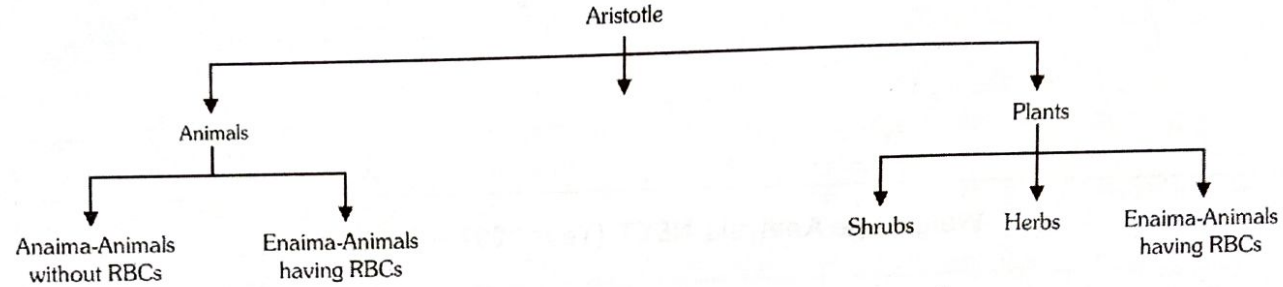
2. Biological Classification

Biological classification is a formal system of distinguishing, naming, and grouping individual organisms. Whereas numerous systems have existed since antiquity, the modern system was initially developed by Carolus Linnaeus in the eighteenth century. It is supported by a binomial naming system and groupings of organisms arebased on traits.

1. History of Classification

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



In above table plants are divided into shrubs, herbs and trees.

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
The word taxonomy is proposed by **A.P. DE. CANDOLLE**.
The term systematic was proposed by **LINNAEUS**.
Neo-systematics- A new branch- Name given by **JULIAN HUXLEY**(1940)

2. Need for Classification

- Out of 1.7 million organisms, 1.2 million are animals and 0.5 million plants.
- The largest group of organisms is insects with over 0.75 million species. Many plant and animal species have not yet been discovered.
- Underwater reefs and tropical rainforests seem to possess innumerable undiscovered species.
- Every year about 15000 new species are discovered.
- It is estimated that total living organisms may range between 5-30 million species.
- About 50-100 times more species have become extinct.
- The study of one or two organisms isn't ample to understand the essential features of the cluster.
- Classification helps in knowing the connection amongst different groups of organisms and the evolutionary relationship between them.

3. Aim of Biological Classification

- To identify and precisely describe the basic units of Classification.
- This is an appropriate method to arrange species in an order on the basis of their similarities and relationships.
- To indicate the phylogeny of the organisms

4. Types of Classification System

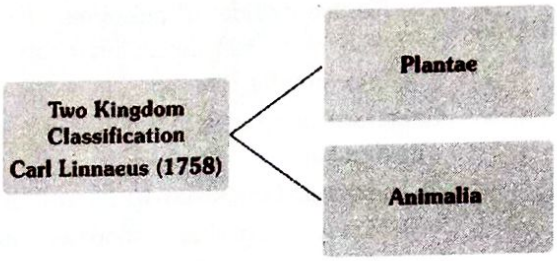
4.1. Two Kingdom Classification

In his Systema Naturae, first published in 1735, Carolus Linnaeus distinguished two kingdoms of living things: Animalia for animals and Plantae (Vegetabilia) for plants. He classified all living organisms into two kingdoms – on the basis of nutrition and locomotion (mobility).
Linnaeus placed unicellular protozoans and multicellular animals (metazoans) under animal kingdom because of their compact body, holozoic nutrition (ingestion of food) and locomotion. All other organisms were grouped under plant kingdom because of their immobility, spread out appearance and autotrophic mode of nutrition. Thus, the traditional plant kingdom comprised bacteria, algae, plants, andfungi.

S. no.	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,

(1) Demerits or Limitations:

- The two-kingdom system of classification did not indicate any evolutionary relationship between plants and animals.
- It grouped together the prokaryotes (bacteria, BGA) with other eukaryotes.
- It also grouped unicellular and multi-cellular organisms together.
- This system did not distinguish the heterotrophic fungi and the autotrophic green plants.
- Dual organisms like Euglena and lichens did not fall into either kingdom.
- Slime mould, a type of fungi, can neither be grouped in fungi nor plants. This is because they are wall-less and holozoic in the vegetative stage, but develop cell wall in the reproductive stage.
- It did not mention some acellular organisms like viruses and viroids.



4.2. Three Kingdom Classification System:

In 1866, Ernst Hackel solved the first objection and proposed a third kingdom i.e. protists to accommodate euglena-like organisms. He also included bacteria in kingdom Protista. In this system, fungi were still included in the kingdom Plantae.

(1) Demerits or Limitations:

- The system did not clear the difference between prokaryotes and eukaryotes.
- Some biologists disagree about the position of fungi in kingdom Plantae.
- Fungi resemble plants in many ways but are not autotrophs.
- They are a special form of heterotrophs that get their food by absorption.
- They do not have cellos in their cell walls rather possess chitin.

4.3. Four Kingdom Classification System:

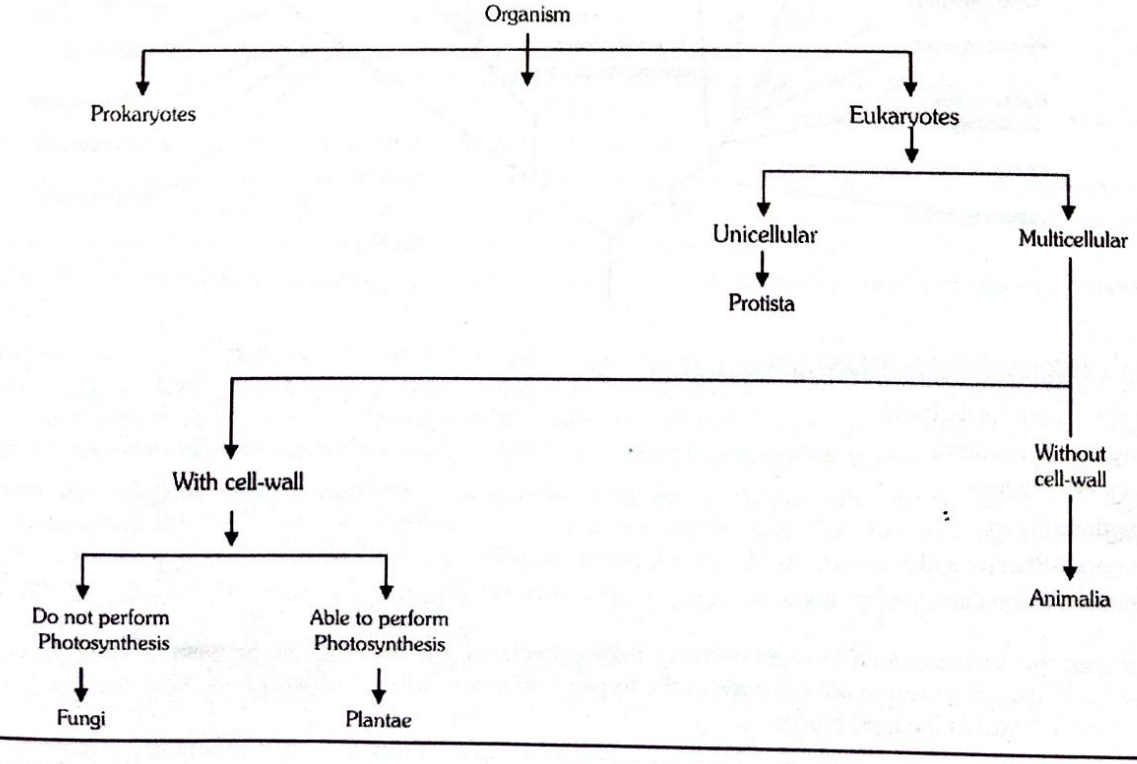
Copeland gave four kingdoms of classification and included Monera as the fourth kingdom. This kingdom includes all the prokaryotic organisms *i.e.,* eubacteria (including cyanobacteria or blue-green algae) and archaebacteria.

(1) Demerits or Limitations: Fungi continued to remain with the group plantae.

4.4. Five Kingdom Classification System:

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

- The complexity of Cell structure (either prokaryotic or eukaryotic)
- Thallus organization (body differentiated or not)
- Mode of nutrition (autotrophic, heterotrophic, saprobic absorption or ingestion)
- The complexity of organisms: Unicellular or multicellular
- Phylogenetic (or evolutionary) relationship: prokaryotes to eukaryotes, unicellular to multicellular organisms



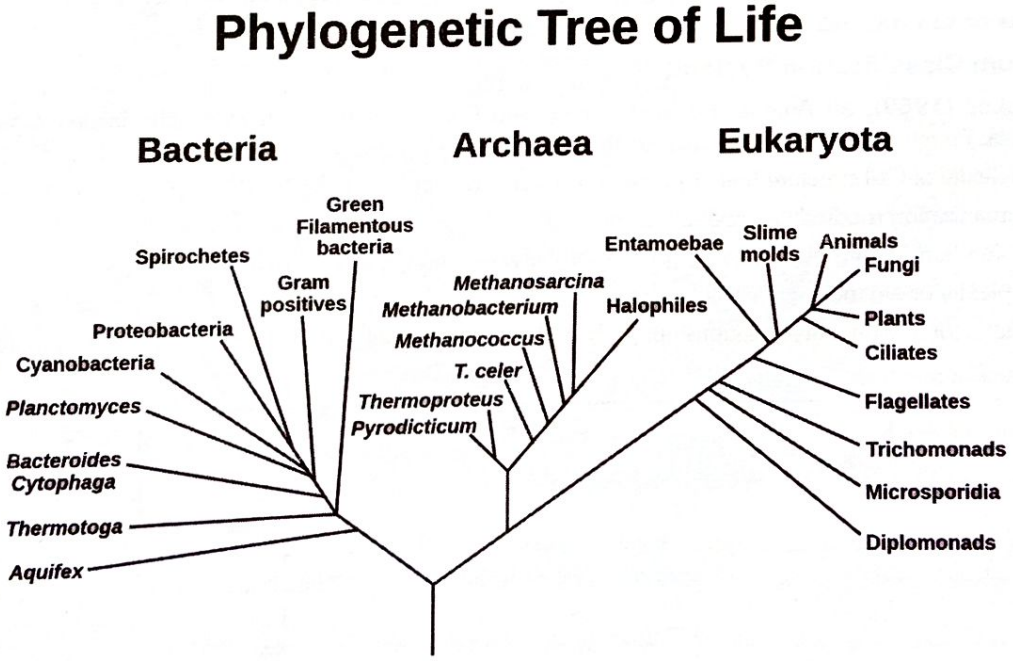
- In the five-kingdom classification, bacteria are included in Kingdom Monera.
- Kingdom Protista includes all single-celled eukaryotes such as Chrysophytes, Dinoflagellates, Euglenoids, Slime-moulds, and Protozoans.
- Members of Kingdom Fungi show a great diversity in structures and habitat. Most fungi are saprophytic in their mode of nutrition.
- The Plantae includes all eukaryotic chlorophyll-containing organisms. Algae, bryophytes, pteridophytes, gymnosperms, and angiosperms are included in this group.
- The heterotrophic eukaryotic, multicellular organisms lacking a cell wall are included in the Kingdom Animalia.
- Some acellular organisms like viruses and viroids as well as the lichens are not included in the five-kingdom system of classification.

(1) Demerits or Limitations:

- This system of classification has drawbacks with reference to the lower forms of life.
- The Kingdom of Monerans and the Protists include diverse, heterogeneous forms of life. In both the kingdoms, there are autotrophic and heterotrophic organisms.
- They also include organisms which have cells with cell wall and cells without a cell wall.
- All the organisms of these three kingdoms do not evaluate from a single ancestor.
- Multicellular organisms have originated from protists several times.
- Organisms like the unicellular green algae like Volvox and chlamydomonas have not been included under the Kingdom Protista because of their resemblance to other green algae.
- The general organization of the slime mouldsis totally different from the members of protists.
- Viruses have not been given proper place in this system of classification.

4.5. Six Kingdom Classification System (Three Domains of Life):

The three domains proposed by Woese, according to three domain **Eukarya** contains all those kingdoms of eukaryotic organisms – the animals, plants, fungi, and protists. Kingdom Monera has been divided into two domains: The domain Bacteria and the Domain Archaea.



Carl Woese proposed the six-kingdom classification.

- Kingdom- Archaebacteria,
- Kingdom-Eubacteria,
- Kingdom-Protista
- Kingdom-Fungi,
- Kingdom-Plantae and
- Kingdom-Animalia.

He separated the archaebacteria (ancient bacteria) from eubacteria(true bacteria) 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.

5. Kingdom Monera

All prokaryotic organism are included in kingdom monera. It includes archaebacteria, bacteria, cyanobacteria (blue green algae), and some smaller groups, such as mycoplasmas, actinomycetes, rickettsias etc.

5.1. Archaebacteria (Ancient Bacteria)

Group of most primitive prokaryotes, evolved immediately after the evolution of the first life. They are placed in a separate subk-ingdom or domain called Archaea. Archaebacteria are characterized by the absence of peptidoglycan in their wall. Instead contains protein and non-cellulosic polysaccharides. It has pseudomurein in some methanogens. The cell membranes are characterized by the presence of a monolayer of branched-chain lipids. Their 16S rRNA nucleotides are quite different from those of other organisms.

(1) Types of Archaebacteria: Archaebacteria are of three major types— methanogens, halophilic and thermoacedophilic.

- **Methanogens:**
  a) The archaebacteria are strict anaerobes. They are "autotrophs" . They occur in marshy areas where they convert formic acid and carbon dioxide into methane with the help of hydrogen.
  b) Helps in the production of methane and fuel gas inside gobar gas plants e.g., Methanobacterium, Methanococcus.
  c) Some of the methanogen archaebacteria live as symbionts (e.g., Methanobacterium) inside rumen or first chamber in the stomach of herbivorous animals that chew their cud (ruminants, e.g., cow, buffalo). These archaebacteria are helpful to the ruminants in fermentation of cellulose.
- **Halophiles (Halophils)**
  a) Halophiles occur in salt richsubstrata ,like the great salt lake, the dead sea, salt pans, salt beds and salt marshes e.g., *Halobacterium, Halococcus*. They are aerobic chemo-heterotrophs.
  b) Their cell membranes have red carotenoid pigment. At low oxygen level, they develop purple pigment bacterio-rhodopsin in their cell membrane which directly convert light energy into ATP.
- **Thermoacidophiles (Thermoacidophils)**
  a) Have dual ability to tolerate high temperature as well as high acidity. They often found in hot (80°C) and ph as low as 2, e.g., *Thermoplasma, Thermoproteus*.
  b) They are chemosynthetic, i.e., they obtain energy from oxidisingsulphur.Under aerobic conditions oxidisesulphur to sulphuric acid.

$$2S + 2H_2O + 3O_2 \rightarrow 2H_2SO_4$$

If the conditions are anaerobic, the thermoacidophiles may reduce sulphur to H_2S.

Archaebacteria are also known as living fossils because they represent one of the earliest forms of life which experimented on the absorption of solar radiations for the first time, lived comfortably under anaerobic conditions and developed techniques to oxidize the chemicals present in the substratum on the availability of oxygen.

5.2. Eubacteria – (True Bacteria)

Eubacteria, or "true" bacteria, are single-celled prokaryotic microorganisms that are ubiquitous (present everywhere) except blood of healthy person, flame, volcano, atmosphere after rain. Bacteria are the sole members of kingdom monera. They are most abundant microbes. Anton van Leeuwenhoek, the Dutchman first observed bacteria through his single-lens microscope in 1674. He made his own simple lenses to try to satisfy his curiosity about living things. Leeuwenhoek called father of microbiology. He stored rain water (fresh rain water has no bacteria). He called them wiled animalcule or tiny animalcule. But Ehrenberg coined the term bacteria. Pasteur is father of modern microbiology, while Robert Koch is considered father of bacteriology (a part of microbiology). Lister developed the technique of aseptic culture of bacteria.

Bacteria are group of prokaryotic organism or monera which is characterized by peptidoglycan wall, a compacted but naked DNA with attached mesosome and reserve food made of glycogen and fat. All monerans are unicellular , they lack true nuclei and generally lack membrane – bound organelles. Reproduction occurs mainly by binary fission.

(1) Nutrition: Their great metabolic diversity is one of the reasons why they are able to colonize in just about every environment on the earth.

- **Photoautotrophic (Photosynthetic autotrophs):**uses energy from sun to produce carbohydrate. It takes place in green bacteria, purple bacteria, and cynobacteria, chlorophyll (bacteriochlorophyll, bacteriophaeophytin) is present, bacterial chlorophyll is chemically different from the chlorophyll in plants. Water is not used as source of reducing power, hydrogen is obtained from various types of inorganic and organic compounds e. g. H_2S.
- **Chemoautotrophic (Chemosynthetic autotrophs):**Their energy requirement are derived from molecules such as ammonia, methane, and hydrogen sulphide gases. With this energy and CO_2 they manufacture carbohydrates, fats, proteins, nucleic acid and other growth factors. Chemoautotrophs are of following types;
  (a) Nitrifying bacteria- *Nitosomonas* and *Nitrosococcus* obtain energy by oxidizing ammonia to nitrite.
  $NH_4^+ + 2O_2 \longrightarrow NO_2^- + 2H_2O + \text{Energy}$
  Nitrocystis and *Nitrobacter* oxidize nitrites to nitrates.
  $2\,NO_2^- + O_2 \longrightarrow 2NO_3^- + \text{Energy}$

(b) Sulphur oxidizing bacteria-*Beggiatoa*, a colourless sulphur bacteria, oxidizes hydrogen sulphide to sulphur.

$2H_2S + O_2 \longrightarrow 2S + 2H_2O$ + Energy

Thiobacillus thioxidans, another sulphur bacteria oxidizes sulphur to sulphate.

$2S + 2H_2O + 3O_2 \longrightarrow 2H_2SO_4$ + Energy

(c) Iron Bacteria-*Ferrobacillus ferro-oxidans* obtain energy by oxidizing ferrous compounds to ferric forms.

$4FeCO_3 + 6H_2O + 0_2 \longrightarrow 4Fe(OH)3 + 4CO_2$ + Energy

(d) Other chemosynthetic bacterias- *Methanomonas* oxidizes methane into CO_2 AND H_2O.

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$ + Energy

Carbon monoxide bacteria- *Carboxydomonas*, oxidize carbon monoxide to CO2 to obtain energy.

$2CO + O_2 \longrightarrow 2CO_2$ + Energy

- **Saprophytic bacteria**: These bacteria grow on decaying organic matters and live by digesting and absorbing them. By secreting enzymes -they break complex organic compound into simpler forms. The breakdown of carbohydrate is known as fermentation. Some bacteria (Escherichia coli) are able to ferment glucose and galactose, thereby CO2 is released. On the other hand, some bacteria like Lactobacillus ferment milk and produce an organic acid, the lactic acid which causes the souring and curding of milk. Carbon dioxide is not evolved in this process. The breakdown of protein material is known as putrefaction. A few species are able to degrade fats into fatty acids and glycerine.
- **Symbiotic bacteria**: These bacteria are useful to the host on one hand and receive food and shelter in return. Different types of E coli bacteria inhabit the intestine of man and other organisms, which help in the digestion of cellulose by various enzymes secreted by them. These bacteria also deposit vitamins which can be used by the host. In return they take shelter and food from the host. In leguminous plants, the bacterium Rhizobium develops root nodules. The Rhizobium possesses nitrogenase enzyme and thus can fix atmospheric nitrogen useful to the plants and, in return, it also takes shelter and food from its host. Frankia spp. of Actinomyceteous fungi develop root nodules in about 178 species of non-leguminous plants like Casuarina, Alnus, Myrica; Elaeagnus, Coriaria, Ceanothus etc. They also fix atmospheric N2 with the help of nitrogenase enzyme.
- **Pathogenic bacteria**: These bacteria cause diseases in plants and animals including humans. They cause diseases by directly attaching on host or by liberation of toxic substances which affect directly or indirectly. Some common human diseases caused by pathogenic bacteria are-
  a) Cholera (Vibrio cholerae)
  b) Diphtheria (Corynebacterium diphtheriae),
  c) Tuberculosis (Mycobacterium tuberculosis),
  d) Typhoid (Salmonella typhi),
  e) Pneumonia (Diplococcus pneumoniae) etc.
  f) The plant diseases caused by bacteria are-
  g) citrus canker (Xanthomonas axonopodis pv. citri),
  h) Bacterial blight of rice (Xanthomonas campestris pv. oryzae),
  i) Tundu disease of wheat (Clavibacter tritici)
  j) Bacterial blight of cotton (Xanthomonas malvacearum), etc.

(2) Respiration : Bacteria can be aerobic or anaerobic. Each of them is further of two types, obligate and facultative.

- **Aerobic**
  a) **Obligate Aerobes:** Bacteria which can respire only aerobically, get killed under anaerobic conditions, e.g., Bacillus subtilis.
  b) **Facultative Aerobes:** Bacteria which respire anaerobically under normal conditions but can respire aerobically when oxygen is available. Most of the photosynthetic bacteria are from this group, e.g., Rhodopseudomonas.
- **Anaerobic:**
  a) **Facultative Anaerobes:** Bacteria which generally respire aerobically but can respire anaerobically if oxygen becomes deficient, e.g., halophiles.
  b) **Obligate Anaerobes:** Bacteria of this category respire only anaerobically. They get killed under aerobic conditions, e.g., Clostridium botulinum.

(3) Size and Shape : Individual bacterial cells are not visible to the unaided eye. In general, bacterial cells do not exceed 1 μm (micrometer or micron) in diameter, though their length may vary widely. The minute size of bacteria gives certain advantages to them. Due to their small size, bacteria have a much greater surface/volume ratio than most eukaryotic organisms having larger cells.

Smallest bacteria 0.15□m (Dialister penumosintes), while largest 750□m (Thiomargarita ramibiensis & Epulopiscium fishilsoni).

Bacteria occur in three main shapes, spherical, rod-like and spiral

- **Coccus:** Spherical bacteria, occur in pairs (Diplococci), in groups of four (tetracocci), in bunches (Staphylococci), in a bead like chain (Streptococci) or in cubical arrangement of eight or more (Sarcinae).
- **Bacillus:** Rod-like bacteria, occur singly but occasionally found in pairs (Diplobacilli) or chains (Streptobacilli).
- **Spirillum:** Spiral shaped bacilli or coiled like a cork-screw e.g.-Spirillum, Spirochaete.
- **Vibrio:** Comma, curved rod or single turn of the spiral e.g. Vibrio cholerae

- **Filament** : The body of bacterium is filamentous like a fungal mycelia. The filaments are very small e.g., Beggiota, Thiothrix etc.
- **Stalked** : The body of bacterium possesses a stalk e.g., Caulobacter.
- **Budded :** The body of bacterium is swollen at places e.g., Rhodomicrobium.

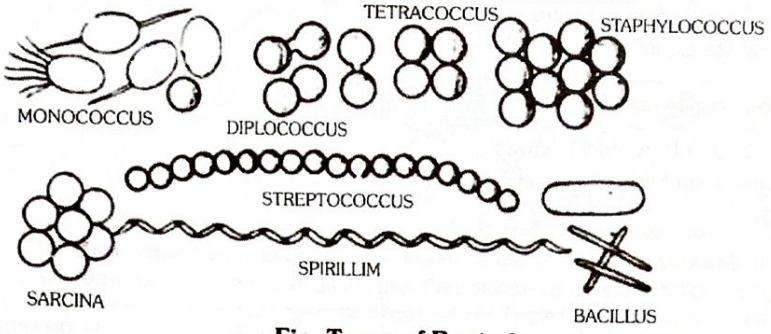


Fig. Types of Bacteria

(4) Structure of Bacteria :A bacterial cell consists of cell envelope, cytoplasm, nucleiod, plasmids, inclusion bodies, flagella, pili and fimbriae.

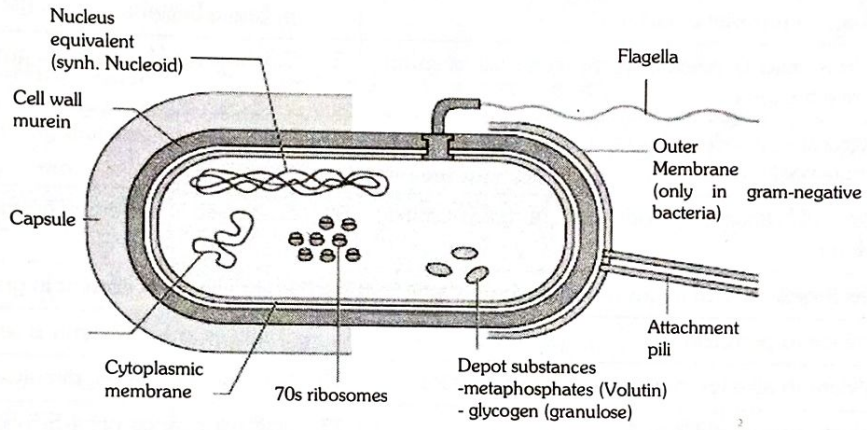


Fig. Structure of Bacteria

- **Cell Envelope-** It is the outer covering of bacterial cell, consist of 3 components- glycocalyx, cell wall and cell membrane.

  a) Glycocalyx-(mucilage sheath)- The glycocalyx represents the gelatinous covering around many bacterial cells present more diffusedly forming a loose mass around the bacterial cell, it is called slime layer. When the gelatinous covering forms a well- defined persistent layer, it is called capsule. They help attaching bacterial cells on diverse surfaces (e.g., plant root surface, human teeth and tissue rocks in fast flowing streams) because of its sticky nature. Pathogenic bacteria that enter the human body by specific routes usually do so by first binding specifically to surface components of host tissues. Glycocalyx helps bacteria in several ways-

  Protect bacterial cells against phagocytosis and desiccation.

  Some bacteria (e.g., *Streptococcus mutans*) use its capsule as source of energy by breaking down the sugars of capsule when stored energy content is considerably reduced during adverse conditions.

  Help inhibit the movements of nutrients from the bacterial cell.

  Prevent bacterial viruses (bacteriophages) and most hydrophobic toxic materials (e.g., detergents) from attaching on its surface.

  b) Cell wall: Cell wall is a dense layer surrounding the plasma membrane and functions to give shape and rigidity to the cell. All bacterial cells are covered by a strong, rigid cell wall. Therefore, they are classified under plants. Inner to the capsule cell wall is present. It is made up of polysaccharides, proteins and lipids. In the cell wall of bacteria there are two important sugar derivatives are found i.e., NAG and NAM (N-acetyl glucosamine and N-acetyl muramic acid) and besides L or D-alanine, D-glutamic acid and diaminopimelic acid are also found. One of the unique components of cell wall of bacteria is peptidoglycan or mucopeptide or murein (made of mucopolysaccharide + polypeptide). In peptidoglycan, NAG and NAM are joined by short peptide chains or cross bridges of amino acids. Outer layer of cell wall of Gram –ve bacteria is made up of lipopolysaccharides and cell wall of Gram +ve bacteria of teichoic acid. The cell wall of Gram positive bacteria is much thicker and contains less lipids as compared to that of Gram –ve bacteria. The enzyme lysozyme can dissolve the bacterial cell wall.

  c) Cell Membrane: The cytoplasmic layer is the boundary layer of the protoplast, situated beneath the cell wall. It is thin (5-10 nm), elastic and semipermeable layer. It appears as a triple-layered structure consisting of a bilayer region of phospholipid molecules, with polar heads on the surface and fatty-acid chains towards the inner side. The proteins are found embedded in the lipid bilayer.

(5) Gram Positive and Gram Negative Bacteria : In a Gram stain test, bacteria are washed with a decolorizing solution after being dyed with crystal violet. On adding a counter stain such as safranin or fuchsine after washing, Gram-negative bacteria are stained red or pink while Gram-positive bacteria retain their crystal violet dye.

This is due to the difference in the structure of their bacterial cell wall. Gram-positive bacteria do not have an outer cell membrane found in Gram-negative bacteria. The cell wall of Gram-positive bacteria is high in peptidoglycan which is responsible for retaining the crystal violet dye.

