic nutrition and utilize non sulphur organic compound as the source of electron and proton in carbon assimilation.
12. A : Sexual spores in pink mould are meiospores produced endogenously.
    R : They develop flask shaped fruiting body in sexual life cycle.
13. A : Azotodesmic lichens are biofertilisers enriching nitrogen contents in soil.
    R : This ability is due to the presence of heterocystous blue-green algae as phycobiont component.
14. A : Viroids are not included in five kingdom system.
    R : They are non-cellular.
15. A : Viruses which infect animals generally possess ssRNA or dsRNA or dsDNA.
    R : Phytophagineae generally contain dsDNA.

❑ ❑ ❑

(a) DNA containing viruses are called deoxyviruses. These are of two types :

(i) Double stranded DNA (dsDNA) virus *e.g.* Pox virus, Cauliflower mosaic virus, Herpes virus.

(ii) Single stranded DNA (ssDNA) *e.g.* Coliphage $\phi \times 174$, M13 phage.

(b) RNA containing viruses or riboviruses are of two types :

(i) Double stranded RNA (dsRNA) virus *e.g.* Reovirus, Wound tumour virus.

(ii) Single stranded RNA (ssRNA) virus *e.g.* TMV, Influenza virus, Foot and Mouth disease virus, Retroviruses (HIV).

On the basis of host specificity viruses are divided into three groups :

Group	Common type of genetic material
1. Phytophagineae/Plant viruses	1. ssRNA
2. Zoophagineae/Animal viruses	2. ss or dsRNA or dsDNA
3. Bacteriophages/Bacterial viruses	3. dsDNA

Structure of Some Viruses

1. **Tobacco Mosaic Virus (TMV)** is elongated rod like, 3000 Å long, 180 Å in diameter with molecular weight 39.4×10^6 dalton. 2130 capsomeres are arranged helically to form the capsid. RNA strand is helical. ssRNA consists of 6400 nucleotides. Thus, the ratio of nucleotides : capsomeres = 3 : 1

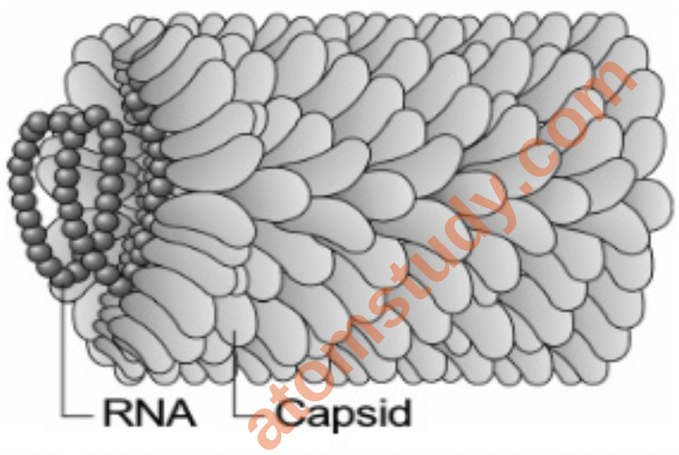


Fig. : Tobacco Mosaic Virus (TMV)

2. **Bacteriophage** (or bacterial viruses) are the viruses that infect the bacteria. Bacteriophages usually have double stranded DNA. **T_4 Bacteriophage** has a tadpole like structure with polyhedral head connected to a helical tail (binal). The head consists of nucleic acid surrounded by a protein coat or capsid. Nucleic acid is double stranded DNA. Tail is proteinaceous tube-like, core surrounded by sheath. At one end, tube is joined to the head by thin collar. At the other end, it has a hexagonal base plate with six small tail pins and six tail fibres which help in attachment of the phage to the host cell.

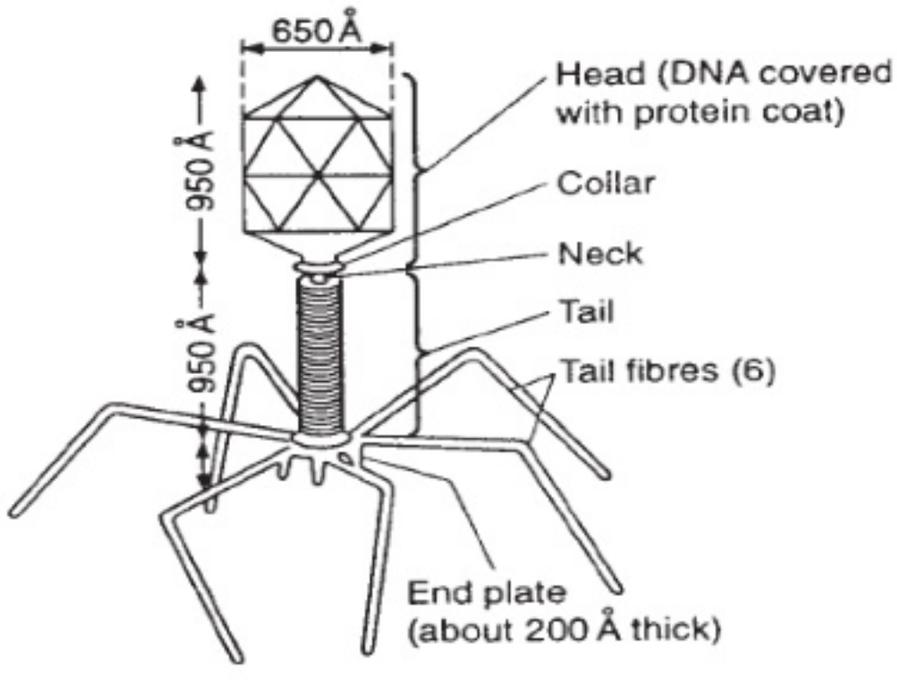


Fig. : Structure of T_4 bacteriophage