Gram-Positive Bacteria	Gram-Negative Bacteria
1. Cell wall thick (150-200 A thick), straight, single layered and outer membrane is absent in gram-positive bacteria.	1. Cell wall thin (75-120 A thick) heavy and two layered. The outer membrane is absent in gram-negative bacteria.
2. Cell wall of gram-positive bacteria contains less % of lipids (2-4%).	2. Lipids % is higher up to 20%.
3. Striking simplicity of amino acids i.e., walls have relatively few amino acids.	3. All the amino acids are present in gram-negative bacteria.
4. Large amount of muramic acid is present in the cell wall of gram-positive bacteria.	4. Less muramic acid is present in the cell wall of gram-negative bacteria.
5. Teichoic acid is present in the cell wall of gram-positive bacteria.	5. Teichoic acid is absent in gram-negative bacteria.
6. Lipopolysaccharides absent in cell wall of gram-positive bacteria.	6. Lipopolysaccharides is present in gram-negative bacteria.
7. Sialic acid absent in cell wall of gram-positive bacteria.	7. Sialic acid is present in gram-negative bacteria.
8. Polar flagella absent in gram-positive bacteria.	8. Polar flagella is present in gram-negative bacteria.
9. Sensitive to penicillin	9. Gram-negative bacteria is sensitive to streptomycin.
10. Resistant to alkalies, not dissolved by 1% KOH	10. Sensitive to alkalies, dissolved by 1% KOH.
11. Isoelectric range pH 2-5 -4	11. Isoelectric range pH 4-5-5-5.
12. Gram-Positive bacteria contain magnesium ribonucleate.	12. Magnesium Ribonucleate is absent in gram-negative bacteria.
13. Porins are absent in gram-positive bacteria.	13. Porins or hydrophilic channels occur in other membrane.
14. Many examples are cocci or spore forming rods e.g., Staphylococcus, streptococcus, Pneumococcus, Pne-umococcus. Bacillus, Clostridium, Mycobacterium, Streptomyces (exception Lactobacillus).	14. Usually non spore forming rods e.g., Salmonella, E. coli, Pseudomonas, Vibrio and Azotobacter, (exceptions Neisseria, a cocci).

(6) Flagellation : Flagella are either confined to the pole or poles or it may be present all-round the body of the bacterium. However, bacteria can be grouped on the basis of flagellation.

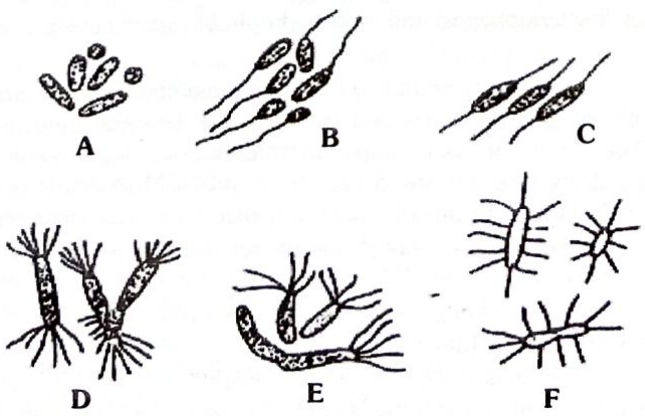


Fig. Bacterial Flagellation: **A.** antrichous **B.** Monotrichous **C.** and **D.** amphitrichous **E.** Iophotrichous **F.** Peritrichous

- Atrichous — Bacteria that lack flagella.
- Monotrichous — Single flagellum on either of the poles of the bacterial cell.
- Amphitrichous — One flagellum or more on each pole of the bacterial cell.
- Lophotrichous — Flagella in groups present on one pole of the bacterium.
- Cephalotrichous- Group of flagella occurs at each of the two ends
- Peritrichous — Flagella present all around the body of the bacterial cell.

(7) Pili and Fimbriae : Both fimbriae and pili are like flagella as both are the appendages on bacterial cell wall. They originate from cytoplasm that protrudes outside after penetrating the peptidoglycan layer of cell wall. Fimbriae are made up of 100% protein called fimbrilin or pilin which consists of about 163 amino acids.

(8) Plasmids : In addition to bacterial chromosome (nucleoid), bacterial cells normally contain genetic elements in their cytoplasm. These genetic elements exist and replicate separately from the chromosome and are called plasmids. The very existence of plasmids in bacterial cytoplasm was revealed by Lederberg in 1952 while working on conjugation process in bacteria. Plasmids are important tool in genetic engineering; they are used as vectors for introduction of genes. Plasmid can also pass from one bacterium to another, therefore called transfer plasmids. Three types of useful plasmids are-

- **F-Plasmids**: They contain gene for conjugation or fertility and called fertility factor or F- factor.
- **R- Plasmid**: They carry genes for resistance against common antibiotics.
- **Col-Plasmids**: They are called colicinogenic factors. They produce toxins called colicins or bacteriocin which are lethal to other enterobacteria.

(9) Reproduction

- **Asexual Reproduction:** Asexual mode of reproduction in bacteria includes

  a) **Binary fission**: In binary fission, single cell divides into two equal cells. Initially the bacterial cell reaches a critical mass in its structure and cellular constituents. The circular double stranded DNA of bacteria undergoes replication, where both the strands separate and new complementary strands are formed on the original strands — results in the formation of two identical double stranded DNA. A transverse septum develops in the middle region of the cell, which separates the two daughter cells.

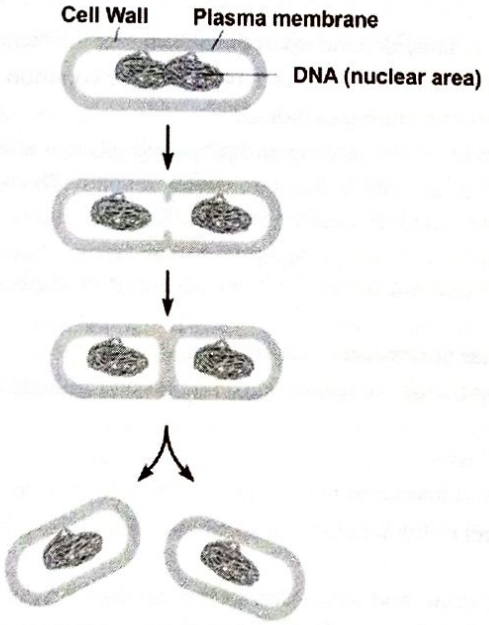


Fig. Binary fission of a bacterium

  b) **Endospore formation:** Some cells form endospore by the process called Sporulation. Spores are formed during unfavourable environmental condition like desiccation and starvation. As the spores are formed within the cell, they are called endospores. On germination, it gives rise to a bacterial cell.

  c) **Budding:** The bacterial cell develops small swelling at one side which gradually increases in size. Simultaneously the nucleus undergoes division, where one remains with the mother and other one with some cytoplasm goes to the swelling. This outgrowth is the bud, which gets separated from the mother by partition wall, e.g., *Hyphomicrobium vulgare, Rhodomicrobium vannielia*, etc

  d) **Conidia formation**: Some filamentous bacteria e.g., *Streptomyces* reproduce by means of conidia. The conidia are spore like in structure and are formed in chains. Each conidium gives rise to a new bacterium.

  e) **By Zoospores**: In rare cases bacterial cell forms some motile spores which give rise to new cells. This process has been rarely seen. e.g., *Rhizobium.*

- **Sexual Reproduction** :Typically sexual reproduction is absent in bacteria instead gene recombination occurs parasexually by three methods.-Transformation, Transduction and Conjugation.

a) **Transformation**- This phenomenon was discovered by Griffith in 1928.It is the absorption of DNA segment from the surrounding medium by a living bacterium. Its mechanism was worked out by Avery (1944). Receptivity for transformation is present for a brief period when the cells have reached the end period of active growth. At this time they develop specific receptor sites in the wall. Normally *E. coli* does not pick up foreign DNA but it can do so in the presence of calcium chloride.

b) **Transduction-** It refers transfer of foreign genes by means of viruses. Transduction was first discovered by Zinder and his teacher Lederberg (1952) in *Salmonella typhimurium*. The process also occurs in *E. coli* and a number of other hosts. A virus may pick up gene of the host in place of its own gene during its multiplication in the host cell. Such a virus is never virulent. It passes over the gene of the previous host to the new host. Transducing viruses may carry the same genes (restricted transduction) or different genes (generalized transduction) at different times.

c) **Conjugation-**It also involves transfer of genetic information from one bacterial cell to another but differs from transformation and transduction in two ways-

1. It requires contact between donor and recipient cells.
2. It transfers much larger quantities of DNA (occasionally whole chromosomes).

Conjugation was discovered in 1946 by Lederberg. The bacteria that are capable of conjugating contain two types of cells, called F^+ and F^-. The F^+cells contain extra chromosomal DNA called F(fertility)plasmids, while the F^-cells lack F plasmids. The F^+ cell makes an F pilus, a bridge by which it attaches to the F^- cell. When F^+ and F^- cells conjugate, a copy of the F plasmid is then transferred from the F^+ cell to the F^- cell. F^+ cells are called donor or male cells, and F^- cells are called recipient or female cells. Since larger amounts of DNA are transferred in conjugation than in other transfers, so conjugation is especially important in increasing genetic diversity.

(10) Economic Importance of Bacteria

- **Role in Agriculture**
  a) **Decay and decomposition:** They act as scavengers removing harmful waste from the earth. The dead bodies and wastes of organisms (both plants and animals) are decomposed by the activities of the saprophytic bacteria.
  b) **Soil fertility:** In nature the presence of a regular supply of salts is ensured by bacteria of certain types. namely, ammonifying bacteria, nitrifying bacteria and nitrogen-fixing bacteria.
- **Role of Bacteria in Industries**
  a) Butter and cheese industries entirely depend upon the activities of the lactic acid bacteria.
  b) The souring and curding of milk by lactic acid bacteria is another common example of application in everyday life.
  c) The curing of tea, tobacco, Manufacturing of indigo.
  d) The process of tanning hides in leather making and preparing sponges also involve the use of bacteria.
  e) The production of linen is impossible without bacterial activity. The tough fibres, which are left behind, are separated. These fibres are spun and woven into linen cloth, ropes, etc.
  f) The preparation of coffee and cocoa is also dependent upon bacterial action. The cocoa beans are white in colour and quite bitter in taste. The bacteria digest the bitter coverings of seeds and give the characteristic colour, flavour and aroma.
  g) Retting of fibres, *Pseudomonas fluorescence*, *Clostridium*.

Many saprophytic bacteria in their metabolic activities excrete waste products of great commercial importance. Some of these are-

Lactic acid, useful in tanning industries.

Citric acid, used to give aroma and flavour to beverages, sweets and other foodstuffs.

Vitamins, Vitamin B is the product of fermentation of sugars and starch by *Clostridium acetobutilicum*. The vitamins are used in medicinal preparations.

Butyl alcohol: Butyl alcohol, acetone and ethyl alcohol are produced in one fermentation operation when a certain bacterium is allowed to act on cooked com starch. These products are important commercial solvents.

Acetone, important ingredient of explosives and is also used in the manufacture of photographic films.

- **Role of Bacteria in Medicine**
  a) **Source of Antibiotics:** The milder antibiotics of bacterial origin are tyrothricin, subtilin, polymyxin B, and bacitracin. *Bacillius subtilis* is the source of subtilin. Bacitracin is obtained from a stain very much like *B. subtilis*.
  b) The *actionomycetes* which are filamentous, bacteria-like organisms produce more powerful antibiotics such as streptomycin, aureomycin and terramycin.
- **Preparation of Serums and Vaccines**
  a) Diphtheria, lockjaw, pneumonia, etc. are the diseases in which the serums are effective. Vaccines are commonly used to make people immune to diseases like typhoid, small-pox, cholera, scarlet fever, etc.
  b) In the preparation of serums, small doses of bacterial toxins (poisons) are injected into the blood of animals such as horses. To combat or neutralize the bacterial poisons, the body of the animal produces antibodies.
- **Harmful Activities of Bacteria:**
  a) **Food Poisoning :** Some saprophytic bacteria produce powerful toxins such as ptomains in the food. Cause food poisoning which results in serious illness and even death.
  Clostridium botulinium, causes botulism—a fatal form of food-poisoning.

b) **Causes Disease:** The bacterial diseases of plants belong to the following categories:

Wilt diseases caused by blocking of the vessels of host plant by masses of bacteria. Example-the wilt diseases of potato, cucumber, water melon and eggplant.

Crown gall and Hairy root diseases. Overgrowth or hyperplasia. The crown gall of beets and hairy root of apple are the examples.

Narcotic blights leaf spots and rots caused by killing of parenchyma cells. Fire blight of apple, and pear and soft rot of carrot and turnip are the common examples.

c) **Denitrification:** Group of bacteria break down nitrates into nitrites and nitrites into ammonia compounds or to free nitrogen in the soil which reverse the nitrifying process. They injure the soil by causing the loss of a part of its combined nitrogen.

5.3. Mollicutes or Mycoplasma (PPLO) (Nocard and Roux):

Mycoplasma MLO (mycoplasma-like organisms in plants) or PPLO (pleuropneumonia like organisms in animals) were discovered by Nocard and Roux in pleural fluid of cattle having bovine pleuropneumonia. In 1898, Nocard and Roux were the first to isolate a mycoplasma species in culture from bovine; however, it was not until 1944 when *Mycoplasma pneumoniae*, known then as Eaton agent or Eaton's agent,[1] was isolated and described from a patient with primary a typical pneumonia.

- They are smallest 0.1-0.15 □m) free living gram negative,
- pleomorphic monerans.
- Cell wall is absent. They can survive without oxygen.
- DNA is linear but coiled.
- Mesosomes are absent. Electron transport system is rudimentary or absent.
- They live as saprophytes and parasites.
- They are facultative anaerobe.

Mycoplasma produces pneumonia and mycoplasmal urethritis in humans, pleuropneumonia in animals, little leaf disease in Brinjal, yellow in Aster, greening stubborn and witches broom in plants. They are not affected by penicillin (inhibitor of wall formation) but are inhibited by tetracyclines. Mycoplasma cells divide unevenly into very minute bodies known as minimal reproductive units. They are formed into mature cells and can pass through bacteria retaining filters.

5.4. Rickettsiae (Ricketts)

Gram negative, obligate, pleomorphic but walled intracellular parasites, which are transmissible from arthropods. They are intermediate between eubacteria and viruses. ATP synthesis is absent, but ADP is exchanged with host cell ATP. The natural habitat of rickettsiae is arthropod gut. In mammals and humans, they cause typhus group of fevers.

5.5. Cyanobacteria or Blue-Green Algae (BGA, Cyanophyceae, Myxophyceae)

Cyanobacteria or blue green algae are found in most of the environments— fresh water, sea water, salt marshes, moist rocks, tree trunks, moist soils, hot springs, frozen waters. Red sea is named after the colouration provided by red coloured planktonic cyanobacteria known as *Trichodesmium erythraeum*. It is a Photosynthetic organisms, Live under every type of environment and on every type of substrate, earliest colonizers of barren areas. Many of them have the ability of nitrogen fixation.

(1) **Characteristics of Cyanobacteria:** Cyanobacteria may be unicellular, colonial or filamentous. Each filament consists of a sheath of mucilage and one or more cellular strands called trichomes. Single trichome filaments may further be of two types, homocystous (= undifferentiated, e.g., Oscillatoria) and heterocystous (= differentiated, having heterocysts, e.g., Nostoc). Spirulina has a spirally coiled filament. Colonies develop in some cases, e.g., Nostoc. Flagella are absent but gliding movements are known in a number of cyanobacteria. The name Oscillatoria has been given to a common blue green alga on the basis of pendulum like oscillating movements of its anterior region.

- Prokaryotic cells , larger and more elaborate than bacteria.
- Cell structure is typically— one envelope organisation with peptidogly can wall, naked DNA, 70S ribosomes and absence of membrane bound structures like endoplasmic reticulum, mitochondria, Golgi bodies, plastids, lysosomes, sap vacuoles.
- Cell wall is four layered with peptidoglycan present in the second layer. The outer part of the protoplast contains a number of photosynthetic thylakoids. It is called chromoplasm.
- The thylakoids lie freely in the cytoplasm. Their membranes contain chlorophyll a, carotenes and xanthophyll's. Chlorophyll b is absent.
- Attached to the thylakoid membranes are small granules known as phycobilisomes. The latter possess accessory photosynthetic pigments known as phycobilins. The phycobilins are of three types— phycocyanin (blue), allophycocyanin (blue) and phycoerythrin (red).
- Differential formation of phycobilins produces specific colouration which is adapted to absorbing maximum amount of solar radiation. Therefore, cyanobacteria are not always blue green. They may appear purplish, violet, brownish, etc.
- Gas vacuoles or pseudo-vacuoles are found. Gas vacuoles provide buoyancy regulating mechanism and pneumatic strength.
- A naked, circular, double stranded DNA lies coiled generally in the central part of.

Heterocyst: It is a large-sized pale coloured thick-walled cell which occurs in terminal, intercalary or lateral position in filamentous cyanobacteria, e.g., Nostoc. The thick wall is impermeable to oxygen but permeable to nitrogen. Mucilage sheath is absent. Photosystem II is absent. Thylakoids lack phycobilisomes. Therefore, photosynthesis is absent but cyclic photophosphorylation occurs. Heterocyst is dependent for its nourishment on adjacent vegetative cells. It has enzyme nitrogenase. Heterocyst is specialised to perform nitrogen fixation.

(2) **Reproduction:** Cyanobacteria mostly multiply by asexual methods. The latter include binary fission, fragmentation with or without formation of small segments called hormogones (hormogonia), hormospores, akinetes, endospores, nanocytes, exospores, etc. Typical sexual reproduction involving formation and fusion of gametes is absent but like bacteria, gene recombination can occur by three types of parasexual methods— conjugation, transformation and transduction.

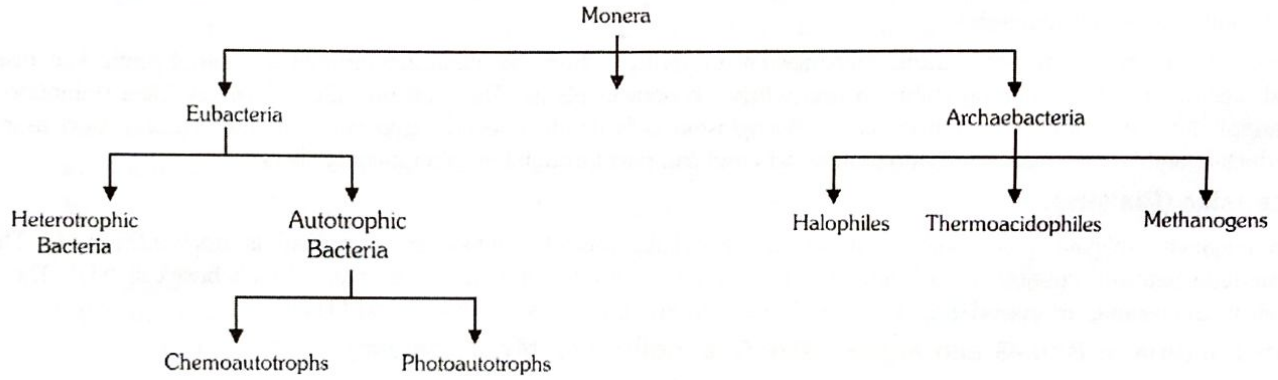
5.6. Actinomycetes (Mycobacteria)

They are mycelial bacteria (filamentous bacteria), which are called ray fungi /Mycobacteria. Actinomyces are decomposers and produce Maximum antibiotics. In pathogenic actinomycetes or *Mycobacterium* a derivative of mycolic acid called mycoside/cord factor causes disease.

(1) **Antibiotics :**Term antibiotic was given by Waksman, He defined antibiotic to be a substance produced by a micro-organism which is antagonistic to the growth of other micro-organism. Antibiotic means against life. Clinically antibiotics are organic products, which in low concentration are able to inhibit the metabolic activity of pathogens without harming host. In 1928, Fleming discovered first antibiotic penicillin from *penicillium notatum*. Waksman also extracted streptomycin from *Streptomyces griseus*.

Florey et, al (1939) discovered the chemotherapeutic value of chemical produced by *Penicillium notatum* and commercialized the product penicillin, which was first used clinically during the second world war. Maximum antibiotics are obtained from Streptomyces genus. A single species of Streptomyces (*S. griseus*) is known to form more than 40 antibiotics while more than 60 antibiotics have been isolated from *Bacillus subtilis* bacteria.

Remember this



6. Kingdom Protista

The Kingdom Protista (GK.*Protistos*= first of all) was proposed by Ernst Haeckel (1866). Although all single-celled eukaryotes are placed in kingdom Protista yet its boundaries are not well defined. Phylogenetically the kingdom Protista acts as a connecting link between the prokaryotic kingdom-Monera on one hand and the complex multicellular kingdoms- Fungi, Plantae, and Animalia on the other hand. Protists are regarded as ancestors of all multicellular eukaryotic organisms.

6.1. General Characteristic of Protista-

- They are simple eukaryotic organisms. Most of the organisms are unicellular, some are colonial and some are multicellular like algae
- Most of the protists live in water, some in moist soil or even, in the body of human and plants.
- These organisms are eukaryotic since they have a membrane-bound nucleus and endomembrane systems.
- They have mitochondria for cellular respiration and some have chloroplasts for photosynthesis.
- Nuclei of protists contain multiple DNA strands, the number of nucleotides is significantly less than complex eukaryotes.
- Movement is often by flagella or cilia.
- Protists are multicellular organisms, they are not a plant, animal or fungus.
  - (1) **Respiration** - cellular respiration is a primarily aerobic process, but some living in the mud below ponds or in digestive tracts of animals are strict facultative anaerobes.
  - (2) **Nutrition** - they can be both heterotrophic and autotrophic. Flagellates are filter feeding, some protists feed by the process of endocytosis (formation of food vacuole by engulfing a bacteria and extending their cell membrane).
  - (3) **Reproduction** - some species have a complex life cycle involving multiple organisms. Example: Plasmodium.
- Some reproduce sexually and others asexually. They can reproduce by mitosis and some are capable of meiosis for sexual reproduction.
- They form cysts in adverse conditions.
- Some protists are pathogens of both animals and plants. Example: Plasmodium falciparum causes malaria in humans.

6.2. Major groups of Protists-

The protists display great variation . some biologist group protist according to the kingdom of macroscopic organisms they most resemble, that is, plant-like, fungus-like or animal-like protists.

(1) **Photosynthetic Protists-(Protistan algae)**- They have plant-like features, such as contain chloroplasts, living in moist, sunny environments. Example- *dinoflagellates, diatoms*, and*Euglenoids.*

(2) **Consumer-Decomposers protists(slime moulds)**-They possess fungus-like features, such as saprotrophic nutrition, unicellular or multicellular structure. Example-Water moulds, Plasmodial, and cellular slime molds.

(3) **Protozoan protists**- They have animals-like features, such as heterotrophic nutrition, unicellular structure, generally free-living but some are parasitic. Example-*Sarcodines*, *apicomplexans*, and *ciliates.*

6.3. Photosynthetic Protists-(Protistan Algae)

They constitute the main portion of the *phytoplankton.* The Phytoplankton are the green photosynthetic organism which is passively drifted by the water current. they include *dinoflagellates, chrysophytes,* and *euglenoids.*

(1) **Dinoflagellates :** The dinoflagellates belongs to division pyrrophyta and class dinophyceae.

The dinoflagellates are an important component of phytoplankton. Most of them are marine but some occur in fresh water. Some dinoflagellates such as *Gymnodinium* and *Gonyaulax* grow in large number in the sea and make the water look red and cause the so-called "red tide". Some marine dinoflagellates show bioluminescence. It means they emit light, e.g., *Noctiluca, Gonyaulax, Pyrocystis, Pyrodinium.*

- **Characteristics**
  - Nutrition is photosynthetic.
  - Dinoflagellates are basically unicellular motile and biflagellate, golden brown, photosynthetic protists. Predominantcolour is golden brown but yellow, green, brown and even blue forms also occur due to change in proportion of various pigments. A few are non motile, non flagellate, amoeboid, and filamentous.
  - Cells are generally covered by a rigid coat the theca or lorica of articulated and sculptured plates of cellulose. Periplast may occur instead of theca. Because of the presence of sculptured plates, these protists are often known as **armoured dinoflagellates**.
  - Theca contains two grooves, the longitudinal groove called the sulcus and the circular groove known as the cingulum or annulus or girdle.
  - The two flagella are different (heterokont), one transverse flagellum and other longitudinal flagellum. The longitudinal flagellum is narrow, smooth, directed posteriorly and lies in the sulcus. The transverse flagellum is ribbon-like and lies in the cingulum or annulus. The two types of flagella beat in different directions. This causes spinning of dinoflagellates while swimming in water.
  - The nucleus is larger in size and has been named as mesokaryon by Dodge (1966). Chromosomes do not have histone or RNA.
  - Plastids or chromatophores have chlorophyll a and chlorophyll c, Mucilage bodies or vesicles occur below the cell membrane
  - A non-contractile vacuole called pusule is present near the flagellar base. Pusule may take part in floatation and osmoregulation. Contractile vacuoles are absent.
  - Varieties of *eye* spots occur in dinoflagellates. Some of them are like ocelli.
  - Trichocysts are found in a number of dinoflagellates. Nematocysts have also been reported in a few dinoflagellates.
  - Reserve food is stored in the form of starch and oils.

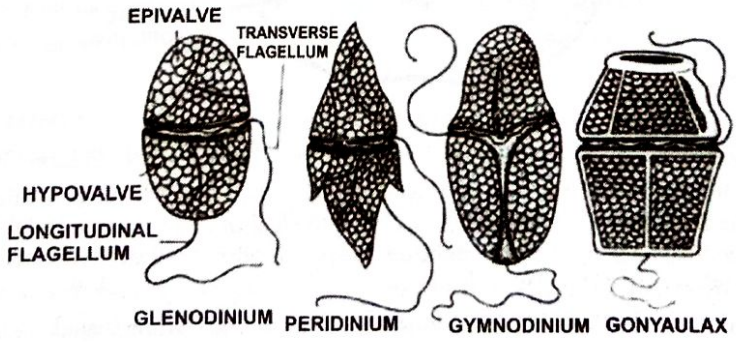


Fig. Some dinoflagellates Note the plates that surround the body and two flagella, one transverse in a groove and other free and logitudinal

- **Reproduction :**Asexual reproduction is commonly through cell division. Cysts occur in a number of dinoflagellates.

Sexual reproduction has been reported in some dinoflagellates (e.g., *Ceratium*). It is isogamous and anisogamous.

The life cycle involves zygotic meiosis in *Ceratium*, *Gymnodinium* and *Woloszynskia*. Gametic meiosis occurs in *Noctiluca.*

Examples: Glenodinium, Peridinium, Gymnodinium, Gonyaulax, Ceratium, Noctiluca.

- **Economic Importance of Dinoflagellates** :The main ecological significance of dinoflagellates lies elsewhere, though. They are second only to diatoms as marine primary producers. As zooxanthellae, dinoflagellates have a pivotal role in the biology of reef-building corals. As phagotrophic organisms they are also important components of the microbial loop in the oceans and help channel significant amounts of energy into planktonic food webs.

Ceratium

Heavy armoured dinoflagellate which occurs in marine, brackish and fresh waters. Sexual reproduction is anisogamous. Male gametes are small.

Cytoplasm possesses a large mesokaryotic nucleus and a number of scattered chromatophores.

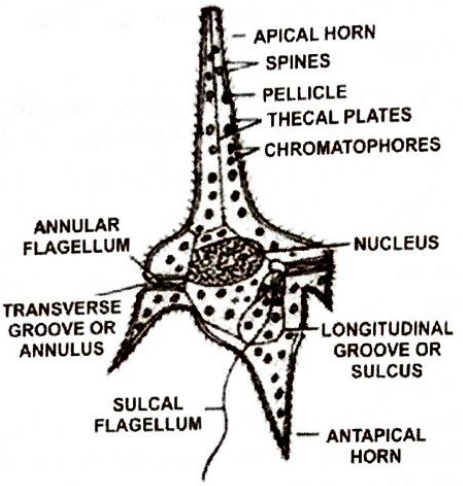


Fig. Ceratium

Noctiluca (The Night Light)

Colourless dinoflagellate, an important constituent of coastal plankton of both temperate and tropical seas.

Holozoic nutrition, Gametes are similar (isogametes).

It is famous for bioluminescence - first dinoflagellate where bioluminescence was reported.

Fragile long tentacle that functions as a flagellum, transverse flagellum is reduced into a tooth-like structure. and longitudinal flagellum is small

Sulcus is developed into an oral groove and a cytostome. Tentacle develops beneath the cytostome.

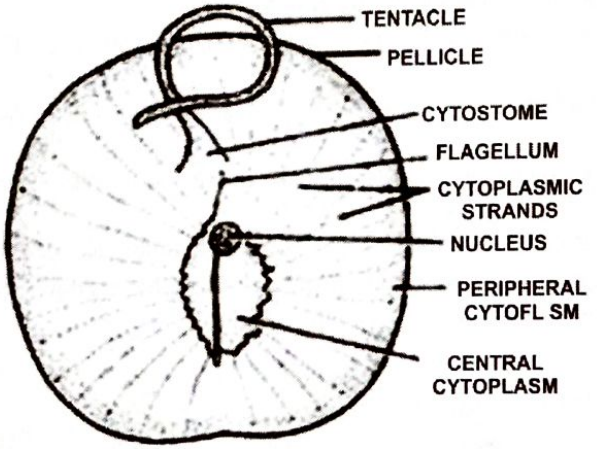


Fig. Noctiluca

(2) Chrysophytes :Chrysophytes includes diatoms and desmids. They belong to the division Chrysophyta/Bacillariophyta.

Diatoms: They occur in various habitats like fresh water, saline water and also in terrestrial condition on or within the soil. Sometimes they also occur as epiphytes along with algae, on the leaf of forest trees, mostly in tropical rain forests. Depending on the mode of nutrition they may be photosynthetic autotrophs or photosynthetic symbionts or heterotrophs.

- **Characteristics**
  - Most of the diatoms occur as phytoplanktons both in fresh and marine waters. A few forms occur as benthos at the bottom of water reservoirs.
  - Diatoms constitute a major part of phytoplankton of the oceans.
  - The cell wall is chiefly composed of cellulose impregnated with glass-like silica. It shows sculpturings and ornamentations. It is composed of two overlapping halves (or theca) that fit together like two parts of a soap box.
  - The upper half (lid) is called epitheca and the lower half(case) is called hypotheca.
  - They exhibit mainly two types of symmetry-radial symmetry as in centrales (e.g., *Cyclotella, Biddulphia, Triceratium*, *Melosira*) and isobilateral symmetry as in Pennales (e.g., *Pinnularia, Synedra, Actinella, Navicula*).
  - Each cell has a large central vacuole in which a prominent nucleus is suspended by means of cytoplasmic strands. The cells are diploid (2N). In case of centrales, the nucleus lies in the peripheral region.

- Raphe is a cleft in the valve which occur in diatoms performing gliding movement. Raphe is often longitudinal, sigmoid with central and polar nodules.
- Diatoms do not possess flagella except in the reproductive stage. They show gliding type of movement with the help of mucilage secretion. They float freely on the water surface due to presence of light weight lipids.
- Some species of diatoms are devoid of chromatophores, e.g., *Nitzschia alba*. They are saprotrophic in nutrition.
- The cells possess plate-like or discoid chromatophores (or chloroplasts). They contain chlorophyll a, and c, carotenes, diatoxanthin, diadinoxanthin and fucoxanthin (chl. b is absent).
- The reserve food material is oil and a polysaccharide – chrysolaminarin (or leucosin).
- Most common method of multiplication is binary fission(cell division) that occurs at night.
- Sexual reproduction takes place by the fusion of gametes. Meiosis is gametic i.e., takes place during the formation of gametes.
- The cells of diatoms are called frustules or shell. They are microscopic, unicellular, photosynthetic organisms of various colours and diverse forms.
- They may be circular, rectangular, triangular, elongated, spindle-shaped, half-moon shaped, boatshaped or filamentous. Incipient filament occur in Melosira.

  Examples : Triceratium, Pleurosigma, Navicula, Cymbella, Amphipleura, Nitzschia, Melosira, Pinnularia.

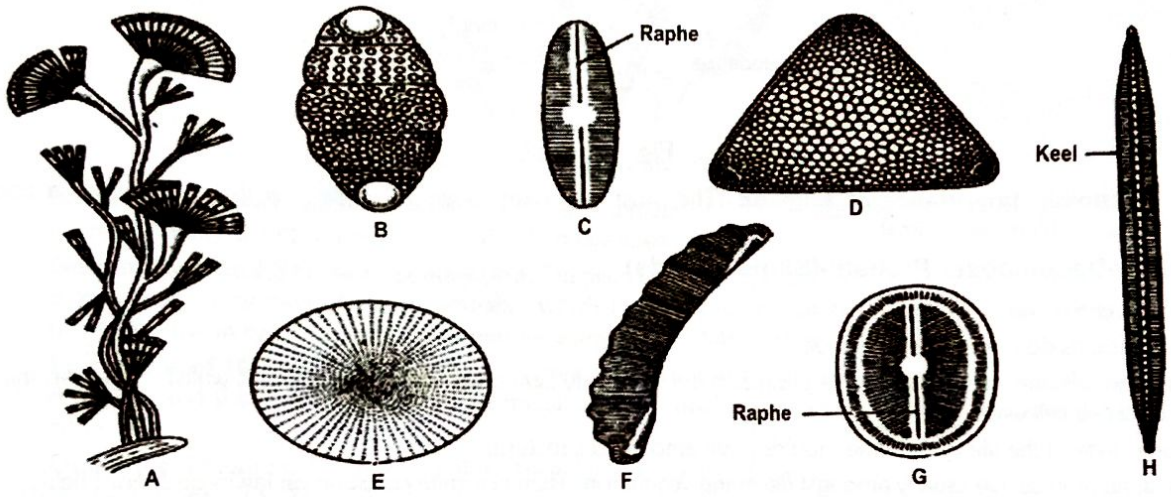


Fig. Different forms of Diatom: A. Licmophora flabellate, B. Biddulphia pulchella, C. Achnanthes linearis, and H. Bacillaria paradoxa

- **Economic Importance of Diatoms-**
  a) Diatoms are an important source of food to aquatic animals.
  b) Diatom deposits are often accompained by petroleum fields.
  c) Diatom is porous and chemically inert therefore used in filtration of sugar, alcohols and antibiotics.
  d) It is also employed as a cleansing agent in tooth pastes and metal polishes.
  e) It is also employed as insulation material in refrigerators, boilers and furnaces.

(3) Euglenoid

- **General characteristics:**
  - These protists are devoid of cellulose cell wall. The body is covered by thin and flexible pellicle. The pellicle has oblique but parallel stripes called myonemes. The pellicle is composed of fibrous elastic protein and small amount of lipid or carbohydrates. Example : *Euglena, Phacus, Eutreptia, Trachelomonas, Peranema*
  - Majority of them are fresh water organisms found in stagnant water.
  - Instead of a cell wall, they have a protein rich layer called pellicle which makes their body flexible.
  - They have two flagella, a short and a long one. The two flagella join with each other at a swelling called paraflagellar body. An orange redcoloured eye-spot or stigma is located at the base of flagellum attached to the membrane of reservoir at the level of paraflagellar body.
  - Both paraflagellar body; and eye spot act as photoreceptors and direct the organism towards the optimum light.
  - Though they are photosynthetic in the presence of sunlight, when deprived of sunlight they behave like heterotrophs by predating on other smaller organisms. Interestingly, the pigments of euglenoids are identical to those present in higher plants. Example: Euglena. They contain red pigment astaxanthin.
  - Product of photosynthesis is paramylon which is stored in the form of paramylum granules in the paramylum bodies in the cytoplasm

- Nutrition is holophytic (photoautotrophic), saprobic (e.g., Rhabdomonas) or holozoic (e.g., Peranema). Even holophytic forms can pick up organic compounds from the outside medium. Such a mode of nutrition is called mixotrophic.
- Euglena is a connecting link between animals and plants. Nutrition in Euglena is mixotrophic, when light is available it is photosynthetic, in darkness it is saprophytic absorbing food from surrounding water.
- These protists perennate during unfavorable periods as cysts

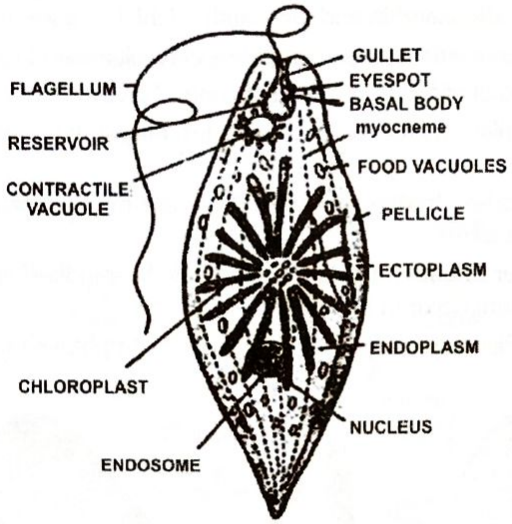


Fig. Euglena

- **Economic Importance of Euglena :**The most important aspect of euglena is that it serves as a connecting link between plant and animal.

6.4. Consumer-Decomposer Protists-(Slime Moulds)

- General characters:
- Slime moulds do not have chlorophyll.
- Slime moulds are surrounded by the plasma membrane only (somatic parts are without cell walls). However, the spores have the cellulose cell walls.
- At one stage of the life cycle Slime moulds have amoeboid structure.
- The slime moulds live usually amongst decaying vegetation. They are quite common on lawns and moist fields.
- Slime moulds exhibit wide range of colouration.
- Phagotrophic or Saprotrophic mode of nutrition. They resemble both protozoa and fungi, they are like protozoa in their amoeboid plasmodial stage and similar to fungi in spore formation.

Slime moulds are of two types-acellular and cellular.

(1) Acellular Slime Moulds (Plasmodial Slime Moulds) : These moulds are commonly found on dead and decaying leaves, twigs, logs of wood and the other decaying vegetable matter. A free living acellular slime moulds is called plasmodium. It is wall-less mass of multinucleate protoplasm covered by slime. It has saprotrophic Mode of nutrition It absorbs food from the decaying organic matter, also feeds on bacteria, protozoa, spores of fungi and other microorganisms through phagotrophic or holozoic nutrition. In Somatic Phase It is diploid multinucleate plasmodium

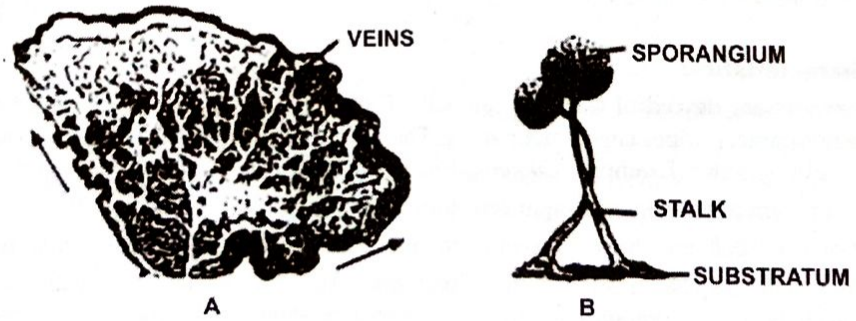


Fig. Physarum,
A. Plasmodium — advancing in the direction of the arrows,
B. Sporangia on stalks developed from the plasmodium

Plasmotomy: plasmodium (multinucleate) may undergo division to form two or more plasmodia.

Under un-favourable conditions the plasmodium divides to form two types of perennating structures, Cyst. and Sclerotium plasmodium secretes a thick covering around itself called sclerotium.

Sporangia: On maturity the contents of plasmodium concentrate at one or more places forming papilla like mounds that grow into sessile or stalked sporophores. Each sporophore bears sporangia ,Each sporangium is surrounded by a hard and brittle wall-like layer, the peridium.

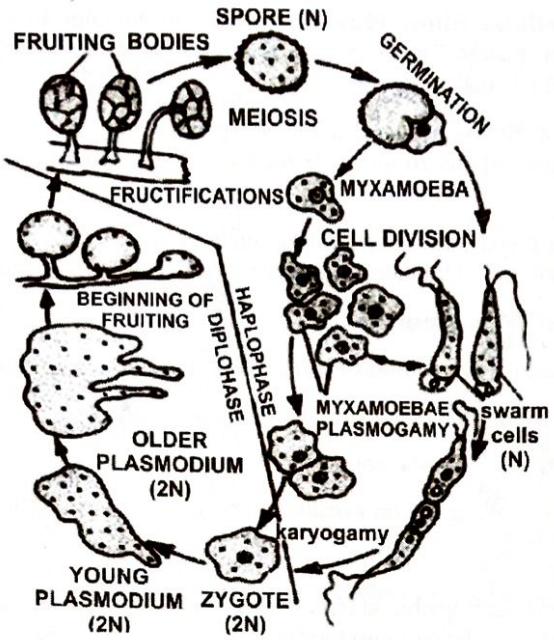


Fig. Life cycle of an acellular slime mould

Spores: The multinucleate protoplasm of the sporangium undergoes cleavage to form uninucleate tiny segments. This becomes rounded and secretes a cell wall to become spore.

Germination and Sexual Reproduction: On germination, a spore generally releases one biflagellate, spindle-shaped swarm cell or a non-flagellate myxamoeba, which in turn feeds on bacteria and yeasts and multiplies in number and ultimately fuse in pairs at the posterior non-flagellate ends to form zygote.

Formation of Plasmodium: The zygote grows in size and diploid nucleus of the zygote undergoes repeated mitotic divisions, and the zygote change into a multinucleate amoeboid structure, plasmodium, and it again repeats the life cycle.

Examples: Physarum, Physarella, Fuligo, Dictydium, Lycogala, Tubifera

(2) Cellular Slime Moulds (Acrasiomycetes): It occurs in all humus-containing damp soil. Somatic Phase is represented by haploid and uninucleate cells called myxamoebae.

Myxamoebae: is a uninucleate, haploid and amoeba-like cells, without cell wall, covered by plasma membrane. Nutrition is phagotrophic or holotrophic nutrition. Under un-favourable conditions, a myxamoeba secretes a rigid cellulose wall to form the micro cyst.

Life Cycle-Pseudo plasmodium: When food is deficient the amoeboid cells get aggregated without any fusion. The stimulus for the aggregation process is due to release of cyclic adenosine monophosphate (cyclic AMP) from the amoeboid cells. This aggregated mass of cells is called pseudo plasmodium. Due to this, cellular slime moulds are called the communal slime moulds. Pseudo plasmodium exhibits a primitive form of multi cellularity, where cells maintain their identity but can live together. They show division of labour as some cells form fruiting body (sporangium) while others form spores. And due to this reason the cellular slime moulds are regarded as advanced protists or primitive fungi. Sporangium-The aggregated cells of pseudo-plasmodium form a stalked sporocarp. The sporocarp bears a sporangium at its terminal end.

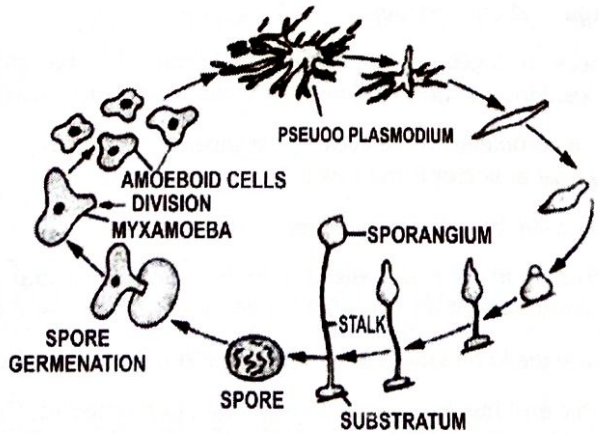


Fig. Life cycle of cellular slime mould

Spores: The cells present inside the sporangium become rounded and are surrounded by the cellulose wall to form the spores. Each spore is an ovoid, haploid, uninucleate mass of protoplast covered by a cellulose cell wall. The spore germinates to produce a single naked amoeba like cell called myxamoeba.

Sexual Reproduction in Cellular Slime Moulds: Sexual reproduction in cellular slime moulds is controversial. In this process, the myxamoebae form clusters. The central myxamoeba of the cluster engulfs a surrounding myxamoeba to become larger structure which forms a thick wall to form the zygote.

This zygote is called macro cyst. Kayos-gamy occurs inside the macro cyst which is followed by meiotic and several mitotic divisions, ultimately the macro cyst wall ruptures to release a number of haploid myxamoebae. Examples-Dictyostelium, Polysphondylium.

The cellular slime moulds have the characters of both plants and animals. The reproductive phase is plant-like as the spores have a cell wall composed of cellulose. However, vegetative phase is animal like having no cell wall and feeding like amoeba.

- **Economic Importance of Slime moulds**

  a) The slime moulds cause the decay and decomposition of the organic matter in the soil.

  b) They creep over the ornamental plants and make them look ugly.

  c) Their attractive colours are of artistic value.

  d) The Plasmodia of slime moulds are an excellent material for the study of structure and physiology of protoplasm.

6.5. Protozoans

Protozoans were first studied by Leeuwenhoek(1677). The name protozoa wascoined by Goldfuss. On the basis of locomotaryorganelles , the protozoans are divided into four groups.

(1) Flagellated Protozoans (Mastigophora)

- They possess flagella for locomotion.
- They may be Free living, aquatic, parasitic, commensals or symbionts.
- Zooflagellates are generally uninucleate, occasionally multinucleate.
- Body is covered by firm pellicle
- Nutrition is holozoic, saprobic and parasitic
- Asexual reproduction is by binary fission and sexual reproduction recorded in some forms only.

  Example: trichonympha, lophomonas,Giardia, Trypanosoma, Leishmania and Trichomonas.

  *Trypanosoma*and *lophomonas,* are cellulose digesting symbionts in the body of termites and wood roachesresp. others are parasites in human beings.

  Trypanosoma Gambiense

- The parasite of sleeping sickness. It was first observed by Forde in 1901. Fruce discovered that the parasite of sleeping sickness is transmitted by tsetse fly. It causes Gambian sleeping sickness. The disease, also called Gambian trypanosomiasis, is found in western and central parts of Africa.
- The parasite is transmitted by blood sucking tse-tse fly, Glossina palpalis. The reserve host is antelope. The parasite does not affect antelope and the fly. Mouth and contractile vacuole are absent. Food is absorbed through the body surface. In human beings the parasite lives in the blood plasma. Later the parasite enters cerebrospinal fluid and damages the brain. It makes the patient lethargic and unconscious.
- Trypanosoma has a nucleus, a flagellum, undulating membrane, blepharoplast (basal granule) and kinetoplast. The flagellum arises from the posterior end and runs anteriorly with undulating membrane.
- Trypanosoma is digenetic, it completes its life cycle in two hosts. The primary or principal or definite host is man and the intermediate or secondary host or vector is the insect, tse-tse fly or bug.
- Trypanosoma is an endoparasite, blood parasite, extra cellular parasite.
- T. rhodesiensi causes Rhodesian trypanosomiasis, it is confined to east central parts of Africa, particularly Rhodesia. The insect vectors for T. rhodesiense are tse-tse flies mainly Glossina morsitans and G. pallidipes.
- Trypanosoma reproduces asexually by longitudinal binary fission. It does not form cysts.
- Trypanosoma is polymorphic and has four forms: Leishmania, Leptomonad, Crithidial and Trypanosomal (=Metacyclic) stages.

- T. cruzi is the causative agent of South American trypanosomiasis or Chaga's disease T. cruzi is transmitted by bugs like Triatoma and Panstrongylus. Symptoms of Chaga's disease are fever, diarrhoea, anaemia and enlargement of lymphoid glands etc.

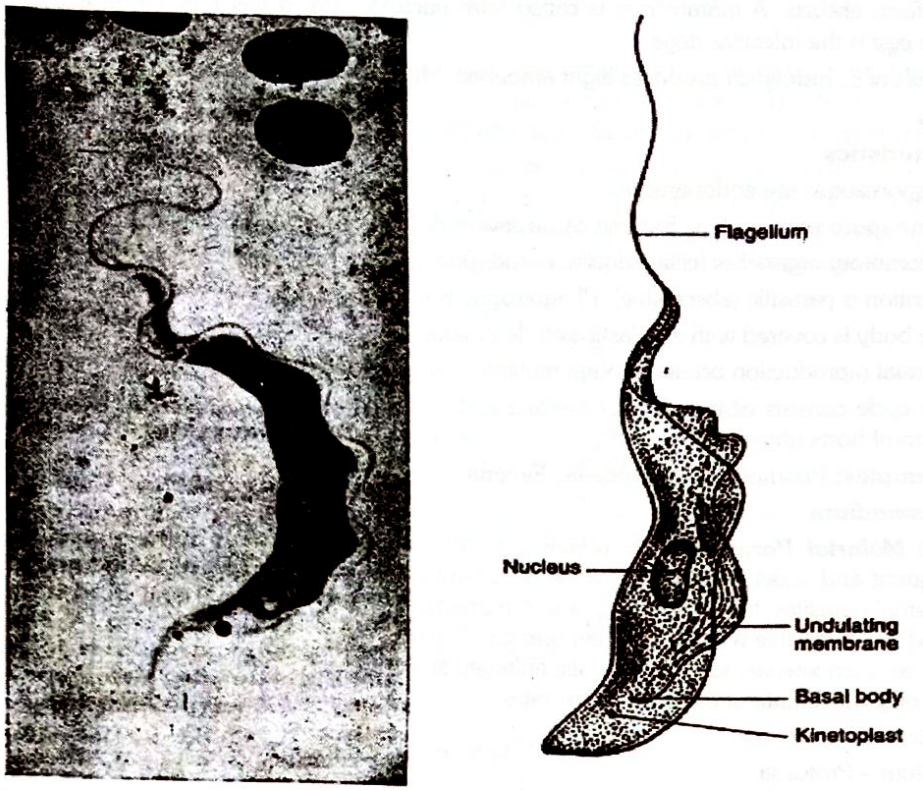


Fig. Trypanosoma gambiense. It causes African sleeping sickness in man. Photograph is of a related species, T. Avium.

Giardia Lamblia:

It is also known as Giardia intestinalis and it lives as parasite in the intestine of man and causes a disease called giardiasis.

(2) Amoeboid Protozoans (Sarcodina)

- They develop pseudopodia which are temporary protoplasmic outgrowth.
- Free living, found in fresh water, sea water and on damp soil, only few are parasitic.
- Nutrition holozoic.
- Sarcodines generally uninucleated, binucleated (arcella) and multi nucleated (pelomyxa)
- Asexual reproduction by binary fission, multiple fission, budding and spores.
- Sexual reproduction occur through syngamy.

Amoeba Proteus-The Proteus Animalcule:

- Amoeba was discovered by Russel von Rosenhoff in 1755. H.I. Hirschfied (1962) has given a detailed account of the biology of Amoeba, found in fresh water.
- Types of pseudopodia are lobo podia.
- Contractile vacuole is for osmoregulation.
- Mitochondria are often seen aggregated around the contractile vacuole of Amoeba. Cytoplasm is differentiated into endosperm and ectoplasm.
- Endoplasm is further differentiated into plasmagel and plasmasol.
- The body is covered by plasma lemma.
- Nutrition is holozoic, Sexual reproduction unknown
- **Economic importance of amoeba-**
  a) It has importance in medical and in nutrient recycling.
  b) Various amoeba species sometimes cause illness and death, but others are critical in maintaining healthy ecosystems. Amoebas are predators of the microscopic world, keeping the populations of bacteria in check.
  c) They are necessary for a healthy ecosystem and for preserving the food chain, and removing them is likely to cause large-scale, cascading economic hardship by harming both.

Entamoeba Histolytica:

- Lamble discovered Entamoeba histolytica in (1859). Entamoeba histolytica has mono-genetic life cycle.(single host life cycle). It resides in the upper part of the human large intestine amoebiasis is caused by Entamoeba histolytica.
- The parasite has generally one pseudopodium. Contractile vacuole is absent as there is no need of osmoregulation. It feeds on red blood corpuscles by damaging the wall of large intestine and reaching the blood capillaries.

- The parasite can also reach other body organs. Multiplication is by binary fission. Entamoeba histolytica has two forms, magna (trophozoite) — pathogenic form found in the mucosa and sub mucosa of intestine forming ulcers and minuta— non-pathogenic form found in the lumen of the intestine.
- Minuta form encysts. A mature cyst is called tetra-nucleate cyst. It has four nuclei and two chromatoid bodies. Tetra nucleate cyst is the infective stage.
- Single cyst of E. histolytica produces eight amoebae. Most effective medicine for amoebiasis is Metrogyl or Flagyl.

(3) Sporozoans

- **Characteristics**
  - All sporozoans are endoparasites.
  - Some sporozoans such as Eimeria cause severe diseases like coccidiosis in the birds,
  - Locomotory organelles (cilia, flagella, pseudopodia, etc.) are absent.
  - Nutrition is parasitic (absorptive). Phagotrophy is rare.
  - The body is covered with an elastic pellicle or cuticle, contractile vacuoles are absent.
  - Asexual reproduction occurs through multiple fission, sexual reproduction takes place through syngamy.
  - Life cycle consists of two distinct asexual and sexual phases. They may be passed in one (monogenetic) or two different hosts (digenetic).

Examples: Plasmodium, Monocystis, Eimeria.

Plasmodium

The Malarial Parasite: *Plasmodium* is a protozoal parasite and a human pathogen. This parasite is the most frequent and widely distributed cause of recurring (Benign tertian) malaria, *P. vivax* is one of the five species of malaria parasites that commonly infect humans. Although it is less virulent than *Plasmodium falciparum*, the deadliest of the five human malaria parasites, *P. vivax* malaria infections can lead to severe disease and death, often due to splenomegaly (a pathologically enlarged spleen).*P. vivax* is carried by the female *Anopheles* mosquito, since it is only the female of the species that bites.

Systematic position

Phylum – Protozoa

Sub-phylum – Plasmodroma

Class – Sporozoa

Sub-class – Telosporidia

Order – Haemosporidia

Genus – Plasmodium

species – vivax

The term malaria was coined by Mucculoch in1827.

Lancisi first suspected a relationship between malaria and mosquito.

Laveran (1880) discovered that malaria is caused by a protozoan parasite, Plasmodium vivax.

Sir Ronald Ross was (1896) the first to observe oocytes of Plasmodium in female Anopheles..

Grassi and Feletti (1898) was the first to describe the life cycle of Plasmodium in Anopheles.

Golgi (1885) Studied erythrocytic cycle of plasmodium.

Host : It is digenetic i.e., life cycle is completed in two hosts

(1) Man (medically primary but biologically secondary host)

(2) Female Anopheles (medically secondary but biologically primary host).

Asexual cycle in man-Trophozoite phase of plasmodium occurs in RBCs of human beings. The parasite first invades the liver cells for asexual multiplication.

Exoerythrocytic cycle-When an Anopheles mosquito bites a human to suck blood. Plasmodium is inoculated into human blood in the form of Sporozoites .The injected sporozoites invade the hepatocyte cells in the liver. In the liver cell, a sporozoite actively feeds on its cytoplasm and grows into a large (about 45 in diameter) and spherical adult like form called cryptozoite.

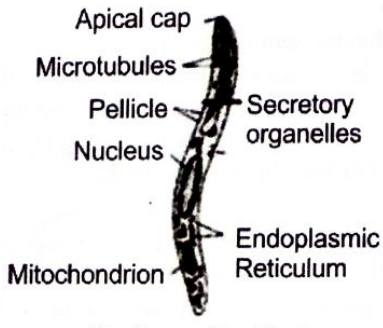


Fig. Sporozoite of P. vivax

This form multiply into thousands of cryptomerozoites by multiple fission called schizogony (exoerythrocytic schizogony). Due to the pressure of cryptomerozoites, the body of cryptozoites as well as the host liver cell ruptures liberating the cryptomerozoites into liver sinusoids. Some of these invade fresh liver cells to continue exo-erythrocytic schizogony, while others remain in blood stream and invade erythrocytes (RBC) to initiate erythrocytic cycle.

Erythrocyic cycle- After the RBCs are invaded by cryptomeromerozoites it soon becomes a rounded, disc like structure called trophozoites. As it grows, a contractile vacuole appears in its centre, pushing the cytoplasm and nucleus to a thin peripheral layer and the parasite attains a ring like appearance to represent the signet ring stage.

After some time, the vacuole disappears and the parasite assumes an amoeboid shape. The trophzoites actively feed upon the haemoglobin of RBCs and increases in size till the entire corpuscle gets filled with it. This forms the schizont stage and its cytoplasm contain yellowish-brown pigment granules, the haemozoin. It is formed by the decomposition of haemoglobin. The schizont undergoes asexual multiplication termed as schizogony or merogony.

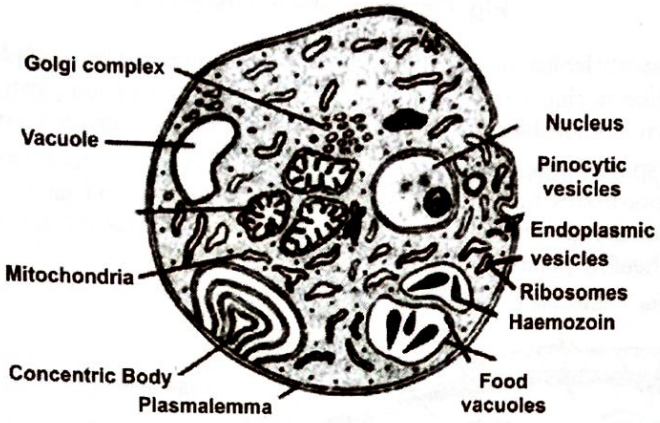


Fig. Trophozoite of P. vivax

Schizogony or merogony- The nucleus or the schizont divides by multiple fission to from 6-24 daughter nuclei which migrate towards the periphery. After some time the totally exhausted erythrocyte bursts liberating the **merozoites** and the toxic waste (haemozoin granules) into the plasma of blood. These attack the fresh R.B. Cs. And repeat the erythrocytic schozogony. One erythrocytic cycle is completed within 48-72 hours.

As the parasite continues to destroy the R.B.Cs. of the host, the host becomes anemic and its toxin accumulates in the plasma. After about 5 successive erythrocytic cycles the malarial symptoms develop for the first time and the host suffers from paroxysm of chill and fever which are now repeated at the end of each schizogony. Thus the parasite passes a latent period of about 10 to 15 days since its inoculation in the body of host. This period is known as incubation period.

Formation of gametocytes-As a result of repeated schizogony in the blood stream, the parasite becomes so potential that its existence is threatened due to lack of fresh R.B.Cs. and the resistance of the host. Consequently, the parasite prepares to enter the new host by the formation of gametocytes. Some of the meozoites, after entering the R.B.Cs. neither form trophozoites nor multiply by binary fission but grow slowly and become compact bodies, the gametocytes. These are of two types: Numerous, but small in size and with a large centrally placed nucleus, are the microgametocytes, potentially male. Less numerous but larger in size and with a greater amount of dense cytoplasm and a small nucleus are the macro or mega gametocytes, potentially female. The mature gametocytes are unable to develop further in the body of primary host and can survive only for two days. They reach the superficial blood vessels and wait for the bite of female Anopheles.

Sexual Life-Cycle in Anopheles- When Anopheles sucks the blood of a diseased man, the parasite under different stages of development enters its alimentary canal. But only the gametocytes are able to survive, while others are digested. The gametocytes are set free by the rupture of R.B.Cs. and develop further to form gametes.

Development of male gametes-The nucleus of microgametocyte divides repeatedly to form 6 to 8 haploid nuclei, as one of these divisions is a reduction division. Each nucleus is surrounded by a little of cytoplasm and metamorphoses into a male gamete. Each has a small body with a nucleus and a cytoplasmic flagellum. By the lashing movement of their flagella the male gametes swim in the stomach fluid.

Development of female gametes or microgamete's-The nucleus of the macrogametocyte undergoes reduction divisions forming two nuclei. One of them protrudes out as a polar body and the other comes to lie in a protuberance which is known as reception cone. Thus the microgamete is formed.

Fertilization (Syngamy) -The actively moving male gamete is attracted by the macrogamete and penetrates it through the reception cone. The nuclei of the two fuses together forming the synkaryon. Syngamy is anisogamous and the zygote thus formed is inert and round

Ookinete- Soon the rounded zygote elongates and assumes the vermiform appearance and becomes motile. It is now known as vermicule or ookinete. Its anterior end is pointed and with this it penetrates the stomach wall to come to lie in the sub-epithelial tissue underneath the outer limiting membrane. It becomes rounded, secretes a thin membranous cyst and is known as sporont or **oocysty**. It feeds by absorption and increases in size.

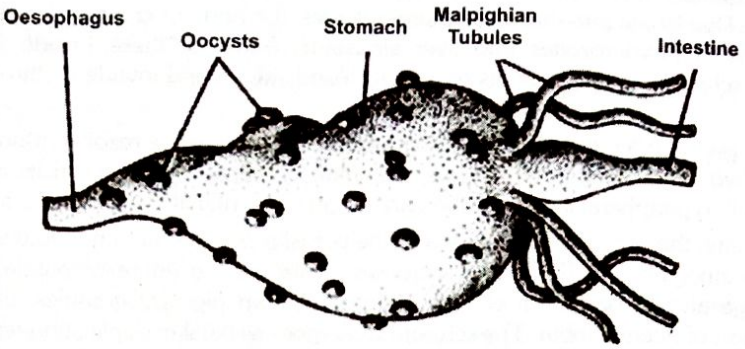


Fig. Oocyst in infected mosquito

Sporogony- The nucleolus of the fully mature oocyst undergoes multiple fission by mitosis producing a large number of daughter nuclei. These get surrounded by fragments of cytoplasm. The irregular uni-nucleate bodies thus formed are known as sporoblasts. The nucleus in each sporoblast divides repeatedly by mitosis.

The nuclei form spindle-shaped sporozoites. These are liberated in the haemocoel or body cavity by the rupture of cyst wall. The sporozoites now move to different body organs and also the salivary gland. With the entrance of parasite in the salivary glands the female Anopheles becomes infective and is able to inoculate the parasite into the blood-stream of healthy persons.

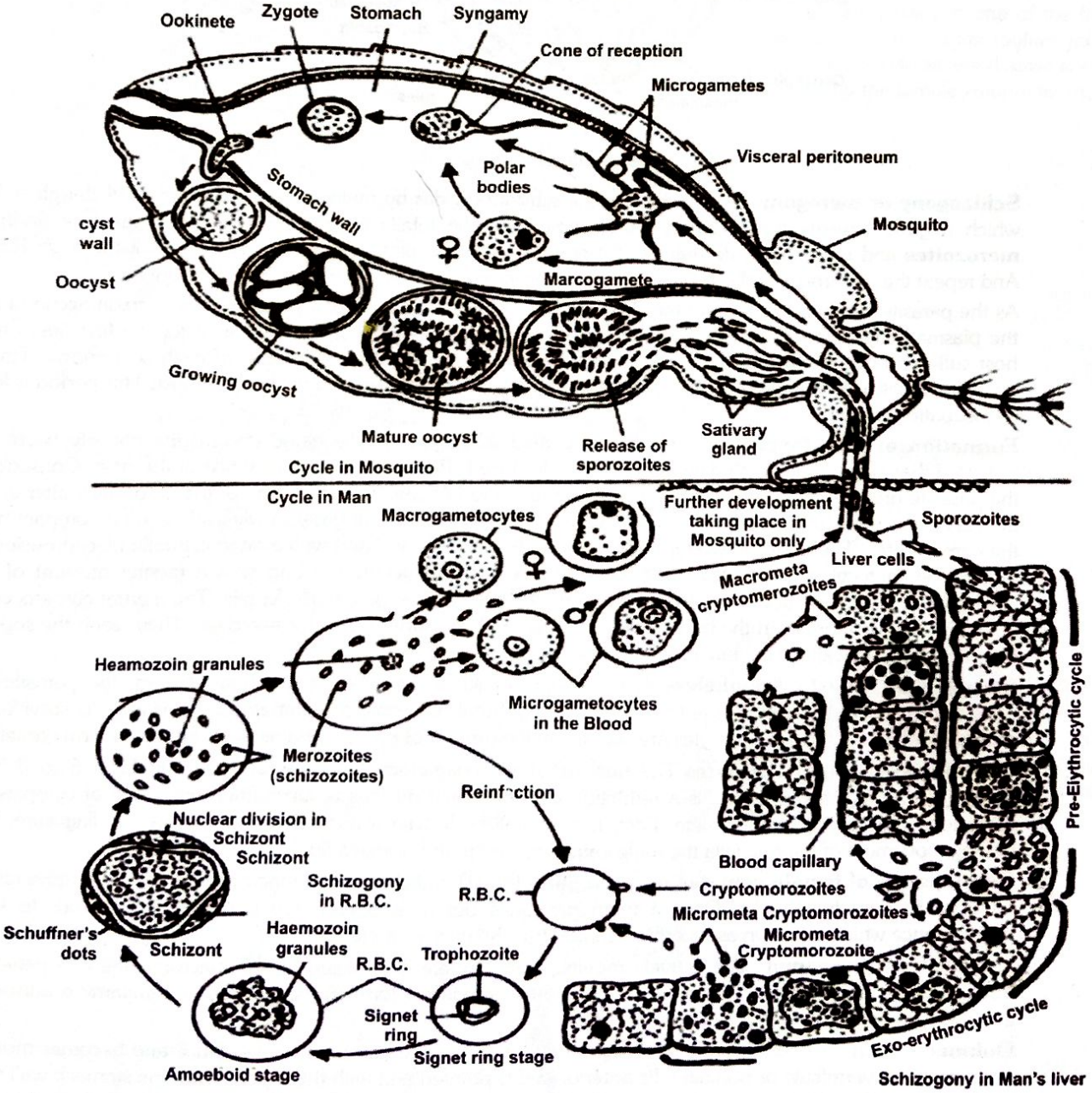


Fig. Life cycle of P. vivax

Control of Malaria

Elimination or destruction of vector, i.e., Anopheles mosquito.

Spraying of DDT, BHC and other insecticides in the house to kill the mosquitoes. Fumigation in the dwelling places.

Use of mosquito nets and repellents to avoid mosquito bites

Prophylaxis, i.e., prevention of infection.

Kerosene and pyrethrum oil are sprayed on the stagnant waters like sewage gutters and ditches were the mosquitoes lay their eggs.

The oil film on the water surface affects the respiration of the larvae and the larvae die of suffocation.

Biological control is one of the most effective methods of destructing the mosquito larvae. Use of larvivorous fishes like Gambusia is one such biological method.

(4) Ciliated protozoans

- Ciliates are protozoan protists which develop a number of cilia during a part or whole of the life cycle.
- Cilia are used for locomotion and driving food.
- There is a high degree of morphological and physiological specialization.
- Most ciliates are free living individuals in fresh and marine waters. A few are parasites.
- The body is covered by a pellicle.
- Nutrition is holozoic except in the parasitic forms.
- There have definite regions for ingestion and egestion. The region of ingestion consists of an oral groove, cytostome (mouth) and gullet.
- Ciliates show nuclear dimorphism or two types of nuclei, larger macronucleus (mega nucleus) and smaller micronucleus. Macronucleus controls metabolic activities and growth. It is also called vegetative nucleus. Micronucleus takes part in reproduction. Hence, it is termed as reproductive nucleus.
- Ciliates often possess minute ejectable trichocysts for defence.
- They have contractile vacuoles for osmoregulation.
- Asexual reproduction takes place by transverse binary fission or budding. Cyst formation occurs under un-favourable conditions.
- Sexual reproduction is by means of conjugation.

Examples Paramecium, Balantidium coli

Paramecium:

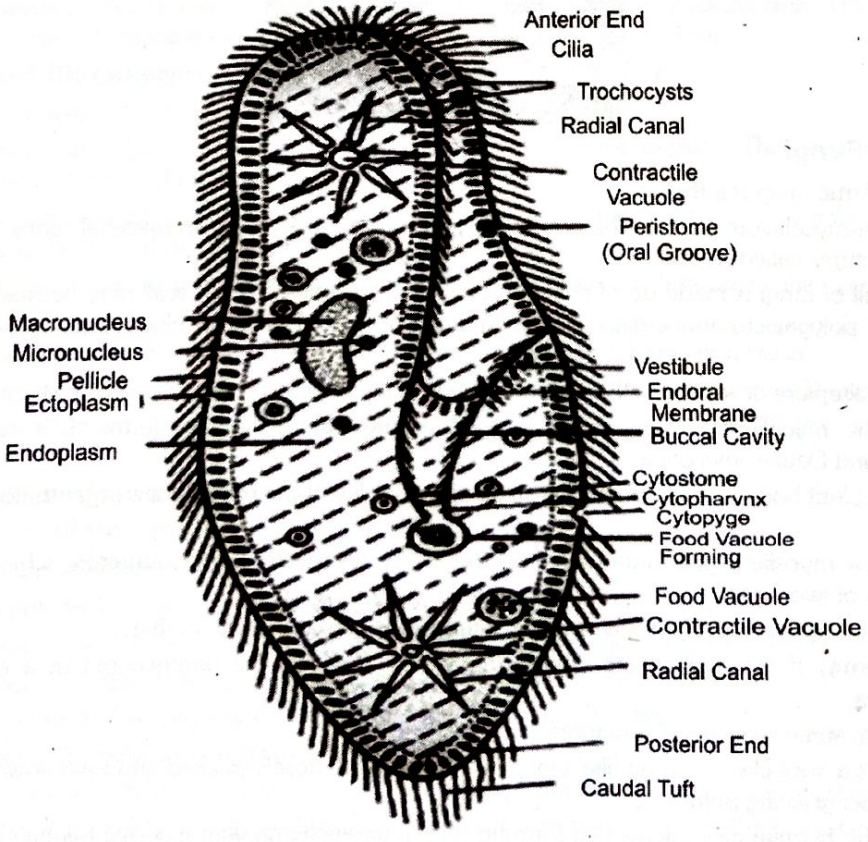


Fig. Paramecium caudaturm

The Slipper Organism or Slipper Animalcule. Paramecium is a free-living ciliate which is found in fresh water. Most widely distributed species are *Paramecium caudatum* and *Paramecium aurelia*. Nutrition is microphageal. Bacteria are its chief food. Paramecium is a surface feeder. Pellicle helps in maintaining the shape.

The cilia of the extreme posterior end are longer and form a bunch called caudal tuft. The discharged trichocysts serve for anchoring or defence or it may be a reaction to injury. Feeding Apparatus consists of peristome (oral groove), vestibule, buccal cavity, cytostome (cell mouth) and cytopharynx.

The latter opens into the endoplasm. A temporary opening, called cytopyge (cytoproct or cell anus), is present a little behind the cytostome. Undigested food is passed out through cytopyge. *Paramecium caudatum* contains a single large macronucleus and one small micronucleus. *Paramecium aurelia* has one macronucleus and two micronuclei.

Paramecium contains two contractile vacuoles surrounded by 5 to 12 radial (feeding) canals. The contractile vacuoles and radial canals are for osmoregulation. Several non-con-tractile food vacuoles (gastrioles) are seen moving along definite course (cyclosis) within the streaming endoplasm. The food vacuoles are meant for intracellular digestion.

Both asexual and sexual reproductions are found in Paramecium.

Asexual reproduction occurs through transverse binary fission. Various methods of sexual reproduction in Paramecium are conjugation, autogamy — it corresponds to self-fertilization, endomixis — it corresponds to parthenogenesis, cytogamy — it shows the characters of both conjugation and autogamy, and hemixis – only the macronucleus takes part in hemixis.

In hemixis the macronucleus first breaks into a few irregular pieces; later some pieces reunite to form the macronucleus. Remaining pieces disintegrate in the endoplasm. Thus hemixis is called Purification Act.

7. Kingdom Fungi

Fungus (pl. fungi) is a Latin word which means mushrooms. Fungi are nucleated, non-green, spore bearing, thallophytes, achlorophyllous organisms which have sexual and asexual mode of reproduction, and whose usually filamentous branched somatic structures are typically surrounded by cell walls containing cellulose or chitin, or both.

Examples of fungi are the yeasts, molds, mushrooms, polypore's, puff balls, rusts and smuts.

Study of fungi is known as mycology, the scientist researching on fungi is known as mycologist.

7.1. Characteristics of Fungi

- The plant body of true fungi is a thallus.
- Fungi may be non-mycelialormycelial. The non-mycelial forms are unicellular. In mycelial forms, the plant body is made up of thread like structures called hyphae.
- Mainly the cell wall of fungi is made up of chitin and cellulose. Besides, the cell wall may be made up of cellulose-glycogen, cellulose-chitin or polygalactosamine-galactan, chitin is a polymer of N-acetyl glucosamine, the celulose is polymer of d-glucose.
- Mycelium may be aseptate or septate. When non-septate and multinucleate, the mycelium is described as coenocytic.
- In lower fungi the mycelium is non-septate *e.g.*, Phycomycetae. In higher forms it is septate *e.g.*, Ascomycotina, Basidiomycotina and Deuteromycotina.
- In some forms the plant body is unicelled at one stage and mycelial at the other. Their organization is sometimes described as dimorphic.
- In higher forms the mycelium gets organised into loosely or compactly woven structure which looks like a tissue called plectenchyma. It is of two types:
- **Prosenchyma:** It comprises loosely woven hyphae lying almost parallel to each other.
- **Pseudoparenchyma:** If the hyphae are closely interwoven, looking like parenchyma in a cross-section, it is called as pseudoparenchyma.
- Mycelium may form some specialized structures –
- **Rhizomorphs:** It's a 'root-like' or 'string-like' elongated structure of closely packed and interwoven hyphae. The rhizomorphs may have a compact growing point.
- **Sclerotia:** Here the hyphae gets interwoven forming pseudoparenchyma with external hyphae becoming thickened to save the inner ones from desiccation.
- **Stroma:** It is thick mattress of compact hyphae associated with the fruiting bodies.

7.2. Nutrition

As being achlorophyllous fungi, cannot prepare their food. They live as heterotrophs *i.e.*, as parasites and saprophytes. Sometimes symbiotically with other green forms.

(1) **Parasites**-Obtain their food from a living hosts. On the basis of their place of occurrence on the host, the parasites can be classified as ectoparasite, endoparasite and hemiendoparasite (or hemiectoparasite).

(2) **Saprophytes**-Obtain their food from dead and decaying organic matter. The saprophytes may be obligate or facultative. An obligate saprophyte remains saprophytic throughout its life. On the other hand, a facultative saprophyte is infact a parasite which has secondarily become saprophytic.

(3) **Symbionts:** Some fungal forms grow in symbiotic association with the green or blue-green algae and constitute the lichen. Here the algal component is photosynthetic and the fungal is reproductive. A few fungal forms grow in association with the roots of higher plants. This association is called as mycorrhiza. They are two types – Ectotrophic mycorrhiza and Endotrophic mycorrhiza *e.g.*, (VAM).

7.3. Reproduction

The fungi may reproduce vegetatively, asexually as well as sexually:

(1) Vegetative Reproduction

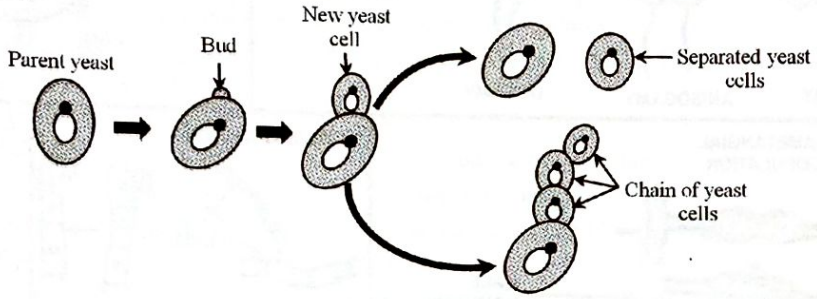


Fig. Budding in yeast

- **Budding:** Some unicelled forms multiply by budding. A bud arises as a papilla on the parent cell and then after its enlargement separates into a completely independent entity.
- **Fragmentation:** Some forms belonging to Ascomycotina and Basidiomycotina multiply by breakage of the mycelium.
- **Fission:** A few unicelled forms like yeasts and slime molds multiply by this process.
- **Oidia:** In some mycelial forms the thallus breaks into its component cells. Each cell then rounds up into a structure called oidium (pl. oidia). They may germinate immediately to form the new mycelium.
- **Chlamydospores :** Some fungi produce chlamydospores which are thick walled cells. They are intercalary in position. They are capable of forming a new plant on approach of favourable conditions.
- **Sclerotia and Rhizomorphs also helps in vegetative reproduction.**

(2) Asexual reproduction

- **Sporangiospores:** Thin-walled, non-motile spores formed in a sporangium. They may be uni-or multinucleate. On account of their structure, they are also called as aplanospores.
- **Zoospores:** Thin-walled, motile spores formed in a zoosporangium. Example: In Pilobulus a sticky mass containing many spores is discharged as a single unit.
- **Conidia:** In this fungi the spores are born freely on the tips of special branches called conidiophores. Spores thus are called as conidia.
- **Chlamydospores , Ascospores Basidiospores helps in Asexual reproduction.**

(3) Sexual reproduction :Sexual reproduction is found in all groups of fungi. except in Deuteromycotina., During sexual reproduction the compatible nuclei show a specific behaviour which is responsible for the onset of three distinct mycelial phases-which are

Plasmogamy :Fusion of two protoplasts.

Karyogamy :Fusion of two nuclei.

Meiosis :The reduction division.

These three acts give rise to three mycelial phases-

Haplophase :As a result of meiosis the haploid (n) or haplophase mycelium is formed.

Dikaryotic phase :The plasmogamy results in the formation of dikaryotic mycelium ($n + n$).

Diplophase :As a result of karyogamy the diplophase mycelium ($2n$) is formed.

Sexual reproduction occurs by five methods

- **Planogametic copulation**: In lower fungi, sexual reproduction takes place by fusion of male and female gametes. The male and female gametes may be morphologically similar (isogamy) or dissimilar (anisogamy). One or both gametes may be motile or non-motile (aplanogamy).

- **Gametangial contact**: The male(antheridia) and female (oogonia) gametangia come in contact and a pore is produced at the point of contact. The male gametes (nuclei) pass through the pore into the female gametangium where they fertilize the eggs or oospheres to produce diploid oospores. Occurs in Phycomycetes, Saprolegnia.
- **Gametangial copulation**: Male and female gametangia come in contact and the entire gametangia fuse with other, produces a zygospore. Occurs in zygomycetes, such as Mucor.
- **Spermatogamy**: The uninucleate non-motile spermatia are passively transferred by insects to the receptive female hyphae leading to plasmogamy. The male nucleus passes into the female receptive hypha and fuse with a female nucleus. It occurs in basidiomycetes, such as the rust-fungus Puccinia.
- **Somatogamy**: Specialized Sex organs are totally absent, male and female nuclei are brought together by fusion of vegetative hyphae. It occurs in higher basidiomycetes, like mushrooms.

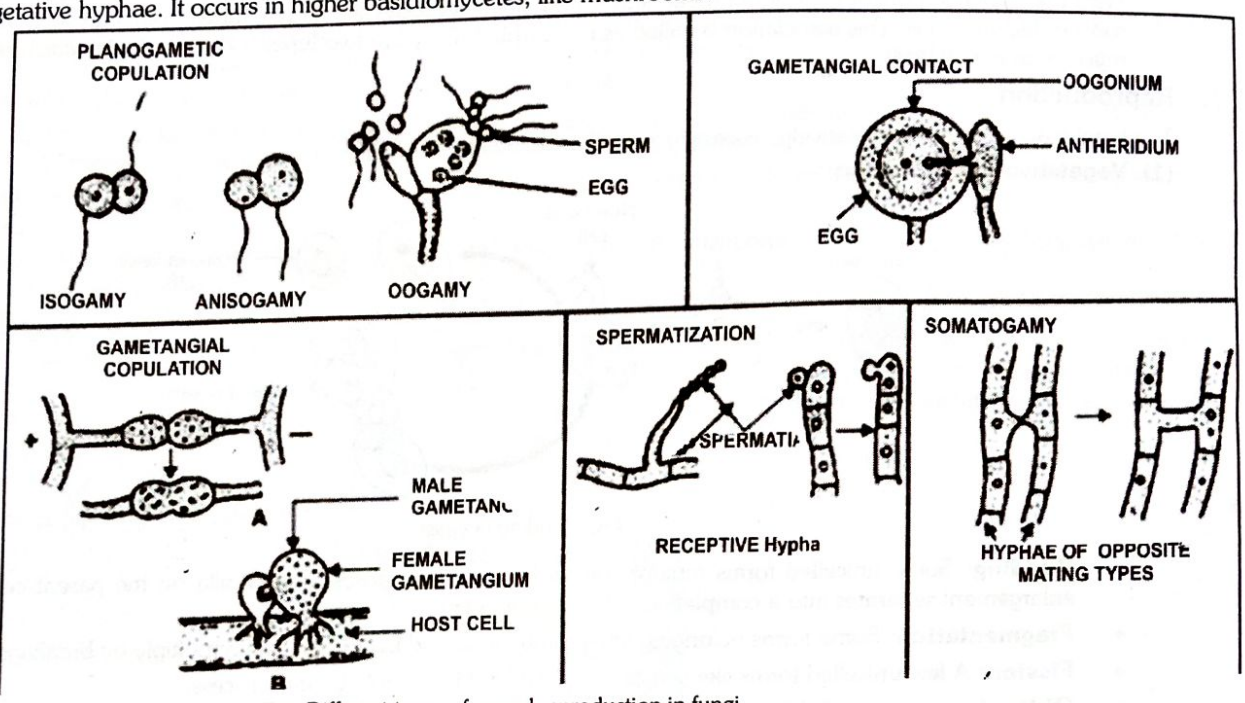


Fig. Different types of sexual reproduction in fungi

Heterothallism : Blakeslee, (1904) while working with *Mucor* sp. observed that in some species sexual union was possible between two hyphae of the same mycelium, in others it occurred between two hyphae derived from 'different' spores. He called the former phenomenon as homothallism and the latter as heterothallism.

7.4. Classification of fungi:

(1) Phycomycetes (Lower or algal fungi) : Found in aquatic habitats and on decaying wood in moist and damp places or as obligate parasites on plants.

The mycelium is aseptate and coenocytic, Asexual reproduction takes place by zoospores (motile) or by aplanospores (non-motile).

These spores are endogeneously produced in sporangium.

Zygospores are formed by fusion of two gametes. These gametes are -similar in morphology (isogamous) or dissimilar (anisogamous or oogamous).

Examples: Mucor, Rhizopus and Albugo.

White Rust of Crucifers : It is caused by *Albugo candida* or *Cystopus candidus.*

Late Blight of Potato : Brownish to blackish appear on leaflets It is caused by *Phytophthora infestans*. Irish/ Iyerland famine of 1845-1847 was due to it.

Damping off of Seedlings : Stem collapses at ground level, e.g., *Pythium debaryanum.*

Kingdom fungi possess branched coenocytic mycelia, so they are categorized under two sub-divisions – Mastigomycotina and Zygomycotina.

(2) Mastigomycotina (Class - Oomycetes) : Mastigomycotina is a former polyphyletic taxonomic grouping, a subdivision, of fungi, similar to Phycomycetes, and that included the zoosporic classes Chytridiomycetes, Hyphochytriomycetes, Plasmodiophoromycetes and Oomycetes.

- **General characteristic**
  a) They produce flagellated cells during their lifetime. May bear rhizoids
  b) Mostly, filamentous and having coenocytic mycelium.
  c) Show centric nuclear division.
  d) Perfect state of spores is typically oospores.
  e) Spores are either motile (Mastigomycotina) or non-motile (in rest members).

(3) Zygomycetes -(Conjugation Fungi)

- Members are unicellular or mycelial and they are parasitic or saprophytic.
- Mycelium is coenocytic. Hyphal wall contains chitin or fungal cellulose. Motile stage is absent
- Spores (Sporangiospores/Aplanospores) are borne inside sporangia.
- Sexual reproduction occurs through gametangial copulation or conjugation.
- Multinucleate gamates called coenogametes.
- Example- Rhizopus and mucor popularly known as black bread mould.

(4) Ascomycetes (sac-fungi)

- Ascomycetes are unicellular, e.g., yeast (Sacharomyces) or multicellular, e.g., Penicillium.
- Saprophytic, decomposers, parasitic or coprophilous (growing on dung).
- Mycelium is branched and septate.
- The asexual spores conidia are produced exogenously on the special mycelium called conidiophores.
- Sexual spores are called ascospores which are produced endogenously in sac like asci. These asci are arranged in different types of fruiting bodies called ascocarps.
- Asci may be aggregated into fructifications called ascocarps(fruiting body).
- The asci are club shaped, elongated, ovoid, globose or rectangular in shape. The ascospores are released from ascus and germinate to produce new mycelia.

  Ascocarps are of four types -

  a) Cleistothecium : Completely covered with no opening. e.g. Penicillium

  b) Perithecium : Flask-shaped with an ostiole or pore. e.g. claviceps.

  c) Apothecium : Saucer-shaped, layer of asci or hymenium exposed. e.g. Peziza

  d) Ascostroma : Asci develop in or within a stroma.

  Examples are Aspergillus, Claviceps and Neurospora, it is used extensively in biochemical and genetic work. Many members like morels and buffles are edible and are-considered delicacies.

Yeast

First described by Antony Von Leeuwenhoek in 1680.

Nonmycelial or unicellular, which is very small and either spherical or oval in shape.

Under favourable conditions they grow rapidly and form false mycelium or pseudomycelium.

Individual cells are colourless but the colonies may appear white, red, brown, creamy or yellow:

The single cell is about 10mm in diameter. It is enclosed in a delicate membrane which is not made up of fungal cellulose but is a mixture of two polysaccharides known as mannan and glycogen.

- **Reproduction**: Yeast reproduces by vegetative or asexual and sexual methods.
- **Vegetative reproduction:** 'Yeast reproduce vegetatively either by budding or by fission.
- **Sexual reproduction**: Sexual reproduction in yeasts takes place during unfavourable conditions, particularly when there is less amount of food. The sex organs are not formed in yeasts 'and the sexual fusion occurs between the two haploid vegetative cells or two ascospores which behave as gametes. The two fusing gametes are haploid and may be isogamous or anisogamous. Such kind of sexual reproduction is called gametic copulation. It is the best example of hologamy i.e., the entire vegetative thallus is transformed into reproductive body. The sexual fusion leads to the formation of diploid zygote. The zygote behaves as an ascus and forms 4 - 8 haploid ascospores. These liberate and function as vegetative cells

  Albugo : It is an obligate parasite distributed all over the world. In India about 18 species of Albugo have been reported which attacks mostly crucifers like turnip, mustard, radish, cabbage, cauliflower etc.

- **Characteristic :** Thallus is eucarpic and mycelia and hyphae are intercellular, coenocytic, aseptate and profusely branched.

  Cell wall is composed of fungal cellulose. The protoplasm contains a large number of nuclei distributed in the cytoplasm.

  Reserve food material is in the form of oil drops and glycogen bodies. Some mycelium is intracellular in the form of knob-like haustoria for the absorption of food material from the host cells.

  It can be differentiated into two parts:

  (a) Haustorial head, and

  (b) Narrow stalk.

- **Asexual Reproduction:** The asexual reproduction takes place by conidia, condiosporangia or zoosporangia.
- **Sexual Reproduction:** The mycelium penetrates into the deeper tissues of the host. The sexual reproduction is highly oogamous type. The antheridium and oogonium develops deeper in the host tissue in close association within the intercellular spaces.

Penicillium

- It is blue-green mould. Mycelium consists of septate hyphae with septal pores. The cells are uninucleate (young) to multinucleate (old).
- Conidiophores of Penicillium are often branched.
- Ultimate branches/metulae has bottle-shaped sterigmata.
- Conidia are borne basipetally exogenous chains at tip of sterigmata.
- Sexual reproduction forms a dikaryophase and a fructification called ascocarp.
- Ascocarps of Penicillium is (cleistothecium).
- Fleming discovered penicillin from Penicillium notatum through a chance finding that bacterial culture is destroyed by growth of the fungus.
- Commercially, penicillin (the wonder drug, first antibiotic drug) is obtained from Penicillium chrysogenum Griseofulvin (griseovin) is got from P. griseofulvum.
- Penicillium brefeldianum yields brefeldin.
- Ripening of Camembert and Roquefort types of cheese is carried out by P. cmemberti and P. roqueforti respectively.
- P. italicum causes blue mould and P. digitatum causes green mould of citrus fruits in storage.
- Some organic acids (gallic acid, fumaric acid and citric acid) and enzymes are obtained commercially from different species of Penicillium.
- A few species of Penicillium causes a respiratory diseases called penicillosis in animals and human beings.

Aspergillus

- The fungus is known as black smoky mould. Most of the species are saprotrophic and grow on dead organic material.
- It is similar to Penicillium except for multinucleate cells and tip of conidiophore which enlarges to bear sterigmata directly.
- Aspergillus is the common laboratory weed, which also grows on a number of food stuffs.
- It may cause pulmonary disease (pulmonary aspergillosis) and skin infections in human beings.
- Aspergillus flavus (formerly called Guinea Pig of Plant Kingdom) grows on stored grains, groundnut, bread, etc.
- It produces a carcinogenic toxin called aflatoxin (Sargent).
- Aspergillus species are exploited in production of citric acid and oxalic acid (both Aspergillus niger), gallic acid (Aspergillus gallomyces) alcoholic beverages like sake from rice (Aspergillus oryzae).
- Antibiotics like flavicin or aspergillic acid and fumigallin(Aspergillus fumigatus).

Neurospora

- This fungus is mostly saprophytic, grow as reddish superficial growth over the substratum called pink bread mould.
- Formerly considered to be Drosophila of Plant Kingdom.
- Neurospora, a genus of widespread species, produces bakery mold, or red bread mold.
- Neurospora is widely used in genetics as a model organism (especially N. crassa) because it is quickly reproducing, is easy to culture, and can survive on minimal media (inorganic salts, glucose, water and biotin in agar).
- Neurospora species are all haploids, spending most of their life cycles in the haploid state.
- Various species of Neurospora show one of three different life cycles called heterothallic, homothallic or pseudohomothallic.

Claviceps

- Claviceps purpurea develops sclerotia in the ears of cereals, especially rye.
- The sclerotia yield ergot which is medicinally useful in treating migraine, enlarged prostate glands and uterine hemorrhages.
- Lysergic acid, got from it, gives a hallucinogen LSD(lysergic acid diethylamide).

Tuber (Truffel)

Underground fructifications or ascocarps are edible, e.g., *Tuber aestivum*.

(5) Basidiomycetes(The Club Fungi)

- Common forms of basidiomycetes are mushrooms, bracket fungi or puffballs.
- Grow in soil, on logs and tree stumps and in living plant bodies as parasites, e.g., rusts and smuts.
- Mycelium is branched and septate.
- Asexual spores are generally not found, but vegetative reproduction by fragmentation is common.
- Sex organs are absent, but plasmogamy is brought about by fusion of two vegetative or somatic cells of different strains or genotypes.
- The resultant structure is dikaryotic which ultimately gives rise to basidium.

- Karyogamy and meiosis take place in the basidium producing four basidiospores.
- The basidiospores are exogenously produced on the basidium, the basidia are arranged in fruiting bodies called basidiocarps.
- Examples- Agaricus (mushroom), 'Ustilago (smut) and Puccinia (rust fungus).

Mushroom :

Agaricus campestris is a common edible mushroom. *Agaricus brunnescens* (A. bisporus- Double mushroom) is cultivated.

Toadstool :

A poisonous mushroom is called toadstool. It often possesses white basidiospores e.g., *Amanita polloides/ A caesarea* (Death Cap/Caesar's Caesar's Mushroom).

Bracket or Shelf Fungi :

The basidiocarps are like brackets or shelves appearing on tree trunks or logs (lignicolous = epixylic), e.g., *Polyporus, Fomes, Ganoderma.*

Puffballs :

They are edible in young state but not on ripening e.g., *Lycoperdon, Calvatia.* (has anticancer properties).

Smuts :

Smuts are pathogenic, basidiomycetes which causes smut of Wheat (Ustilago tritici).

Rusts:

Pathogens produce rusty pustules, e.g., *Puccinia*

(6) Deuteromycetes (Fungi Imperfecti)

Known as imperfect fungi because only the asexual or vegetative phases of these fungi are known.

The deuteromycetes reproduce only by asexual spores known as conidia.

The mycelium is septate and branched.

Some members are saprophytes, most of them become parasites and cause serious diseases in plants, animals and humans. while a large number of them are decomposers of litter and help in mineral cycling. Examples: Alternaria, Colleiotrichum and Trichoderma.

Early Blight of Potato (and Tomato) : *Alternaria solani.*

Tikka Disease of Groundnut : Disease is caused by *Cercospora personata*

Red Rot of Sugarcane : Colletotrichum *flacatum.*

Sesame or Brown Leaf Spot or Rice : *Helminthosporium oryzae.* Bengal famine (1942-43) was due to it.

Gibberella fujikori : Gibberellin was discovered from it as it produces bakanae disease in Rice.

Ringworm Fungi : Species of *Microsporum, Epidermophyton and Trichophyton rubrum.*

7.5. Lichens

Constitute a small group of thallophytic and autotrophic plants. They form a unique combination of two completely different individuals, of which one belongs to algae and the other to fungi.

The algal component is called phycobiont and the fungal component is known as mycobiont . The two components remain in close contact and appear to be a single plant. Therefore, lichens are also known as composite or dual organism.

(1) In shape lichens are of 3 types-

- **Crustose:** Crust-like closely appressed to the substratum and attached to it at several places, e.g., Graphis, Lecanora, Rhizocarpon, Haematoma
- **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, e.g., Parmelia, Peltigera. Foliose lichen Cora (Dictyonema) pavonia resembles bracket fungi in appearance
- **Fruticose:** The lichen is branched like a bush and attached to the substratum by means of disc, e.g., Cladonia, Usnea, Evernia. The bulk of lichen body is formed by fungal partner or mycobiont. It includes the surface, medulla and rhizines. The algal partner or phycobiont constitutes hardly 5% of the lichen body. It is generally restricted to a narrow zone (algal zone) below the surface.

(2) Relationships of Lichens : The fungus performs three functions-

- Body structure and covering
- Anchoring
- 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 fungus partner of the lichen to dissolve minerals from the substratum. 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 lichen the association between alga and fungus is that of mutual benefit (mutualism) popularly called symbiosis.

some workers believe that the fungus is a controlled parasite over the alga. The phenomenon is called helotism.

(3) Reproduction of Lichens

Lichens multiply by four methods

- Progressive death and decay resulting in the separation of a lichen into two or more parts,
- Fragmentation caused by mechanical injury due to wind, trampling or animal bites,
- Isidia are superficial outgrowths of the lichens which are primarily meant for increasing surface area and photosynthetic activity. At times, they are broken off. Each isidium is capable of forming new lichen because it has a core of algal cells surrounded by a sheath of fungal hyphae.
- Soredia. 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.

(4) Economic Importance of Lichens

- Lichens are used as food and fodder. For example, Reindeer moss(Cladonia rangifernia), Parmelia(used as curry powder)
- Lichens also have several medical uses. Example, they are use in curing lung diseases, Jaundice (Xanthioria parietina), coùgh (Evernia furfurasia) or uterine disorders, in ointments for treating wounds and burns (usnic acid), etc
- Lichens also found use in perfumery. Example- Ramalina and Evernia (used in preparation of Dhup, havan material and soap).
- They are used in tanning and dyeing, Example-Litmus from Roccella linchoris, orchill from Roccella and Lecanora.
- Helps in bringing vegetation in rocky and barren lands by secreting acids and producing cracks on crevices on the rock.
- Used as indicator of air pollution, especially, sulphur dioxide (so2) as they grow only in clean environment.
- Used in brewing industry in production of alcohol and in production of organic acids like carbonic acid etc.

7.6. Mycorrhizae

- It is an association between a fungus and the root of a higher plant, e.g., Pine, Birch.
- Mycorrhizae form a network of filaments that associate with plant roots and draw nutrients from the soil that the root system would not be able to access otherwise.
- This fungus-plant alliance stimulates plant growth and accelerates root development.
- Mycorrhizal roots occur in superficial layers of soil. They are thick, irregular with woolly covering devoid of root hair and root cap.
- It is of two types – ectomycorrhiza and end mycorrhiza.
- **Ectomycorrhizae:** Fungus partner is commonly a basidiomycete. It lives in intercellular spaces of cortex and forms a thick woody covering on the outside
- **Endomycorrhizae:** Fungus is commonly a zygomycete. Tips of fungal hyphae pass into cortical cells forming swollen vesicles or finely branched masses called arbuscules. Therefore it is also called VAM or vesicular-arbuscular mycorrhiza
- Mycorrhiza is a example of symbiosis or mutualism. Fungus obtains shelter and food from root.
- Mycorrhizae provide different benefits to the plants and to the environment, It helps the root in absorption of water, dissolution and absorption of inorganic nutrients locked in organic matter (especially nitrogen and phosphorus) and protection from other fungi.
- Produce more vigorous and healthy plants. Increase plant establishment and survival at seeding or transplanting. Increase yields and crop quality. Improve drought tolerance, allowing watering reduction. Enhance flowering and fruiting. Contribute to maintain soil quality and nutrient cycling Contribute to control soil erosion

7.7. Viruses, Viroids

In the five kingdom classification of Whittaker, there is no mention of some acellular organisms like viruses, viroids.

These are briefly introduced here-

- Viruses are infectious agents, with simple, acellular organization. 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. They can mutate.
- They are acellular, that is, they contain no cytoplasm or cellular organelles.
- They carry out no metabolism on their own and must replicate using the host cell's metabolic machinery.
- In other words, viruses don't grow and divide. Instead, new viral components are synthesized and assembled within the infected host cell.
- The vast majority of viruses possess either DNA or RNA but not both.
- They are totally dependent on a host cell for replication. Viral components must assemble into complete viruses (virions) to go from one host cell to another.
- They have spikes, which helps them to attach to the host cell. They do not respire, do not metabolize.
- Ribosomes and enzymes are absent, which are needed for metabolism.

- 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. Beijerinek (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) crystallized TMV (Tobacco mosaic virus) for the first time. He showed that viruses could be crystallized and crystals consists largely of proteins.
- 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 truly 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.

(1) Structural Components of Viruses

The structural components of viruses are envelops, capsid and nucleoid.

- **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.
- **Capsid-** It is the outer protein coat made up of small subunits called capsomeres for the protection of nucleic acid (their genetic material).
- **Nucleoid**-Viruses contain either DNA or RNA. DNA containing viruses are called deoxy viruses. These are of two types-
  1. Double stranded DNA (dsDNA) *e.g.* Pox virus, Cauliflower mosaic virus. Herpes virus.
  2. Single stranded DNA (ssDNA) *e.g.* Coliphase M13 phage.

  RNA containing viruses or riboviruses are of two types.
  3. Double stranded RNA (dsRNA) virus *e.g.* Reovirus, Wound tumour virus.
  4. Single stranded RAN (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-
  5. Phytophagineae/Plant viruses having genetic material ssRNA
  6. Zoophagineae/Animal viruses having genetic material ss or dsRNA or dsDNA
  7. Bacteriophages/Bacterial viruses having genetic material dsDNA

(2) Structure of Some Viruses

TMV : It is elongated rod-like virus. Genetic material is ssRNA.

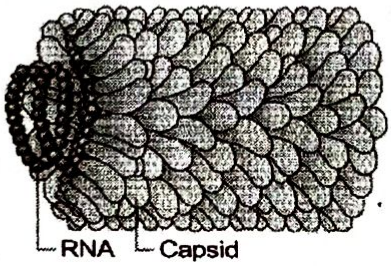


Fig. : Tobacco Mosaic Virus (TMV)

Bacteriophage (or bacterial viruses): are the viruses that infect the bacteria. Bacteriophages usually have double stranded DNA.

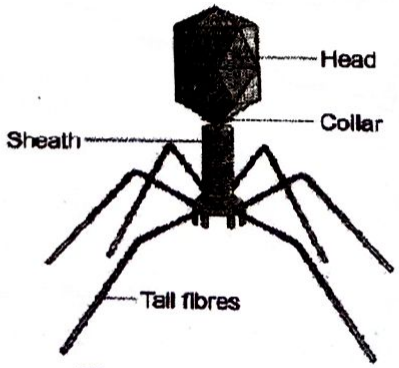


Fig. : Bacteriophage

Influenza Virus : They are polyhedral shapes like the influenza virus.
Ebola Virus : They are helical in shape like the Ebola virus.

(3) List of some diseases caused by viruses

Viral diseases of Man-Name of the disease Causative agent

- Influenza - Influenza virus
- Small pox -Variola virus
- Mumps - Paramyxo virus
- AIDS - Retroviruses
- Poliomyelitis - Polio virus
- German measles - Rubella virus
- Measles - Measles virus

(4) Viral diseases of Plants

Name of the disease Causal agent

- Tobacco mosaic –TMV
- Cucumber mosaic- Cucumber mosaic virus
- Potato leaf roll- Potato leaf roll virus
- Bunchy top of banana -Banana bunchy top virus

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

(5) Viroids : Viroids are smaller than viruses, self-replicating particles which were discovered by T.O. Diener (1971).

Viroids are infectious RNA particles which are devoid of protein coat. Molecular weight of RNA in viroid is low in comparison to viruses.

Potato spindle tuber is a viroid causing disease.

(6) Prions : Discovered by Alper *et al.* Proteinaceous infectious particles, causing certain diseases like

Kuru disease (laughing death disease in humans).

Bovine spongiform encephalopathy (BSE or Mad cow disease).

Scrapie disease in sheep.

Creutz Feldt Jakob disease.

(7) Advantages of Viruses : They are use full in delivering genes to target cells and play a vital role in and gene therapy researches.

(8) Disadvantages of Viruses : There are many pathogenic viruses, which causes harm for human beings, plants and animals.

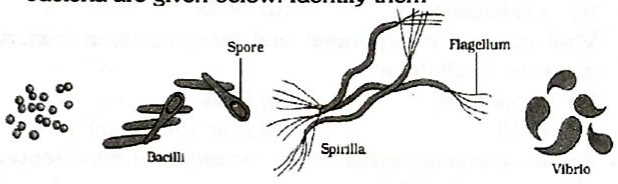
In human beings the diseases caused by viruses are: HIV, influenza, herpes, hepatitis small pox, cowpox, etc

The diseases caused by viruses in plants are tobacco mosaic viruses, etc. The diseases caused by bacteria in animals are bovine tuberculosis and etc.

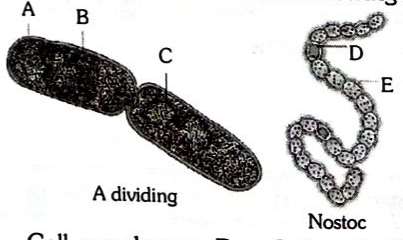
2. Biological Classification – Multiple Choice Questions

1. Structure, shape and nutrition of bacteria

1. Which of the following fixes CO_2 in carbohydrates
   (a) Bacillus (b) Rhizobium
   (c) Nitrobacter (d) Rhodospirillium
2. Which of the following statement is correct
   (a) All bacteria are heterotrophic
   (b) Bacteria are either heterotrophic or chemoautotrophic
   (c) Bacteria can also be photoautotrophic
   (d) Bacteria are either photoautotrophic or chemoautotrophic
3. The shape of the cocci bacteria is
   (a) Rod shaped (b) Spherical
   (c) Comma shaped (d) Spiral
4. Muramic acid is present in the cell wall of
   (a) Bacteria/Blue green algae (b) Green algae
   (c) Yeast (d) *Rhizopus*
5. Bacteria bearing flagella all over the body are called
   (a) Peritrichous (b) Atrichous
   (c) Monotrichous (d) Cephalotrichous
6. Bacterial ribosomes are called
   (a) Autosomes (b) Dictyosomes
   (c) Centrosomes (d) Polyribosomes
7. Bacterial ribosomes are present
   (a) In cytoplasm
   (b) On endoplasmic reticulum
   (c) On nuclear membrane
   (d) On cell wall
8. Bacterial flagella do not show *ATP*ase activity and 9 + 2 organization. These are chemically
   (a) Flagellin (b) Pilin
   (c) Tubulin (d) Bacterin
9. Plasmids are extra chromosomal genetic material of
   (a) Bacteria (b) Virus
   (c) Algae (d) Amoeba
10. Teichoic acid is found in
    (a) Gram (+ve) bacteria (b) Gram (-ve) bacteria
    (c) Cyanobacteria (d) Mycoplasma
11. The nitrifying bacteria are
    (a) Autotrophic (b) Saprophytic
    (c) Parasitic (d) Chemosynthetic
12. Smallest bacteria is
    (a) Spirillium (b) Bacillus
    (c) Dialister (d) None of these
13. *Salmonella* sp. is
    (a) Monotrichous (b) Lophotrichous
    (c) Amphitrichous (d) Peritrichous
14. Bacteria are included in which of the following kingdoms
    (a) Protista (b) Plantae
    (c) Monera (d) Animalia
15. What is a genophore
    (a) DNA in prokaryotes
    (b) DNA and RNA in prokaryotes
    (c) DNA and protein in prokaryotes
    (d) RNA in prokaryotes
16. Genes for antibiotic resistance are located in
    (a) Chromosome (b) Nucleus
    (c) Cell wall (d) Plasmid
17. The cells of bacterium *Staphylococcus* remain arranged in the form of
    (a) Plate (b) Cube
    (c) Irregular cluster (d) Chain
18. Bacteria and other monerans do not possess
    (a) Ribosomes (b) Mitochondria
    (c) Nucleoid (d) Plasma membrane
19. Many bacteria bear minute hairy structures on their cell wall, these are called
    (a) Hairs (b) Flagella
    (c) Pili (d) Cilia
20. Which of the following is not correct statement about the plasmids
    (a) It is the extra chromosomal DNA in bacteria
    (b) It is not a integral part but inert genetic material
    (c) Host chromosome can be integrated with the plasmid
    (d) Transfer of plasmid can be done from cell to cell without killing the host
21. According to the shapes the names of the different bacteria are given below. Identify them



    (a) A - *Spirilla*, B – *Vibrio*, C – *Cocci*, D - *Bacilli*
    (b) A - *Spirilla*, B – *Bacilli*, C – *Cocci*, D - *Vibrio*
    (c) A - *Bacilli*, B – *Cocci*, C – *Spirilla*, D - *Vibrio*
    (d) A - *Cocci*, B – *Bacilli*, C – *Spirilla*, D – *Vibrio*
22. *Escherichia coli* has the following combination of characters
    (a) Rod shaped, 1–3 μm long, gram negative
    (b) Rod shaped, 1– 3 μm long, gram positive
    (c) Spiral, 1–3 μm long, gram negative
    (d) Spiral, 1–3 μm long, gram positive
23. Monera possess
    (a) Membrane bound nucleoproteins lying free in the cytoplasm
    (b) Gene containing nucleoproteins condensed together in compact masses
    (c) Nucleoproteins in direct contact with the rest of the cell substance
    (d) Only free nucleic acid aggregates
24. The murein found in bacterial cell is
    (a) Derivative of protein
    (b) Derivative of fat
    (c) Derivative of organic acids
    (d) Derivative of sugars
25. Bacteroids are
    (a) Enlarged non-motile cellular bacteria *Rhizobiumleguminosarum* in root nodules of legumes
    (b) A bacterial cell infected with viruses
    (c) A motile bacterium
    (d) *Nitrosomonas* bacteria in soil
26. Identify the A, B, C, D and E in the following diagram



    (a) A – Cell membrane, B – Cell wall, C – DNA, D – Heterocyst, E – Mucilagenous sheath
    (b) A – Mucilagenous sheath, B – Cell membrane, C – DNA, D – Heterocyst, E - Cell wall
    (c) A – Cell wall, B – Cell membrane, C – DNA, D – Heterocyst, E – Mucilagenous sheath
    (d) A – Cell wall, B – Cell membrane, C – Heterocyst, D – DNA, E – Mucilagenous sheath

2. Life cycle/Reproduction in bacteria

1. The process in which viruses are involved in sexual reproduction of bacteria is called
   (a) Transduction (b) Transcription
   (c) Transformation (d) Translation
2. Under the optimum condition of temperature and nutrition most of the bacteria divide at the interval
   (a) 24 hours (b) 20 minutes
   (c) 60 minutes (d) 5 minutes
3. Bacteria commonly reproduce vegetatively by

   or

   Which one of the following processes results in the formation of clone of bacteria
   (a) Binary fission (b) Budding
   (c) Conjugation (d) Oidia
4. Viral genome incorporated and integrates with bacterial genomes is refer to as
   (a) Prophages (b) RNA
   (c) DNA (d) Both (b) and (c)
5. The experimental system used in studies of the discovery of replication of DNA has been
   (a) Drosophila melanogaster (b) Pneumococcus
   (c) Escherichia coli (d) Neurosporacrassa
6. Pili in bacteria represent
   (a) Extra-chromosomal genetic element
   (b) Protoplasmic outgrowths of donor cells
   (c) Small flagella
   (d) Special bacterial cilia
7. Amitosis is shown by
   (a) Bacteria (b) *Euglena*
   (c) *Syllis* (d) *Hydra*
8. Why bacteria do not survive in the salt pickle which has high salt contents
   (a) Salt retards the rate of reproduction of bacteria
   (b) Bacteria do not get light for photosynthesis
   (c) Due to plasmolysis bacteria die
   (d) Essential elements for bacterial viability are not present in the pickle
9. For reproduction, 'endospores' are formed in the following genera
   (a) Bacillus and Clostridium
   (b) Mucor and Bacillus
   (c) Monococcus and Clostridium
   (d) Saccharomyces and Clostridium
10. Identify the correct pair of events when temperate phages infect bacteria
    I. No prophages are formed
    II. Bacterial cell undergoes many divisions
    III. Bacterial cell undergoes immediate lysis
    IV. Prophages are formed
    The correct pair is
    (a) I, II (b) II, III
    (c) III, IV (d) II, IV

3. Economic importance of bacteria

1. Which bacteria is responsible for the reduction of nitrates into nitrogen, (denitrifying Bacteria) in soil
   (a) Nitrosomonas (b) Pseudomonas
   (c) Rhizobium (d) Clostridium
2. Which of the following represents obligate anaerobes
   (a) Spirogyra (b) Pisum sativum
   (c) Onion (d) Methane bacteria
3. Select the correct match

A.	*Nitrosomonas*	-	Nitrite to nitrate
B.	*Thiobacillus*	-	Denitrification
C.	*Nostoc*	-	Free-living nitrogen-fixer
D.	*Azotobacter*	-	Anaerobic nitrogen-fixer

   (a) A and B (b) C and D
   (c) B and C (d) B and D
   (e) A and C
4. The purple sulphur bacteria use hydrogen sulphide and release sulphur but not oxygen. Which of the following agrees with above observation
   (a) The H_2 that reduces CO_2 comes from H_2S that liberates sulphur
   (b) Photosynthesis does not require chlorophyll
   (c) Photosynthesis consist of a light and a dark reaction
   (d) The H_2 which reduces CO_2 in photosynthesis comes from H_2O that releases O_2
5. Match the types of bacteria listed in column I with their activity given in column II. Choose the correct combination of alphabets of the two columns

Column-I (Types of bacterial)		**Column-II** (Activity)	
A.	*Streptomyces*	p.	Food poisoning
B.	*Rhizobium*	q.	Source of antibiotics
C.	*Nitrosomonas*	r.	Nitrogen fixation
D.	*Acetobacter*	s.	Nitrification
		t.	Vinegar synthesis

   (a) A = q; B = r; C = p; D = t
   (b) A = q; B = r; C = s; D = t
   (c) A = s; B = t; C = p; D = r
   (d) A = t; B = p; C = r; D = s
6. Match the items in **column I** with those in **column II** and choose the correct answer

	Column I		**Column II**
P.	Blue green algae as biofertilizers	i.	Ectomycorrhiza
Q.	Fungi as biofertilizers	ii.	*Thiobacillus sp*
R.	Free living nitrogen fixing bacteria	iii.	*Anabaena sp*
S.	Phosphate solubilizing bacteria	iv.	*Clostridium sp*
		v.	*Azospirillum sp*

   (a) P–iii, Q-i, R-v, S-ii (b) P-v, Q-i, R-ii, S-iv
   (c) P-v, Q-iv, R-i, S-ii (d) P-iv, Q-ii, R-v, S-iii

4. Bacterial Disease

1. Cause of 'Mad Cow' disease of England
   (a) Virions (b) Mycoplasma
   (c) Scrapie Protein (d) Viral protein
2. The poisonous substances commonly produced by bacteria are known as
   (a) Toxin (Exotoxins) (b) Auxins
   (c) Antibiotic (d) Antitoxins
3. Black rot of crucifers is caused by a
   (a) Fungus (b) Bacterium
   (c) Virus (d) None of these
4. 'Citrus canker' is caused by a
   (a) Fungus (b) Bacterium
   (c) Virus (d) Nematoda
5. Which is the cause of Anthrax disease
   (a) Virus (b) Bacteria
   (c) Mycoplasma (d) Algae

6. "Crown gall" is caused by
(a) Mycobacterium
(b) Agrobacterium tumefaciens
(c) Erwinia
(d) Clostridium

7. Pullorum disease of poultry is caused by
(a) Hemophilus (b) Clostridium
(c) Salmonella (d) Mycobacterium

8. Which one of the following pathogen cause canker disease
(a) Meloidogyne incognita
(b) Anguina tritici
(c) Xanthomonas citri
(d) Pseudomonas rubilineans
(e) Phytophthora infestans

9. The 2005 noble prize for physiology/medicine was awarded to Barry Marshall and Robin Warren of Australia for their discovery of
(a) Human papilloma virus causing cervical cancer
(b) Bacterium *Helicobacter pylori* causing peptic ulcer
(c) Prions, a new biological principle of infection
(d) Human immunodeficiency virus

5. Mycoplasma

1. What is incorrect for mycoplasma
(a) They are osmotically inactive
(b) Show absence of cell wall
(c) Are sensitive to modern antibiotics
(d) Are obligate intracellular parasites

2. Little leaf of brinjal is caused by
(a) Virus (b) Mycoplasma
(c) Fungus (d) Algae

3. The outermost limiting layer of mycoplasma is made up of
(a) Cell wall (b) Cell membrane
(c) Mucilaginous sheath (d) Slime layer

4. Tendency of abortion in ladies is caused by
(a) Cyanobacteria (b) Bacteria
(c) Mycoplasma (d) None of these

5. Organisms without any specific shape are
(a) Mycoplasmas (b) Bacteria
(c) Viruses (d) Cyanobacteria

6. An organism having cytoplasm DNA and RNA but no cell wall is
(a) Cyanobacterium (b) Mycoplasma
(c) Bacterium (d) Virus

7. Mycoplasma is related to
(a) Algae (b) Bacteriophage
(c) Virus (d) L–form bacteria

8. Mycoplasma differs from virus in being sensitive to
(a) Sugar (b) Tetracycline
(c) Protein (d) Amino acid

9. Clover phyllody is caused by
(a) Spirochaetes (b) Protoplasts
(c) Spheroplasts (d) Mycoplasmas

10. Elementary cell body in mycoplasma perform the function
(a) Metabolism (b) Excretion
(c) Reproduction (d) Respiration

6. Cyanobacteria / Blue green algae

1. Which of the following may cause water blooms
(a) Bacteria (b) Mycoplasma
(c) Virus (d) Blue-green algae

2. Which of the following plants is used as biofertiliser
(a) Nostoc (b) Funaria
(c) Volvox (d) Rhizopus

3. The most primitive in the following are
(a) Cyanobacteria (b) Bryophytes
(c) Gymnosperms (d) Monocots

4. Cyanobacteria are
(a) Mosses which attack bacteria
(b) Bacteria which attack cyanophyceae
(c) Autotrophic organism with phycocyanin
(d) None of these

5. Pigment phycocyanin and phycoerythrin are found in
(a) Bacillariophyceae (b) Archaebacteria
(c) Eubacteria (d) Cyanobacteria
(e) Chlorophyceae

6. The blue-green algae are so called as they have in addition to green pigment chlorophyll, a blue pigment known as
(a) Phycocyanin (b) Chromoplasm
(c) Cyanophycin (d) Phycoerythrin

7. Red sea phenomena due to
(a) Red algae
(b) Dinophyceae
(c) Diatoms
(d) Blue-green algae (*Trichodesmium erythrium*)

8. Which is not a cyanobacterium
(a) Lyngbya (b) Plectonema
(c) Anabaena (d) Sinorhizobium

9. *Nostoc* is known to perform
(a) Only photosynthesis
(b) Photosynthesis and nitrogen fixation simultaneously
(c) Only nitrogen fixation
(d) Either photosynthesis or nitrogen fixation at a time

10. Prokaryotes are characterized by
(a) A true nucleus with double layered nuclear membrane is absent
(b) Well developed nucleus with double layered nuclear membrane present
(c) Presence of cell wall made of chitins, muco polysaccharides and absence of cell organelles like mitochondria and chloroplasts
(d) Autotrophic in nature and only DNA is present

11. Heterocysts are found in certain
(a) Viruses (b) Bacteria
(c) Cyanobacteria (d) Mycoplasmas

12. Cyanobacteria are classified under
(a) Protista (b) Plantae
(c) Monera (d) Algae

13. Which were the organisms who changed earth's surface from reducing to the oxidizing
(a) Autotrophs (b) Heterotrophs
(c) Photoautotrophs (d) Chemotrophs

14. During rainy seasons, the ground becomes slippery due to dense growth of
(a) Lichens (b) Bacteria
(c) Green algae (d) Cyanobacteria

15. Cyanophyceae has got
(a) Definite nucleus and plastid
(b) No definite nucleus but plastid
(c) Neither definite nucleus nor plastid
(d) Definite nucleus but no plastid

16. *Spirulina* is a
(a) Blue green algae (b) Fungi
(c) Pteridophyte (d) Bryophyte

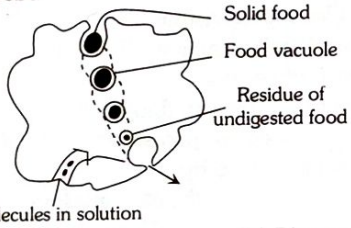
17. *Nostoc* is a
(a) Cyanobacteria (b) Beaded bacterium
(c) Bacteriophage (d) Parasite

7. Photosynthetic and consumer protists

1. Which one of the following is a saprophytic protist
   (a) Desmid (b) Slime mould
   (c) *Euglena* (d) *Gonyaulax*
   (e) *Nostoc*
2. Planktons are organisms which
   (a) Float on water surface (b) Are free swimmers
   (c) Are deep sea forms (d) Are burrowing forms
3. If phytoplanktons are destroyed in the sea, then
   (a) No effect will be seen
   (b) Primary consumers will grow luxuriantly
   (c) It will affect the food chain
   (d) Algae will get more space to grow
4. Slime moulds in the division Myxomycota (true slime moulds) have
   (a) Pseudoplasmodia
   (b) Spores that develop into free living amoeboid cells
   (c) Spores that develop into flagellated gametes
   (d) Feeding stages consisting of solitary individual cells
5. Red oceanic tides can be due to
   (a) Diatoms (b) Dinophyceae
   (c) Red algae (d) Blue-green algae
6. The slime moulds are characterized by the presence of
   (a) Elaters (b) Pseudoelaters
   (c) Capillitium (d) Capitulum
7. Diatoms are
   (a) Fungi (b) Plantae
   (c) Protista (d) Protozoans
8. Some protists possess structures for regulation of their water content. They are
   (a) Nuclei (b) Contractile vacuoles
   (c) Chromatophores (d) Membranes
9. Which protist reproduces both by binary fission and conjugation
   (a) Amoeba (b) Paramecium
   (c) Euglena (d) Monocystis
10. Unicellularity is characteristic of
   (a) Cyanobacteria (b) Monera
   (c) Protista (d) All of these
11. Protozoans are able to live efficiently due to their
   (a) Motility
   (b) Rapid reproduction
   (c) Ability to manufacture food
   (d) Specialised organelles
12. Which one of the following can photosynthesise its food
   (a) Hydra (b) Paramecium
   (c) Monocystis (d) Euglena
13. Diatom frustule/shell is made of
   (a) Silica (b) Lime
   (c) Magnesium carbonate (d) Calcium
14. Protista contains
   (a) *Euglena*, Dinoflagellates and Yeast
   (b) *Amoeba, Paramaecium, Hydra*
   (c) *Euglena, Paramaecium*, Mushroom
   (d) *Amoeba, Paramaecium* and Dinoflagellates
15. Which of the following can be used as bacteriological filter
   (a) Gelidium (b) Batrachospermum
   (c) Oscillatoria (d) Cymbella
16. Which of the following are the characters of dinoflagellates
   A. Planktonic golden yellow algae with soap box like structure
   B. Marine red biflagellated protista
   C. Appear yellow, green, brown, blue and red in colour
   D. Biflagellated organisms with pellicle
   E. Saprophytic (or) parasitic unicellular forms
   (a) A, B and C only (b) B, D and E only
   (c) B and C only (d) B and E only
   (e) C, D and E only
17. Ceratium is
   (a) Dinoflagellate (b) Diatom
   (c) Slime mould (d) Sporozoan
18. Flagellum of *Astasia/Euglena* is
   (a) Pantonematic (b) Acronematic
   (c) Pantachronematic (d) Stichonematic
19. Microfossile often present in petroleum producing formation are those of
   (a) Radiolarians (b) Diatoms
   (c) Helizoans (d) Foraminiferans
20. Mode of feeding in free living protozoans is
   (a) Holozoic (b) Saprozoic
   (c) Both (a) and (b) (d) None of these
21. The type of nutrition present in *Entamoeba* is
   (a) Saprozoic (b) Parasitic
   (c) Autotrophic (d) None of these

8. Protozoan protists

1. The protozoan parasite which possesses a food vacuole is
   (a) Leptomonas (b) Plasmodium
   (c) Trypanosoma (d) Leishmania
2. In the diagram, which of the following processes are shown in *Amoeba*



   (a) Exocytosis (b) Phagocytosis
   (c) Pinocytosis (d) All of these
3. Slimy mass of protoplasm with many nuclei and an *Amoeba* like thalloid body is a characteristic feature of
   (a) Ascomycetes (b) Actinomycetes
   (c) Phycomycetes (d) Basidiomycetes
   (e) Myxomycetes
4. Which is not the locomotory organ of protozoa
   (a) Cilia (b) Flagella
   (c) Pseudopodia (d) Parapodia
5. Which one of the following pairs is correctly matched
   (a) Aedes – plague (b) Anopheles – malaria
   (c) House fly – yellow fever (d) Body louse – typhoid
6. Total parasites belong to protozoan group
   (a) Sporozoa (b) Ciliata
   (c) Sarcodina (d) Zooflagellata
7. Which is not true for *Paramecium*
   (a) Under unfavourable conditions, form cysts
   (b) Presence of large number of cilia on whole body surface
   (c) Contain contractile vacuoles for osmoregulation
   (d) Use pseudopodia for capturing prey
8. Man in the life cycle of *Plasmodium* is
   (a) Primary host (b) Secondary host
   (c) Intermediate host (d) None of these
9. Animals of class ciliata
   (a) Have two nuclei (b) Are autotrophs
   (c) Reproduce sexually (d) Possess cilia
10. Which is filter feeder
   (a) Amoeba (b) Leech
   (c) Spider (d) Paramecium
11. Which of the following is not true for nutrition in *Amoeba*
   (a) Photoheterotrophic (b) Phagocytosis
   (c) Intracellular (d) Holozoic

12. Sexual mode of reproduction in protozoa is
(a) Anisogamy (b) Plasmotomy
(c) Autogamy (d) Schizogony

13. Conjugation in protozoa is found in
(a) Sarcodina (b) Flagellata
(c) Sporozoa (d) Ciliata

14. Locomotory organ of sporozoa is
(a) Tentacles (b) Reticulocytes
(c) Legs (d) None of the above

15. A metazoa without tissue organisation is called
(a) Parazoa (b) Protozoa
(c) Eumetazoa (d) Dermatozoa

16. *Trichonympha* is a symbiont in alimentary canal of
(a) Earthworm (b) Snails
(c) Hermit Crab (d) Termite

17. Reproduction in *Paramecium* is controlled by
(a) Flagella (b) Micronucleus
(c) Macronucleus (d) Cell wall

18. Which of the following is a flagellated protozoan
(a) Amoeba (b) Entamoeba
(c) Plasmodium (d) Trypanosoma
(e) Paramecium

19. In which of the following binary fission is not seen
(a) Plasmodium (b) Amoeba
(c) Euglena (d) Paramecium

20. In *Paramecium*, both autogamy and conjugation are sexual processes because of
(a) Gene recombination
(b) Involvement of two individuals
(c) Fusion of two haploid nuclei
(d) Rejuvenation

21. *Entamoeba* differs from *Amoeba* is not having
(a) Nucleus (b) Pseudopodia
(c) Ectoplasm (d) Contractile vacuole

22. The poisonous substance released as a result of rupturing of schizont in R.B.C. of malarial patient is
(a) Haematin (b) Haemoglobin
(c) Haemozoin (d) Haem

23. Discovery of *Amoeba* was made by
(a) Jenner (b) Rossenhoff
(c) Hofkins (d) Twait

24. Amoebiasis is prevented by
(a) Eating balanced food (b) Eating plenty of fruits
(c) Drinking boiled water (d) Using mosquito nets

25. Locomotory structures of *Amoeba* are
(a) Cilia (b) Flagella
(c) Pseudopodia (d) None of the above

26. Male mosquito (*Anopheles*) does not transmit malarial parasite because
(a) It lacks blood sucking mouth parts
(b) It catches fever
(c) It is too small to carry parasite
(d) The parasite is killed in its stomach

27. Highest incubation period occurs in *Plasmodium*
(a) P. malariae (b) P. vivax
(c) P. ovale (d) P. falciparum

28. Erythrocytic phase of *Plasmodium vivax* is completed in
(a) 24 hours (b) 72 hours
(c) 36 hours (d) 48 hours

29. Erythrocytic cycle of *Plasmodium* occurs in
(a) Liver (b) Spleen
(c) RBC (d) Gut

30. Which one is monogenetic parasite
(a) *Plasmodium* (b) Liver Fluke
(c) *Taenia solium* (d) *Entamoeba histolytica*

31. Which one does not spread disease
(a) Entamoeba coli (b) Entamoeba histolytica
(c) E. gingivalis (d) Plasmodium ovale

32. Which does not occur in sporozoa
(a) Cilia (b) Pseudopodia
(c) Flagella (d) None of the above

33. Who was awarded Nobel Prize in 1902 for discovery of oocyst of *Plasmodium*

Or

Who discovered oocysts in the stomach of female Anopheles

Or

Malaria is transmitted by "Anopheles". This was discovered by
(a) Golgi (b) Ronald Ross
(c) Laveran (d) Shortt

34. Infection of *Entamoeba histoloytica* is prevented by
(a) Avoiding kissing (b) Avoiding clothes of patient
(c) Uncontaminated food (d) None of the above

35. Cyst wall of *Euglena* is formed of
(a) Silica (b) Carbohydrate
(c) Proteins (d) Calcium

36. Which one is not a symptom of *Entamoeba histolytica* infection
(a) Relapsing fever (b) Abdominal pain
(c) Blood in stool (d) Irregular bowels

37. Which one of the following is a characteristic feature of Chrysophytes
(a) They are parasitic forms which cause diseases in animals
(b) They have a protein rich layer called pellicle
(c) They have indestructible wall layer deposited with silica
(d) They are commonly called dinoflagellates
(e) They are saprophytic Protista

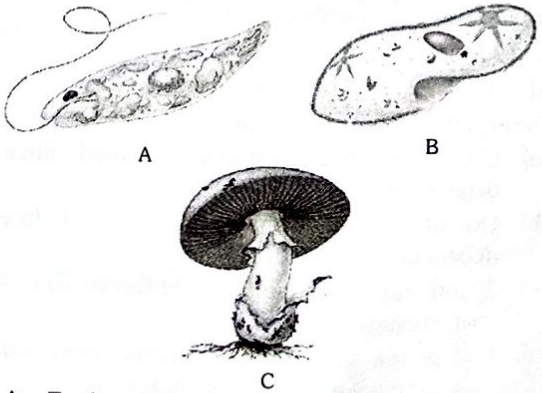
38. Leishmania tropica produces
(a) Sleeping sickness (b) Kala-azar
(c) Dysentery (d) Oriental sores

39. Sandfly is causative agent of
(a) Kala-azar (b) Sleeping sickness
(c) Typhoid (d) Dysentery

40. Trypanosoma brucei produces
(a) Sleeping sickness (b) Kala-azar
(c) Dysentery (d) A disease of animals

41. *Amoeba* is eukaryotic because it possesses
(a) Plasmid (b) Nucleus
(c) Plasmalemma (d) DNA

42. Study the following figures and identify A, B and C



(a) A – *Euglena*, B – *Paramecium*, C - *Aspergillus*
(b) A – *Planaria*, B – *Paramecium*, C - *Agaricus*
(c) A – *Euglena*, B – *Planaria*, C - *Agaricus*
(d) A – *Euglena*, B – *Paramecium*, C – *Agaricus*

43. In *Amoeba*, contractile vacuole is present
(a) Near trailing end (b) Near advancing end
(c) At the middle of body (d) Any where inside body

44. Which structure is formed at the time of exchange of gamete nuclei in given animal during sexual reproduction

(a) Plasmodesmata
(b) Cytoplasmic filaments
(c) Internal tubule
(d) Cytoplasmic bridge

45. Which of the following is not correct with respect to malaria
(a) RBC's rupture and release haemozoin which causes chills
(b) Sporozoites multiply in blood
(c) Female anopheles mosquito is the vector
(d) Malignant malaria is caused by *Plasmodium falciparum*

46. In *Amoeba*, pseudopodia are formed due to
(a) Contact with food
(b) Sol $\rightleftharpoons$ gel change
(c) Movement towards area of higher temperature
(d) All the above

47. Periodic appearance of malaria symptoms occurs due to periodic
(a) Entry of merozoites into erythrocytes
(b) Attack of liver cells by merozoites
(c) Formation of signet ring
(d) Release of pyrogen in blood

48. *Amoeba* stops producing pseudopodia during
(a) Alkaline condition (b) Starvation
(c) Acidic condition (d) Touch

49. *Amoeba* moves when
(a) Upper part of plasma-gel changes to plasmasol
(b) Lower part of plasmasol changes into gel
(c) Upper part of plasmasol changes into plasmagel
(d) All the above

50. In *Plasmodium*, gametocytes are formed from
(a) Schizont (b) Trophozoite
(c) Sporozoite (d) Merozoite

51. In *Plasmodium*, diploid stage is
(a) Oocyst (b) Gamont
(c) Schizont (d) Sporozoite

52. Hyaline cap in *Amoeba* is formed
(a) Around food vacuole
(b) Around contractile vacuole
(c) Around nucleus
(d) In front of pseudopodium

53. During conjugation in *Paramecium*
(a) Out of the four micronuclei formed, three nuclei degenerate
(b) Out of the twelve macronuclei formed, four nuclei degenerate
(c) Zygote nucleus undergoes eight successive divisions in each conjugant
(d) Out of the sixteen nuclei formed from zygote, 12 become macronuclei and 4 micronuclei

54. The infection of *Entamoeba histolytica* takes place by
(a) Trophozoite (b) Binucleated cyst
(c) Trinucleated cyst (d) Quadrinucleated cyst

55. Match the following and choose the correct combination from the options given

Column I (Group Protista)		Column II (Example)	
A.	Chrysophytes	i.	Paramecium
B.	Dinoflagellates	ii.	Euglena
C.	Euglenoids	iii.	Gonyaulax
D.	Protozoans	iv.	Diatoms

(a) A – i, B – iii, C – ii, D – iv
(b) A – ii, B – iv, C – iii, D – i
(c) A – iv, B – ii, C – iii, D – i
(d) A – iii, B – iv, C – i, D – ii
(e) A – iv, B – iii, C – ii, D – i

56. Which one show bioluminiscence
(a) Noctiluca (b) Polystomella
(c) Entamoeba (d) Suctoria

57. Which one of the following genus of insects prefer to breed in clean water and their larvae lie parallel to the surface of water
(a) Anopheles (b) Culex
(c) Aedes (d) Phlebotomus

58. Microphagial nutrition occurs in
(a) Amphioxus (b) Insects
(c) Paramecium (d) Hydra
(e) Euglena

59. Sprinkling oil over ponds would control malaria because
(a) Fishes die (b) Water gets polluted
(c) Larvae are asphyxiated (d) Mosquitoes are repelled

60. Quartan malaria is due to

Or

Your patient shows paroxysms of malaria after every 72 hours. Which species of plasmodium will be considered responsible to cause the infection
(a) Plasmodium falciparum (b) P. vivax
(c) P. ovale (d) P. malariae

61. Which one is spindle-shaped mobile with microtubules
(a) Sporont (b) Ookinete
(c) Cryptozoite (d) Sporozoite

62. Relapsing malaria is due to
(a) Plasmodium falciparum and P. vivax
(b) Plasmodium ovale and P. vivax
(c) Plasmodium falciparum and P. ovale
(d) P. falciparum only

63. Two species of *Amoeba* X and Y were kept in fresh water and got adapted. Species X developed contractile vacuole. When both were transferred to sea water and got adapted, both X and Y lost their contractile vacuole. From these observation we conclude that
(a) Both X and Y are marine species
(b) Species Y is marine and X is fresh water
(c) Species X is marine and Y is fresh water
(d) Both X and Y are fresh water

64. In Trypanosoma gambiense
(a) Reproduction is by multiple fission
(b) There are two nuclei, a micronucleus and a macronucleus
(c) There are two locomotory organelles, a flagellum and an undulating membrane
(d) Tse-tse fly has no role to play in life cycle

65. In patient suffering from malaria, the cells having Schuffner's granules are
(a) Gametocytes (b) Signet ring trophozoites
(c) Infected erythrocytes (d) Infected liver cells

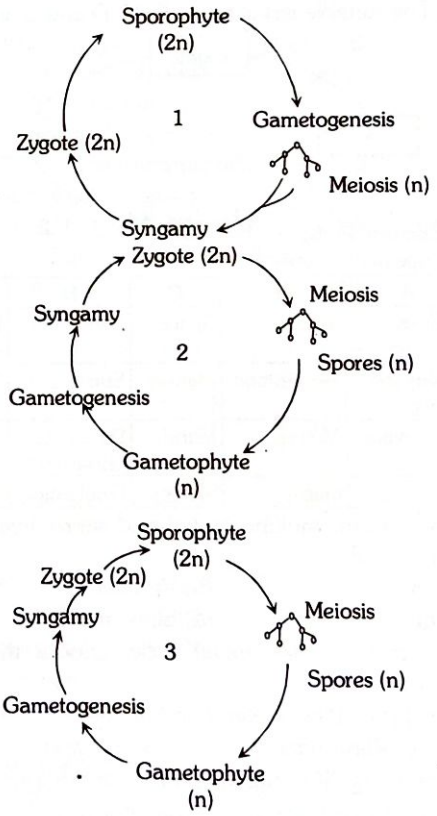
66. *E.histolytica* does not show
(a) Binary fission (b) Budding
(c) Encystation (d) Excystation

9. Fungi (General)

1. A group of fungi with septate mycelium in which sexual reproduction is either unknown or lacking are classified under
   (a) Phycomycetes (b) Deuteromycetes
   (c) Ascomycetes (d) Basidiomycetes
2. The product of which of the following organisms has been commercialised as blood cholesterol lowering agent
   (a) Trichoderma polysporum
   (b) Saccharomyces cerevisiae
   (c) Aspergillus niger
   (d) Monascus purpureus
3. Mycology (Mycetology) is a branch which deals with the study of
   (a) Viruses (b) Algae
   (c) Bacteria (d) Fungi
4. Fungal spores produced asexually at the tips of hyphae are called
   (a) Sporangiophores (b) Anthospores
   (c) Conidiophores (d) Meiospores
5. Thread like filaments of fungi are known as
   (a) Conidia (b) Mycorrhiza
   (c) Sporangium (d) Hyphae
6. In 1943 the causal organism and host of Bengal famine was
   (a) Wheat rust by *Puccinia*
   (b) Blast of rice by *Pyricularia oryzae*
   (c) Blast of rice by *Xanthomonasoryzae*
   (d) Brown leaf spot of rice by *Helminthosporium oryzae*
7. The disease of potato responsible for famous famine of Europe was caused by or late blight of potato is caused by
   (a) Colletotrichum falcatum (b) Phytophthora infestans
   (c) Potato mosaic virus (d) Alternaria solani
8. Septum in eumycota fungi, bearing a complex pore is designated as a
   (a) Coenocyte (b) Septate hypha
   (c) Dolipore septum (d) Secondary simple pore
9. The hyphae of *Aspergillus* are
   (a) Aseptate and multinucleate
   (b) Septate and multinucleate
   (c) Aseptate and uninucleate
   (d) Septateanduninucleate
10. Asexual reproduction in fungi takes place by
    (a) Endospore (b) Gametangia
    (c) Exospores (d) Conidiospore
11. A dikaryotic cell has
    (a) Two haploid nuclei
    (b) Diploid zygotes
    (c) Two similar nuclei
    (d) Two dissimilar haploid nuclei
12. Fungus used in genetic experiments is
    (a) Rhizopus (b) Mucor
    (c) Neurospora (d) Claviceps
13. A coprophillous fungus is
    (a) Trichoderma (b) Pilobolus
    (c) Fusarium (d) Humicola
14. Fungi differ from algae in being
    (a) Coenocytic
    (b) Without motile gametes
    (c) Without unicellular forms
    (d) Without chlorophyll and possessing chitinised wall
15. Parasexuality is involved with
    (a) Fusion of gamete and protoplast
    (b) Fusion of male gamete with secondary nucleus
    (c) Fusion of protoplast
    (d) Fusion of male and female gamete
16. Which of the following is the characteristic feature of ascomycetes
    (a) Hyphae (b) Spores
    (c) Zoospores (d) Ascospores
17. Match the different types of spores listed under column I with the names of the organisms given under column II. Choose the answer which gives correct combination of the alphabets of the two columns

Column I Spores	**Column II Organisms**
A. Ascospores	p. Diatoms
B. Endospores	q. *Agaricus*
C. Auxospores	r. Bacteria
D. Basidiospores	s. Yeast
	t. Nephrolepis

    (a) A = s, B = r, C = p, D = q
    (b) A = s, B = p, C = r, D = q
    (c) A = s, B = p, C = t, D = q
    (d) A = s, B = t, C = p, D = q
18. Clamp connection is found in
    (a) Basidiomycetes (b) Ascomycetes
    (c) Saccharomycetes (d) Haplomycetes
19. Which of the following correctly represents the type of life cycle patterns from the options given



    (a) 1. Diplontic 2. Haplodiplontic 3. Haplontic
    (b) 1. Haplodiplontic 2. Haplontic 3. Diplontic
    (c) 1. Haplontic 2. Diplontic 3. Haplodiplontic
    (d) 1. Diplontic 2. Haplontic 3. Haplodiplontic
    (e) 1. Haplontic 2. Haplodiplontic 3. Diplontic
20. Saprophytic and parasitic modes of nutrition are found in
    (a) Bacteria (b) Viruses
    (c) Fungi (d) Both (a) and (c)

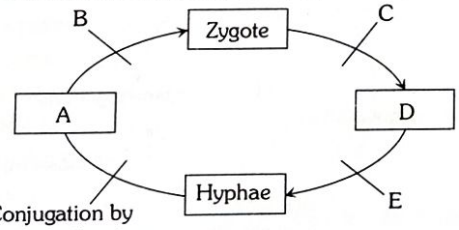
21. Which of the following is an edible 'Fungi'
(a) Mucor (b) Penicillium
(c) Agaricus (d) Rhizopus

22. Select the false statement
(a) Scientists who study and contribute to the classification of organisms are known as taxonomist
(b) Carolus Linnaeus developed the first scientific system of naming species
(c) A five Kingdom arrangement of organisms was introduced by R. H. Whittaker
(d) Genus is a group of species which are related and have less characters in common as compared to species
(e) Phycomycetes are called club fungi because of a club shaped end of mycelium known as basidium

23. Bakanae disease was due to
(a) Fungi toxin
(b) Growth hormones released by fungal infection
(c) Inadequate nutrients
(d) Change in photoperiods

24. Red rot of sugarcane and white rust of radish are respectively caused by
(a) Albugo candida and Cercospora
(b) Colletotrichum and Fusarium
(c) Pythium and Phytophthora
(d) Albugo candida and Puccinia graminis
(e) Colletotrichum and Albugo candida

25. The given below figure shows a generalized life cycle of a fungus. The suitable terms for A, B, C, D and E are



	A	B	C	D	E
(a)	Meiosis	Mitosis	Spore	Fertilization	Dikaryotic phase
(b)	Dikaryotic phase	Fertilization	Meiosis	Spore	Mitosis
(c)	Fertilization	Meiosis	Mitosis	Dikaryotic phase	Amitosis
(d)	Mycelium	Mitosis	Meiosis	Fertilization	Spore

26. Naked cytoplasm, multinucleated and saprophytic are the characteristics of
(a) Monera (b) Protista
(c) Fungi (d) Slime molds

27. With respect to fungal sexual cycle, choose the correct sequence of events
(a) Karyogamy, Plasmogamy and Meiosis
(b) Meiosis, Plasmogamy and Karyogamy
(c) Plasmogamy, Karyogamy and Meiosis
(d) Meiosis, Karyogamy and Plasmogamy

28. Members of phycomycetes are found in
I. Aquatic habitats
II. On decaying wood
III. Moist and damp places
IV. As obligate parasites on plants
Choose from the following options
(a) None of the above (b) I and IV
(c) II and III (d) All of the above

29. Match the following and choose the correct combination from the options given

Column I (Group)	Column II (Example)
A. Eubacteria	1. *Trichoderma*
B. Dinoflagellates	2. *Albugo*
C. Phycomycetes	3. *Gonyaulax*
D. Deuteromycetes	4. *Anabaena*

(a) A-1; B-2; C-3; D-4 (b) A-2; B-3; C-4; D-1
(c) A-4; B-3; C-2; D-1 (d) A-3; B-4; C-1; D-2
(e) A-4; B-3; C-1; D-2

30. Asci are formed in
(a) Ascobolus (b) Saccharomyces
(c) Penicillium (d) All the above

31. The edible part of mushroom is
(a) Basidiocarp (b) Tertiary mycelium
(c) Primary mycelium (d) Secondary mycelium

32. Catabolism Considering mode of asexual reproduction, match the Column I with II and select the correct option

Column I		Column II	
A.	Yeast	I.	Fragmentation
B.	*Penicillium*	II.	Zoospores
C.	Filamentous algae	III.	Budding
D.	*Chlamydomonas*	IV.	Conidia

33. LSD is obtained from[CPMT 1998; AFMC 2000; BVP 2002]
(a) Clavatia (b) Claviceps
(c) Amantia (d) Trichoderma

34. Who gave the parasitic nature of fungus in plants
(a) Pasteur (b) Anton De Bary
(c) Robert Koch (d) J.F. Kuhn

35. Wart disease caused by *Synchytriume endobioticum* is found in
(a) Cabbage (b) Potato
(c) Pea (d) Groundnut

36. Chitin present in fungal wall has a formula
(a) $(C_{22}H_{54}N_4O_{21})_n$ (b) $(C_{21}H_{54}N_4O_{22})_n$
(c) $(C_{22}H_{54}N_4O_{13})_n$ (d) $(C_{22}H_{24}N_4O_{21})_n$

37. The fungus used for the commercial production of SCP is
(a) Pentadiplandra brazzeana
(b) Fusarium graminearum
(c) Brassica napus
(d) Bacillus thuringiensis
(e) Phytophthora infestans

38. Covered smut of *Sorghum* is caused by
(a) Sphacelotheca cruenta
(b) Sphacelotheca sorghii
(c) Sphacelotheca reiliana
(d) Tolyposporium ehrenbergii

39. The fungus that may cause disease in human beings is
(a) Puccinia (b) Aspergillus
(c) Cystopus (d) Rhizopus

40. A combined solution of copper sulphate and calcium hydroxide which is used as a fungicide is
(a) Fehling solution (b) Folins mixture
(c) Carminative mixture (d) Bordeaux mixture

41. Fungal flagellum originates from
(a) Dictyosome (b) Kinetosome
(c) Glyoxysomes (d) Oxysomes

42. Which of the following fungi is found useful in the biological control of plant disease
(a) Penicillium notatum (b) Phytophthora parasitica
(c) Mucor mucido (d) Trichoderma viridae

43. Ray fungi are
(a) Ascomycetes (b) Basidiomycetes
(c) Actinomycetes (d) Phycomycetes

44. In *Puccinia*, infection from barberry leaf to wheat plant is caused by
(a) Pycnospores (b) Aecidiospores
(c) Uredospores (d) Teleutospores

45. In all members of Ascomycetes, the number of ascospores and their arrangement in an ascus are as follows
(a) Eight ascospores in a linear order
(b) Four ascospores in a linear order
(c) Either eight or four ascospores, but always in a linear order
(d) Either eight or four ascospores in a linear order or unordered

46. Fungi causing hair loss are
(a) Keratophilous (b) Pyrophilous
(c) Coprophilous (d) None of these

10. Mucor and Rhizopus

1. Coenogametes are formed in
(a) Albugo (b) Saccharomyces
(c) Rhizopus (d) Alternaria

2. Zygospores are formed in
(a) Puccinia (b) Penicillium
(c) Alternaria (d) Mucor / Rhizopus

3. *Mucor* shows
(a) Isogamy (b) Anisogamy
(c) Oogamy (d) None of the above

4. Which one of the following fungus shows heterothallism
(a) Erisyphe (b) Peziza
(c) Rhizopus (d) Peronospora

5. Which of the following plant and its mode of nutrition is not correctly matched
(a) *Cuscuta* – Stem parasite
(b) *Mucor* – Autotroph
(c) *Orobanche* – Root parasite
(d) *Drosera* – Insectivorous

6. Mode of nutrition in *Rhizopus* is
(a) Parasitic (b) Symbiotic
(c) Saprophytic (d) Autotrophic

7. Heterothallism in *Mucor* was first reported by
(a) Robert Hooke (b) Blakeslee
(c) Louis Pasteur (d) Fleming

8. Collumella is found in
(a) Mucor / Rhizopus (b) Spirogyra
(c) Moss (d) Both (a) and (c)

9. Fusion of gametangia in *Rhizopus* is
(a) Planogemetic copulation (b) Gametangial contact
(c) Gametangial copulation (d) Spermatogamy

10. Arrange the following in correct sequence with reference to sexual reproduction in *Rhizopus*
(I) Formation of germ tube
(II) Formation of zygophores
(III) Formation of warty wall layer of zygospore
(IV) Secretion of trisporic acid
The correct sequence is
(a) IV, III, II, I (b) IV, II, III, I
(c) II, I, IV, III (d) I, III, II, IV

11. Which one secretes pheromones for the function
(a) *Rhizopus* for formation of zygospore
(b) All fungi for sexual reproduction
(c) Yeast for mating
(d) Plants for growth and development

12. Motile sperms are absent in
(a) Rhizopus (b) Funaria
(c) Fern (d) Cycas

11. Yeast and Albugo

1. Yeast produces an enzyme complex that is responsible for fermentation. The enzyme complex is
(a) Aldolase (b) Dehydrogenase
(c) Invertase (d) Zymase

2. Fungus without any mycelium is
(a) Albugo (b) Agaricus
(c) Puccinia (d) Saccharomyces

3. Botanical name of species which cause white rust of cruciferae
(a) Peronospora parasitica (b) Puccinia graminis
(c) Pythium debaryanum (d) Albugo candida

4. Which organism is used to obtain the single cell protein
(a) Bacteria (b) Yeast
(c) Filamentous Fungi (d) All of the above

5. Yeast is divided under the class
(a) Basidiomycetes (b) Deuteromycetes
(c) Ascomycetes (d) Zygomycetes

6. Life cycle of yeast is
(a) Haplodiplobiontic (b) Haplobiontic
(c) Diplobiontic (d) All of the above

7. A plant example in which reproductive structures lack a layer of sterile vegetative cells surrounding the egg
(a) Funaria (b) Riccia
(c) Saccharomyces (d) Cycas

8. In yeast, cell wall contains
(a) Amylose and glucose
(b) Glucose and mannose
(c) Glucose and muramic acid
(d) Sucrose and mannose

9. Sometimes, in yeast, the conjugation takes place between a parent cell and a bud. It is called
(a) Isogamy (b) Syngamy
(c) Pedogamy (d) Parthenogenesis

10. Which of the following is not matched correctly

(a)	*Anabaena*	-	Cyanobacteria
(b)	*Amoeba*	-	Protozoa
(c)	*Gonyaulax*	-	Dinoflagellates
(d)	Thermoacidophils	-	Archaebacteria
(e)	*Albugo*	-	Chrysophytes

11. Zoospore of *Albugo* possesses flagella
(a) Two similar and apical
(b) Four similar and medium
(c) Four apical
(d) Two dissimilar and laterally

12. Lichen and Mycorrhiza

1. 'Mycorrhizae' are useful for plants mainly due to their following attribute
(a) Fixing atmospheric nitrogen
(b) Enhanced absorption of nutrients from soil
(c) Killing insects and pathogens
(d) Providing resistance against abiotic stresses

2. Fungal partner of a lichen is commonly
(a) Ascomycetes (b) Basidiomycetes
(c) Phycomycetes (d) Deuteromycetes

3. Reindeer moss is
(a) Sphagnum (b) Marchantia
(c) Cladonia rangiferina (d) None of these

4. Mycobiont and Phycobiont are found in
(a) Mycorrhiza (b) Root
(c) Lichens (d) BGA

5. VAM represents
(a) Saprophytic fungi (b) Symbiotic fungi
(c) Saprophytic bacteria (d) Symbiotic bacteria

6. A teacher was explaining about a constant physical contact involving almost equal physiological interdependence in two different thaloid forms. He was trying to explain one of the following
(a) Mycorrhizal association
(b) Establishment of heterothallism
(c) Operation of heterothallism
(d) Advent of lichen formation

7. Association of fungus with roots of tracheophytes is
(a) Mycorrhiza (b) Commensalism
(c) Helotism (d) Amensalism

8. Fungus/Lichens which grow on wood is
(a) Terricolous (b) Saxicolous
(c) Lignocolous (d) Corticolous

9. Lichens multiply by
(a) Conidia (b) Oidia
(c) Ascospores (d) Soredia

13. Virus

1. A virus containing ssRNA act as a template for DNA synthesis is called as
(a) Polio virus (b) Retro virus
(c) Pox virus (d) Adeno virus

2. The rabies virus consists of
(a) Single stranded RNA (b) Double stranded RNA
(c) Single stranded DNA (d) Double stranded DNA

3. Which one is absent in viruses
(a) Replication (b) Protein synthesis
(c) Energy liberation (d) Mutation

4. Which one of the following are intracellular obligate parasites
(a) Bacteria (b) Viruses
(c) Slime moulds (d) Blue-green algae

5. Virus was discovered by whom
(a) Stanley (b) Ivanowski
(c) Herelle (d) Beijerinck

6. In which virus, DNA is double stranded
(a) Hepatitis A (b) Hepatitis B
(c) Hepatitis C (d) Hepatitis D

7. The size of TMV is
(a) 17.5 × 300Å (b) 17.5 × 300*nm*
(c) 19.5 × 250Å (d) 19.5 × 250*nm*

8. Temin worked on which virus
(a) Herpesvirus (b) Rhinovirus
(c) Retrovirus (d) Denguvirus

9. Influenza is caused by
(a) Bacterium (b) Virus
(c) Fungus (d) Cyanobacterium

10. Viruses multiply in[EAMCET 1995; BVP 2001; BHU 2004]
(a) Bacteria only (b) All living cells
(c) Specific living cells (d) Rotten food

11. Potato tuber spindle disease is caused by
(a) Virus (b) Viroid
(c) Plasmid (d) None of these

12. Tobacco mosaic Virus (TMV) has
(a) A single stranded RNA molecule
(b) A double stranded RNA molecule
(c) A single stranded DNA molecule
(d) A double stranded DNA molecule

13. A bacteriophage is
(a) A virus attacking a bacterium
(b) A bacterium attacking a virus
(c) A stage in the life-cycle of bacterium
(d) A virus attacking another virus

14. The spread of AIDS disease is promoted by
(a) Homosexuality
(b) Immoral way of life
(c) Use of infected needles in blood transfusion
(d) All the above

15. Sometimes when a virus attacks a bacterium, neither the virus multiplies nor the bacterium dies. This phenomenon is called as
(a) Adsorption (b) Assimilation
(c) Lysogeny (d) Viral stability

16. Potato leaf-roll disease is caused by
(a) Mycoplasma (b) Virus
(c) Microspores (d) Bacterium

17. Viral genome incorporated host DNA is called
(a) Prophase (b) Prophage
(c) Bacteriophage (d) None of these

18. Plant virus was first crystallized by
(a) Pirie (b) Bawden
(c) Stanley (d) Beijerinck

19. Which of the following sequence is found in *Rous sarcoma virus*
(a) DNA→ RNA → Protein
(b) RNA → RNA →Protein
(c) RNA →DNA→ RNA → Protein
(d) DNA→DNA→ Protein

20. Coliphage T_2 has
(a) *ss*RNA (b) *ss*DNA
(c) *ds*RNA (d) *ds*DNA

21. Viroids have
(a) Double stranded RNA enclosed by protein coat
(b) Double stranded DNA enclosed by protein coat
(c) Single stranded DNA not enclosed by protein coat
(d) Single stranded RNA not enclosed by protein coat

22. Which of the following diseases are known to be caused by viruses (In this item one or more of the answers given may be correct. Decide which are correct and mark the answer sheet according to the code)
1. Burkitt's lymphoma
2. Adult T–cell leukemia
3. Phenyl ketonuria
Code
(a) 1, 2 and 3 are correct (b) Only 1 and 2 are correct
(c) Only 2 and 3 are correct (d) Only 1 and 3 are correct

23. A single stranded DNA molecule is the genetic material of bacteriophage
(a) T_2 (b) T_4
(c) ϕ× 174 (d) λ

24. The genome of transducing phages is
(a) Single stranded RNA (b) Double stranded RNA
(c) Single stranded DNA (d) Double stranded DNA

25. Bacteriophage is similar to fungus
(a) In having DNA as genetic material
(b) In having RNA as genetic material
(c) In mode of reproduction
(d) In having cell wall

26. Difference between Virus and Viroid is
(a) Absence of protein coat in viroid but present in virus
(b) Presence of low molecular weight RNA in virus but absent in viroid
(c) Both a and b
(d) None of the above

27. Viruses are non-cellular organisms but replicate themselves once they infect the host cell. To which of the following kingdom do viruses belong to
(a) Monera (b) Protista
(c) Fungi (d) None of the above

28. Most of the plant viruses are characterized in having
(a) DNA (b) RNA
(c) DNA and RNA (d) Lipids

29. Viruses enter plant cells only through
(a) Lenticels (b) Wounds
(c) Stomata (d) Roots

30. The agents which are known to cause CJD are
(a) Protein particles (b) A class of bacteria
(c) A class of viruses (d) Fungi

31. The filterable property of tobacco mosaic virus (TMV) was shown by
(a) Ivanowsky (b) Beijerinck
(c) Stanley (d) Winogradsky

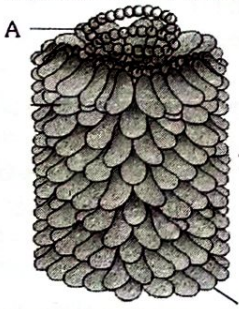
32. Viruses were called *Contagium vivum fluidum* by
(a) de Herelle (b) Bawden and Pirie
(c) Twort (d) Beijerinck

33. Genetic material of reovirus is
(a) *ds*DNA (b) ssDNA
(c) *ds* RNA (d) *ss* RNA

34. Banana bunchy top is caused by
(a) Mycoplasma
(b) Deutromycetes
(c) Xanthomonas
(d) Pentalonia nigronervosa (Virus)

35. Dog distemper is a disease carried by a
(a) Bacterium (b) Viroid
(c) Prion (d) Virus

36. The diagram of a virus is given below. In which of the options A, B and C are correct



Type of virus – C

	A	B	C
(a)	RNA	Protein	HIV
(b)	RNA	Lipid	Tobacco Mosaic Virus
(c)	DNA	Capsid	Tobacco Mosaic Virus
(d)	RNA	Capsid	Tobacco Mosaic Virus

37. Identify the correct sequence of events in the viral replication process.
I. Eclipse II. Maturation
III. Adsorption IV. Assembly
V. Penetration VI. Lysis
(a) I → II → III → IV → V → VI
(b) II → I → III → IV → V → VI
(c) III → V → I → II → IV → VI
(d) III → V → I → IV → II → VI

14. NEET-AIPMT

1. How many organisms in the list given below are autotrophs Lactobacillus, Nostoc, Chara, Nitrosomonas, Nitrobacter, Streptomyces, Sacharomyces, Trypanosoma, Porphyra, Wolfia **[2012]**
(a) Four (b) Five
(c) Six (d) Three

2. In Escherichia coli **[1993]**
(a) An organised nucleus is present
(b) One chromosome is present
(c) One DNA molecule is present
(d) One RNA molecule is present

3. Bacteria were first discovered by **[1995]**
(a) Robert Koch (b) L. Pasteur
(c) Robert Hooke (d) A.V. Leeuwenhoek

4. Membrane-bound organelles are absent in **[2010]**
(a) Plasmodium (b) Saccharomyces
(c) Streptococcus (d) Chlamydomonas

5. Some hyperthermophilic organisms that grow in highly acidic (*pH2*) habitats belong to the two groups **[2010]**
(a) Liverworts and yeasts
(b) Eubacteria and archaea
(c) Cyanobacteria and diatoms
(d) Protists and mosses

6. The main difference between Gram positive and Gram negative bacteria lies in the composition of **[1990, 2001]**
(a) Cilia (b) Cell wall
(c) Nucleolus (d) Cytoplasm

7. Which one of the following organisms is not an example of eukaryotic cells **[2011]**
(a) Amoeba proteus (b) Paramecium caudatum
(c) Escherichia coli (d) Euglena viridis

8. The habitat of *E. coli* is **[1989, 98]**
(a) Water (b) Colon (Intestine)
(c) Soil (d) Organic food

9. 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 **[2008]**
(a) Archaea completely differ from both prokaryotes and eukaryotes
(b) Archaea completely differ from prokaryotes
(c) Archaea resemble eukarya in all respects
(d) Archaea have some novel features that are absent in other prokaryotes and eukaryotes

10. Mesosome in a bacterial cell is **[1997]**
(a) Plasmid
(b) Connection between two cells
(c) Plasma membrane infolded for respiration
(d) None of these

11. First organism which was evolved on the earth **[2001]**
(a) Saprotrophs (b) Chemohetrotrophs
(c) Photoautotrophs (d) Chemoautotrophs

12. The correct sequence of stages of growth curve for bacteria is **[1999]**
(a) Decline, lag, log phase
(b) Lag, log, stationary phase
(c) Stationary, lag, log, decline phase
(d) Lag, log, stationary, decline phase

13. Circular DNA molecule occurs in **[1996]**
(a) Viruses
(b) Bacteria, chloroplasts and mitochondria
(c) Bacteria and chloroplasts only
(d) Bacteria only

14. Why is a capsule advantageous to a bacterium **[2013]**
(a) It protects the bacterium from desiccation
(b) It provides means of locomotion
(c) It allows bacterium to "hide" from host's immune system
(d) It allows the bacterium to attach to the surface

15. Lysozyme that is present in perspiration, saliva and tears, destroys **[2007]**
(a) Certain fungi (b) Certain types of bacteria
(c) All viruses (d) Most virus - infected cells

16. The motile bacteria are able to move by **[2014]**
(a) Cilia (b) Pili
(c) Fimbriae (d) Flagella

17. Pick up the wrong statement **[2015]**
(a) Protista have photosynthetic and heterotrophic modes of nutrition
(b) Some fungi are edible
(c) Nuclear membrane is present in monera
(d) Cell wall is absent in animalia

18. The term 'glycocalyx' is used for **[2013]**
(a) A layer present between cell wall and membrane of bacteria
(b) Cell wall of bacteria
(c) Bacterial cell glyco-engineered to possess N-glycosylated proteins
(d) A layer surrounding the cell wall of bacteria

19. Archaebacteria differ from eubacteria in **[2014]**
(a) Cell shape
(b) Mode of reproduction
(c) Cell membrane structure
(d) Mode of nutrition

20. The structure that help some bacteria to attach to rocks and/or host tissues are **[2015]**
(a) Fimbriae (b) Mesosomes
(c) Holdfast (d) Rhizoids

21. Which among the following is not a prokaryote **[2018]**
(a) Oscillatoria (b) Nostoc
(c) Mycobacterium (d) Saccharomyces

22. There is no alternation of generation in *Escherichia coli* because there is no **[1994]**
(a) Syngamy (b) Reduction division
(c) Conjugation (d) None of these

23. Transformation experiment was performed on which of the following bacteria **[2002]**
(a) E. coli (b) Salmonella
(c) Pasturella pestis (d) Diplococcus pneumoniae

24. Sex factor in bacteria is **[1996]**
(a) F–replicon (b) Chromosomal replicon
(c) RNA (d) Sex pills

25. In Griffith's experiment, the conversion of R-type to S-type of *Diplococcus Pneumoniae* when mixed with heat killed S-type is called **[2002]**
(a) Transduction (b)Transportation
(c) Transition (d)Transformation

26. The guts of cow and buffalo possess **[2015]**
(a) *Chlorella* spp. (b) Methanogens
(c) Cyanobacteria (d) *Fucus* spp.

27. Koch's postulates are not applicable to **[1999]**
(a) T. B. (b) Leprosy
(c) Cholera (d) Diphtheria

28. A bacterium divides every 35 minutes. If a culture containing 10^5*cells / ml* is grown for 175 minutes. What will be the cell concentration / *ml* after 175 minutes **[1998]**
(a) 175×10^5 cells (b) 85×10^5 cells
(c) 35×10^5 cells (d) 32×10^5 cells

29. Curing of tea leaves is brought about by the activity of **[2006]**
(a) Viruses (b) Fungi
(c) Bacteria (d) Mycorrhiza

30. Which of the following is free-living aerobic non-photosynthetic nitrogen fixing bacterium **[1997]**
(a) Rhizobium (b) Azotobacter
(c) Nostoc (d) Azospirillum

31. A free living anaerobic bacterium capable of N_2 fixation in soil is **[1990]**
(a) Rhizobium (b) Azotobacter
(c) Streptococcus (d) Clostridium

32. Which of the following groups of plants are highly useful in increasing soil fertility **[1993]**
(a) Red algae (b) Fungi
(c) Bacteria (d) Bryophytes

33. Consider the following four statements (1-4) and select the option which includes all the correct ones only
(1) Single cell *Spirulina* can produce large quantities of food rich in protein, minerals, vitamins etc
(2) Body weight-wise the microorganism *Methylophilus methylotrophus* may be able to produce several times more proteins then the cows per day
(3) Common button mushrooms are a very rich source of vitamin C
(4) A rice variety has been developed which is very rich in calcium
Options : **[2012]**
(a) Statements (3), (4)
(b) Statements (1), (3) and (4)
(c) Statements (2), (3) and (4)
(d) Statements (1), (2)

34. For retting of jute the fermenting microbe used is **[2005]**
(a) *Methophilic bacteria* (b) Butyric acid
(c) *Helicobactor pylori* (d) *Streptococcus lactin*

35. Which of the following is symbiotic nitrogen fixes **[2009]**
(a) Streptomyces (b) Anabaena
(c) Frankia (d) Rhizobium

36. Which of the following is non-symbiotic biofertilizer **[1998]**
(a) VAM (b) *Azotobacter*
(c) *Anabaena* (d) *Rhizobium*

37. The main role of bacteria in the carbon cycle involves **[1998]**
(a) Photosynthesis
(b) Assimilation of nitrogenous compounds
(c) Chemosynthesis
(d) Digestion or breakdown of organic compounds

38. Which of the following is a flowering plant with nodules containing filamentous nitrogen-fixing microorganism **[2007]**
(a) *Casuarina equisetifolia* (b) *Crotalaria juncea*
(c) *Cycas revoluta* (d) *Cicer arietinum*

39. One of the free-living, anaerobic nitrogen-fixer is [2010]

Or

Anoxygenic photosynthesis is characteristic of [2014]

(a) Azotobacter (b) Beijernickia
(c) Rhodospirillum (d) Rhizobium

40. A prokaryotic autotrophic nitrogen fixing symbiont found in [2011]

Or

Besides paddy fields, cyanobacteria are also found inside vegetative part of [2013]

(a) *Pisum* (b) *Alnus*
(c) *Cycas* (d) *Cicer*

41. Organisms called Methanogens are most abundant in a [2011]

(a) Hot spring (b) Sulphur rock
(c) Cattle yard (d) Polluted stream

42. During biological nitrogen fixation, inactivation of nitrogenase by oxygen poisoning is prevented by [2015]

(a) Xanthophyll (b) Carotene
(c) Cytochrome (d) Leghaemoglobin

43. Azotobacter and Polymyxa are example of [1996]

(a) Symbiotic nitrogen fixation
(b) Non-symbiotic nitrogen fixation
(c) Disease causing bacteria
(d) Ammonifying bacteria

44. Oxygenic photosynthesis occurs in [2009]

(a) Chromatium (b) Oscillatoria
(c) Rhodospirillum (d) Chlorobium

45. The symbiotic nitrogen fixing bacteria present in root nodules of legumes belong to genus [1999]

(a) Xanthomonas (b) Pseudomonas
(c) Rhizobium (d) Acetobacter

46. Thermococcus, Methanococcus and Methanobacterium exemplify [2008]

(a) Bacteria whose DNA is relaxed or positively supercoiled but which have a cytoskeleton as well as mitochondria
(b) Bacteria that contain a cytoskeleton and ribosomes
(c) Archaebacteria that contain protein homologous to eukaryotic core histones.
(d) Archaebacteria that lack any histones resembling those found in eukaryotes but whose DNA is negatively supercoiled

47. Nitrifying bacteria, *Nitrosomonas* and *Nitrobactor* [2011]

(a) Convert (oxidise) ammonia or ammonium compounds into nitrates
(b) Convert nitrate into nitrogen
(c) Convert nitrogen into nitrates
(d) Convert carbon dioxide into carbohydrates

48. The most abundant prokaryotes helpful to humans in making curd from milk and in production of antibiotics are the ones categorised as [2012]

(a) Cyanobacteria
(b) Archaebacteria
(c) Chemosynthetic autotrophs
d) Heterotrophic bacteria

49. Nitrogen fixation in root nodules or *Alnus* is brought about by [2008]

(a) Frankia (b) Azorhizobium
(c) Bradyrhizobium (d) Clostridium

50. All of the following statements concerning the actinomycetous filamentous soil bacterium *Frankia* are correct except that *Frankia* [2005]

(a) Can induce root nodules on many plant species
(b) Can not fix nitrogen in the free-living state
(c) Can not fix specialized vesicles in which the nitrogenase is protected from oxygen by a chemical barrier involving triterpene hapanoids
(d) Like *Rhizobium*, it usually infects its host plant through root hair deformation and stimulates cell proliferation in the host's cortex

51. Plasmid are used as carrier because [2000]

(a) It has antibiotic resistance genes
(b) Its both ends are replication points
(c) It can go between eukaryotic and prokaryotic cells
(d) It is circular DNA which has capacity to bind eukaryote DNA

52. A large number of organic compounds can be decomposed by [1995]

(a) Chemoorgano (b) *Pseudomonas*
(c) *Acetobacter* (d) Mycoplasma

53. Probiotics are [2007]

(a) Safe antibiotics
(b) Cancer inducing microbes
(c) New kind of food allergens
(d) Live microbial food supplement

54. Which one of the following is wrong statement [2012]

(a) *Anabaena* and *Nostoc* are capable of fixing nitrogen in free living state also
(b) Root nodule forming nitrogen fixers live as aerobes under free living conditions
(c) Phosphorus is a constituent of all membranes , certain nucleic acids and all proteins
(d) *Nitrosomonas* and *Nitrobacter* are chemoautotrophs

55. The most throughly studied of the known bacteria-plant interactions is the [2004]

(a) Nodulation of *Sebania* stems by nitrogen fixing bacteria
(b) Plant growth stimulation by phosphate-solubilising bacteria
(c) Cyanobacterial symbiosis with some aquatic ferns
(d) Gall formation on certain angiosperms by *Agrobacterium*

56. Bacterial blight of rice is caused due to [2008]

(a) Xanthomonas oryzae
(b) Helminthosporium oryzae
(c) Pseudomonas falcatum
(d) Xanthomonas falcatum

57. Prokaryota includes [1996]

(a) Mycoplasma
(b) *Ulothrix*
(c) Fungi
(d) Mycoplasma and blue-green algae

58. Which one of the following statements about mycoplasma is wrong [2007]

(a) They are also called PPLO
(b) They are pleomorphic
(c) They are sensitive to penicillin
(d) They cause diseases in plants

59. Which one is the smallest organism capable of autonomous growth and reproduction

Or

Which among the following are the smallest living cells, known without a definite cell wall, pathogenic to plants as well as animals and can survive without oxygen **[2017]**

(a) Virus (b) Viroid
(c) Mycoplasma (PPLO) (d) None of the above

60. Which of the following statement is true for Mycoplasma **[2015]**

(a) Presence of cell wall (b) Presence of nucleus
(c) Absence of cell wall (d) Definite shape

61. 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 algae which fixes atmospheric nitrogen
(C) Chemosynthetic autotrophic bacteria synthesize cellulose from glucose
(D) Mycoplasma lack a cell and can survive without oxygen

The correct statements are **[2010]**

(a) (B), (C) (b) (A), (B), (C)
(c) (B), (C), (D) (d) (A), (B), (D)

62. Nitrogen fixation by *Nostoc*/Anabaena takes place in **[2013]**

(a) Heterocysts (b) Vegetative cells
(c) Akinetes (d) Hormogonia

63. The characteristic of blue green algae is **[1999]**

Or

Blue- green algae are called cynobacteria because

(a) DNA without histone (b) Nuclear membrane absent
(c) 70 S ribosomes (d) All of the above

64. In which of the following there is no sexual reproduction **[1995, 99]**

(a) Ulothrix (b) Nostoc
(c) Aspergillus (d) Volvox

65. The name cyanobacteria refers to **[2012]**

(a) Bacteria (b) Blue–green algae
(c) Yeast (d) Fungi

66. Nuclear membrane is absent in **[2012]**

(a) Penicillium (b) Agaricus
(c) Volvox (d) Nostoc

67. A few organisms are known to grow and multiply at temperatures of 100 – 105°*C*. They belong to **[1998]**

(a) Thermophilic subaerial fungi
(b) Marine archaebacteria
(c) Thermophilic sulphur bacteria
(d) Hot spring blue-green algae

68. Which of the following are likely to be present in deep sea water **[2013]**

(a) Saprophytic fungi (b) Archaebacteria
(c) Eubacteria (d) Blue-green algae

69. Which one of the following statements is wrong **[2016]**

(a) Cyanobacteria are also called blue-green algae
(b) Golden-algae are also called desmids
(c) Eubacteria are also called false bacteria
(d) Phycomycetes are also called algal fungi

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

(a) Chromatophores (b) Heterocysts
(c) Basal bodies (d) Pneumatophores

71. The thalloid body of a slime mould (Myxomycetes) is known as **[2006]**

(a) Fruiting body (b) Mycelium
(c) Protonema (d) Plasmodium

72. Protists obtain food as **[1994]**

(a) Photosynthesisers, symbionts and holotrophs
(b) Photosynthesisers
(c) Chemosynthesisers
(d) Holotrophs

73. Protistan genome has **[1994]**

(a) Membrane bound nucleoproteins embedded in cytoplasm
(b) Free nucleic acid aggregates
(c) Gene containing nucleoproteins condensed together in loose mass
(d) Nucleoprotein in direct contact with cell substance

74. Which of the following is a slime mould **[2007]**

(a) Rhizopus (b) Physarum
(c) Thiobacillus (d) Anabaena

75. Which protozoan is unlikely to have a contractile vacuole **[2001]**

(a) Euglena (b) Paramecium
(c) Amoeba (d) Plasmodium

76. Which of the following unicellular organism has a macronucleus for trophic function and one or more micronuclei for reproduction **[2005]**

(a) Euglena (b) Amoeba
(c) Paramecium (d) Trypanosoma

77. Malaria fever coincides with liberation of

(a) Cryptomerozoites (b) Metacryptomerozoites
(c) Merozoites (d) Trophozoites

78. The part of life cycle of malarial parasite *Plasmodium vivax*, that is passed in female *Anopheles* is **[1992]**

(a) Sexual cycle
(b) Pre-erythrocytic schizogony
(c) Exoerythrocytic schizogony
(d) Post-erythrocytic schizogony

79. What is common about Trypanosoma, Noctiluca, Monocystis and Giardia **[2006]**

(a) They produce spores
(b) These are all parasites
(c) These are all unicellular protists
(d) They have flagella

80. In which group of organisms the cell walls form two thin overlapping shells which fit together **[2015]**

(a) Euglenoids (b) Dinoflagellates
(c) Slime moulds (d) Chrysopytes

81. The active form of *Entamoeba-histolytica* feeds upon **[2015]**

(a) Mucosa and submucosa of colon only
(b) Food in intestine
(c) Blood only
(d) Erythrocytes, mucosa and submucosa of colon

82. The major function of contractile vacuole is **[1995]**

(a) Excretion (b) Circulation
(c) Osmoregulation (d) All the above

83. Motile elongate zygote of *Plasmodium* occurs in **[2012]**

(a) Human RBCs
(b) Human liver
(c) Salivary glands of mosquito (*Anopheles*)
(d) Gut of mosquito (*Anopheles*)

84. Which of the following diseases is caused by a protozoan **[2015]**
(a) Influenza (b) Babesiosis
(c) Blastomycosis (d) Syphilis

85. In which of the following animal dimorphic nucleus is found **[2002]**
(a) Amoeba proteus (b) Plasmodium vivax
(c) Paramecium caudatum (d) Trypanosoma gambiense

86. The chief advantage of encystment to an *Amoeba* is **[2003]**
(a) The chance to get rid of accumulated waste products
(b) The ability to survive during adverse physical conditions
(c) The ability to live for some time without ingesting food
(d) Protection from parasites and predators

87. Which is true about *Trypanosoma* **[1990]**
(a) Polymorphic (b) Monogenetic
(c) Facultative parasite (d) Non-pathogenic

88. When a fresh-water protozoan possessing a contractile vacuole, is placed in a glass containing marine water, the vacuole will **[2004]**
(a) Increase in size (b) Decrease in size
(c) Increase in number (d) Disappear

89. Malignant tertian malaria is due to
or
Cerebral malaria is due to **[1991]**
(a) Plasmodium falciparum (b) P. vivax
(c) P. ovale (d) P. malariae

90. *Plasmodium*, the malarial parasite, belongs to class **[1990]**
(a) Sarcodina (b) Ciliata
(c) Sporozoa (d) Dinophyceae

91. If all ponds and puddles are destroyed, the organism likely to be destroyed is **[1993]**
(a) Leishmania (b) Trypanosoma
(c) Ascaris (d) Plasmodium

92. Which one of the following sets of items in the options a-d are correctly categorized with one exception in it **[2012]**

	Items	Category	Exception
(a)	UAA, UAG, UGA	Stop codons	*UAG*
(b)	Kangaroo, Koala, Wombat	Australian marsupials	*Wombat*
(c)	*Plasmodium, Cuscuta, Trypanosoma*	Protozoan parasites	*Cuscuta*
(d)	*Typhoid, Pneumonia, Diphtheria*	*Bacterial diseases*	*Diphtheria*

93. Ciliates differ from all other protozoans in **[2018]**
(a) Having two types of nuclei
(b) Using pseudopodia for capturing prey
(c) Having a contractile vacuole for removing excess water
(d) Using flagella for locomotion

94. The highest number of species in the world is represented by **[2012; 2013]**
(a) Fungi (b) Mosses
(c) Lichens (d) Algae

95. Match column I with column II, and select the correct option

Column I (Kingdom)		Column II (Class)	
A.	Morels	1.	Deuteromycetes
B.	Smut	2.	Ascomycetes
C.	Bread mould	3.	Basidiomycetes
D.	Imperfect fungi	4.	Phycomycetes

[2015]
(a) A–3, B–4, C–1, D–2 (b) A–2, B–3, C–4, D–1
(c) A–4, B–1, C–2, D–3 (d) A–3, B–4, C–2, D–1
(e) A–2, B–1, C–4, D–3

96. Which one of the following has haplontic life cycle **[2009]**
(a) Funaria (b) Polytrichum
(c) Ustilago (d) Wheat

97. Which one is the wrong pairing for the disease and its causal organism **[2009]**
(a) Late blight of potato – *Alternaria solani*
(b) Black rust of wheat – *Puccinia graminis*
(c) Loose smut of wheat – *Ustilago nuda*
(d) Root-knot of vegetables-*Meloidogyne sp*

98. The cell wall of fungi is made up of **[2016]**
(a) Chitin (b) Cellulose
(c) Pectin (d) Suberin

99. Ergot is caused by **[2007]**
(a) Claviceps (b) Penicillium
(c) Aspergillus (d) Rhizobium

100. According to their modes of nutrition, the fungi are classified into **[2000]**
(a) One category (b) Three categories
(c) Four categories (d) Six categories

101. Cellulose is the major component of cell walls of **[2008]**
(a) Pseudomonas (b) Saccharomyces
(c) Pythium (d) Xanthomonas

102. Fungal hyphae are able to penetrate the host with the help of **[2001]**
(a) Mechanical pressure (b) Softening by enzymes
(c) Both(a)and(b) (d) Suckers and hooks

103. The disease produced by fungus *Ustilago* are known as smuts because **[1994]**
(a) They parasite cereals
(b) The affected host becomes completely black
(c) Their mycelium is black
(d) They produced sooty mass of spores

104. Reserve food material of fungi is **[2000]**
(a) Starch (b) Protein
(c) Glucose (d) Glycogen

105. Black rust of wheat is caused by **[2010]**
(a) Puccinia graminis (b) Ustilago
(c) Pythium (d) None of these

106. Which one of the following is true for fungi **[2013]**
(a) They lack a rigid cell wall
(b) They are heterotrophs
(c) They lack nuclear membrane
(d) They are phagotrophs

107. Which one of the following matches is correct **[2015]**

(a)	*Alternaria*	Sexual reproduction absent	Deuteromycetes
(b)	*Mucor*	Reproduction by Conjugation	Ascomycetes
(c)	*Agaricus*	Parasitic fungus	Basidiomycetes
(d)	*Phytophthora*	Aseptate mycelium	Badidiomycetes

108. Choose the wrong statements **[2015]**
(a) Neurospora is used in the study of biochemical genetics
(b) Morels and truffles are poisonous mushrooms
(c) Yeast is unicellular and useful in fermentation
(d) Penicillium is multicellular and produces antibiotics

109. Which of the following fungal disease spreads by seed and flowers **[2002]**
(a) Corn stunt (b) Covered smut
(c) Potato root (d) Loose smut of wheat

110. Which pair of the following belongs to basidiomycetes **[2007]**

(a) Birds nest fungi and Puffballs
(b) Puffballs and *Claviceps*
(c) *Peziza* and Stink horns
(d) *Morchella* and Mushrooms

111. Which one of the following is wrongly matched **[2011]**

(a) Cassia - Imbricate aestivation
(b) Root pressure - Guttation
(c) *Puccinia* - Smut
(d) Root - Exarch protoxylem

112. Which of the following secretes toxins during storage conditions of crop plants **[2002]**

(a) Fusarium (b) Pencillium
(c) Aspergillus (d) Colletotrichum

113. Which one of the following is wronglymatched **[2011]**

(a) Cassia - Imbricate aestivation
(b) Root pressure - Guttation
(c) *Puccinia* - Smut
(d) Root - Exarch protoxylem

114. Which one of the following fungi contains hallucinogens **[2014]**

(a) *Neurospora* sp. (b) *Ustilago* sp.
(c) *Morchella esculenta* (d) *Amanita muscaria*

115. Chitin is chemically a polymer of

Or

The chitinous exoskeleton of arthropods is formed by the polymerisation of **[2015]**

(a) N-acetyl gluconic acid (b) N-acetyl glucosamine
(c) N-acetyl muramic acid (d) None of these

116. After karyogamy followed by meiosis, spores are produced exogenously in **[2018]**

(a) Saccharomyces (b) Agaricus
(c) Alternaria (d) Neurospora

117. Columella is a specialized structure found in the sporangium of **[1999]**

(a) Ulothrix (b) Rhizopus
(c) Spirogyra (d) None of these

118. The pathogen *Microsporum* responsible for ringworm disease in humans belongs to the same Kingdom of organisms as that of **[2011]**

(a) *Rhizopus*, a mould (b) *Ascaris*, a round worm
(c) *Taenia*, a tapeworm (d) *Wuchereria*, a filarial worm

119. Food stored in *Rhizopus* / *Mucor* as **[1992]**

(a) Protein and steroids (b) Sugar and oil
(c) Protein and starch (d) Glycogen and oil

120. Which one is wrong statement **[2015]**

(a) *Mucor* has biflagellate zoospores
(b) Haploid endosperm is typical feature of gymnosperms
(c) Brown algae have chlorophyll a and c and fucoxanthin
(d) Archegonia are found in bryophyte, pteridophyta and gymnosperms

121. 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 **[2006]**

(a) B, D and E only (b) B, C and F only
(c) A, C and E only (d) A, D and E only

122. Which one single organism or the pair of organisms is correctly assigned to its or their named taxonomic group **[2012]**

(a) *Paramecium* and *Plasmodium* belong to the same kingdom as that of *Penicillium*
(b) Lichen is a composite organism formed from the symbiotic association of an algae and a protozoan
(c) Yeast used in making bread and beer is a fungus
(d) *Nostoc* and *Anabaena* are examples of protista

123. The symbiotic association of fungi and algae is called **[1990;2001]**

(a) Lichen (b) Mycorrhiza
(c) Both (a) and (b) (d) Mycoplasma

124. In majority of lichens, there is association of **[2001]**

(a) Green algae and ascomycetes
(b) Green algae and basidiomycetes
(c) Blue green algae and ascomycetes
(d) Blue green algae and basidiomycetes

125. There exists a close association between the algae and the fungus within a lichen. The fungus **[2005]**

(a) Fixes the atmospheric nitrogen for the alga
(b) Provides protection, anchorage and absorption for the alga
(c) Provides food for the alga
(d) Releases oxygen for the alga

126. An example of endomycorrhiza is **[2010]**

(a) Nostoc (b) Glomus
(c) Agaricus (d) Rhizobium

127. Which one of the following helps in absorption of phosphorus from soil by plants **[2011]**

Or

Which one of the following microbes forms symbiotic association with plants and helps them in their nutrition **[2012]**

(a) Azotobacter (b) Glomus
(c) Aspergillus (d) Trichoderma

128. Mycorrhiza exhibits the phenomenon of **[1994]**

(a) Antagonism (b) Endemism
(c) Parasitism (d) Symbiosis

129. Which statements is wrong about lichens **[1996]**

(a) Some species are eaten by reindeers
(b) Lichens are indicators of pollution
(c) Theygrowrapidlyabout2*cm*perday
(d) They have symbiotic relationship between alga and fungus

130. The genetic material in viruses is **[1997]**

(a) Only RNA
(b) Only DNA
(c) RNA and DNA both
(d) RNA or DNA *i.e.* one nucleic acid in a virus

131. Algal viruses are known as **[1993]**

(a) Binal viruses (b) Cyanophages
(c) Mycophages (d) Phycophages

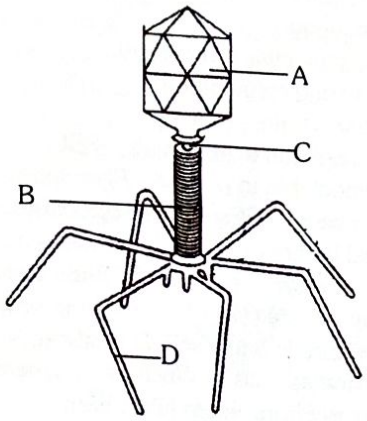
132. The causative agent of mad-cow disease is a **[2006]**

(a) Worm (b) Virus
(c) Bacterium (d) Prion

133. Viruses usually infect the whole plant except the **[1993]**

(a) Stem apex (b) Cortex
(c) Pith (d) Phloem

134. 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



Options: **[2010]**

	A	B	C	D
(a)	Tail fibres	Head	Sheath	Collar
(b)	Sheath	Collar	Head	Tail fibres
(c)	Head	Sheath	Collar	Tail fibres
(d)	Collar	Tail fibres	Head	Sheath

135. Infectious proteins are presents in **[2010]**
(a) Satellite viruses (b) Gemini viruses
(c) Prions (d) Viroids

136. Viruses that infect bacteria, multiply and cause their lysis, are called **[2004]**
(a) Lytic (b) Lysogenic
(c) Lysozymes (d) Lipolytic

137. Tailed bacteriophages are **[1995]**
(a) Motile on surface of bacteria
(b) Non-motile
(c) Actively motile in water
(d) Motile on surface of plant leaves

138. Influenza virus has **[1996]**
(a) RNA (b) DNA
(c) Neither RNA nor DNA (d) Both DNA and RNA

139. Which one is the smallest among the following **[1988]**
(a) Bacteriophage (b) TMV
(c) *E. coli* (d) Neurospora

140. The protein coat of virus is called **[2010]**
(a) Capsid (b) Cosmid
(c) Capsomere (d) Chromophore

141. Which statement is wrong for viruses **[2012]**
(a) All are parasites
(b) All of them have helical symmetry
(c) They have ability of synthesize nucleic acids and proteins
(d) Antibiotics have no effect on them

142. Which of the following statements is not true for retroviruses **[2004]**
(a) The genetic material in mature retroviruses in RNA
(b) Retroviruses are causative agents or certain kinds of cancer in man
(c) DNA is not present at any stage in the life cycle of retroviruses
(d) Retroviruses carry gene for RNA-dependent DNA polymerase

143. Which of the following statements is wrong for viroids **[2016]**
(a) They lack a protein coat
(b) They are smaller than viruses
(c) They cause infections
(d) Their RNA of high molecular weight

144. Viruses have **[2014]**
(a) Single chromosome
(b) Both DNA and RNA
(c) DNA enclosed in a protein coat
(d) Prokaryotic nucleus

145. Interferon is a **[2000]**
(a) Low molecular weight protein which inhibits viral multiplication
(b) RNA used for DNA synthesis
(c) Protein used for the transportation of oxygen
(d) Protein inhibits DNA synthesis

146. AIDS virus contains **or** human immuno deficiency virus (HIV) virus has protein coat and genetic material which is **[1998]**
(a) Single stranded RNA with protein
(b) Double stranded RNA
(c) Single stranded DNA with protein
(d) Double stranded DNA

147. Which of the following is false **[2005]**
(a) Most plant viruses are RNA viruses
(b) Most animal viruses are DNA viruses
(c) TMV has double stranded RNA molecule
(d) T_4 bacteriophage has double stranded DNA molecule

148. Select the wrong statements **[2015]**
(a) W.M. Stanley showed that viruses could be crystallized
(b) The term '*contagium vivum fluidum*' was coined by M.W. beijerinck
(c) Mosaic disease in tobacco and AIDS in human being are caused by viruses
(d) The viroids were discovered by D.J. Ivanowski

149. Satellite RNA are present in some **[2013]**
(a) Viroids (b) Prions
(c) Bacteriophages (d) Plant viruses

150. Which of the following shows coiled RNA strand and capsomeres **[2014]**
(a) Measles virus (b) Retrovirus
(c) Polio virus (d) Tobacco mosaic virus

151. Pair of viral diseases is **[2009]**
(a) Ringworm, AIDS
(b) Typhoid, Tuberculosis
(c) Dysentary, Common cold
(d) Common cold, AIDS

152. Which one of the following statement is correct **[2010]**
(a) Prions are the smallest free living cells
(b) The cell wall of mycoplasmas is made up of amino sugars
(c) Viroids consist of single stranded RNA molecule
(d) Rickettside lack cell wall

153. The infectious ribonucleic acid is referred to as **[2016]**
(a) Prion (b) Viroid
(c) Phycobiont (d) Ribozyme

15. AIIMS

1. Bacterial flagella is made up of **[2004]**
(a) Protein (b) Amines
(c) Lipids (d) Carbohydrates

2. 'Peptidoglycan' is a characteristic constituent of the cell wall of **[1999]**
(a) Eubacteria and unicellular eukaryotes
(b) Bacteria and cyanobacteria
(c) Archaebacteria and eukaryotes
(d) All members of 'monera' and 'protista'

3. The bacteria grown in the medium containing S^{35} as a one source of sulphur show its incorporation into **[1994]**
(a) DNA (b) Protein
(c) RNA (d) None of the above

4. The bacteria *Pseudomonas* is useful because of its ability to **[2004]**
(a) Transfer genes from one plant to another
(b) Decompose a variety of organic compounds
(c) Fix atmospheric nitrogen in the soil
(d) Produce a wide variety of antibiotics

5. Cattle ranches are known to cause acute green house effect. This is due to **[2012]**
(a) Mechanised milking practices
(b) Methanogenic bacteria in rumen
(c) Decomposition of left over fodder
(d) Decomposition of organic remains in faeces

6. In the following table identify the correct matching of the crop, its disease and the corresponding pathogen **[2008]**

	Crop	Disease	Pathogen
(a)	Citrus	Canker	*Pseudomonas rubrilineans*
(b)	Potato	Late blight	*Fusarium udum*
(c)	Brinjal	Root–knot.	*Meloidogyne incognita*
(d)	Pigeon pea	Seed gall	*Phytophthora infestans*

7. Single filament of *Nostoc* without mucilage sheath is known as **[1998]**
(a) Hyphae (b) Colony
(c) Trichome (d) Mycelium

8. Hormogonia are the vegetatively reproducing structures of **[1999]**
(a) Ulothrix (b) Spirogyra
(c) Oscillatoria (d) Chlamydomonas

9. These organisms are fungus like in one phase of their life cycle and *Amoeba* like in another phase of their life cycle **[2009, 13]**
(a) Diatoms (b) Slime molds
(c) Dinoflagellates (d) Water molds

10. Sporogony of malarial parasite occurs in **[1999]**
(a) Liver of man
(b) RBCs of man
(c) Stomach wall of mosquito
(d) Salivary glands of mosquito

11. Primary grouping of protozoan protists is based on **[1999]**
(a) Locomotor organelles (b) Size and shape
(c) Mode of feeding (d) Mode of reproduction

12. Infective stage of *Trypanosoma gambiense* is **[1999]**
(a) Metacyclic (b) Crithidial
(c) Leptomonas (d) Leishmania

13. Recurrence of high temperature in malaria at intervals is due to completion of **[1996]**
(a) Erythrocytic schizogony
(b) Sporogony
(c) Gamogony
(d) Exoerythrocytic schizogony

14. Which is wrong combination **[2001]**
(a) Haemocyanin – Prawn
(b) Haemoglobin in mammals – RBC
(c) Haemoglobin in plasma – *Pheretima*
(d) Haemozoin – *Plasmodium* cytoplasm

15. Chromatid bodies occurs in *Entamoeba* during **[2002]**
(a) Precyst stage (b) Early cysts
(c) Tetranucleate cysts (d) Trophozoites

16. Just a *Xenopsylla* is to *Yersinia pestis*, so is **[2003]**
(a) Glossina palpalis to Wuchereria banerofti
(b) Culex to Plasmodium falciparum
(c) Homo sapiens to Taenia solium
(d) Phlebotomus to Leishmania donovani

17. Which of the following is not correctly matched **[1998]**
(a) Root knot disease – *Meloidogyne javanica*
(b) Smut of bajra – *Tolysporium penicillariae*
(c) Covered smut of barley – *Ustilago nuda*
(d) Late blight of potato – *Phytophthora infestans*

18. Plasmogamy is fusion of **[1992, 97]**
(a) Two haploid cells including their nuclei
(b) Two haploid cells without nuclear fusion
(c) Sperm and egg
(d) Sperm and two polar nuclei

19. Deuteromycetes are known as fungi imperfecti because **[2012]**
(a) Their zygote undergoes meroblastic and holoblastic cleavage
(b) Only asexual stages are known
(c) They have aseptate mycelium
(d) They are autotrophic

20. Aflatoxicosis of poultry is caused by **[2000]**
(a) A.flavus (b) A.fumigatus
(c) Candida albicans (d) Rhizopus

21. Which of the following is famous mycologist of India **[1992]**
(a) P. Maheshwari (b) M.O.P. Iyengar
(c) K. Sharma (d) Sadasivan

22. Powdery mildews of crops are caused by **[2001]**
(a) Bacteria (b) Ascomycetes
(c) Phycomycetes (d) Basidiomycets

23. In *Rhizopus* if conjugation fails, gametangia behave as zygospore. It is called as **[2000]**
(a) Conidia (b) Parthenospore
(c) Gametangia (d) Sporangiospore

24. Yeast is **[1997]**
(a) Purely aerobic (b) Anaerobic
(c) Rarely anaerobic (d) Both aerobic and anaerobic

25. Which one of the following pairs is correctly matched **[2003, 07]**
(a) Rhizobium – Parasite in the roots of leguminous plants
(b) Mycorrhizae – Mineral uptake from soil
(c) Yeast – Production of biogas
(d) Myxomycetes – The disease ring worm

26. Which of the following structure helps in the respiration of lichens **[2002]**
(a) Soredia (b) Cyphella
(c) Isoidia (d) Cephalodia

16. Assertion & Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both the assertion and the reason are true and the reason is a correct explanation of the assertion
(b) If both the assertion and reason are true but the reason is not a correct explanation of the assertion
(c) If the assertion is true but the reason is false
(d) If both the assertion and reason are false
(e) If the assertion is false but reason is true

1. Assertion : Bacteria have three basic shapes, *i.e.*, round, rod, spiral.
Reason : Cocci and Bacilli may form clusters or chain of a definite length.

2. Assertion : Bacteria do not always move with the help of flagella.
Reason : Flagellated bacteria employs rotary motion of flagellum when it moves.

3. Assertion : None autotrophic bacteria carry out chemosynthesis.
Reason : Chemosynthetic bacteria trap the small amount of energy released from inorganic compound's oxidation to use in the reactions that synthesize carbohydrates.

4. Assertion : *Bacillus butschli* is true bacterium.
Reason : Its cell wall is composed of acetyl muramic acid.

5. Assertion : *Agrobacterium tumefaciens* is the causative agent of crown gall disease of dicots .
Reason : *Agrobacterium tumefaciens* causes infection by entering the plant through wounds and injuries.

6. Assertion : Bacteria are prokaryotic.
Reason : Bacteria do not possess true nucleus and membrane bound cell organelles.

7. Assertion : Bacterial photosynthesis occurs by utilizing wavelength longer than 700 *nm*.
Reason : Here reaction centre is B-890.

8. Assertion : Some bacteria have the capacity to retain Gram stain after treatment with acid alcohol.
Reason : They are known as Gram positive as they are attracted towards positive pole under influence of electric current.

9. Assertion : Broad spectrum antibiotics are produced by *streptomyces*.
Reason : They can destroy microorganisms by inhibiting DNA replication or protein synthesis.

10. Assertion : Root nodules in leguminous plants are inhabited by *Anabaena*.
Reason : Leguminous plants are an example of symbiotic nitrogen fixation.

11. Assertion : Plasmids are double-stranded extra chromosomal DNA.
Reason : Plasmids are possessed by eukaryotic cells.

12. Assertion : *Euglena* is studied as an animal as well as a plant.
Reason : *Euglena* is more an animal than a plant.

13. Assertion : Schizogony is an asexual reproduction of female *Anopheles* mosquito.
Reason : It takes place only in human liver cells.

14. Assertion : *Amoeba* contains a contractile vacuole.
Reason : It helps in both digestion and osmoregulation.

15. Assertion : Erythrocytic merozoites form gametocytes.
Reason : Gametocytes are of two types – male and female.

16. Assertion : Fruticose are well branched leafy lichens.
Reason : These lichens are upright and have pendulous organisation and are attached to substratum by a discoid structure.

17. Assertion : Deuteromycetes lack sexual reproduction.
Reason : Fungi show three type of reproduction asexual, sexual and vegetative.

18. Assertion : *Rhizopus* and *Mucor* are used in liquor industry.
Reason : They cause fermentation.

19. Assertion : *Saccharomyces ellipsoidens* is Baker's yeast and *Saccharomyces cerevisiae* is Wine yeast.
Reason : Yeast is used to make dry ice.

20. Assertion : The fungi are widespread in distribution and they even live on inside other plants and animals.
Reason : Fungi are able to grow anywhere on land, water or on other organisms because they have a variety of pigments, including chlorophyll, carotenoids, fucoxanthin and phycoerythrin.

21. Assertion : Symbiosis is furnished by mycorrhiza.
Reason : In mycorrhiza, symbiosis is established between fungus and alga.

22. Assertion : Aflatoxins are produced by *Aspergillus flavus*.
Reason : These toxins are useful to mankind.

23. Assertion : Yeast are the best source of vitamin B complex.
Reason : *Ashbya gossypii* is a filamentous yeast.

24. Assertion : Tobacco mosaic virus which causes mosaic disease
Reason : TMV has RNA as a genetic material.

25. Assertion : Interferons are a type of antibodies produced by body cells infected by bacteria.
Reason : Interferons stimulate inflammation at the site of injury.